This document describes the following products:

- **P-225**
  - preloaded high-load piezo actuator
  - P-225.10/.20/.40/.80: Without sensor
  - P-225.10V/.20V/.40V/.80V: Without sensor; high temperature range and high vacuum
  - P-225.1S/.2S/.4S/.8S: With sensor
  - P-225.1SV/.2SV/.4SV/.8SV: With sensor; high temperature range and high vacuum

- **P-235**
  - Preloaded high-load piezo actuator
  - P-235.10/.20/.40/.80/.90: without sensor
  - P-235.10V/.20V/.40V/.80V/.90V: without sensor; high-temperature range and high vacuum
  - P-235.1S/.2S/.4S/.8S/.9S: with sensor
  - P-235.1SV/.2SV/.4SV/.8SV/.9SV: with sensor; high-temperature range and high vacuum
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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-2x5 (x stands for the different models (p. 7)).

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

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

1.2 Symbols and Typographic Conventions

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

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.
1 About this Document

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label | Meaning
--- | ---
1. | Action consisting of several steps whose sequential order must be observed
2. | Action consisting of one or several steps whose sequential order is irrelevant
▪ | List item
p. 5 | Cross-reference to page 5
RS-232 | Labeling of an operating element on the product (example: socket of the RS-232 interface)
⚠ | Warning signs affixed to the product that refer to detailed information in this manual.

1.3 Figures

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

1.4 Other Applicable Documents

The devices and software tools from PI 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-421.00: High-power piezo amplifier module</td>
<td>PZ178E User Manual</td>
</tr>
<tr>
<td>E-470.20: High-power piezo amplifier</td>
<td>PZ178E User Manual</td>
</tr>
<tr>
<td>E-471.20: High-power piezo amplifier</td>
<td>PZ178E User Manual</td>
</tr>
<tr>
<td>E-472.20: High-power piezo amplifier, 2 channels</td>
<td>PZ178E User Manual</td>
</tr>
<tr>
<td>E-462.00: HVPZT piezo amplifier</td>
<td>PZ210E User Manual</td>
</tr>
<tr>
<td>E-462.OE1: HVPZT high-power piezo amplifier, 10 to 1000 V, OEM version</td>
<td>PZ210E User Manual</td>
</tr>
<tr>
<td>E-464.00: HVPZT piezo amplifier, 3 channels</td>
<td>PZ176E User Manual</td>
</tr>
<tr>
<td>E-481.00: High-power piezo amplifier / controller</td>
<td>PZ170E User Manual</td>
</tr>
</tbody>
</table>
### 1.5 Downloading Manuals

**INFORMATION**

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 39).

**INFORMATION**

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

You need the product CD to get the access data.

---

**For products with CD: Get access data**

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. Get the access data for downloading protected content in the "User login for software download" section of the Release News. Possible methods for getting the access data:
   - Link to a page for registering and requesting the access data
   - User name and password is specified
5. If the access data needs to be requested via a registration page:
   a) Follow the link in the Release News.
   b) Enter the required information in the browser window.
   c) Click *Show login data* in the browser window.
   d) Note the user name and password shown in the browser window.
1 About this Document

Downloading manuals

If you have requested access data for protected contents via a registration page (see above):

- Click the links in the browser window to change to the content for your product and log in using the access data that you received.

General procedure:

1. Open the website 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-225) or the product family (e.g., PICA Power) 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 bottom of the list.
   c) Click the corresponding product in the list.
7. Click the Downloads tab.
   The manuals are shown 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 .............................................................................................................. 6

2.1 Intended Use

The P-2x5 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in
interior spaces and in an environment which is free of dirt, oil and lubricants.

In accordance with its design, the P-2x5 is intended for the following applications:

- Positioning of high loads; see "Specifications" (p. 41)
- Dynamic positioning
- Vibration damping
- Force generation

The motion takes place in one axis.

The specifications of the P-2x5 apply to mounting with a vertically oriented motion axis.
Mounting with a horizontally oriented motion axis is not recommended.

The intended use of the P-2x5 is only possible in a completely mounted and connected state
and only in combination with suitable drive or control electronics (p. 12) available from PI. The
electronics is not included in the scope of delivery of the P-2x5.

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

2.2 General Safety Instructions

The P-2x5 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-2x5.

- Only use the P-2x5 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-2x5.
Temperature changes and compressive stresses can induce charges in the P-2x5 piezo actuator. After being disconnected from the electronics, the piezo actuator can stay charged for several hours. Touching the live parts of the P-2x5 can result in serious injury or death from electric shock.

