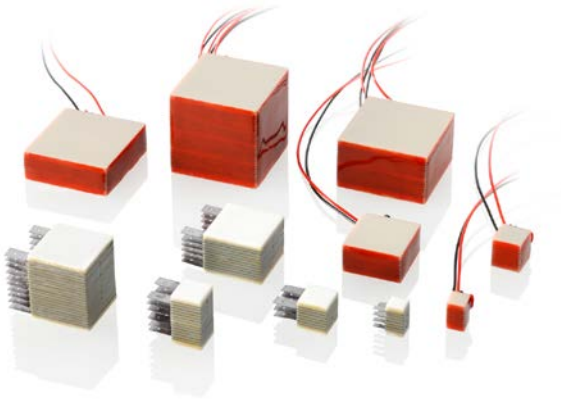
PZ252E

P-1xx Piezo Actuator

User Manual

Version: 1.0.0 Date: 29.06.2015



This document describes the following products:

- **P-111 - P-151**
  PICA Shear Actuators
  Travel ranges up to 10 µm

This document also applies to custom products from the PICA Shear Actuator product line.

PI Ceramic GmbH, Lindenstrasse, 07589 Lederhose, Germany
Phone: +49 36604 882-0, Fax: +49 36604 882-4109, Email: info@piceramic.com



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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 This manual is superseded by any new release.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

Objective and Target Audience of this User Manual 1
Validity for Custom Products 1
Symbols and Typographic Conventions 2
Figures 3
Other Applicable Documents 3
Downloading Manuals 3

1.1 Objective and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-1xx (x stands for the different models, p. 9).

Basic knowledge of 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 Validity for Custom Products

This user manual also applies to custom products from the PICA Shear Actuator product line if nothing else is stated in their accompanying documentation.

The product line is stated on the delivery note of the custom product.

The properties of custom products may differ from those stated in this manual.

1.3 Symbols and Typographic Conventions

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

DANGER



Imminently hazardous situation

If not avoided, the hazardous situation will result in death or serious injury.

➢ Actions to take to avoid the situation.

CAUTION



Dangerous situation

Failure to observe can result in minor injuries or damage to the equipment.

➢ Actions to take to avoid the situation.

NOTICE



Dangerous situation

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

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)

1.4 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.

1.5 Other Applicable Documents

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

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

Product	Document
E-413 Piezo Amplifier	PZ199E user manual
E-500 Modular Piezo Controller	PZ62E user manual

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 45).

INFORMATION

For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD. Availability of the manuals:

- Password-protected manuals: FTP download directory
- Freely available manuals: PI website

➢ Follow the corresponding instructions for downloading.

Downloading freely accessible manuals

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding product category.
4. Go to the corresponding product code.

   The available manuals are displayed.
5. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Downloading password-protected manuals

1. Insert the product CD in 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.
5. Open the FTP download directory (ftp://pi-ftp.ws).
   - Windows operating systems: Open the FTP download directory in Windows Explorer.
6. Log in with the user name and the password from the Release News.
7. In the directory of the corresponding product, go to the Manuals sub-directory.
8. Copy the desired manual to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

Intended Use 5
General Safety Instructions 6
Organizational Measures..... 7

2.1 Intended Use

The P-1xx is intended to be used in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the P-1xx is intended for integration into a mechanical system and for the following applications:

- Positioning of loads
- Dynamic positioning
- Vibration damping

Depending on the model, the motion is performed as follows:

Model	Motion	Axis
P-111, P-121, P-141, P-151	on one axis horizontally	X
P-112, P-122, P-142, P-152	on two axes horizontally	X, Y
P-123, P-143, P-153	on two axes horizontally and on one axis vertically	X, Y, Z

The operator is responsible for standards compliant integration of the P-1xx into the overall system.

When mounting, the maximum shear load according to the data table (p. 47) may not be exceeded.

For operation of the P-1xx, suitable electronics that provide the required operating voltages are required. The electronics are not included in the scope of delivery of the P-1xx. We recommend the use of suitable electronics (p. 15) from PI.

2.2 General Safety Instructions

The P-1xx 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-1xx.

- Only use the P-1xx 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-1xx.

Temperature changes and compressive stresses can induce charges in the P-1xx piezo actuator. After disconnection from the electronics, the piezo actuator can stay charged for several hours. Touching the live parts of the P-1xx can result in serious injury or death from electric shock.

- Do **not** touch the P-1xx unless it is discharged (p. 38).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves and suitable protective goggles.
- Keep the piezo actuator short-circuited (p. 40) when it is not connected to the electronics.
- Do **not** disassemble the piezo actuator.

The system in which the P-1xx is integrated (e.g. case or surrounding mechanical system) must be connected to a protective earth conductor. If the protective earth conductor is missing or not properly connected, dangerous touch voltages can occur on the overall system in case of malfunction or failure of the system. If touch voltages exist, touching the overall system can result in serious injury or death from electric shock.

- Before start-up, connect the overall system to a protective earth conductor in accordance with the applicable standards.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be temporarily removed (e.g. for modifications), reconnect the overall system to the protective earth conductor before starting it up again.

During operation, the P-1xx is subject to voltages up to 250 V. The protective polymer layer of the piezo actuator does **not** protect against electric shock. Touching the live parts of the P-1xx can result in serious injury or death from electric shock.

- Do **not** touch the piezo actuator during operation.
- Electrically insulate the piezo actuator from the surrounding mechanical system to prevent direct or indirect contact with live parts. Observe the clearances and creepage distances required for the operating voltage, and observe the standards applicable to your application.

Mechanical forces can damage or misalign the P-1xx.

- Avoid impacts that affect the P-1xx.
- Do **not** drop the P-1xx.
- Prevent torques and lateral forces on the P-1xx.
- Do **not** use metal tools during installation.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 47).

2.3 Organizational Measures

User manual

- Always keep this user manual available with the P-1xx.
  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-1xx to other users, also include this manual as well as all other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. If your user manual is incomplete and is therefore missing important information, serious or fatal injury as well as damage to the equipment can result.
- Only install and operate the P-1xx after you have read and understood this user manual.

Personnel qualification

The P-1xx may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

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Product View 12
Product Labeling 13
Direction of Motion and Polarity 14
Scope of Delivery 15
Suitable Electronics 15
Operating Principle of a Shear Actuator 16
Technical Features 16

3.1 Model Overview

Model	Description
P-111.01	PICA Shear X piezo actuator, 1 µm travel range, 3 mm × 3 mm cross section
P-111.03	PICA Shear X piezo actuator, 3 µm travel range, 3 mm × 3 mm cross section
P-111.05	PICA Shear X piezo actuator, 5 µm travel range, 3 mm × 3 mm cross section
P-121.01	PICA Shear X piezo actuator, 1 µm travel range, 5 mm × 5 mm cross section
P-121.03	PICA Shear X piezo actuator, 3 µm travel range, 5 mm × 5 mm cross section
P-121.05	PICA Shear X piezo actuator, 5 µm travel range, 5 mm × 5 mm cross section
P-141.03	PICA Shear X piezo actuator, 3 µm travel range, 10 mm × 10 mm cross section
P-141.05	PICA Shear X piezo actuator, 5 µm travel range, 10 mm × 10 mm cross section
P-141.10	PICA Shear X piezo actuator, 10 µm travel range, 10 mm × 10 mm cross section

