This document describes the following products:

- **P-882 – P-888**
  PICMA® Stack multilayer piezo actuators

- **P-080**
  PICMA® Stack multilayer ring actuators with inner hole

- **P-088**
  PICMA® Stack multilayer piezo actuators, round cross section
Contents

1 About this Document

1.1 Objective and Target Audience of this User Manual .................................................. 1
1.2 Validity for Custom Products ...................................................................................... 1
1.3 Symbols and Typographic Conventions ...................................................................... 2
1.4 Figures ........................................................................................................................ 2
1.5 Other Applicable Documents ..................................................................................... 3
1.6 Downloading Manuals ................................................................................................. 3

2 Safety

2.1 Intended Use .............................................................................................................. 5
2.2 General Safety Instructions ........................................................................................ 5
2.3 Organizational Measures ............................................................................................ 7

3 Product Description

3.1 Model Overview ......................................................................................................... 9
3.2 Product View ............................................................................................................. 11
3.3 Product Labeling ....................................................................................................... 12
3.4 Scope of Delivery ...................................................................................................... 12
3.5 Suitable Electronics .................................................................................................. 12
3.6 Accessories ............................................................................................................... 13
3.7 Technical Features .................................................................................................... 13

4 Unpacking


5 Installation

5.1 General Notes on Installation ................................................................................... 17
5.2 Soldering Stranded Wires to a Piezo Actuator (Only Models Without Stranded Wires) ................................................................. 22
5.3 Mounting the P-88x/P-08x ....................................................................................... 26
5.4 Applying a Preload .................................................................................................... 27
5.5 Applying the Load ..................................................................................................... 27
5.6 Connecting the P-88x/P-08x to the Electronics ........................................................ 28

6 Start-Up and Operation

6.1 General Notes on Start-Up and Operation .................................................................. 31
6.2 Determining the Operating Parameters ...................................................................... 35
6.2.1 Overview of Limiting Factors .............................................................................. 36
6.2.2 Calculating the Effective Mass .............................................................................. 37
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..................................................................................................................................... 2
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-88x/P-08x (x stands for the different models, p. 9).

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

1.2 Validity for Custom Products

This user manual also applies to custom products from the PICMA® Stack piezo actuator and
PICMA® Stack ring actuator product lines 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.

The latest versions of the user manuals are available for download (p. 3) on our website.
1.3 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 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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Action consisting of several steps whose sequential order must be observed</td>
</tr>
<tr>
<td>2.</td>
<td>Action consisting of one or several steps whose sequential order is irrelevant</td>
</tr>
<tr>
<td>•</td>
<td>List item</td>
</tr>
<tr>
<td>p. 5</td>
<td>Cross-reference to page 5</td>
</tr>
<tr>
<td>RS-232</td>
<td>Labeling of an operating element on the product (example: socket of the RS-232 interface)</td>
</tr>
</tbody>
</table>

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 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>Product</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-503 piezo amplifier module</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-504 piezo amplifier module</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-505 piezo amplifier module</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-506 piezo charge amplifier</td>
<td>PZ62E user manual</td>
</tr>
<tr>
<td>E-610 piezo amplifier / servo controller</td>
<td>PZ72E user manual</td>
</tr>
<tr>
<td></td>
<td>PZ70E user manual</td>
</tr>
<tr>
<td>E-617 high-performance piezo amplifier</td>
<td>PZ201E user manual</td>
</tr>
<tr>
<td>E-618 high-performance piezo amplifier / servo controller</td>
<td>PZ221E user manual</td>
</tr>
<tr>
<td>E-663 piezo amplifier</td>
<td>PZ69E user manual</td>
</tr>
<tr>
<td>E-831 piezo amplifier module</td>
<td>PZ191E user manual</td>
</tr>
<tr>
<td></td>
<td>PZ235E user manual</td>
</tr>
<tr>
<td>E-836 compact piezo amplifier / OEM module</td>
<td>PZ250E user manual</td>
</tr>
</tbody>
</table>

1.6 Downloading Manuals

**INFORMATION**

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 47).

**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.
1 About this Document

**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

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

2.1 Intended Use

The P-88x/P-08x is intended to be used in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the P-88x/P-08x is intended for integration into a mechanical system and for the following applications:

- Positioning of loads
- Dynamic positioning
- Vibration damping
- Force generation

The operator is responsible for a standards-compliant integration of the P-88x/P-08x into the overall system.

The motion of the P-88x/P-08x takes place on one axis. When mounting the actuator without applying a preload, observe the maximum tensile stress capacity (p. 55).

For operation of the P-88x/P-08x, suitable electronics that provide the required operating voltages are required. The electronics are not included in the scope of delivery of the P-88x/P-08x. We recommend the use of suitable electronics (p. 12) from PI.

2.2 General Safety Instructions

The P-88x/P-08x 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-88x/P-08x.

- Only use the P-88x/P-08x 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-88x/P-08x.
Temperature changes and compressive stresses can induce charges in the P-88x/P-08x piezo actuator. After disconnection from the electronics, the piezo actuator can remain charged for several hours. Touching the live parts of the P-88x/P-08x can result in minor injury from electric shock.

- Do not touch the piezo actuator unless it is discharged (p. 40).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves.
- Keep the piezo actuator short-circuited (p. 41) when it is not connected to the electronics.
- Do not disassemble the piezo actuator.

The system into which the piezo actuator is integrated (e.g., housing or surrounding mechanical system) must be connected to a protective earth conductor. If the protective earth conductor is not or not properly connected, touching the system in which the piezo actuator was incorporated can lead to minor injury from electric shock in the case of a malfunction.

- 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 piezo actuator carries voltages of up to 120 V (P-88x models) or 100 V (P-08x models). Touching the piezo actuator can lead to minor injuries from electric shock.

- Do not touch the piezo actuator during operation.
- Before start-up, insulate the piezo actuator electrically 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-88x/P-08x.

- Avoid impacts that affect the P-88x/P-08x.
- Do not drop the P-88x/P-08x.
- Prevent torques and lateral forces on the P-88x/P-08x.
- Do not use metal tools during installation.
- Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 49).
2.3 Organizational Measures

User manual

- Always keep this user manual available with the P-88x/P-08x. 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-88x/P-08x 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-88x/P-08x after you have read and understood this user manual.

Personnel qualification

The P-88x/P-08x may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.
3 Product Description

In this Chapter

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

3.1 Model Overview

PICMA® Stack multilayer piezo actuators

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-882.11</td>
<td>PICMA® piezo actuator, 6.5 µm travel range, 3 mm × 2 mm × 9 mm, stranded wires</td>
</tr>
<tr>
<td>P-882.31</td>
<td>PICMA® piezo actuator, 11 µm travel range, 3 mm × 2 mm × 13.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-882.51</td>
<td>PICMA® piezo actuator, 15 µm travel range, 3 mm × 2 mm × 18 mm, stranded wires</td>
</tr>
<tr>
<td>P-883.11</td>
<td>PICMA® piezo actuator, 6.5 µm travel range, 3 mm × 3 mm × 9 mm, stranded wires</td>
</tr>
<tr>
<td>P-883.31</td>
<td>PICMA® piezo actuator, 11 µm travel range, 3 mm × 3 mm × 13.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-883.51</td>
<td>PICMA® piezo actuator, 15 µm travel range, 3 mm × 3 mm × 18 mm, stranded wires</td>
</tr>
<tr>
<td>P-885.11</td>
<td>PICMA® piezo actuator, 6.5 µm travel range, 5 mm × 5 mm × 9 mm, stranded wires</td>
</tr>
<tr>
<td>P-885.31</td>
<td>PICMA® piezo actuator, 11 µm travel range, 5 mm × 5 mm × 13.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-885.51</td>
<td>PICMA® piezo actuator, 15 µm travel range, 5 mm × 5 mm × 18 mm, stranded wires</td>
</tr>
<tr>
<td>P-885.91</td>
<td>PICMA® piezo actuator, 32 µm travel range, 5 mm × 5 mm × 36 mm, stranded wires</td>
</tr>
</tbody>
</table>
## Product Description