- Do not open the P-2x5.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-2x5 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-2x5 can result in serious injury or death from electric shock.

- Connect the P-2x5 to a protective earth conductor (p. 22) before startup.
- Do not remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-2x5 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-2x5.

- Avoid knocks that affect the P-2x5.
- Do not drop the P-2x5.
- Avoid torques, bending forces, and lateral forces on the tip of the P-2x5.
- Do not exceed the maximum permissible loads (p. 41).

### 2.3 Organizational Measures

#### User manual

- Always keep this user manual available with the P-2x5. 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-2x5 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-2x5 after you have read and understood this user manual.

#### Personnel qualification

The P-2x5 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.
3 Product Description

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Product View ................................................................................................................................ 10
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Suitable Electronics ....................................................................................................................... 12
Accessories ................................................................................................................................... 13
Technical Features ....................................................................................................................... 15

3.1 Model Overview

INFORMATION

Optional accessories are available for the P-2x5 piezo actuators that have to be integrated during the manufacturing of the P-2x5 (p. 13). If a P-2x5 piezo actuator is ordered with these options, it receives a customer-specific product number (beginning with "P-2x5K").

This manual also applies to all piezo actuators that have a customer-specific product number due to integrated options.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-225.10</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 12500 N</td>
</tr>
<tr>
<td>P-225.20</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 12500 N</td>
</tr>
<tr>
<td>P-225.40</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 12500 N</td>
</tr>
<tr>
<td>P-225.80</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 12500 N</td>
</tr>
<tr>
<td>P-235.10</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 30000 N</td>
</tr>
<tr>
<td>P-235.20</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 30000 N</td>
</tr>
<tr>
<td>P-235.40</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 30000 N</td>
</tr>
<tr>
<td>P-235.80</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 30000 N</td>
</tr>
<tr>
<td>P-235.90</td>
<td>Preloaded high-load piezo actuator, 180 µm, 1000 V, 30000 N</td>
</tr>
</tbody>
</table>
### Piezo actuators without a sensor, suitable for high-temperature range and high vacuum

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-225.10V</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 12500 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-225.20V</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 12500 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-225.40V</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 12500 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-225.80V</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 12500 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.10V</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 30000 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.20V</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 30000 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.40V</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 30000 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.80V</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 30000 N, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.90V</td>
<td>Preloaded high-load piezo actuator, 180 µm, 1000 V, 30000 N, high temperature / vacuum</td>
</tr>
</tbody>
</table>

### Piezo actuators with a position sensor

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-225.1S</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 12500 N, SGS</td>
</tr>
<tr>
<td>P-225.2S</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 12500 N, SGS</td>
</tr>
<tr>
<td>P-225.4S</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 12500 N, SGS</td>
</tr>
<tr>
<td>P-225.8S</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 12500 N, SGS</td>
</tr>
<tr>
<td>P-235.1S</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 30000 N, SGS</td>
</tr>
<tr>
<td>P-235.2S</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 30000 N, SGS</td>
</tr>
<tr>
<td>P-235.4S</td>
<td>Preloaded high-load piezo actuator, 60 µm, 1000 V, 30000 N, SGS</td>
</tr>
<tr>
<td>P-235.8S</td>
<td>Preloaded high-load piezo actuator, 120 µm, 1000 V, 30000 N, SGS</td>
</tr>
<tr>
<td>P-235.9S</td>
<td>Preloaded high-load piezo actuator, 180 µm, 1000 V, 30000 N, SGS</td>
</tr>
</tbody>
</table>

### Piezo actuators with a sensor, suitable for high-temperature range and high vacuum

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-225.15V</td>
<td>Preloaded high-load piezo actuator, 15 µm, 1000 V, 12500 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-225.25V</td>
<td>Preloaded high-load piezo actuator, 30 µm, 1000 V, 12500 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>Model</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>P-225.4SV</td>
<td>Preloaded high-load piezo actuator, 60 μm, 1000 V, 12500 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-225.8SV</td>
<td>Preloaded high-load piezo actuator, 120 μm, 1000 V, 12500 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.1SV</td>
<td>Preloaded high-load piezo actuator, 15 μm, 1000 V, 30000 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.2SV</td>
<td>Preloaded high-load piezo actuator, 30 μm, 1000 V, 30000 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.4SV</td>
<td>Preloaded high-load piezo actuator, 60 μm, 1000 V, 30000 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.8SV</td>
<td>Preloaded high-load piezo actuator, 120 μm, 1000 V, 30000 N, SGS, high temperature / vacuum</td>
</tr>
<tr>
<td>P-235.9SV</td>
<td>Preloaded high-load piezo actuator, 180 μm, 1000 V, 30000 N, SGS, high temperature / vacuum</td>
</tr>
</tbody>
</table>
3.2 Product View