Model	Description
P-151.03	PICA Shear X piezo actuator, 3 µm travel range, 16 mm × 16 mm cross section
P-151.05	PICA Shear X piezo actuator, 5 µm travel range, 16 mm × 16 mm cross section
P-151.10	PICA Shear X piezo actuator, 10 µm travel range, 16 mm × 16 mm cross section
P-112.01	PICA Shear XY piezo actuator, 1 µm × 1 µm travel range, 3 mm × 3 mm cross section
P-112.03	PICA Shear XY piezo actuator, 3 µm × 3 µm travel range, 3 mm × 3 mm cross section
P-122.01	PICA Shear XY piezo actuator, 1 µm × 1 µm travel range, 5 mm × 5 mm cross section
P-122.03	PICA Shear XY piezo actuator, 3 µm × 3 µm travel range, 5 mm × 5 mm cross section
P-122.05	PICA Shear XY piezo actuator, 5 µm × 5 µm travel range, 5 mm × 5 mm cross section
P-142.03	PICA Shear XY piezo actuator, 3 µm × 3 µm travel range, 10 mm × 10 mm cross section
P-142.05	PICA Shear XY piezo actuator, 5 µm × 5 µm travel range, 10 mm × 10 mm cross section
P-142.10	PICA Shear XY piezo actuator, 10 µm × 10 µm travel range, 10 mm × 10 mm cross section
P-152.03	PICA Shear XY piezo actuator, 3 µm × 3 µm travel range, 16 mm × 16 mm cross section
P-152.05	PICA Shear XY piezo actuator, 5 µm × 5 µm travel range, 16 mm × 16 mm cross section
P-152.10	PICA Shear XY piezo actuator, 10 µm × 10 µm travel range, 16 mm × 16 mm cross section
P-123.01	PICA Shear XYZ piezo actuator, 1 µm × 1 µm × 1 µm travel range, 5 mm × 5 mm cross section
P-123.03	PICA Shear XYZ piezo actuator, 3 µm × 3 µm × 3 µm travel range, 5 mm × 5 mm cross section
P-143.01	PICA Shear XYZ piezo actuator, 1 µm × 1 µm × 1 µm travel range, 10 mm × 10 mm cross section

Model	Description
P-143.03	PICA Shear XYZ piezo actuator, 3 µm × 3 µm × 3 µm travel range, 10 mm × 10 mm cross section
P-143.05	PICA Shear XYZ piezo actuator, 5 µm × 5 µm × 5 µm travel range, 10 mm × 10 mm cross section
P-153.03	PICA Shear XYZ piezo actuator, 3 µm × 3 µm × 3 µm travel range, 16 mm × 16 mm cross section
P-153.05	PICA Shear XYZ piezo actuator, 5 µm × 5 µm × 5 µm travel range, 16 mm × 16 mm cross section
P-153.10	PICA Shear XYZ piezo actuator, 10 µm × 10 µm × 10 µm travel range, 16 mm × 16 mm cross section

Versions with inner hole

Model	Description
P-151.03H	PICA Shear X piezo actuator, 3 µm travel range, 16 mm × 16 mm cross section, ID 10 mm
P-151.05H	PICA Shear X piezo actuator, 5 µm travel range, 16 mm × 16 mm cross section, ID 10 mm
P-151.10H	PICA Shear X piezo actuator, 10 µm travel range, 16 mm × 16 mm cross section, ID 10 mm
P-153.10H	PICA Shear XYZ piezo actuator, 10 µm × 10 µm × 10 µm travel range, 16 mm × 16 mm cross section, ID 10 mm

Versions for cryogenic and UHV environments

Model	Description
P-111.01T	PICA Shear X piezo actuator, 1 µm travel range, 3 mm × 3 mm cross section, vacuum-compatible to 10^{-9} hPa, operating temperature to -269 °C
P-111.03T	PICA Shear X piezo actuator, 3 µm travel range, 3 mm × 3 mm cross section, vacuum-compatible to 10^{-9} hPa, operating temperature to -269 °C
P-121.01T	PICA Shear X piezo actuator, 1 µm travel range, 5 mm × 5 mm cross section, vacuum-compatible to 10^{-9} hPa, operating temperature to -269 °C
P-121.03T	PICA Shear X piezo actuator, 3 µm travel range, 5 mm × 5 mm cross section, vacuum-compatible to 10^{-9} hPa, operating temperature to -269 °C

3.2 Product View

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

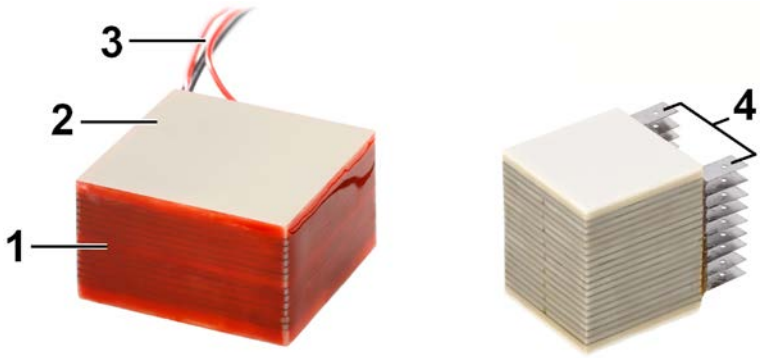


Figure 1: Example of product view

1 *Lateral surface: Protective polymer layer (epoxy resin)*

2 *End piece (model dependent):*
P-1xx.xx and P-1xx.xxH: Ceramic (passive PZT)
P-1xx.xxT: Ceramic (Al_2O_3, 96 % pure)

3 *Stranded wires for models P-1xx.xx and P-1xx.xxH*
(Not shown here: Contact strips at the stranded wire exits.)

4 *Tantalum electrodes (connecting lugs) of models P-1xx.xxT: Contacting with conductive adhesive or by welding.*

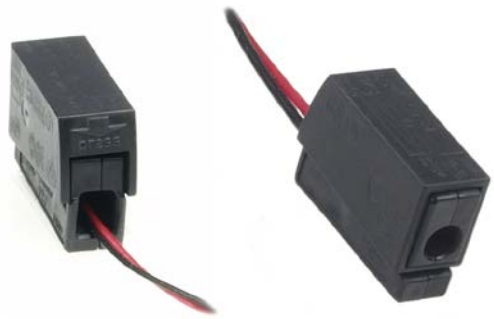


Figure 2: INYY-0005 shorting clamp: Front side for clamping the stranded wires (left) and rear side of the clamp (right)

3.3 Product Labeling

Depending on the model, the product labeling is affixed to the following areas:

- Models with stranded wires: On the black stranded wire of the piezo actuator
- Models with tantalum electrodes: On the bag that contains the piezo actuator on delivery

The product labeling includes the following information:

Labeling	Description
	Data matrix code (example; contains the serial number)
P-153.10H	Product name (example), the characters following the period refer to the model
215003005	Serial number (example), individual for each P-1xx Meaning of the places (counting from left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive numbers
Country of origin: Germany	Country of origin
WWW.PICERAMIC.COM	Manufacturer's address (website)
PI	Manufacturer's logo

3.4 Direction of Motion and Polarity

Models with stranded wires

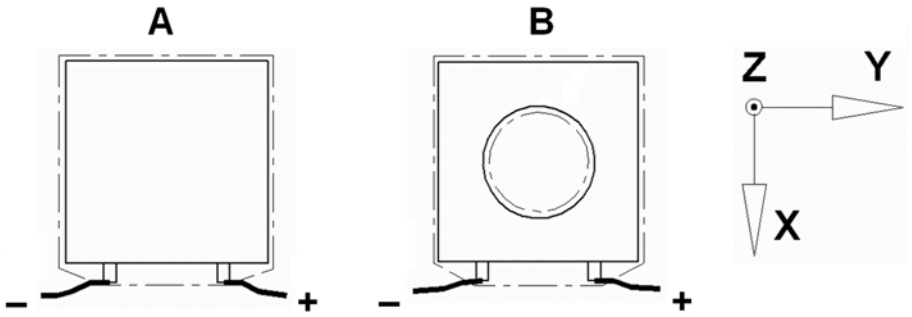


Figure 3: Models with stranded wires (example view from above): Direction of motion and the polarity of the shear actuator clamped to the bottom