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-887.31</td>
<td>PICMA® piezo actuator, 11 µm travel range, 7 mm × 7 mm × 13.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-887.51</td>
<td>PICMA® piezo actuator, 15 µm travel range, 7 mm × 7 mm × 18 mm, stranded wires</td>
</tr>
<tr>
<td>P-887.91</td>
<td>PICMA® piezo actuator, 32 µm travel range, 7 mm × 7 mm × 36 mm, stranded wires</td>
</tr>
<tr>
<td>P-888.31</td>
<td>PICMA® piezo actuator, 11 µm travel range, 10 mm × 10 mm × 13.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-888.51</td>
<td>PICMA® piezo actuator, 15 µm travel range, 10 mm × 10 mm × 18 mm, stranded wires</td>
</tr>
<tr>
<td>P-888.91</td>
<td>PICMA® piezo actuator, 32 µm travel range, 10 mm × 10 mm × 36 mm, stranded wires</td>
</tr>
</tbody>
</table>

**PICMA® Stack multilayer ring actuators with inner hole**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-080.311</td>
<td>PICMA® Stack multilayer ring actuator with inner hole, 5.5 µm travel range, OD 8 mm × ID 4.5 mm × L 8.5 mm, stranded wires</td>
</tr>
<tr>
<td>P-080.341</td>
<td>PICMA® Stack multilayer ring actuator with inner hole, 11 µm travel range, OD 8 mm × ID 4.5 mm × L 16 mm, stranded wires</td>
</tr>
<tr>
<td>P-080.391</td>
<td>PICMA® Stack multilayer ring actuator with inner hole, 25 µm travel range, OD 8 mm × ID 4.5 mm × L 36 mm, stranded wires</td>
</tr>
</tbody>
</table>

**PICMA® Stack multilayer piezo actuators, round cross section**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-088.721</td>
<td>PICMA® Stack multilayer piezo actuator, round cross section, 14 µm travel range, OD 16 mm × L 16 mm, stranded wires</td>
</tr>
<tr>
<td>P-088.741</td>
<td>PICMA® Stack multilayer piezo actuator, round cross section, 32 µm travel range, OD 16 mm × L 36 mm, stranded wires</td>
</tr>
<tr>
<td>P-088.781</td>
<td>PICMA® Stack multilayer piezo actuator, round cross section, 70 µm travel range, OD 16 mm × L 77 mm, stranded wires</td>
</tr>
</tbody>
</table>

All models are optionally available with solderable contacts. The product numbers of the models with solderable contacts end with the number 0 (e.g., P-882.10).
3.2 Product View

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

Figure 1: Example of product view: P-88x (A) and P-080 (B)

1. Ceramic end surface (passive PZT ceramic)
2. Marking for positive pole
3. Contact strip
4. Shrink tube (strain relief of the stranded wires)
5. Black stranded wire: Connection for ground (-)
6. Red stranded wire: Voltage connection (+)

The arrows in the figure indicate the expansion direction of the piezo actuator when a positive voltage is applied.
3.3 Product Labeling

Before delivery, each P-88x/P-08x is vacuum-packed in an ESD protection bag that prevents the piezo actuator from becoming charged during transport. Larger actuators are additionally packed in tubes to protect them against breakage.

Every ESD protection bag has a sticker with the following information:

<table>
<thead>
<tr>
<th>Labeling</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Matrix code (example; contains the abbreviated batch number and the product number)</td>
<td>P-885.51 Product number (example), the digits after the period refer to the model The product number of custom products consists of nine digits (without identification of the model).</td>
</tr>
<tr>
<td>16CEP0653128979</td>
<td>Batch number (example), individual for each P-88x/P-08x</td>
</tr>
<tr>
<td>PI</td>
<td>Manufacturer’s logo</td>
</tr>
<tr>
<td>1 piece</td>
<td>Quantity</td>
</tr>
<tr>
<td>Country of origin: Germany</td>
<td>Country of origin</td>
</tr>
<tr>
<td><a href="http://WWW.PICERAMIC.COM">WWW.PICERAMIC.COM</a></td>
<td>Manufacturer’s address (website)</td>
</tr>
</tbody>
</table>

3.4 Scope of Delivery

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-88x/P-08x</td>
<td>Piezo actuator according to order (p. 9)</td>
</tr>
<tr>
<td>PZ264EK</td>
<td>Short instructions for PICMA® multilayer piezo actuators</td>
</tr>
</tbody>
</table>

3.5 Suitable Electronics

To operate a P-88x/P-08x, you need electronics. The device is selected depending on the type of application. The table below lists the suitable devices.

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-503</td>
<td>Piezo amplifier module (for E-500 piezo controller system)</td>
</tr>
<tr>
<td>E-504</td>
<td>Piezo amplifier module (for E-500 piezo controller system)</td>
</tr>
<tr>
<td>E-505</td>
<td>Piezo amplifier module (for E-500 piezo controller system)</td>
</tr>
</tbody>
</table>
3 Product Description

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-506</td>
<td>Piezo charge amplifier (for E-500 piezo controller system)</td>
</tr>
<tr>
<td>E-610</td>
<td>Piezo amplifier / servo controller</td>
</tr>
<tr>
<td>E-617</td>
<td>High-performance piezo amplifier</td>
</tr>
<tr>
<td>E-618</td>
<td>High-performance piezo amplifier / servo controller</td>
</tr>
<tr>
<td>E-663</td>
<td>Piezo amplifiers</td>
</tr>
<tr>
<td>E-831</td>
<td>OEM piezo driver</td>
</tr>
<tr>
<td>E-836</td>
<td>Compact piezo amplifier / OEM module</td>
</tr>
</tbody>
</table>

➢ To order, contact our customer service department (p. 47).

➢ Before selecting electronics, calculate the power requirements of your application (p. 38).

3.6 Accessories

<table>
<thead>
<tr>
<th>Product number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-890.10</td>
<td>Cable for piezo voltage, LEMO connector/open end, 1 m</td>
</tr>
<tr>
<td>P-890.20</td>
<td>Cable for piezo voltage, LEMO connector/open end, 5 m</td>
</tr>
</tbody>
</table>

The P-890.xx cable is for connecting the P-88x/P-08x to a low-voltage piezo amplifier with a single-pole LEMO socket. The cable is soldered on the actuator side.

Connector: FFS.00.250.CTCE24
Cable: RG 178 (Teflon)

➢ To order, contact our customer service department (p. 47).

3.7 Technical Features

**PICMA® piezo actuators**

P-88x/P-08x are PICMA® multilayer piezo actuators for static and dynamic applications. PICMA® actuators have all-ceramic insulation and their performance and lifetime are therefore far superior to conventional actuators. The ceramic insulation layer protects the monolithic piezoceramic block against humidity or failure due to increased leakage current. In this way, an especially high reliability is achieved even under extreme ambient conditions.
4 Unpacking

**NOTICE**

Destruction of the piezo actuator due to contamination!
Contamination on the surface of the P-88x/P-08x 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.
- Prevent the piezo actuator 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-88x/P-08x" (p. 43).