3.2.1 Overview

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

Figure 1: Example product view

1. Housing, consisting of:
   1a: Base with wrench flats
   1b: Housing tube
   Not shown here: Optional inlets and outlets for purge air, optional water protection
2. Tip with wrench flat and M8 inner thread
3. Cable exit for piezo voltage
   Not shown here: Cable exits for sensors
4. Protective earth connector

Arrow: Positive direction of motion of the tip
### 3.2.2 Product Labeling

<table>
<thead>
<tr>
<th>Labeling</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data matrix code</td>
<td>Data matrix code (example; contains the serial number)</td>
</tr>
<tr>
<td>P-225.80</td>
<td>Product number (example), the digits after the period refer to the model</td>
</tr>
<tr>
<td>123456789</td>
<td>Serial number (example), individual for each P-2x5</td>
</tr>
<tr>
<td></td>
<td>Meaning of the places (counting from left):</td>
</tr>
<tr>
<td></td>
<td>1 = internal information</td>
</tr>
<tr>
<td></td>
<td>2 and 3 = year of manufacture</td>
</tr>
<tr>
<td></td>
<td>4 to 9 = consecutive numbers</td>
</tr>
<tr>
<td>PI</td>
<td>Manufacturer's logo</td>
</tr>
<tr>
<td>Warning sign</td>
<td>&quot;Observe manual!&quot;</td>
</tr>
<tr>
<td>Old equipment disposal</td>
<td>Country of origin (p. 51)</td>
</tr>
<tr>
<td>Country of origin: Germany</td>
<td>Manufacurer's address (website)</td>
</tr>
<tr>
<td><a href="http://WWW.PI.WS">WWW.PI.WS</a></td>
<td>CE conformity mark</td>
</tr>
<tr>
<td></td>
<td>Symbol for the protective earth conductor, marks the protective earth connection of the P-2x5 (p. 22)</td>
</tr>
</tbody>
</table>

Figure 2:  P-2x5: Warning sign "DANGER" on voltage connection (with attached shorting plug)

Warning sign "DANGER": Indicates risk of electric shock (p. 5)
3.3 **Scope of Delivery**

<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-2x5</td>
<td>Piezo actuator according to order (p. 7)</td>
</tr>
</tbody>
</table>
| 000036450   | M4 screw set for protective earth, consisting of:  
  - 1 M4x8 flat-head screw with cross recess, ISO 7045  
  - 2 safety washers  
  - 2 flat washers |
| P-202.01    | Shorting plug for high-voltage piezo actuators |
| PZ246EK     | Short instructions for "PICA Piezo Actuators 1000 V" |

3.4 **Suitable Electronics**

You need electronics to operate a P-2x5. The device is selected depending on the type of application. The table below lists the suitable devices.

<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-421.00</td>
<td>High-power piezo amplifier module, without housing, 1 channel, 1100 V voltage range, 550 W, integrated power supply</td>
</tr>
<tr>
<td>E-470.20</td>
<td>High-power piezo amplifier, 1 channel, 1100 V voltage range, 550 W, benchtop device</td>
</tr>
<tr>
<td>E-471.20</td>
<td>High-power piezo amplifier, 1 channel, 1100 V voltage range, 550 W, 19&quot;, prepared for servo controller and display / PC interface</td>
</tr>
<tr>
<td>E-472.20</td>
<td>2-channel high-power piezo amplifier, 1100 V voltage range, 550 W, 19&quot;</td>
</tr>
<tr>
<td>E-462.00</td>
<td>HVPZT piezo amplifier, 10 to 1000 V, benchtop device</td>
</tr>
<tr>
<td>E-462.OE1</td>
<td>HVPZT piezo amplifier module, 10 to 1000 V, OEM Version</td>
</tr>
<tr>
<td>E-464.00</td>
<td>HVPZT piezo amplifier, 3 channels, 1100 V voltage range, benchtop device</td>
</tr>
<tr>
<td>E-481.00</td>
<td>PICA high-performance piezo amplifier / controller with energy recovery, 1100 V voltage range, 2000 W, 19&quot;</td>
</tr>
<tr>
<td>E-482.00</td>
<td>PICA high-performance piezo amplifier / controller with energy recovery, 1050 V, 6 A, 19&quot;</td>
</tr>
</tbody>
</table>
3 Product Description

<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
</tr>
</thead>
</table>
| E-500       | Modular piezo controller (example configuration)  
High-voltage piezo amplifier for PICA HVPZT, 3 channels, with PC interface and display, consisting of:  
1 × E-500.00  
19" housing 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-518.I3  
Interface module, 3 channels, TCP/IP, USB, and RS-232 interfaces  
Optionally as high-voltage amplifier / servo controller additionally with:  
1 × E-509.S3  
Sensor / servo controller module, strain gauge sensors, 3 channels |

➢ To order, contact our customer service department (p. 39).
➢ Before selecting electronics, calculate the power requirements of your application (p. 32).