A	*P-1xx models without inner hole*
B	*P-1xx models with inner hole*
–	*Connection for ground (black stranded wire)*
+	*Voltage connection (red stranded wire)*
XYZ	*X, Y, and Z direction of motion when applying positive voltage*

Models with tantalum electrodes

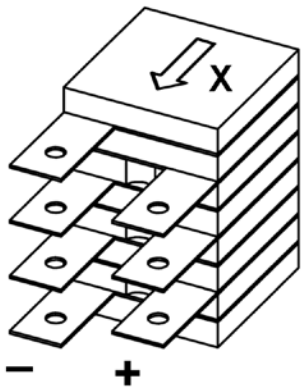


Figure 4: Models with tantalum electrodes (example view): Direction of motion and polarity of the shear actuator clamped to the bottom

–	*Connections for ground (vertical electrode stack with larger number of electrodes)*
+	*Voltage connections (vertical electrode stack with smaller number of electrodes)*
X	*X direction of motion when applying positive voltage*

3.5 Scope of Delivery

Item ID	Description
P-1xx	Piezo actuator according to order (p. 9)
PZ257EK	Short instructions for piezo actuators without case
Additional scope of delivery for models with stranded wires:	
INYY-0005	Shorting clamp, 2.5 mm^2 for the stranded wires of the piezo actuator (one shorting clamp per axis)

3.6 Suitable Electronics

To operate a P-1xx, you need electronics. The device is selected depending on the type of application. The table below lists the suitable products.

Item ID	Description
E-413.00	Piezo amplifier for PICA shear actuators, -250 to +250 V, bench-top device
E-413.OE	Piezo amplifier for PICA shear actuators, -250 to +250 V, OEM module
E-500	Modular piezo amplifier (configuration example) High-voltage piezo amplifier for PICA HVPZT, 3 channels, with PC interface and display, consisting of: 1 × E-500.00 19" case for modular piezo controller system, 1 to 3 channels 3 × E-508.00 HVPZT piezo amplifier module, 3 to 1100 V, 1 channel 1 × E-517.i3 Interface/display module, 24 bit D/A, TCP/IP, USB, RS-232, IEEE488, 3 channels

- To order, contact our customer service department (p. 45).
- Before selecting electronics, calculate the power requirements of your application (p. 36).

3.7 Operating Principle of a Shear Actuator

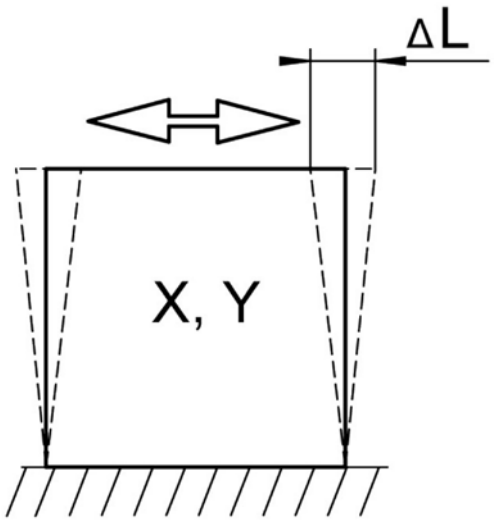


Figure 5: P-1xx: Principle of shear motion. ΔL refers to the travel range.

3.8 Technical Features

PICA shear actuators

P-1xx are PICA shear actuators for static and dynamic applications. They offer a response time in the microsecond range and subnanometer resolution.

The PICA shear actuators are manufactured as stacks of piezo ceramic disks. Due to their high stiffness, they are ideal for scanning applications, microscopy, precision mechanics, switching applications and are suitable for use in a cryogenic environment.

4 Unpacking

NOTICE



Destruction of the piezo actuator due to contamination!

Contamination on the surface of the P-1xx can result in the destruction of the piezo actuator by electric flashovers during operation.

- ➢ When handling the piezo actuator, wear powder-free nitrile or latex gloves and suitable protective goggles.
- ➢ Prevent the ceramic insulation or polymer insulation from coming into contact with conductive liquids (e.g. finger sweat) and conductive materials (e.g. metal dust).
- ➢ If the piezo actuator has been accidentally contaminated, clean it in accordance with the instructions in "Cleaning the P-1xx" (p. 41).

NOTICE



Damage due to bending of the tantalum electrodes!

The P-1xx.xxT models are equipped with tantalum electrodes that can be bent if handled improperly.

- ➢ Make sure that you do not touch the tantalum electrodes during unpacking and handling.

1. Unpack the P-1xx 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 Ceramic immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation 19
Mounting the P-1xx 24
Applying the Load 24
Connecting the P-1xx to the Electronics 25

5.1 General Notes on Installation

DANGER



Dangerous voltage and residual charge in piezo actuators!

Temperature changes and compressive stresses can induce charges in the P-1xx piezo actuator. After disconnection from the electronics, the piezo actuator can stay charged for several hours. Touching the live parts of the P-1xx can result in serious injury or death from electric shock.

- Do **not** touch the P-1xx unless it is discharged (p. 38).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves and suitable protective goggles.
- Keep the piezo actuator short-circuited (p. 40) when it is not connected to the electronics.
- Do **not** disassemble the piezo actuator.

NOTICE

Destruction of the piezo actuator due to rapid discharging!

If the P-1xx has stranded wires and is not connected to the electronics, the stranded wires must be short-circuited to prevent the piezo actuators from charging during temperature fluctuations and compressive stress. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- ➢ Remove shorting clamps (p. 15) connected to the stranded wires only when this is required for installation or operation.
- ➢ If the shorting clamp has been removed:
  - – Ensure adequate protection against touching live parts.
  - – Short-circuit the stranded wires of the P-1xx using a **10 kΩ discharge resistor** or discharge the piezo actuator (p. 38) in a suitable manner before reconnecting the shorting clamp.

NOTICE

Destruction of the piezo actuator due to excessive loads!

Excessive loads can destroy the P-1xx.

- ➢ Do **not** exceed the maximum compressive stress of 15 MPa.
- ➢ Avoid tensile stress.

NOTICE

Destruction of the piezo actuator due to mechanical overload!

Torques, bending forces and lateral forces can destroy the piezo actuator.

- ➢ Avoid torques, bending forces and lateral forces on the piezo actuator.
- ➢ Do **not** exceed the maximum shear load according to the data table (p. 47).
- ➢ Establish contact over as large an area as possible on the end surfaces of the piezo actuator, and select opposing surfaces with an evenness of only a few micrometers. Minor unevenness can be compensated by full-surface gluing, for example.

NOTICE



Damage due to tensile stress on the stranded wires of the piezo actuators!

Impermissible forces on the stranded wires (if applicable) can damage the piezo actuator.

- ➢ Avoid tensile stress on the stranded wires of the piezo actuator.

NOTICE



Damage due to bending of the tantalum electrodes!

The P-1xx.xxT models are equipped with tantalum electrodes than can be bent if handled improperly.

- ➢ Make sure that you do not touch the tantalum electrodes during unpacking and handling.

NOTICE



Damage due to scratches on the surface of the piezo actuator!

The surface of the piezo actuator is scratch-sensitive. Scratches on the surface can cause damage to the piezo actuator.

- ➢ Do **not** use metal tools to install the piezo actuator.
- ➢ When installing the piezo actuator, make sure that the ceramic or polymer insulation or end surfaces of the piezo actuator cannot be scratched during installation and operation.

NOTICE



Heating up of the P-1xx during operation!

The heat produced during operation of the P-1xx can affect your application.

- ➢ Install the P-1xx so that your application is not affected by the dissipating heat.

INFORMATION

Ground loops can occur when the shield of the connecting cable of the P-1xx is connected to an actuator case that is additionally grounded via a separate protective earth conductor.

➢ If a ground loop occurs, contact our customer service department (p. 45).