1. Unpack the P-88x/P-08x 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 ................................................................. 17
Soldering Stranded Wires to a Piezo Actuator (Only Models Without Stranded Wires) .......... 22
Mounting the P-88x/P-08x ........................................................................ 26
Applying a Preload .................................................................................... 27
Applying the Load ...................................................................................... 27
Connecting the P-88x/P-08x to the Electronics ........................................... 28

5.1 General Notes on Installation

**CAUTION**

**Dangerous voltage and residual charge in piezo actuators!**

Temperature changes and compressive stresses can induce charges in the P-88x/P-08x piezo actuator. After disconnection from the electronics, the piezo actuator can remain charged for several hours. Touching the live parts of the P-88x/P-08x can result in minor injury from electric shock.

- Do not touch the piezo actuator unless it is discharged (p. 40).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves.
- Keep the piezo actuator short-circuited (p. 41) 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 piezo actuator is not connected to the electronics, it must be short-circuited in order to prevent the piezo actuator from becoming charged during temperature changes and compressive stresses. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- As soon as you have removed the piezo actuator from the conductive original packaging, short-circuit it as follows:
  - Models with stranded wires: Twist the stranded wires of the piezo actuator with each other.
  - Models without stranded wires: Affix a suitable, conductive aid on the piezo actuator that does not leave any scratches on the surface of the piezo actuator (e.g., conductive rubber).
- Only disconnect the short-circuit connection of the piezo actuator if this is necessary for installation or operation.
- If the piezo actuator is not short-circuited:
  - Ensure adequate protection against touching live parts.
  - Discharge the piezo actuator in a suitable way before short-circuiting again (p. 40).

---

NOTICE

**Destruction of the piezo actuator due to excessively high loads!**
Excessive loads can destroy the P-88x/P-08x.

- Do **not** exceed the maximum compressive/tensile stress capacity (p. 55).

---

NOTICE

**Damage to the piezo actuator due to excessive preloading!**
Excessive preloading can mechanically depolarize the piezo actuator. Depolarization damages the piezo actuator.

- Only apply preloads that are just as high as necessary.
- Do **not** exceed the maximum preload (p. 55).
5 Installation

**NOTICE**

**Destruction of the piezo actuator due to mechanical overload!**

Torques and lateral forces can destroy the piezo actuator.

- Avoid torques and lateral forces on the piezo actuator.
- Make sure that the center of load of the moving system is on the motion axis of the piezo actuator.
- Avoid an uneven load distribution by using suitable structures or guide elements (e.g., ball tips or flexure guides).
- Establish contact over as large an area as possible on the end surfaces of the piezo actuator, and select opposing surfaces with a flatness 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 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.
- Install the piezo actuator so that the ceramic insulation and the end surfaces of the piezo actuator are not scratched during installation and operation.

**NOTICE**

**Heating up of the P-88x/P-08x during operation!**

The heat produced during operation of the P-88x/P-08x can affect your application.

- Install the P-88x/P-08x so that your application is not affected by the dissipating heat.

**INFORMATION**

Ground loops can occur when the piezo actuator is installed in a housing that is grounded via the shield of the connecting cable of the piezo actuator as well as a separate protective earth conductor.

- If a ground loop occurs, contact our customer service department (p. 47).
Avoiding mounting errors

Piezo actuators may only be loaded axially. Moreover, piezo actuators should be preloaded (p. 27) mechanically in order to avoid tensile stress. The following figures are to help you avoid mounting errors.

Figure 2: Prevention of lateral forces and torques

Figure 3: Prevention of torques

Figure 4: Prevention of tensile stresses by means of a mechanical preload
5 Installation

Figure 5: Prevention of an irregular load application (1: Tensile stresses)

Figure 6: Full-area contact of the piezo actuator

Figure 7: Proper dimensioning of the end pieces in the case of point contact (1: Tensile stresses)

Figure 8: Mechanical or thermal loads electrically charge the piezo actuator. Mount only when short-circuited.
5.2 Soldering Stranded Wires to a Piezo Actuator (Only Models Without Stranded Wires)

This section describes how to solder stranded wires to the models without stranded wires. If your application permits it, we recommend using models that already have stranded wires.

**NOTICE**

**Destruction of the piezo actuator due to incorrect soldering!**

Long and repeated soldering processes can dissolve the termination layer that creates the contact between the inner electrodes and the contact strips of the piezo actuator. The dissolution of the termination layer destroys the piezo actuator. In addition, the piezo ceramic can be damaged by depolarization when it is continuously heated above the Curie temperature.

- The soldering temperature should not be any higher than necessary (max. 350 °C).
- Make sure that the soldering time does not exceed 1 to 2 seconds.
- Use the respective soldering point only once to solder a stranded wire.

If you have to repeat the soldering process:

1. Allow the solder point to cool down.
2. Desolder the stranded wire from the soldering point.
3. Use a different (pre-tinned) soldering point to solder the stranded wire again.

**NOTICE**

**Damage from mechanical stress on the solder connection!**

Mechanical stresses (e.g., shear forces) on the solder connection can damage the piezo actuator.

- Make sure that stranded wires that move are relieved of strain with shrink tubing.
- Solder the stranded wires so that the distance between the soldering point and the firmly clamped side of the piezo actuator is as small as possible. This reduces mechanical stresses especially during dynamic operation.
Design and polarity of the electrodes

The positive electrode is identified by a plus sign or a point next to the electrode.
- Use a red stranded wire for the voltage connection (+).
- Use a black stranded wire for ground (-).

Contacting of the electrodes

Depending on the design, the electrodes are contacted via special soldering points or soldering strips.

Contacting of standard electrodes

Except for the outer soldering points on the upper or lower ceramic end surface of the piezo actuator (p. 11), all pre-tinned soldering points of the positive and negative electrode can be used to solder stranded wires.
5 Installation

Figure 11: Pre-tinned soldering points of the positive electrode (example: P-885)

1. Soldering points of the electrode that are suitable for soldering stranded wires
2. Soldering points of the electrode that are **not** suitable for soldering stranded wires

**Contacting of special electrodes**

The electrodes of certain special products are equipped with a soldering strip in the middle, to which stranded wires can be soldered.

Figure 12: Example view of a special electrode (detail) with stranded wire soldered to soldering strip

1. Soldering strip
2. Contact strip
3. Termination layer
4. Ceramic
5. Stranded wire
5 Installation

Strain relief of the stranded wires

Figure 13: Shrink tubing (see arrow) as strain relief of the stranded wires (example: P-885)

Requirements

- You have read and understood the general notes on installation (p. 17).
- The P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

- Suitable stranded wires that meet the applicable standards for the conditions of use
- Suitable soldering iron
- Suitable solder: Sn 95.5, Ag 3.8, Cu 0.7
- Suitable flux according to one of the following standards:
  - DIN EN 29454, part 1, category 1.1.3 or 1.2.3
  - ANSI J-STD-004, flux type ROL0
- Suitable cable tools

Soldering stranded wires to a piezo actuator (only models without stranded wires)

1. Prepare the stranded wire according to the following illustrations:

   - **Twisting**
   - **Tinning**
   - **Shortening to 2 mm**

2. Apply the flux to the tinned end of the wire and the intended soldering point of the electrode.
3. Hold the stranded wire flat with the tinned end on the soldering point.
4. Coat the tip of the soldering iron with a small amount of solder.
5. Hold the tip of the soldering iron at the soldering point on the tinned end of the stranded wire for a maximum of 1 to 2 seconds so that the solder flows and a flat or point-shaped solder connection results after soldering.

![Figure 14: Solder connection [2] of stranded wire [1] and electrode [3]](image)

6. Repeat steps 1 to 5 for the second stranded wire.
7. Remove flux residue according to the instructions in the section "Cleaning the P-88x/P-08x" (p. 43).
8. Place suitable shrink tubing on the solder connection to ensure strain relief of the stranded wires.