3.5 Accessories

For production-related reasons, the P-177.50 and P-706.00 options must be ordered together with the P-2x5 piezo actuator. Piezo actuators equipped with these options have a customer-specific product number (begins with "P-2x5K").

<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-177.50</td>
<td>PT1000 temperature sensor and purge air connector for PICA high-voltage piezo actuators (with E-481 and E-482 controllers)</td>
</tr>
<tr>
<td>P-706.00</td>
<td>Splash-proof housing (IP64), for P-225 and P-235</td>
</tr>
<tr>
<td>P-176.B25</td>
<td>Ball tip (p. 46), contact surface hardened and polished, for P-225 and P-235</td>
</tr>
<tr>
<td>P-176.F25</td>
<td>Flat tip (p. 47), contact surface hardened and polished, for P-225</td>
</tr>
<tr>
<td>P-176.F35</td>
<td>Flat tip (p. 47), contact surface hardened and polished, for P-235</td>
</tr>
</tbody>
</table>
| P-203.VA    | Vacuum feedthrough for high-voltage piezo actuators, to 10⁻⁶ hPa, 100 °C, consisting of:  
▪ Vacuum feedthrough LEMO SJG.0B.701.CJA.1173  
▪ Air-side cable with 2 LEMO connectors, 2 m |
| P-892.VA    | Vacuum feedthrough strain gauge sensor, to 10⁻⁶ hPa, 100 °C, consisting of:  
▪ Vacuum feedthrough LEMO SWH.0S.304.CLLSV  
▪ Air-side cable with 2 LEMO connectors, 2 m |
| P-899.VA    | Vacuum feedthrough temperature sensor, to 10⁻⁶ hPa, 100 °C, consisting of:  
▪ Vacuum feedthrough LEMO SWH.0S.303.CLLSV  
▪ Air-side cable with 2 LEMO connectors, 2 m |
## Product Description

<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>P-203.01</td>
<td>Extension cable for PICA HVPZT actuators, 1 m</td>
</tr>
<tr>
<td>P-203.02</td>
<td>Extension cable for PICA HVPZT actuators, 2 m</td>
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<tr>
<td>P-203.03</td>
<td>Extension cable for PICA HVPZT actuators, 3 m</td>
</tr>
<tr>
<td>P-203.05</td>
<td>Extension cable for PICA HVPZT actuators, 5 m</td>
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<tr>
<td>P-203.10</td>
<td>Extension cable for PICA HVPZT actuators, 10 m</td>
</tr>
<tr>
<td>P-203.15</td>
<td>Extension cable for PICA HVPZT actuators, 15 m</td>
</tr>
<tr>
<td></td>
<td>Connector (m): FGG.0B.701.CJA.1173; connector (f): PHG.0B.701.CJL.1173</td>
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<tr>
<th>Product no.</th>
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<tr>
<td>P-892.01</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 1 m</td>
</tr>
<tr>
<td>P-892.02</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 2 m</td>
</tr>
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<td>P-892.03</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 3 m</td>
</tr>
<tr>
<td>P-892.05</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 5 m</td>
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<tr>
<td>P-892.10</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 10 m</td>
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<td>P-892.15</td>
<td>Extension cable, for strain gauge sensors, LEMO connector(s), 15 m</td>
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<tr>
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<td>Connector (m): FFA.0S.304.CLAC32; connector (f): PCA.0S.304.CLLC32</td>
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<table>
<thead>
<tr>
<th>Product no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-899.01</td>
<td>Extension cable for temperature sensor, LEMO connectors, 1 m</td>
</tr>
<tr>
<td>P-899.02</td>
<td>Extension cable for temperature sensor, LEMO connectors, 2 m</td>
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<tr>
<td>P-899.03</td>
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<td>P-899.05</td>
<td>Extension cable for temperature sensor, LEMO connectors, 5 m</td>
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<td>P-899.07</td>
<td>Extension cable for temperature sensor, LEMO connectors, 7 m</td>
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<td>P-899.10</td>
<td>Extension cable for temperature sensor, LEMO connectors, 10 m</td>
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<td>P-899.15</td>
<td>Extension cable for temperature sensor, LEMO connectors, 15 m</td>
</tr>
<tr>
<td></td>
<td>Connector (m): FFA.0S.303.CLAC32; connector (f): PCA.0S.303.CLLC32</td>
</tr>
</tbody>
</table>

- To order, contact our customer service department (p. 39).
3.6 Technical Features

3.6.1 PICA Piezo Actuators

P-2x5 are PICA preloaded high-load piezo actuators for static and dynamic applications. They have a submillisecond response time and subnanometer resolution.