INFORMATION

Normally, shear actuators are not preloaded mechanically, because shear stress inside the actuator cannot be compensated. Light preloading can be useful when the width of the shear actuator is greater (aspect ratio length/width >1:1) or in the event of additional lateral forces.

➢ If preloading is required, contact our customer service department (p. 45).

The following figures are to help you avoid mounting errors.

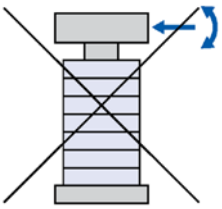


Figure 6: Prevention of lateral forces and torques

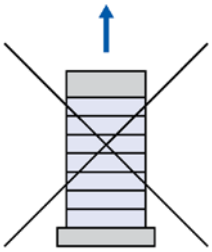


Figure 7: Avoiding tensile stress

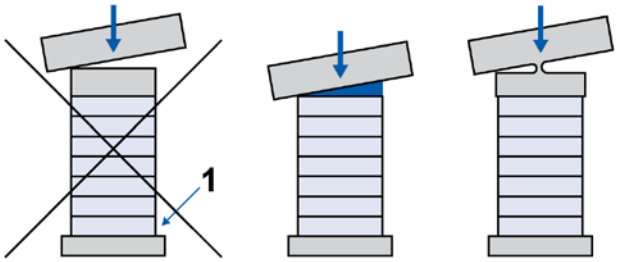


Figure 8: Prevention of an irregular load application (1: Tensile stresses)

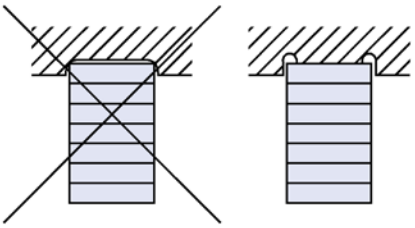


Figure 9: Full-area contact of the piezo actuator

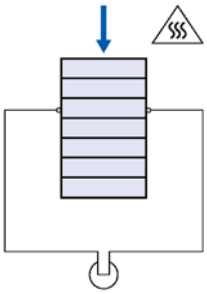


Figure 10: Mechanical or thermal loads electrically charge the piezo actuator. Mount only when short-circuited.

5.2 Mounting the P-1xx

P-1xx piezo actuators are glued to metal or ceramic surfaces.

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ The P-1xx is discharged (p. 38) and short-circuited (p. 40).

Tools and accessories

- Grease-free and even surface
- Suitable adhesive (e.g. cold-hardening epoxy resin adhesive)

Mounting the P-1xx

- ➢ Glue the piezo actuator to the surface:
  - – Apply the thinnest possible layer of adhesive.
  - – During the hardening process, maintain the operating temperature range (p. 51) specified for the piezo actuator.
  - – Observe the temperature expansion coefficients of the materials involved.

5.3 Applying the Load

Mechanical coupling of the P-1xx to a load is done by gluing the piezo actuator (p. 24) to the mechanical system to be moved or to a flexure joint, depending on the application.

INFORMATION

Diagrams showing how to couple the P-1xx to a load can be found in "General Notes on Installation" (p. 19).

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ The P-1xx is discharged (p. 38) and short-circuited (p. 40).

Tools and accessories

- Suitable adhesive (e.g. cold-hardening epoxy resin adhesive)
- When using a flexure joint: Suitable flexure joint

Applying the load

➢ Apply the load evenly.

If the piezo actuator is coupled in a milling pocket:

➢ Ensure that there is full-area contact at the end surface of the piezo actuator. For this purpose, choose the dimensions of the milling pocket correspondingly or make free cuts in the milling pocket.

5.4 Connecting the P-1xx to the Electronics

Models with stranded wires

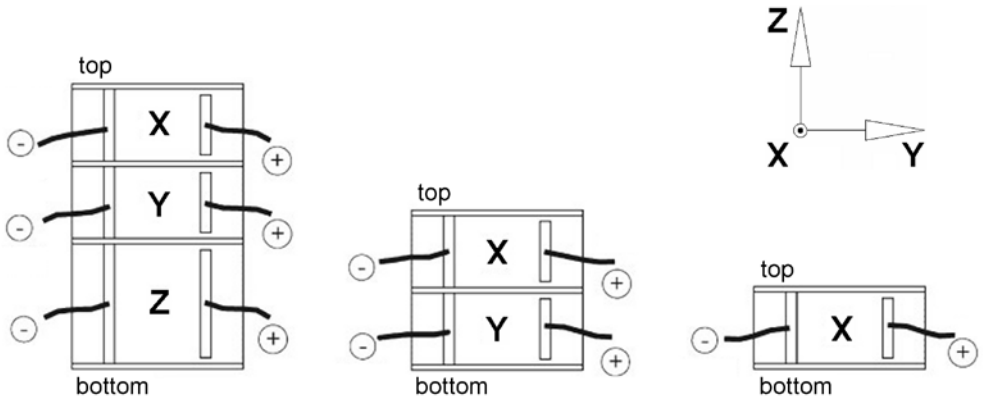


Figure 11: Models with stranded wires: Axis and cable assignment

–	*Connection for ground (black stranded wire)*
+	*Voltage connection (red stranded wire)*
XYZ	*X, Y, and Z axes*

Models with tantalum electrodes

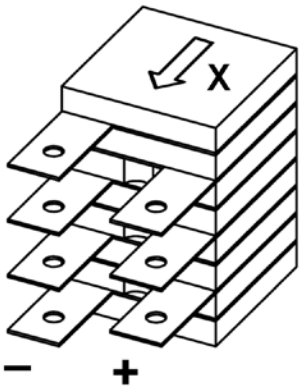


Figure 12: Models with tantalum electrodes: X axis and polarity of the electrodes

–	*Connections for ground (vertical electrode stack with larger number of electrodes)*
+	*Voltage connections (vertical electrode stack with smaller number of electrodes)*
X	*X axis*

Connection of the P-1xx to the electronics depends on the electronics (p. 15) used.

- When using electronics with LEMO socket, see "Connecting the P-1xx to Electronics with LEMO Socket (p. 27).
- When using electronics with Sub-D Mix socket, see "Connecting the P-1xx to Electronics with Sub-D Mix Socket" (p. 29).

5.4.1 Connecting the P-1xx to Electronics with LEMO Socket

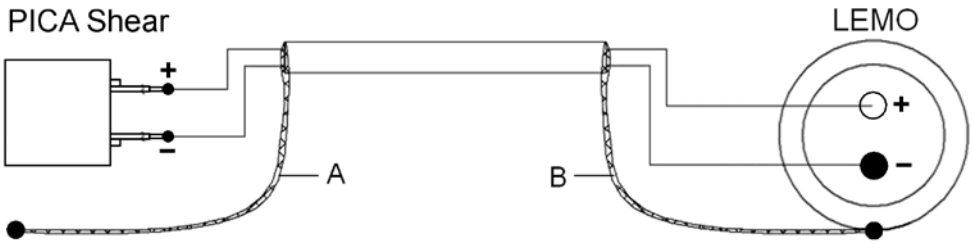


Figure 13: P-1xx PICA Shear actuator (left) to LEMO connector (right)

PICA Shear	*P-1xx shear actuator:* *Voltage connection (+) with red stranded wire* *Ground (-) with black stranded wire*
LEMO	*LEMO connector:* *Voltage connection (+) with female contact* *Ground (-) with male contact*
A	*Cable shield (actuator side)*
B	*Cable shield (connector side)*

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ If the P-1xx is not short-circuited: The P-1xx is discharged (p. 38).
- ✓ The electronics are **switched off**.
- ✓ Only P-1xx.xxT: The tantalum electrodes of the piezo actuator are contacted electrically by welding or by gluing with conductive glue and connected to stranded wires as follows:
  - Voltage connection (+) with red stranded wire
  - Ground (-) with black stranded wire

Tools and accessories

- Suitable connector: LEMO FGG.0B.701.CJA.1173 (available on request)
- Shielded 2-wire cable (not included in scope of delivery) which complies with the voltage and current specifications of the electronics (p. 15) to be connected and meets the applicable standards with regard to the conditions of use
- Suitable soldering iron
- Suitable solder
- Suitable cable tools

Connecting the P-1xx to electronics with LEMO socket

1. If the P-1xx is short-circuited, separate the short-circuited stranded wires of the P-1xx from each other. If a shorting clamp (p. 15) or a discharge resistor is connected, remove this component from the stranded wires.
2. Solder the stranded wires of the P-1xx and the LEMO connector with the wires of the shielded cable as shown in the connection diagram above.
   - When soldering, pay attention to the polarity of the P-1xx: The red connection is positive in contrast to the other connection.
3. Connect the cable shield:
   a) Connect the cable shield on the actuator side (A) to the actuator case. If there is no actuator case, cut the shield on the actuator side and insulate it.
   b) Connect the cable shield on the connector side (B) to the connector shell.
4. Connect the connector of the P-1xx to the corresponding connection on the electronics.