5.3 Mounting the P-88x/P-08x

P-88x/P-08x piezo actuators are glued to metal or ceramic surfaces.

Requirements

- You have read and understood the general notes on installation (p. 17).
- The P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).
- You have read and understood the user information of the manufacturer of the adhesive.

Tools and accessories

- Level surface that is dry, dust-free, and grease-free
- Suitable adhesive (e.g., cold-hardening epoxy resin adhesive)

Mounting the P-88x/P-08x

1. Glue the piezo actuator to the surface:
   - Apply the thinnest possible layer of adhesive.
   - During the hardening process, maintain the operating temperature range (p. 56) specified for the piezo actuator.
   - Observe the temperature expansion coefficients of the materials involved.
2. Press the piezo actuator until the adhesive has hardened.
5.4 Applying a Preload

The tensile stress capacity of piezo actuators is relatively low. It is therefore recommended to mechanically preload the piezo actuators in the application, either externally in the mechanical structure or internally in a housing.

Requirements

✓ You have read and understood the general notes on installation (p. 17).
✓ The P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

▪ When installing in a housing: Suitable housing
▪ Suitable guide elements
▪ When creating the preload with a spring:
  Suitable preload spring with the following characteristics:
  - The stiffness of the preload spring does not exceed 10 % of the stiffness (p. 49) of the piezo actuator. This is to minimize the displacement loss. If the stiffness of the preload spring is equal to that of the actuator, the free displacement drops by half.
  - With highly dynamic applications: The resonant frequency (p. 49) of the preload spring exceeds that of the piezo actuator.

Applying a preload

➢ Apply the preload near the axis within the core cross section of the piezo actuator.

5.5 Applying the Load

The P-88x/P-08x can be coupled to a load in various ways, depending on the application:

▪ Gluing the piezo actuator (p. 26) into the mechanical system to be moved or into a flexure
▪ Using a ball tip:
  - A hardened ball tip is glued to the ceramic end surface of the actuator; the ball tip makes contact to the even surface at a single point
  - A hardened ball tip is glued to the ceramic end surface of the actuator; the contact area at the calotte is circular
5 Installation

INFORMATION

Diagrams showing how to couple the P-88x/P-08x to a load can be found in "General Notes on Installation" (p. 20).

Requirements

✓ You have read and understood the general notes on installation (p. 17).
✓ The P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

▪ Suitable adhesive (e.g., cold-hardening epoxy resin adhesive)
▪ When using a ball tip: Suitable ball tip
▪ When using a flexure: Suitable flexure

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.

If a point load is applied to the end piece of the piezo actuator:

➢ Dimension the end piece so that its thickness corresponds to half the cross-sectional dimension in order to prevent tensile stresses on the piezo actuator.

5.6 Connecting the P-88x/P-08x to the Electronics

The P-88x/P-08x piezo actuator is connected to a LEMO socket, a terminal, or soldering pins, depending on the electronics.

This section describes how the P-88x/P-08x piezo actuator is connected with the P-890.xx coaxial cable to electronics with a single-pole LEMO socket.

➢ If you use a self-made connecting cable instead of the P-890.xx coaxial cable for connection to a single-pole LEMO socket, observe the relevant standards as well as the assembly information of the manufacturer of the connector used.

➢ For connection to the electronics with a two-pole LEMO socket, contact our customer service department (p. 47).

➢ For connection to terminals or solder pins, see the manual of the respective electronics used (p. 3).
INFORMATION

The models with stranded wires have color-coded wires:

- Red stranded wire: Voltage connection (+)
- Black stranded wire: Ground (-)

Figure 15: Connection of the P-88x/P-08x piezo actuator to the P-890.xx coaxial cable

+ On the piezo actuator (left): Red stranded wire for voltage connection
  On the LEMO connector (right): Inner contact for voltage connection

- On the piezo actuator (left): Black stranded wire for ground
  On the LEMO connector (right): Connector housing

S Cable shield
LEMO LEMO connector, single-pole

Requirements

- You have read and understood the general notes on installation (p. 17).
- You have read and understood the user manual of the electronics used.
- If the P-88x/P-08x is not short-circuited: The P-88x/P-08x is discharged (p. 40).
- The electronics are switched off.
- The electronics have a single-pole LEMO socket.
- Models without stranded wires: You have soldered a red stranded wire to the positive electrode (+) and a black stranded wire to the negative electrode (-) of the P-88x/P-08x (p. 22).

Tools and accessories

- P-890.xx coaxial cable (p. 13), LEMO single-pole to open end (can be ordered separately)
- Suitable soldering iron
- Suitable solder
- Suitable cable tools
5 Installation

Connecting the P-88x/P-08x to the electronics

1. If necessary, shorten the wire and the cable shield of the coaxial cable to the correct length.

2. Make the stranded wires of the P-88x/P-08x accessible:
   − When the stranded wires of the P-88x/P-08x are short-circuited, disconnect the connection between the stranded wires.
   − Remove all aids and components that have been connected to the P-88x/P-08x for short-circuiting or discharging (e.g., conductive rubber or discharging resistor).

3. Solder the red stranded wire of the P-88x/P-08x to the wire of the coaxial cable that is connected to the inner contact of the LEMO connector.

4. Solder the black stranded wire of the P-88x/P-08x to the cable shield of the coaxial cable.

5. Insulate the soldered cable connections in a suitable manner.

6. Connect the connector of the P-88x/P-08x to the corresponding connection on the electronics.
6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation ................................................................. 31
Determining the Operating Parameters ...................................................................... 35
Operating the P-88x/P-08x ...................................................................................... 39
Discharging the P-88x/P-08x .................................................................................... 40
Short-Circuiting the P-88x/P-08x ............................................................................ 41

6.1 General Notes on Start-Up and Operation

**CAUTION**

Dangerous voltage in piezo actuators during operation!
During operation, the piezo actuator carries voltages of up to 120 V (P-88x models) or 100 V (P-08x models). Touching the piezo actuator can lead to minor injuries from electric shock.

- Do **not** touch the piezo actuator during operation.
- Before start-up, insulate the piezo actuator electrically 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.

**CAUTION**

Risk of electric shock if the protective earth conductor is not connected!
The system into which the piezo actuator is integrated (e.g., housing or surrounding mechanical system) must be connected to a protective earth conductor. If the protective earth conductor is not or not properly connected, touching the system in which the piezo actuator was incorporated can lead to minor injury from electric shock in the case of a malfunction.

- 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.
6 Start-Up and Operation

CAUTION

Burning from hot surface!
The surface of the P-88x/P-08x and the surrounding area can heat up during operation.
Touching the P-88x/P-08x and surrounding parts can result in minor injuries from burning.

- Cool the P-88x/P-08x so that the temperature of its surface and surrounding parts does **not** exceed 65 °C. Do **not** use liquids for cooling. If liquid cooling is to be used, contact our customer service department (p. 47).
- If sufficient cooling is not possible: Make sure that the hot P-88x/P-08x 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!
Using the P-88x/P-08x 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).

- Avoid operating the P-88x/P-08x in environments that can increase the electrical conductivity.
- Only operate the P-88x/P-08x within the permissible ambient conditions and classifications (p. 56).
- Prevent the piezo actuator from coming into contact with liquids. If liquid cooling is to be used, contact our customer service department (p. 47).
- Protect the piezo actuator against moisture by means of hermetic sealing or the supply of dry air.
- If the P-88x/P-08x is to be operated in a special gas atmosphere, contact our customer service department (p. 47).

NOTICE

Destruction of the piezo actuator by dynamic forces!
During dynamic operation, dynamic forces can occur that cancel the preload of the piezo actuator. Operation without a preload can destroy the actuator.