The piezo actuators have a friction-free, preloaded PICA Power piezo ceramic that is integrated in a stainless-steel housing. The high load capacity and internal preload make them ideal for applications such as precision manufacturing and active vibration damping.

3.6.2 Strain Gauge Sensors (SGS)

Strain gauge sensors derive the position information from their expansion. A strain gauge sensor consists of an electrically conductive film, the resistance of which changes with the strain. Strain gauge sensors are attached to the actuator and measure its displacement. The sensors are equipped with a full-bridge circuit that is insensitive to thermal drift, and assure optimum position stability in the nanometer range.
## 4 Unpacking

**NOTICE**

**Destruction of the piezo actuator due to rapid discharging!**

If the P-2x5 is not connected to the electronics, the lines on the voltage connection must be short-circuited in order to prevent the piezo actuator from charging 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.

- Remove the supplied shorting plug from the voltage connection of the piezo actuator only when this is necessary for installation or operation.
- Keep the shorting plug near the piezo actuator after removing it.

When the shorting plug has been removed, proceed as follows:

1. Discharge the piezo actuator (p. 33).
2. Connect the shorting plug provided to the voltage connector of the discharged piezo actuator. Do not short-circuit the piezo actuator in any other way.

![Figure 3: Voltage connection of the P-2x5 with attached shorting plug](image)

1. Voltage connection of the P-2x5
2. P-202.01 shorting plug, in the scope of delivery
4 Unpacking

**INFORMATION**

When handling the vacuum version of the piezo actuator, appropriate cleanliness must be ensured. At PI, all parts are cleaned before assembly. During assembly and calibration, powder-free gloves are worn. Afterwards, the piezo actuator is cleaned once again by wiping and shrink-wrapped twice in vacuum-compatible film.

- Touch the piezo actuator only with powder-free gloves.
- If necessary, wipe the piezo actuator clean after unpacking.

1. Unpack the P-2x5 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 parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.
5 Installation

In this Chapter

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Connecting the P-2x5 to the Protective Earth Conductor ............................. 22
Mounting the P-2x5 ................................................................................. 23
Optional: Mounting a Tip ...................................................................... 24
Affixing the Load .................................................................................. 25
Optional: Connecting the Purge Air ......................................................... 25

5.1 General Notes on Installation

NOTICE

Destruction of the piezo actuator due to rapid discharging!
If the P-2x5 is not connected to the electronics, the lines on the voltage connection must be
short-circuited in order to prevent the piezo actuator from charging 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.

- Remove the supplied shorting plug from the voltage connection of the piezo actuator only
  when this is necessary for installation or operation.
- Keep the shorting plug near the piezo actuator after removing it.

When the shorting plug has been removed, proceed as follows:
1. Discharge the piezo actuator (p. 33).
2. Connect the shorting plug provided to the voltage connector of the discharged piezo
   actuator. Do not short-circuit the piezo actuator in any other way.

NOTICE

Destruction of the piezo actuator due to excessive loads!
Excessive loads can destroy the P-2x5.

- Do not exceed the maximum push/pull capacity according to the specifications (p. 41).
NOTICE

Destruction of the piezo actuator due to mechanical overload!
Torques, bending forces, shearing forces, and lateral forces can destroy the piezo actuator.

- Avoid torques and lateral forces on the tip of the P-2x5.
- Do not exceed the maximum torque and the maximum shearing load on the tip according to the specifications (p. 41).
- Avoid torques on the base when the tip is tightly clamped.
- Make sure that the center of load of the moving system is on the motion axis of the piezo actuator.
- Use suitable structures or guide elements (e.g., ball tips or flexure guides) to avoid uneven load distribution.
- Pay attention to the information on parallelism in the "Dimensions" section (p. 45).
- Do not screw the piezo actuator tight at both ends.

NOTICE

Damage due to unsuitable cables!
Unsuitable cables can damage the P-2x5 and the electronics.