5.4.2 Connecting the P-1xx to Electronics with Sub-D Mix Socket

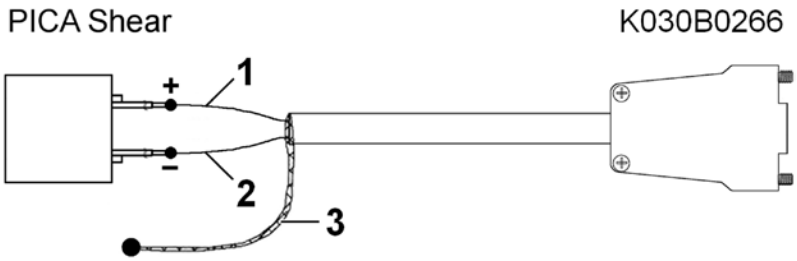


Figure 14: P-1xx PICA Shear actuator (left) to K030B0266 connecting cable (right)

PICA Shear	*P-1xx shear actuator:* *Voltage connection (+) with red stranded wire* *Ground (-) with black stranded wire*
K030B0266	*Connecting cable with Sub-D Mix connector 5W1*
1	*Red wire of the connecting cable: Voltage connection (+)*
2	*Black wire of the connecting cable: Ground (-)*
3	*Cable shield of the connecting cable*

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ If the P-1xx is not short-circuited: The P-1xx is discharged (p. 38).
- ✓ The electronics are **switched off**.
- ✓ Only P-1xx.xxT: The tantalum electrodes of the piezo actuator are contacted electrically by welding or by gluing with conductive glue and connected to stranded wires as follows:
  - Voltage connection (+) with red stranded wire
  - Ground (-) with black stranded wire

Tools and accessories

- K030B0266 connecting cable (in the scope of delivery of the electronics)
- Suitable soldering iron
- Suitable solder
- Suitable cable tools

Connecting the P-1xx to electronics with D-Sub Mix socket

1. If the P-1xx is short-circuited, separate the short-circuited stranded wires of the P-1xx from each other. If a shorting clamp (p. 15) or a discharge resistor is connected, remove this component from the stranded wires.
2. Solder the stranded wires of the P-1xx to the wires of the connecting cable as shown in the connection diagram above. During soldering, pay attention to the polarity of the P-1xx.
3. Insulate the soldered joint between the cables.
4. Connect the cable shield of the connecting cable to the actuator case. If there is no actuator case, cut the shield on the actuator side and insulate it.
5. Connect the connector of the P-1xx to the corresponding connection on the electronics.

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation 31
Calculating the Power Requirement for Sinusoidal Operation 36
Operating the P-1xx 38
Discharging the P-1xx 38
Short-Circuiting the P-1xx 40

6.1 General Notes on Start-Up and Operation

DANGER



Dangerous voltage in piezo actuators during operation!

During operation, the P-1xx is subject to voltages up to 250 V. The protective polymer layer of the piezo actuator does **not** protect against electric shock. Touching the live parts of the P-1xx can result in serious injury or death from electric shock.

- Do **not** touch the piezo actuator during operation.
- Electrically insulate the piezo actuator from the surrounding mechanical system to prevent direct or indirect contact with live parts. Observe the clearances and creepage distances required for the operating voltage, and observe the standards applicable to your application.

DANGER



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

The system in which the P-1xx is integrated (e.g. case or surrounding mechanical system) must be connected to a protective earth conductor. If the protective earth conductor is missing or not properly connected, dangerous touch voltages can occur on the overall system in the event of malfunction or failure of the system. If touch voltages exist, touching the overall system can result in serious injury or death from electric shock.

- Before start-up, connect the overall system to a protective earth conductor in accordance with the applicable standards.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be temporarily removed (e.g. for modifications), reconnect the overall system to the protective earth conductor before starting it up again.

CAUTION



Burning from hot surface!

The surface of the P-1xx and its vicinity can heat up during operation. Touching the P-1xx and surrounding parts can result in minor injuries from burning.

- Cool the P-1xx so that the temperature of its surface and surrounding parts does **not** exceed 65 °C.
- If sufficient cooling is not possible: Make sure that the hot P-1xx and its surrounding parts **cannot** be touched.
- If sufficient cooling and protection against contact are not possible: Mark the danger zone in accordance with the legal regulations.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

The use of the P-1xx in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials such as metal dust. In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- Avoid operating the P-1xx in environments that can increase the electrical conductivity.
- Only operate the P-1xx within the permissible ambient conditions and classifications (p. 51).
- Prevent the piezo actuator from coming into contact with liquids. If liquid cooling is to be used, contact our customer service department (p. 45).
- Protect the piezo actuator from moisture by means of hermetic sealing or the supply of dry air.
- In the air pressure range between 1 hPa and 500 hPa:
  Do **not** operate the P-1xx, or operate it only at reduced voltage (max. 200 V).
- For operation in vacuum below 0.1 hPa:
  Do **not** operate the P-1xx during evacuation.
- If the P-1xx is to be operated in a special gas atmosphere, contact our customer service department (p. 45).

NOTICE



Destruction of the piezo actuator due to dynamic forces!

During dynamic operation, dynamic forces can be generated that lead to mechanical overload of the piezo actuator. Dynamic forces can cancel preloading of preloaded piezo actuators. Dynamic operation at too high loads or dynamic operation without preloading can destroy the piezo actuator.

- Do **not** exceed the maximum compressive stress of 15 MPa.
- Avoid tensile stress.
- Do **not** exceed the maximum shear load according to the data table (p. 47).
- If preloading is required, contact our customer service department (p. 45).

NOTICE

Destruction of the piezo actuator due to excessive operating frequencies!

An excessive operating frequency can cause thermal and mechanical overload, thereby destroying the piezo actuator.

- ➢ Select the operating frequency so that the following conditions are met:
  - The operating frequency of the piezo actuator does not exceed one third of the resonant frequency. The resonant frequencies specified in the data tables (p. 47) apply to operation of the piezo actuator when it is unloaded and not clamped on both sides. In an arrangement with unilateral clamping, the value must be halved.
  - Dynamic forces generated during operation do **not** exceed the maximum compressive stress capability of the piezo actuator of 15 MPa and do not result in tensile stress.
- ➢ If your application involves operation of the piezo actuator with greater loads, contact our customer service department (p. 45).

NOTICE

Damage due to steep edges in the control signal!

If the actuator does not have a preload, steep edges in the control signal can trigger strong dynamic forces which damage the piezo actuator. Steep edges can occur, for example, when digital wave generators are switched on.

- ➢ Avoid steep edges in the control signal on actuators with low preload.

NOTICE

Damage after reconnecting due to a charged piezo actuator!

The piezo actuator can remain charged if its connecting cable is pulled out of the electronics during operation. Reconnecting a charged piezo actuator to electronics during operation can cause a mechanical impulse that will damage the piezo actuator.