- Do **not** exceed the maximum compressive/tensile stress capacity (p. 55).
- Observe the notes in "Determining the Operating Parameters" (p. 35).
NOTICE

Destruction of the piezo actuator due to excessive operating frequencies!

An excessive operating frequency can cause thermal and mechanical overloading that destroys 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 frequency according to the data table (p. 49) applies to unclamped operation without load. In an arrangement with unilateral clamping, the value must be halved. For loaded piezo actuators that are clamped on one side, see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 37).
  - The dynamic forces occurring during operation do not exceed the maximum compressive/tensile stress capacity of the piezo actuator (see "Calculating the Forces that Occur During Dynamic Operation" (p. 38) and "Compressive/Tensile Stress Capacity and Preload" (p. 55)).
- Reduce the voltage at high operating frequencies to minimize the heating of the piezo actuator.
- If your application involves the operation of a piezo actuator which is not clamped on both sides, contact our customer service department (p. 47).

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. This applies in particular to operation in a humid
environment.
- When the P-88x/P-08x is not in use but the electronics remain switched on to ensure
temperature stability: Set the piezo voltage to 0 V on the electronics.
- If possible: Limit the maximum operating voltage during continuous operation.
- 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-88x/P-08x does not exceed the
relative humidity specified in "Ambient Conditions and Classifications" (p. 56).

NOTICE

Operating voltage excessively high or incorrectly connected!
Operating voltages that are too high or incorrectly connected can cause damage to the
P-88x/P-08x.
- Do not exceed the operating voltage range (p. 53) for which the P-88x/P-08x is specified.
- Operate the P-88x/P-08x only when the operating voltage is properly connected; see
"Connecting the P-88x/P-08x to the Electronics" (p. 28).
- If you have accidently applied the operating voltage with the wrong polarity, contact our
customer service department (p. 47).

NOTICE

Destruction of the piezo actuator due to overheating!
During the operation of the piezo actuator, dielectric losses that are converted into heat
energy occur in the piezo ceramic due to ferroelectric polarization processes. The resulting
heat can overheat and destroy the piezo actuator, especially in dynamic operation.
- 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. 56), "Maximum Ratings" (p. 53), and "Determining the
Operating Parameters" (p. 35).
- Cool the piezo actuator. Do not use liquids for cooling. If liquid cooling is to be used,
contact our customer service department (p. 47).
NOTICE
Destruction of the piezo actuator due to rapid cooling or heating!
Cooling down or heating up too quickly leads to a thermomechanical overload that can destroy the piezo actuator.
➢ Allow the piezo actuator to cool down or warm up slowly.

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 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 piezo actuator.

INFORMATION
The positive direction of motion (p. 11) corresponds to the expansion direction of the piezo actuator when a positive voltage is applied.

6.2 Determining the Operating Parameters

INFORMATION
For determination of the operating parameters, it is assumed that the piezo actuator is clamped on one side.
➢ If you require operating parameters for unclamped operation of the piezo actuator, contact our customer service department (p. 47).
6.2.1 Overview of Limiting Factors

Limiting factors for the operation of the piezo actuator:

- Resonant frequency:

  The resonant frequency of the piezo actuator serves as a basis for calculating the operating frequency, which must not exceed one third of the resonant frequency. The resonant frequency according to the data table (p. 49) applies to unclamped operation without load. In an arrangement with unilateral clamping, the value must be halved.

  For loaded piezo actuators that are clamped on one side, see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 37).

- Maximum compressive/tensile stress capacity (p. 55):

  The mass of the load to be moved, the preload, and the operating frequency of the piezo actuator must be selected so that the dynamic forces occurring during operation do not exceed the maximum tensile/compressive stress capacity of the piezo actuator. See "Calculating the Forces that Occur During Dynamic Operation" (p. 38).

- Maximum permissible operating temperature of the piezo actuator (p. 56):

  The greater the operating frequency, the operating voltage (peak-to-peak), and the capacitance of the piezo actuator, the greater the thermal power generated in the piezo actuator. The operating frequency, operating voltage and operating time must be selected so that the maximum permissible operating temperature of the piezo actuator is not exceeded. For the maximum permissible operating frequency without cooling, see column B of the table in "Maximum Ratings" (p. 53).

  When cooling measures are used, the limit values for the operating frequency, operating voltage and operating time increase.

- Peak and average output current of the electronics (p. 12) used:

  The electronics must be selected so that it fulfills the following requirements:

  - The electronics can provide the required current. See "Calculating the Power Requirement for Sinusoidal Operation" (p. 38).
  - The output current of the electronics does not exceed the maximum power consumption of the piezo actuator. See "Maximum Ratings" (p. 53).
  - The control signal of the electronics does not have steep edges. See "General Notes on Start-Up and Operation" (p. 31).
6.2.2 Calculating the Effective Mass

Figure 16: Calculation of the effective mass of a unilaterally clamped piezo stack actuator without load (left) and with additional load (right).

1. Determine the mass m of your piezo actuator.
2. Determine the additional load M.
3. Calculate the effective mass \( m_{\text{eff}} \) of the unloaded piezo actuator and \( m'_{\text{eff}} \) of the loaded piezo actuator using the formulas in the figure above.

6.2.3 Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator

**INFORMATION**

In the following calculation, the maximum permissible operating temperature of the piezo actuator is **not** taken into account. During operation without cooling, the maximum operating temperature may already be exceeded when the operating frequency is still below the limit value calculated in the following.

- For the maximum permissible operating frequency without cooling, see column B of the table in "Maximum Ratings" (p. 53).

1. Calculate the resonant frequency of the loaded, unilaterally clamped piezo actuator using the following formula:

\[
f_0' = f_0 \sqrt{\frac{m_{\text{eff}}}{m'_{\text{eff}}}}
\]
6.2.4 Calculating the Forces that Occur During Dynamic Operation

- Calculate the dynamic forces acting on the unilaterally clamped piezo actuator during sinusoidal operation at the frequency \( f \) using the following formula:

\[
F_{\text{dyn}} = \pm 4\pi^2 \cdot m_{\text{eff}}' \left( \frac{\Delta L}{2} \right) f^2
\]

- \( F_{\text{dyn}} \) = Dynamic force [N]
- \( m_{\text{eff}}' \) = Effective mass \( m_{\text{eff}} \) (approx. 1/3 of the mass of the piezo actuator) + additional load \( M \) [kg], see also "Calculating the Effective Mass" (p. 37)
- \( \Delta L \) = Displacement in the application (peak-to-peak) [m]
- \( f \) = Frequency [Hz]

**Example:** The dynamic forces at 1000 Hz, 2 \( \mu \)m displacement (peak-to-peak) and 1 kg effective mass are approximately ±40 N.

6.2.5 Calculating the Power Requirement for Sinusoidal Operation

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

\[
I_a \approx f \cdot C \cdot U_{p-p}
\]

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

\[
I_{\text{max}} \approx f \cdot \pi \cdot C \cdot U_{p-p}
\]
### 6.3 Operating the P-88x/P-08x

#### Requirements

- You have read and understood the general notes on start-up and operation (p. 31).
- You have determined the operating parameters for your application (p. 35).
- You have installed (p. 17) the P-88x/P-08x correctly and connected it to the electronics (p. 28).
- You have provided suitable electronics that can supply the required currents (p. 38).
- You have read and understood the user manual of the electronics used.