- Only use cables provided by PI for connecting the P-2x5 to the electronics.

NOTICE

Heating up of the P-2x5 during operation!
The heat produced during operation of the P-2x5 can affect your application.

- Install the P-2x5 so that your application is not affected by the dissipating heat.

INFORMATION

Extended cables can affect the performance of the P-2x5.

- Only use extension cables from PI (p. 13).

INFORMATION

When handling the vacuum version of the piezo actuator, appropriate cleanliness must be ensured.

- Touch the piezo actuator only with powder-free gloves.
- If necessary, wipe the piezo actuator clean.

INFORMATION

The outward motion of the tip corresponds to the positive direction of motion and is proportional to the operating voltage applied.
Avoiding mounting errors

Piezo actuators may only be loaded axially. The following figures are to help you avoid mounting errors.

Figure 4:  Not tightly screwed at both ends and no angles

A: Wrong: Angular error at the tip
B: Right: Axial loading of the actuator
C: Wrong: Both ends of the actuator screwed in tight

Figure 5:  Ball tips or flexures for decoupling lateral forces and bending forces
5.2 Connecting the P-2x5 to the Protective Earth Conductor

**INFORMATION**

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

There is an M4 hole in the P-2x5 for connecting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor 🌋. The position of the hole is shown in the product view (p. 10).

**Requirements**

- You have read and understood the general notes on installation (p. 19).
- The P-2x5 is not connected to the electronics.
- The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.

**Tools and accessories**

- Suitable protective earth conductor: Cable cross section ≥0.75 mm² and protective earth conductor resistance <0.1 Ω at 25 A
- M4 protective earth screw set (p. 12) supplied for connecting the protective earth conductor
- Suitable screwdriver
5 Installation

Figure 7: Connecting the protective earth conductor (profile view)

1. Base of the P-2x5
2. Flat washer
3. Safety washer
4. Screw
5. Cable lug
6. Protective earth conductor

Connecting the P-2x5 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the P-2x5 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is <0.1 $\Omega$ at 25 A.

5.3 Mounting the P-2x5

Requirements

- You have read and understood the general notes on installation (p. 19).
- The P-2x5 is not connected to the electronics.
- The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.

Tools and accessories

- M8 screw of suitable length; see "Dimensions" (p. 45)
- Open-end wrench AF 27
- Suitable screwdriver
### Mounting the P-2x5

1. Use an SW 27 open-end wrench to hold the base of the P-2x5.
2. Attach the P-2x5 to a suitable surface with an M8 screw. For this purpose, use the M8 mounting hole on the bottom of the base; see "Dimensions" (p. 45).
3. Remove the open-end wrench from the base.

---

### 5.4 Optional: Mounting a Tip

**INFORMATION**

Different mechanical connections to a load are made possible by optionally available flat or ball tips (p. 13).

**Requirements**

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ The P-2x5 is not connected to the electronics.
- ✓ The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.

**Tools and accessories**

- Optionally available flat or ball tip (p. 13)
- Open-end wrench for holding the tip of the P-2x5 (p. 10) in place:
  - P-225: AF 13
  - P-235: AF 17

**Mounting a flat or ball tip**

1. Use an open-end wrench with a matching jaw size to hold the tip of the P-2x5 in place.
2. Screw the flat or ball tip into the mounting hole of the P-2x5 by hand.
3. Remove the open-end wrench from the tip.
5.5 Affixing the Load

Requirements

✓ You have read and understood the general notes on installation (p. 19).
✓ The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.

Tools and accessories

 M8 screw of suitable length; see "Dimensions" (p. 45)
 Suitable screwdriver
 Open-end wrench for holding the tip of the P-2x5 (p. 10) in place:
  – P-225: AF 13
  – P-235: AF 17

Affixing the load

1. Use an open-end wrench with a matching jaw size to hold the tip of the P-2x5 in place.
2. Fasten the load to the mounting hole in the tip with an M8 screw; see "Dimensions" (p. 45).
3. Remove the open-end wrench from the tip.

5.6 Optional: Connecting the Purge Air

NOTICE

Destruction of the piezo actuator by cooling too quickly!

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

➢ Only connect the purge air to the piezo actuator when the piezo actuator has cooled down to room temperature.

INFORMATION

The piezo actuator can be cooled with purge air when the P-2x5 has been ordered with the option "PT1000 temperature sensor and purge air connector for PICA high-voltage piezo actuators" (P-177.50) (p. 13).
Figure 8: P-2x5: Purge air connector with P-177.50 option

1. Inlet for purge air, M3-PK-2 plug nipple
2. Outlet for purge air, M3-PK-2 plug nipple

Requirements

✓ You have read and understood the general notes on installation (p. 19).
✓ The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.