- ➢ Do **not** pull the connecting cable of the piezo actuator out of the electronics during operation.

If the connecting cable of the piezo actuator is accidentally pulled out of the electronics during operation:

- ➢ Switch off the electronics before you reconnect the piezo actuator.

NOTICE

Reduced lifetime due to permanently high voltage and high air humidity!

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic of the piezo actuator. This applies in particular to operation in a humid environment.

- When the P-1xx is not in use but the electronics remain switched on to ensure temperature stability, discharge the P-1xx (p. 38).
- Reduce offset voltages to a minimum.
- Protect the piezo actuator against moisture by means of hermetic sealing or the supply of dry air.
- Make sure that the air humidity in the vicinity of the P-1xx does not exceed the relative humidity specified in "Ambient Conditions and Classifications" (p. 51).

NOTICE

Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the P-1xx.

- Do **not** exceed the operating voltage range (p. 49) for which the P-1xx is specified.
- Operate the P-1xx only when the operating voltage is properly connected; see "Connecting the P-1xx to the Electronics" (p. 25).

NOTICE

Destruction of the piezo actuator due to overheating!

Overheating can destroy the piezo actuator.

- Adjust the operating voltage, operating frequency and/or operating time so that the maximum operating temperature of the piezo actuator is not exceeded, see "Ambient Conditions and Classifications" (p. 51) and "Maximum Ratings" (p. 49).
- If necessary, cool the piezo actuator.
- Monitor the temperature of the piezo actuator with a temperature sensor.

NOTICE

Destruction of the piezo actuator due to rapid cooling!

If cooling is too fast, the resulting thermomechanical load can destroy the piezo actuator.

- ➢ Ensure that the piezo actuator cools down slowly to room temperature.
- ➢ Connect additional cooling systems only after the piezo actuator has cooled down to room temperature.

NOTICE

Uncontrolled oscillation!

Oscillation can cause irreparable damage to the piezo actuator. 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 piezo actuator is operated near its resonant frequency.

If you notice oscillation:

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

INFORMATION

The positive direction of motion (p. 12) corresponds to the expansion direction of the piezo actuator when a positive voltage is applied.

6.2 Calculating the Power Requirement for Sinusoidal Operation

- ➢ Calculate the average current requirement for sinusoidal operation using the following formula:

$$I_a \approx f \cdot C \cdot U_{p\text{-}p}$$

- ➢ Calculate the peak current requirement for sinusoidal operation using the following formula:

$$I_{max} \approx f \cdot \pi \cdot C \cdot U_{p\text{-}p}$$

Variable	Description	Notes
I_a	Required average current of the amplifier (source / sink) [A]	It is essential that the power supply can supply enough current.
I_{max}	Required peak current of the amplifier (source / sink) [A]	
f	Operating frequency [Hz]	The operating frequency may not exceed one third of the resonant frequency. The resonant frequencies specified in the data tables (p. 47) apply to operation of the piezo actuator when it is unloaded and not clamped on both sides. In an arrangement with unilateral clamping, the value must be halved.
C	Capacitance of the piezo actuator [F (= As/V)]	See "Data Table" (p. 47) for the small-signal capacitance of the piezo actuator. For large-signal conditions, a safety factor of 70 % should be added to the small-signal capacitance.
U_{p-p}	Operating voltage (peak-to-peak) [V]	

6.3 Operating the P-1xx

INFORMATION

To determine the optimum operating parameters (e.g., operating frequency, operating voltage, operating time and load) for your application, contact our customer service department (p. 45).

Prerequisites

- ✓ You have read and understood the general notes on start-up and operation (p. 31).
- ✓ You have installed (p. 19) the P-1xx correctly and connected it to the electronics (p. 25).
- ✓ You have provided suitable electronics that can supply the required currents (p. 36).
- ✓ You have read and understood the user manual of the electronics used.

Operating the P-1xx

- ➢ For starting up and operating the P-1xx, follow the instructions in the manual of the electronics (p. 15) used.

6.4 Discharging the P-1xx

INFORMATION

The models P-1xx.xxT only need to be discharged when the tantalum electrodes have made contact and are equipped with stranded wires.

The P-1xx must be discharged in the following cases:

- When the P-1xx is not in use but the electronics remain switched on to ensure temperature stability
- If the stranded wires of the P-1xx are to be short-circuited without discharge resistor, e.g., with a shorting clamp (p. 12)
- If the connecting cable of the P-1xx is accidentally pulled out of the electronics during operation

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ You have read and understood the general notes on start-up and operation (p. 31).

Tools and accessories

If the P-1xx is not connected to the electronics:

- Only for P-1xx **without** connector (delivery state):
  - 10 kΩ discharge resistor (not included in scope of delivery); touchable parts must be adequately insulated for the operating voltage range (p. 49) of the actuator
- Only for P-1xx **with** connector (p. 25):
  - Electronics (p. 15) from PI or suitable shorting plug (available on request)

Discharging a P-1xx connected to the electronics

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

Discharging a P-1xx not connected to the electronics

If the P-1xx does **not** have a connector:

1. Ensure adequate protection against touching live parts.
2. Short-circuit the stranded wires of the P-1xx for at least a few seconds using a **10 kΩ discharge resistor**.

If the P-1xx has a connector (p. 25):

- ➢ Connect the voltage connector of the P-1xx to the switched off PI electronics, which has an internal discharge resistor, for at least a few seconds.
- ➢ Alternative: Connect a suitable shorting plug with integrated discharge resistor to the voltage connector of the P-1xx for at least a few seconds.

6.5 Short-Circuiting the P-1xx

INFORMATION

The models P-1xx.xxT must only be discharged when the tantalum electrodes have made contact and are equipped with stranded wires.

The P-1xx must be discharged (p. 38) and short-circuited before demounting (e.g. before cleaning and transportation of the P-1xx) as well as for modifications.

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ You have discharged (p. 38) the P-1xx and disconnected it from the electronics.

Tools and accessories

- Only for P-1xx **without** connector (delivery state):
  - Suitable shorting clamp (in the scope of delivery (p. 15) of models P-1xx.xx and P-1xx.xxH)
- Only for P-1xx **with** connector (p. 25):
  - Suitable shorting plug (available on request)

Short-circuiting the P-1xx

If the P-1xx does **not** have a connector:

- ➢ Short-circuit the stranded wires of the **discharged** P-1xx with a suitable shorting clamp.

If the P-1xx has a connector (p. 25):

- ➢ Connect a suitable shorting plug with integrated discharge resistor to the voltage connector of the P-1xx.

7 Maintenance

In this Chapter

General Notes on Maintenance 41
Cleaning the P-1xx 41

7.1 General Notes on Maintenance

The P-1xx is maintenance-free.

7.2 Cleaning the P-1xx

NOTICE



Destruction of the piezo actuator due to electric flashovers!

If the piezo actuator comes into contact with liquids, it can be destroyed by electric flashovers.

Before cleaning the P-1xx:

➢ Ensure that the P-1xx is discharged (p. 38) and short-circuited (p. 40).

After cleaning the P-1xx:

➢ Dry the P-1xx completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).

Prerequisites

✓ The P-1xx is discharged (p. 38) and short-circuited (p. 40).

✓ The P-1xx is disconnected from the electronics.

Cleaning the P-1xx

- Touch the piezo actuator only with powder-free nitrile or latex gloves.
- Do **not** use acetone.
- When necessary, clean the surfaces of the P-1xx with a cloth that is slightly dampened with a mild cleanser (e.g. ethanol or isopropanol).
- When cleaning in an ultrasonic bath:
  - Reduce the energy input to the necessary minimum.
  - Only use isopropanol as cleaning fluid.
  - Observe the maximum cleaning time of 2 minutes.
- After cleaning, dry the P-1xx completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).