#### Operating the P-88x/P-08x

- For starting up and operating the P-88x/P-08x, follow the instructions in the manual of the electronics (p. 3) used.
6.4 Discharging the P-88x/P-08x

The P-88x/P-08x must be discharged in the following cases:

- If the P-88x/P-08x has become accidentally charged due to thermal or mechanical loading
- If a charged P-88x/P-08x is to be short-circuited (p. 41)
- If the connecting cable of the P-88x/P-08x is accidentally pulled out of the electronics during operation

Requirements

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

Tools and accessories

If the P-88x/P-08x is not connected to the electronics:

- Only for P-88x/P-08x without connector (condition as supplied):
  - 10 kΩ discharge resistor (not included in scope of delivery); touchable parts must be adequately insulated for the operating voltage range (p. 53) of the actuator
- Only for P-88x/P-08x with connector (p. 28):
  - Electronics (p. 12) from PI

Discharging a P-88x/P-08x connected to the electronics

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

Discharging a P-88x/P-08x not connected to the electronics

If the P-88x/P-08x does not have a connector:

1. If necessary, let the P-88x/P-08x cool down.
2. Ensure adequate protection against touching live parts.
3. Short-circuit the electrodes of the P-88x/P-08x for at least a few seconds using a 10 kΩ discharge resistor.

If the P-88x/P-08x has a connector:

➢ Connect the voltage connection of the P-88x/P-08x to the switched off PI electronics, which has an internal discharge resistor, for at least a few seconds.
6.5 **Short-Circuiting the P-88x/P-08x**

The P-88x/P-08x must be discharged (p. 40) and short-circuited before demounting (e.g., before cleaning and transportation of the P-88x/P-08x) as well as for modifications.

**Requirements**

- You have read and understood the general notes on installation (p. 17).
- You have discharged the P-88x/P-08x and disconnected it from the electronics.

**Tools and accessories**

- If no open stranded wires are accessible on the piezo actuator: Suitable conductive aid for short-circuiting the piezo actuator that does not scratch the surface of the piezo actuator (e.g., conductive rubber)

**Short-circuiting the P-88x/P-08x**

- If bare stranded wires are accessible on the P-88x/P-08x:
  Twist the stranded wires of the **discharged** piezo actuator with each other.
- If no bare stranded wires are accessible on the P-88x/P-08x:
  a) If necessary, let the P-88x/P-08x cool down.
  b) Affix a suitable, conductive aid on the **discharged** piezo actuator that does not scratch the surface of the piezo actuator (e.g., conductive rubber).
7 Maintenance

In this Chapter

General Notes on Maintenance ................................................................................................... 43
Cleaning the P-88x/P-08x........................................................................................................... 43

7.1 General Notes on Maintenance

The P-88x/P-08x is maintenance-free.

7.2 Cleaning the P-88x/P-08x

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-88x/P-08x:
➢ Ensure that the P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).
After cleaning the P-88x/P-08x:
➢ Dry the P-88x/P-08x completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).

Requirements
✓ The P-88x/P-08x is discharged (p. 40) and short-circuited (p. 41).
✓ The P-88x/P-08x is disconnected from the electronics.

Cleaning the P-88x/P-08x
➢ Touch the piezo actuator only with powder-free nitrile or latex gloves.
➢ Do not use acetone and do not use water for cleaning.
➢ When necessary, clean the surfaces of the P-88x/P-08x with a lint-free cloth that is slightly dampened with a mild cleanser (e.g., isopropanol or ethanol).
When cleaning in an ultrasonic bath:
- Reduce the energy input to the necessary minimum.
- Only use isopropanol or ethanol as cleaning fluid.
- Observe a cleaning time of 5 minutes.

After cleaning, dry the P-88x/P-08x completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).
# 8 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>Excessive load</td>
<td>➢ Do not exceed the maximum compressive/tensile stress capacity (p. 55).</td>
</tr>
<tr>
<td></td>
<td>Piezo actuator is depolarized due to overheating or reverse polarity</td>
<td>➢ Contact our customer service department (p. 47).</td>
</tr>
<tr>
<td>Piezo actuator moves in the opposite direction to that specified when voltage increases</td>
<td>Reverse polarity of the piezo actuator</td>
<td>➢ Contact our customer service department (p. 47).</td>
</tr>
</tbody>
</table>

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. 47).
9 Customer Service

You can contact PI Ceramic by telephone under +49 36604 882-0 or by email at the following address:

- For general questions or for orders:
  info@piceramic.com
- In the case of technical problems or faults:
  service@piceramic.com

➢ If you have questions concerning your product, provide the following information:
  – Product and serial numbers of all products concerned
  – Firmware version of the electronics (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 ............................................................................................................................... 49
Dimensions ................................................................................................................................... 57

10.1 Specifications

10.1.1 Data Table

<table>
<thead>
<tr>
<th>PICMA® Stack multilayer piezo actuators</th>
<th>Dimensions A × B × L</th>
<th>Nominal travel range μm</th>
<th>Max. travel range μm</th>
<th>Blocking force N</th>
<th>Stiffness N/μm</th>
<th>Electrical capacitance μF</th>
<th>Resonant frequency kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-882.11 3 mm × 2 mm × 9 mm</td>
<td>6.5 8</td>
<td>190 24</td>
<td>0.15</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-882.31 3 mm × 2 mm × 13.5 mm</td>
<td>11 13</td>
<td>210 16</td>
<td>0.22</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-882.51 3 mm × 2 mm × 18 mm</td>
<td>15* 18*</td>
<td>210 12</td>
<td>0.31</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-883.11 3 mm × 3 mm × 9 mm</td>
<td>6.5 8</td>
<td>290 36</td>
<td>0.21</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-883.31 3 mm × 3 mm × 13.5 mm</td>
<td>11 13</td>
<td>310 24</td>
<td>0.35</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-883.51 3 mm × 3 mm × 18 mm</td>
<td>15* 18*</td>
<td>310 18</td>
<td>0.48</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-885.11 5 mm × 5 mm × 9 mm</td>
<td>6.5 8</td>
<td>800 100</td>
<td>0.6</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-885.31 5 mm × 5 mm × 13.5 mm</td>
<td>11 13</td>
<td>870 67</td>
<td>1.1</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-885.51 5 mm × 5 mm × 18 mm</td>
<td>15* 18*</td>
<td>900 50</td>
<td>1.5</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-885.91 5 mm × 5 mm × 36 mm</td>
<td>32* 38*</td>
<td>950 25</td>
<td>3.1</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-887.31 7 mm × 7 mm × 13.5 mm</td>
<td>11 13</td>
<td>1700 130</td>
<td>2.2</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Technical Data

<table>
<thead>
<tr>
<th>Dimensions (A \times B \times L)</th>
<th>Nominal travel range (\mu m)</th>
<th>Max. travel range (\mu m)</th>
<th>Blocking force (N)</th>
<th>Stiffness (N/\mu m)</th>
<th>Electrical capacitance (\mu F)</th>
<th>Resonant frequency (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-887.51 7 mm × 7 mm × 18 mm</td>
<td>15*</td>
<td>18*</td>
<td>1750</td>
<td>100</td>
<td>3.1</td>
<td>70</td>
</tr>
<tr>
<td>P-887.91 7 mm × 7 mm × 36 mm</td>
<td>32*</td>
<td>38*</td>
<td>1850</td>
<td>50</td>
<td>6.4</td>
<td>40</td>
</tr>
<tr>
<td>P-888.31 10 mm × 10 mm × 13.5 mm</td>
<td>11</td>
<td>13</td>
<td>3500</td>
<td>267</td>
<td>4.3</td>
<td>90</td>
</tr>
<tr>
<td>P-888.51 10 mm × 10 mm × 18 mm</td>
<td>15*</td>
<td>18*</td>
<td>3600</td>
<td>200</td>
<td>6.0</td>
<td>70</td>
</tr>
<tr>
<td>P-888.91 10 mm × 10 mm × 36 mm</td>
<td>32*</td>
<td>38*</td>
<td>3800</td>
<td>100</td>
<td>13.0</td>
<td>40</td>
</tr>
</tbody>
</table>

Nominal travel range: At 0 to 100 V, tolerance ±20 %, * ±10 %.