Tools and accessories

▪ Hoses for feeding and discharging the purge air, suitable for M3-PK-2 plug nipple
▪ Suitable purge air:
  The requirements on purge air quality can generally be met by running compressed air conformant to ISO 8573-1:2010.
  Particulates: Class 2
  Humidity: Class 4 (Temperature at least 3 °C above dew point)
  Residual oil content: Class 1 (<0.01 mg/m³, measured at 1 bar and 20 °C)
  The pressure in the purge air supply should be between 0.5 bar and 1 bar.

Connecting the purge air

1. Make sure that the piezo actuator has cooled down to room temperature.
2. Connect the purge air:
   - Attach the hose for feeding the purge air to the corresponding plug nipple on the P-2x5 (see above figure).
   - Attach the hose for discharging the purge air to the corresponding plug nipple on the P-2x5 (see above figure).
6 Startup and Operation

In this Chapter

General Notes on Startup and Operation ................................................................. 27
Determining the Operating Parameters ................................................................. 30
Operating the P-2x5 ............................................................................................... 33
Discharging the P-2x5 ......................................................................................... 33

6.1 General Notes on Startup and Operation

DANGER

Risk of electric shock if the protective earth conductor is not connected!
If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-2x5 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-2x5 can result in serious injury or death from electric shock.

➢ Connect the P-2x5 to a protective earth conductor (p. 22) before startup.
➢ Do not remove the protective earth conductor during operation.
➢ If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-2x5 to the protective earth conductor before starting it up again.

CAUTION

Burning due to hot surface!
The surface of the P-2x5 can heat up during operation. Touching the P-2x5 can lead to minor injuries from burning.

➢ Cool the P-2x5, for example, with purge air (p. 25) so that the temperature of the surface does not exceed 65 °C.
➢ If sufficient cooling is not possible: Make sure that the hot P-2x5 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-2x5 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids, and conductive materials (e.g., metal dust). In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.
- Avoid operating the P-2x5 in environments that can increase the electrical conductivity.
- Only operate the P-2x5 within the permissible ambient conditions and classifications (p. 44).
- When using in a vacuum under 100 hPa: Do not operate the P-2x5 while evacuating or ventilating.

NOTICE

Destruction of the piezo actuator due to dynamic forces!
Dynamic forces can be generated during dynamic operation that cancel out the preload of the piezo actuator. Operating without a preload can destroy the actuator.
- Do not exceed the maximum push/pull capacity according to the specifications (p. 41).
- Pay attention to the notes in "Determining the Operating Parameters" (p. 30).

NOTICE

Destruction of the piezo actuator due to excessive operating frequencies!
Excessive operating frequencies can destroy the piezo actuator.
- Select the operating frequency so that the following conditions are met:
  - The maximum operating frequency must be one third of the resonant frequency (see "Data Table" (p. 41) for the resonant frequency of the unloaded piezo actuator and see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 31) for the resonant frequency of the loaded piezo actuator).
  - Any dynamic forces generated during operation do not exceed the maximum push/pull force of the piezo actuator (see "Calculating the Forces that Occur During Dynamic Operation" (p. 32) and "Specifications" (p. 41)).

NOTICE

Reduced lifetime of the piezo actuator due to permanently high voltage!
The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic.
- When the P-2x5 is not used but the electronics remain switched on to ensure temperature stability, discharge the P-2x5 (p. 33).
- If possible: Limit the maximum operating voltage to 750 V during continuous operation.
**NOTICE**

**Operating voltage too high or incorrectly connected!**

Operating voltages that are too high or incorrectly connected can cause damage to the P-2x5.

- Only operate the P-2x5 with controllers/drivers and original accessories from PI.
- **Do not** exceed the operating voltage range (p. 43) for which the P-2x5 is specified.
- Only operate the P-2x5 when the operating voltage is properly connected; see "Pin Assignment" (p. 50).

**NOTICE**

**Destruction of the piezo actuator due to overheating!**

Overheating can destroy the piezo actuator.

- Cool the piezo actuator, for example, with purge air (p. 25).
- Monitor the temperature of the piezo actuator with a temperature sensor (p. 13).
- 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. 44), "Maximum Ratings" (p. 43) and "Determining the Operating Parameters" (p. 30).

**NOTICE**

**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-2x5. Oscillation is indicated by a humming noise and can be caused by the following:

- A change in the load and/or dynamics requires the servo control parameters to be adjusted.
- The P-2x5 is operated near to its resonant frequency.