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 compressive stress of 15 MPa. ➢ Avoid tensile stress.
	Piezo actuator is depolarized due to overheating or reverse polarity	➢ Contact our customer service department (p. 45).
Piezo actuator moves in the opposite direction (p. 14) to that specified when voltage increases	Reverse polarity of the piezo actuator	➢ Contact our customer service department (p. 45).

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. 45).

9 Customer Service

For inquiries and orders, call PI Ceramic (phone: +49 36604 882-0) or send us an email (info@piceramic.com).

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

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

10 Technical Data

In this Chapter

Specifications 47
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10.1 Specifications

10.1.1 Data Table

	Travel	Surface A × B	Length L	Max. Shear Load	Axial Stiffness	Electrical Capacitance	Axial Resonant Frequency
	µm		*mm*	*N*	*N/µm*	*nF*	*kHz*
Active axis X							
P-111.01	1*	3 mm × 3 mm	3.5	20	70	0.5	330
P-111.03	3*	3 mm × 3 mm	5.5	20	45	1.5	210
P-111.05	5	3 mm × 3 mm	7.5	20	30	2.5	155
P-121.01	1*	5 mm × 5 mm	3.5	50	190	1.4	330
P-121.03	3*	5 mm × 5 mm	5.5	50	120	4.2	210
P-121.05	5	5 mm × 5 mm	7.5	40	90	7	155
P-141.03	3*	10 mm × 10 mm	5.5	200	490	17	210
P-141.05	5	10 mm × 10 mm	7.5	200	360	28	155
P-141.10	10	10 mm × 10 mm	12	200	230	50	100
P-151.03	3*	16 mm × 16 mm	5.5	300	1300	43	210
P-151.05	5	16 mm × 16 mm	7.5	300	920	71	155
P-151.10	10	16 mm × 16 mm	12	300	580	130	100
Active axes XY							
P-112.01	1 × 1*	3 mm × 3 mm	5	20	50	0.5 / 0.5	230
P-112.03	3 × 3*	3 mm × 3 mm	9.5	10	25	1.5 / 1.5	120
P-122.01	1 × 1*	5 mm × 5 mm	5	50	140	1.4 / 1.4	230
P-122.03	3 × 3*	5 mm × 5 mm	9.5	40	70	4.2 / 4.2	120
P-122.05	5 × 5	5 mm × 5 mm	14	30	50	7 / 7	85
P-142.03	3 × 3*	10 mm × 10 mm	9.5	200	280	17 / 17	120
P-142.05	5 × 5	10 mm × 10 mm	14	100	190	28 / 28	85
P-142.10	10 × 10	10 mm × 10 mm	23	50	120	50 / 50	50
P-152.03	3 × 3*	16 mm × 16 mm	9.5	300	730	43 / 43	120
P-152.05	5 × 5	16 mm × 16 mm	14	300	490	71 / 71	85
P-152.10	10 × 10	16 mm × 16 mm	23	100	300	130 / 130	50
Active axes XYZ							
P-123.01	1 × 1 × 1*	5 mm × 5 mm	7.5	40	90	1.4 / 1.4 / 2.9	155
P-123.03	3 ×3 × 3*	5 mm × 5 mm	15.5	10	45	4.2 / 4.2 / 7.3	75
P-143.01	1 × 1 × 1*	10 mm × 10 mm	7.5	200	360	5.6 / 5.6 / 11	155
P-143.03	3 × 3 × 3*	10 mm × 10 mm	15.5	100	170	17 / 17 / 29	75
P-143.05	5 × 5 × 5	10 mm × 10 mm	23	50	120	28 / 28 / 47	50
P-153.03	3 × 3 × 3*	16 mm × 16 mm	15.5	300	450	43 / 43 / 73	75
P-153.05	5 × 5 × 5	16 mm × 16 mm	23	100	300	71 / 71 / 120	50
P-153.10	10 × 10 × 10	16 mm × 16 mm	40	60	170	130 / 130 / 230	30

Travel range: At -250 to 250 V, tolerance -10/+20 %; * ±30 %.
Length L: Tolerance ±0.3 mm.
Electrical capacitance: Tolerance ±20 %, measured at 1 V_{pp}, 1 kHz, RT.
Axial resonant frequency: Measured at 1 V_{pp}, unloaded, unclamped. The value is halved for unilateral clamping.
Piezo ceramic type: PIC255.
Standard connections: PTFE-insulated wire leads, 100 mm, AWG 32, Ø 0.49 mm.
Operating voltage: -250 to 250 V.
Operating temperature range: -20 to 85 °C.
Standard mechanical interfaces: Ceramic (passive PZT).
Outer surface: Epoxy resin.
Custom designs or different specifications on request.

	Active Axes	Travel	Surface A × B / ID	Length L	Max. Shear Load	Axial Stiffness	Electrical Capacitance	Axial Resonant Frequency
		µm	*mm*	*mm*	*N*	*N/µm*	*nF*	*kHz*
P-151.03H	X	3*	16 × 16 / 10	5.5	200	870	30	210
P-151.05H	X	5	16 × 16 / 10	7.5	200	640	49	155
P-151.10H	X	10	16 × 16 / 10	12	200	400	89	100
P-153.10H	XYZ	10 × 10 × 10	16 × 16 / 10	40	20	120	89 / 89 / 160	30

Displacement: At -250 to 250 V, tolerance -10 / 20 %, * ±30 %.
Length L: Tolerance ±0.3 mm.
Electrical capacitance: Tolerance ±20 %, measured at 1 V_{pp}, 1 kHz, RT.
Axial resonant frequency: Measured at 1 V_{pp}, unloaded, unclamped. The value is halved for unilateral clamping.
Piezo ceramic type: PIC255.
Standard connections: PTFE-insulated wire leads, 100 mm, AWG 32, Ø 0.49 mm.
Operating voltage: -250 to 250 V.
Operating temperature range: -20 to 85 °C.
Standard mechanical interfaces: Ceramic (passive PZT).
Outer surface: Epoxy resin.
Custom designs or different specifications on request.

	Active Axis	Travel	Surface A × B	Length L	Max. Shear Load	Axial Stiffness	Electrical Capacitance	Axial Resonant Frequency
		µm		*mm*	*N*	*N/µm*	*nF*	*kHz*
P-111.01T	X	1	3 mm × 3 mm	2.2	20	110	2 × 0.25	530
P-111.03T	X	3	3 mm × 3 mm	4.4	20	55	6 × 0.25	260
P-121.01T	X	1	5 mm × 5 mm	2.2	50	310	2 × 0.70	530
P-121.03T	X	3	5 mm × 5 mm	4.4	50	150	6 × 0.70	260

Displacement: At -250 to 250 V, measured at RT. Value is reduced at lower temperatures. Tolerance ±30 %.
Length L: Tolerance ±0.3 mm.
Electrical capacitance: Tolerance ±20 %, measured at 1 V_{pp}, 1 kHz, RT.
Axial resonant frequency: Measured at 1 V_{pp}, unloaded, unclamped. The value is halved for unilateral clamping.
Piezo ceramic type: PIC255.
Standard connections: Possible with Ta. contacting with conductive adhesive or welding.
Operating voltage: -250 to 250 V.
Operating temperature range: -269 to 150 °C. Bake-out only when short-circuited.
Standard mechanical interfaces: Ceramic (Al_2O_3, 96 % pure).
Outer surface: Epoxy resin.
Custom designs or different specifications on request.

10.1.2 Maximum Ratings

P-1xx piezo actuators are designed for the operating data specified in the table below.

Additional information on the maximum ratings table

- Maximum operating frequency without load, without considering thermal aspects, column A:

  The values apply to unilaterally clamped piezo actuators and are calculated as follows: A third of the shear resonant frequency of the unloaded piezo actuator (operation when not clamped on both sides) divided by two.