Maximum travel range: At 0 to 120 V, tolerance ±20 %, * ±10 %.

Blocking force: At 0 to 120 V.

Electrical capacitance: Measured at 1 \(V_{pp}\) 1 kHz, RT, tolerance ±20 %.

Resonant frequency at 1 \(V_{pp}\), unloaded, unclamped. The value is halved for unilateral clamping, tolerance ±20 %.

Piezo ceramic type: PIC252.

Standard connections: PTFE-insulated stranded wires, 100 mm; P-882, P-883: AWG 32 (Ø 0.49 mm); P-885, P-887, P-888: AWG 30 (Ø 0.61 mm). For optional solderable contacts without stranded wires, change the last digit of the product number to 0 (e.g., P-882.10).

Operating voltage range: -20 to 120 V.

Operating temperature range: -40 to 150 °C.

Recommended preload for dynamic operation: 15 MPa.

Maximum preload for constant force: 30 MPa.

Custom designs or different specifications on request.
PICMA® Stack multilayer ring actuators with inner hole

<table>
<thead>
<tr>
<th></th>
<th>P-080.311</th>
<th>P-080.341</th>
<th>P-080.391</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions OD × ID × L</td>
<td>8 × 4.5 × 8.5</td>
<td>8 × 4.5 × 16</td>
<td>8 × 4.5 × 36</td>
<td>mm</td>
</tr>
<tr>
<td>Nominal travel range</td>
<td>5.5 ±20 %</td>
<td>11 ±20 %</td>
<td>25 ±10 %</td>
<td>µm</td>
</tr>
<tr>
<td>Blocking force</td>
<td>800</td>
<td>825</td>
<td>850</td>
<td>N</td>
</tr>
<tr>
<td>Stiffness</td>
<td>145</td>
<td>75</td>
<td>34</td>
<td>N/µm</td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>0.86</td>
<td>1.7</td>
<td>4.0</td>
<td>µF</td>
</tr>
<tr>
<td>Resonant frequency</td>
<td>135 ±20 %</td>
<td>85 ±20 %</td>
<td>40 ±20 %</td>
<td>kHz</td>
</tr>
</tbody>
</table>

All data at 0 to 100 V.
Axial resonant frequency: Measured at 1 V<sub>pp</sub>, unloaded, unclamped. The value is halved for unilateral clamping.

Electrical capacitance: Measured at 1 V<sub>pp</sub>, 1 kHz, RT, tolerance ±20 %.

Piezo ceramic type: PIC252. Ceramic end surfaces made of Al<sub>2</sub>O<sub>3</sub>.

Standard connections: PTFE-insulated stranded wires, 100 mm, AWG 30 (Ø 0.61 mm). For optional solderable contacts without stranded wires, change the last digit of the product number to 0 (e.g., P-080.310).

Operating voltage range: -20 to 100 V.
Operating temperature range: -40 to 150 °C.
Recommended preload for dynamic operation: 15 MPa.
Maximum preload for constant force: 30 MPa.
Ask about custom designs!
**PICMA® Stack multilayer piezo actuator, round cross section**

<table>
<thead>
<tr>
<th></th>
<th>P-088.721</th>
<th>P-088.741</th>
<th>P-088.781</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions OD × L</td>
<td>16 × 16</td>
<td>16 × 36</td>
<td>16 × 77</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Nominal travel range</td>
<td>14</td>
<td>32</td>
<td>70</td>
<td>µm</td>
<td>-10 % / +20 %</td>
</tr>
<tr>
<td>Blocking force</td>
<td>7500</td>
<td>7500</td>
<td>7500</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Stiffness</td>
<td>535</td>
<td>235</td>
<td>105</td>
<td>N/µm</td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>13</td>
<td>30</td>
<td>68</td>
<td>µF</td>
<td>±20 %</td>
</tr>
<tr>
<td>Resonant frequency</td>
<td>68</td>
<td>35</td>
<td>17</td>
<td>kHz</td>
<td>±20 %</td>
</tr>
</tbody>
</table>

Nominal travel range, blocking force and stiffness at 0 to 100 V.

Axial resonant frequency: Measured at 1 V<sub>pp</sub>, unloaded, unclamped. The value is halved for unilateral clamping.

Electrical capacitance: Measured at 1 V<sub>pp</sub>, 1 kHz, RT.

Piezo ceramic type: PIC252. Ceramic end surfaces made of Al₂O₃.

Standard connections: PTFE-insulated stranded wires, 100 mm, AWG 28 (Ø 0.69 mm). For optional solderable contacts without stranded wires, change the last digit of the product number to 0 (e.g., P-088.720).

Operating voltage range: -20 to 100 V.

Operating temperature range: -40 to 150 °C.

Recommended preload for dynamic operation: 15 MPa.

Maximum preload for constant force: 30 MPa.

Ask about custom designs!
10.1.2 Maximum Ratings

P-88x/P-08x 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 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 140 V peak-to-peak (P-88x models) or 120 V peak-to-peak (P-08x models). 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 that is operated at an operating voltage of 140 V peak-to-peak (P-88x models) or 120 V peak-to-peak (P-08x models) with the operating frequency from column B of this table.

<table>
<thead>
<tr>
<th>Piezo actuator*</th>
<th>Maximum operating voltage range</th>
<th>Maximum operating frequency without load</th>
<th>Maximum power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A: Without considering thermal aspects</td>
<td>B: Considering thermal aspects</td>
</tr>
<tr>
<td>P-882.1x</td>
<td>–20 V to 120 V</td>
<td>22.5 kHz</td>
<td>200 Hz</td>
</tr>
<tr>
<td>P-882.3x</td>
<td>–20 V to 120 V</td>
<td>15 kHz</td>
<td>190 Hz</td>
</tr>
<tr>
<td>P-882.5x</td>
<td>–20 V to 120 V</td>
<td>11.7 kHz</td>
<td>180 Hz</td>
</tr>
<tr>
<td>P-883.1x</td>
<td>–20 V to 120 V</td>
<td>22.5 kHz</td>
<td>170 Hz</td>
</tr>
<tr>
<td>P-883.3x</td>
<td>–20 V to 120 V</td>
<td>15 kHz</td>
<td>160 Hz</td>
</tr>
<tr>
<td>P-883.5x</td>
<td>–20 V to 120 V</td>
<td>11.7 kHz</td>
<td>150 Hz</td>
</tr>
<tr>
<td>P-885.1x</td>
<td>–20 V to 120 V</td>
<td>22.5 kHz</td>
<td>100 Hz</td>
</tr>
<tr>
<td>P-885.3x</td>
<td>–20 V to 120 V</td>
<td>15 kHz</td>
<td>90 Hz</td>
</tr>
<tr>
<td>Piezo actuator*</td>
<td>Maximum operating voltage range</td>
<td>Maximum operating frequency without load</td>
<td>Maximum power consumption</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A: Without considering thermal aspects</td>
<td>B: Considering thermal aspects</td>
</tr>
<tr>
<td>P-885.5x</td>
<td>−20 V to 120 V</td>
<td>11.7 kHz</td>
<td>80 Hz</td>
</tr>
<tr>
<td>P-885.9x</td>
<td>−20 V to 120 V</td>
<td>6.7 kHz</td>
<td>75 Hz</td>
</tr>
<tr>
<td>P-887.3x</td>
<td>−20 V to 120 V</td>
<td>15 kHz</td>
<td>60 Hz</td>
</tr>
<tr>
<td>P-887.5x</td>
<td>−20 V to 120 V</td>
<td>11.7 kHz</td>
<td>55 Hz</td>
</tr>
<tr>
<td>P-887.9x</td>
<td>−20 V to 120 V</td>
<td>6.7 kHz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>P-888.3x</td>
<td>−20 V to 120 V</td>
<td>15 kHz</td>
<td>40 Hz</td>
</tr>
<tr>
<td>P-888.5x</td>
<td>−20 V to 120 V</td>
<td>11.7 kHz</td>
<td>38 Hz</td>
</tr>
<tr>
<td>P-888.9x</td>
<td>−20 V to 120 V</td>
<td>6.7 kHz</td>
<td>35 Hz</td>
</tr>
<tr>
<td>P-080.31x</td>
<td>−20 V to 100 V</td>
<td>26.7 kHz</td>
<td>110 Hz</td>
</tr>
<tr>
<td>P-080.34x</td>
<td>−20 V to 100 V</td>
<td>14.2 kHz</td>
<td>105 Hz</td>
</tr>
<tr>
<td>P-080.39x</td>
<td>−20 V to 100 V</td>
<td>6.7 kHz</td>
<td>100 Hz</td>
</tr>
<tr>
<td>P-088.72x</td>
<td>−20 V to 100 V</td>
<td>11.4 kHz</td>
<td>30 Hz</td>
</tr>
<tr>
<td>P-088.74x</td>
<td>−20 V to 100 V</td>
<td>5.9 kHz</td>
<td>25 Hz</td>
</tr>
<tr>
<td>P-088.78x</td>
<td>−20 V to 100 V</td>
<td>2.9 kHz</td>
<td>25 Hz</td>
</tr>
</tbody>
</table>