- Maximum operating frequency without load, considering thermal aspects, column B:

  In order to prevent the maximum permissible operating temperature from being exceeded, the operating frequency of the unloaded, **uncooled** piezo actuator must not exceed the specified frequency when the operating voltage is **500 V peak-to-peak**. In the case of smaller amplitudes of the operating voltage and/or the use of cooling measures, higher operating frequencies are possible.

- Maximum power consumption:

  Power consumption of the unloaded, uncooled piezo actuator operated at a voltage of **500 V peak-to-peak** with the operating frequency from column B of this table.

Piezo Actuator	Maximum Operating Voltage Range	Maximum Operating Frequency without Load		Maximum Power Consumption
		A: Without Considering Thermal Aspects	B: After Considering Thermal Aspects	After Considering Thermal Aspects
P-111.01	–250 V to 250 V	17.1 kHz	0.69 kHz	0.07 W
P-111.03	–250 V to 250 V	8.4 kHz	0.53 kHz	0.16 W
P-111.05	–250 V to 250 V	4.8 kHz	0.5 kHz	0.25 W
P-121.01	–250 V to 250 V	19.5 kHz	0.45 kHz	0.13 W
P-121.03	–250 V to 250 V	11.1 kHz	0.35 kHz	0.29 W
P-121.05	–250 V to 250 V	7 kHz	0.33 kHz	0.46 W
P-141.03	–250 V to 250 V	12.4 kHz	0.17 kHz	0.58 W

Piezo Actuator	Maximum Operating Voltage Range	Maximum Operating Frequency without Load		Maximum Power Consumption
		A: Without Considering Thermal Aspects	B: After Considering Thermal Aspects	After Considering Thermal Aspects
P-141.05	–250 V to 250 V	9 kHz	0.17 kHz	0.92 W
P-141.10	–250 V to 250 V	4.9 kHz	0.17 kHz	1.67 W
P-151.03	–250 V to 250 V	10.9 kHz	0.11 kHz	0.90 W
P-151.05	–250 V to 250 V	8.9 kHz	0.1 kHz	1.41 W
P-151.10	–250 V to 250 V	5.6 kHz	0.1 kHz	2.56 W
P-112.01	–250 V to 250 V	9.9 kHz	0.46 kHz	0.09 W
P-112.03	–250 V to 250 V	3.1 kHz	0.5 kHz	0.29 W
P-122.01	–250 V to 250 V	12.7 kHz	0.3 kHz	0.17 W
P-122.03	–250 V to 250 V	4.7 kHz	0.33 kHz	0.54 W
P-122.05	–250 V to 250 V	2.3 kHz	0.33 kHz	0.92 W
P-142.03	–250 V to 250 V	6.8 kHz	0.16 kHz	1.08 W
P-142.05	–250 V to 250 V	3.9 kHz	0.17 kHz	1.83 W
P-142.10	–250 V to 250 V	1.7 kHz	0.17 kHz	3.33 W
P-152.03	–250 V to 250 V	7.2 kHz	0.1 kHz	1.66 W
P-152.05	–250 V to 250 V	4.7 kHz	0.1 kHz	2.82 W
P-152.10	–250 V to 250 V	2.3 kHz	0.1 kHz	5.12 W
P-123.01	–250 V to 250 V	7 kHz	0.26 kHz	0.29 W
P-123.03	–250 V to 250 V	1.9 kHz	0.31 kHz	0.96 W
P-143.01	–250 V to 250 V	9 kHz	0.13 kHz	0.58 W
P-143.03	–250 V to 250 V	3.3 kHz	0.15 kHz	1.92 W
P-143.05	–250 V to 250 V	1.7 kHz	0.16 kHz	3.17 W
P-153.03	–250 V to 250 V	4.1 kHz	0.09 kHz	2.94 W
P-153.05	–250 V to 250 V	2.3 kHz	0.09 kHz	4.86 W
P-153.10	–250 V to 250 V	0.9 kHz	0.1 kHz	9.22 W
P-153.10H	–250 V to 250 V	0.9 kHz	0.06 kHz	3.69 W
P-151.03H	–250 V to 250 V	10.9 kHz	0.06 kHz	0.36 W
P-151.05H	–250 V to 250 V	8.9 kHz	0.06 kHz	0.56 W
P-151.10H	–250 V to 250 V	5.6 kHz	0.06 kHz	1.02 W
P-111.01T	–250 V to 250 V	30.8 kHz	0.55 kHz	0.05 W
P-111.03T	–250 V to 250 V	12.1 kHz	0.52 kHz	0.15 W
P-121.01T	–250 V to 250 V	29.9 kHz	0.36 kHz	0.10 W
P-121.03T	–250 V to 250 V	14.9 kHz	0.34 kHz	0.28 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-1xx must be observed:

Area of application	For indoor use only
Air pressure	>500 hPa or <1 hPa
Relative humidity	Maximum relative humidity 50 % Continuous operation with high static voltage in humid environments significantly reduces piezo actuator lifetime. ➢ Observe the information on lifetime in "General Notes on Start-Up and Operation" (p. 31).
Operating temperature	Models P-1xx.xx and P-1xx.xxH: –20 °C to 85 °C Models P-1xx.xxT: –269 °C to 150 °C
Storage temperature	–20 °C to 80 °C
Transport temperature	–20 °C to 80 °C
Overvoltage category	II
Degree of pollution	1

The P-1xx is intended for installation in devices that fulfil the following classifications:

Protection class	I
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

Dimensions in mm

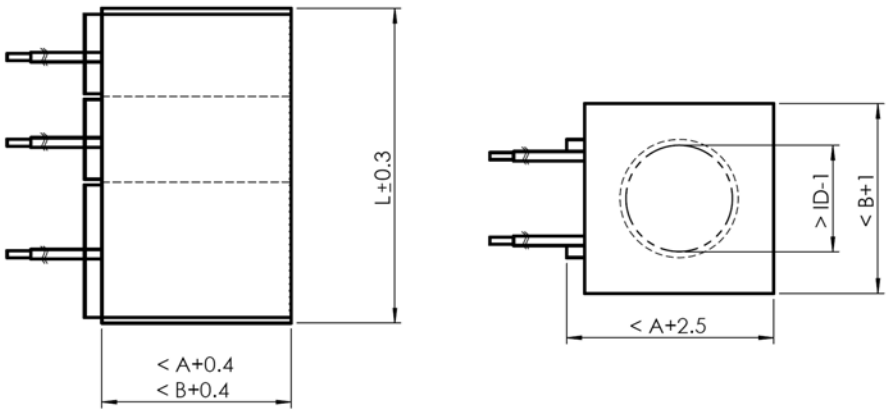


Figure 15: P-1xx.xx and P-1xx.xxH (with inner hole): A, B, L, see data table for ID. The number of axes and wires depends on the type.

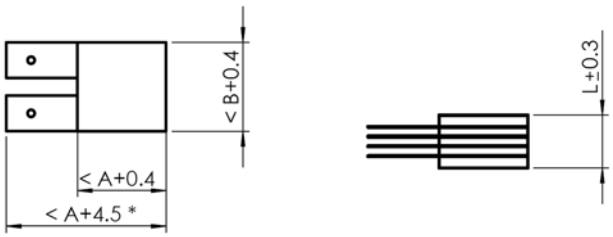


Figure 16: P-1xx.xxT: A, B, L, see data table. (<A+2.5 when cross section 3 × 3)*

11 Old Equipment Disposal

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

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

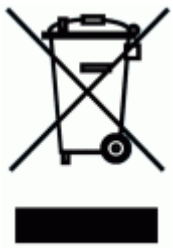
In order to fulfil its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

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

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstr. 1

D-76228 Karlsruhe, Germany



12 EC Declaration of Conformity

For the P-1xx, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

RoHS: EN 50581:2012

If an electrical operating device is designed to be integrated into another electrical operating device: The operator is responsible for standards compliant integration of the electrical device into the overall system.