* The letter x in the product number of the piezo actuator stands for the model:
1: Models with stranded wires (e.g., P-882.11)
0: Models without stranded wires (e.g., P-882.10)
10.1.3  **Compressive/Tensile Stress Capacity and Preload**

Piezo ceramic withstands a pressure of up to 250 MPa but starts to depolarize at significantly lower compressive loads. Since stacked piezo actuators are also made of different materials (piezo ceramic, metallic electrodes), the mechanical load capacity does not depend solely on the strength of the ceramic material. Consideration must be given to additional parameters such as slenderness ratio, bending, tilt and homogeneity of the force application.

The tensile stress capacity of piezo actuators is just 5 to 10 % of the compressive load capacity. It is therefore recommended to mechanically preload the actuators. The preload should be chosen only as high as necessary.

**Compressive/tensile stress capacity and preload of the P-88x/P-08x**

<table>
<thead>
<tr>
<th>Type of mechanical stress</th>
<th>P-88x/P-08x*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum compressive load capacity</td>
<td>30 MPa</td>
</tr>
<tr>
<td>Maximum tensile stress capacity without preload</td>
<td>2 MPa**</td>
</tr>
<tr>
<td>Recommended preload for dynamic operation</td>
<td>15 MPa</td>
</tr>
<tr>
<td>Maximum preload for constant force</td>
<td>30 MPa</td>
</tr>
</tbody>
</table>

* 1 MPa corresponds to a pressure of 1 N per square millimeter of the base area of the piezo actuator. Dimensions see data table (p. 49).

** Depends on the strength of the glued connections (p. 26)
10.1.4 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-88x/P-08x must be observed:

<table>
<thead>
<tr>
<th>Area of application</th>
<th>For indoor use only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pressure</td>
<td>500 hPa to 1500 hPa</td>
</tr>
<tr>
<td></td>
<td>If you want to operate the P-88x/P-08x outside of the specified air pressure range, contact our customer service department (p. 47).</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Maximum relative humidity 55 %</td>
</tr>
<tr>
<td></td>
<td>Continuous operation with high static voltage in humid environments significantly reduces piezo actuator lifetime.</td>
</tr>
<tr>
<td></td>
<td>If you want to operate the P-88x/P-08x at a relative humidity of more than 55 %, contact our customer service department (p. 47).</td>
</tr>
<tr>
<td></td>
<td>Observe the information on service life, which can be found here:</td>
</tr>
<tr>
<td></td>
<td>− Section &quot;General Notes on Start-Up and Operation&quot; (p. 31)</td>
</tr>
<tr>
<td></td>
<td>− Internet site of PI Ceramic (<a href="http://www.piceramic.com/piezo-technologie/picma.html">www.piceramic.com/piezo-technologie/picma.html</a>)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>−40 °C to 150 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>−40 °C to 80 °C</td>
</tr>
<tr>
<td>Transport temperature</td>
<td>−40 °C to 80 °C</td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>II</td>
</tr>
<tr>
<td>Degree of pollution</td>
<td>1</td>
</tr>
</tbody>
</table>

The P-88x/P-08x 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

![Figure 17: P-88x Dimensions](image)

<table>
<thead>
<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>L</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-882.11</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>mm</td>
</tr>
<tr>
<td>P-882.31</td>
<td>3</td>
<td>2</td>
<td>13.5</td>
<td>mm</td>
</tr>
<tr>
<td>P-882.51</td>
<td>3</td>
<td>2</td>
<td>18</td>
<td>mm</td>
</tr>
<tr>
<td>P-883.11</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>mm</td>
</tr>
<tr>
<td>P-883.31</td>
<td>3</td>
<td>3</td>
<td>13.5</td>
<td>mm</td>
</tr>
<tr>
<td>P-883.51</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>mm</td>
</tr>
<tr>
<td>P-885.11</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>mm</td>
</tr>
<tr>
<td>P-885.31</td>
<td>5</td>
<td>5</td>
<td>13.5</td>
<td>mm</td>
</tr>
<tr>
<td>P-885.51</td>
<td>5</td>
<td>5</td>
<td>18</td>
<td>mm</td>
</tr>
<tr>
<td>P-885.91</td>
<td>5</td>
<td>5</td>
<td>36</td>
<td>mm</td>
</tr>
<tr>
<td>P-887.31</td>
<td>7</td>
<td>7</td>
<td>13.5</td>
<td>mm</td>
</tr>
<tr>
<td>P-887.51</td>
<td>7</td>
<td>7</td>
<td>18</td>
<td>mm</td>
</tr>
<tr>
<td>P-887.91</td>
<td>7</td>
<td>7</td>
<td>36</td>
<td>mm</td>
</tr>
<tr>
<td>P-888.31</td>
<td>10</td>
<td>10</td>
<td>13.5</td>
<td>mm</td>
</tr>
<tr>
<td>P-888.51</td>
<td>10</td>
<td>10</td>
<td>18</td>
<td>mm</td>
</tr>
<tr>
<td>P-888.91</td>
<td>10</td>
<td>10</td>
<td>36</td>
<td>mm</td>
</tr>
</tbody>
</table>
Figure 18: P-080: Dimensions

P-080.311 model: L = 8.5 mm; P-080.341 model: L = 16 mm; P-080.391 model: L = 36 mm
Figure 19:  P-088: Dimensions

P-088.721 model: L = 16 mm; P-088.741 model: L = 36 mm; P-088.781 model: L = 77 mm
11 Disposal

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

For disposal, observe the international, national, and local rules and regulations.

In order to fulfil the responsibility as the product manufacturer, PI Ceramic GmbH offers the environmentally correct disposal of PI products made available on the market after August 13, 2005, without charge.

Any product from PI Ceramic that is to be disposed of can be sent free of shipping costs to the following address:

PI Ceramic GmbH
Lindenstrasse
D-07589 Lederhose, Germany
An EU Declaration of Conformity was issued for the P-88x/P-08x in accordance with the following European directives:

RoHS Directive
The applied standards certifying the conformity are listed below.
RoHS: EN 50581

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.