If you notice oscillation:

- In closed-loop operation, switch off the servo mode immediately.
- In open-loop operation, stop the P-2x5 immediately.

**INFORMATION**

The outward motion of the tip corresponds to the positive direction of motion and is proportional to the operating voltage applied.
6.2 Determining the Operating Parameters

6.2.1 Overview of Limiting Factors

Limiting factors for the operation of the piezo actuator:

- **Resonant frequency:**
  The operating frequency must **not** exceed one third of the resonant frequency of the loaded piezo actuator. See "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 31).

- **Maximum push/pull force capacity (p. 41):**
  The mass of the load to be moved and the operating frequency of the piezo actuator must be selected so that any dynamic forces generated during operation do not exceed the maximum push/pull force capacity of the piezo actuator. See "Calculating the Forces that Occur During Dynamic Operation" (p. 32).

- **Maximum permissible operating temperature of the piezo actuator (p. 44):**
  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. 43).

  When cooling measures (p. 25) are used, the limit values for the operating frequency, operating voltage and operating time increase. The use of a temperature sensor (p. 13) can prevent the piezo actuator from overheating.

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

The electronics must be selected so that they fulfill the following requirements:

- The electronics can provide the required current. See "Calculating the Power Requirement for Sinusoidal Operation" (p. 32).

- The output current of the electronics does not exceed the maximum power consumption of the piezo actuator. See "Maximum Ratings" (p. 43).
6.2.2 Calculating the Effective Mass

Figure 9: Calculation of the effective mass of a unilaterally clamped piezo stack actuator without load (left) and with additional load (right).

1. Find the mass $m$ of your piezo actuator in the data table (p. 41).
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 with the formulas in the above figure.

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. 43).

1. Calculate the resonant frequency of the loaded piezo actuator with the following formula:

   $$f_0' = f_0 \frac{m_{\text{eff}}}{m_{\text{eff}}'}$$

   $f_0'$ = Resonant frequency of the loaded piezo actuator [Hz]
   $f_0$ = Resonant frequency of the unloaded piezo actuator [Hz]; see "Data Table" (p. 41).
   $m_{\text{eff}}$ = Effective mass; approx. 1/3 of the mass of the piezo actuator [kg]
   $m_{\text{eff}}'$ = Effective mass $m_{\text{eff}}$ + additional load $M$ [kg]

   See also "Calculating the Effective Mass" (p. 31).
6.2.4 Calculating the Forces that Occur During Dynamic Operation

- Calculate the dynamic forces that act on the piezo actuator during sinusoidal operation with the frequency \( f \) with 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. 31)
- \( \Delta L \) = 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:

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_a )</td>
<td>Required average current of the amplifier (source / sink) [A]</td>
<td>It is essential that the power supply can supply enough current.</td>
</tr>
<tr>
<td>( I_{\text{max}} )</td>
<td>Required peak current of the amplifier (source / sink) [A]</td>
<td>The provided peak current depends on the internal storage capacity of the amplifier.</td>
</tr>
<tr>
<td>( f )</td>
<td>Operating frequency [Hz]</td>
<td>Details on the operating frequency see &quot;Overview of Limiting Factors&quot; (p. 30).</td>
</tr>
<tr>
<td>( C )</td>
<td>Capacitance of the piezo actuator [F (= As/V)]</td>
<td>See &quot;Data Table&quot; (p. 41) 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.</td>
</tr>
<tr>
<td>( U_{p-p} )</td>
<td>Operating voltage (peak-to-peak) [V]</td>
<td>Voltage difference between positive and negative peak voltage</td>
</tr>
</tbody>
</table>
6.3 Operating the P-2x5

Requirements

✓ You have read and understood the general notes on startup and operation (p. 27).
✓ You have determined the operating parameters for your application (p. 30).
✓ You have installed the P-2x5 correctly (p. 19).
✓ You have provided suitable electronics that can supply the required currents (p. 32).
✓ You have read and understood the user manual for the electronics.

Operating the P-2x5

➢ Follow the instructions in the manual for the electronics (p. 12) when connecting, starting, and operating the P-2x5.

6.4 Discharging the P-2x5

The P-2x5 must be discharged in the following cases:

➢ When the P-2x5 is not in use but the electronics remain switched on to ensure temperature stability
➢ Before disassembling (e.g., for cleaning and transporting the P-2x5) as well as for modifications
➢ If the P-2x5 is to be short-circuited with the shorting plug (p. 12) provided

Requirements

✓ You have read and understood the general notes on installation (p. 19).

Tools and accessories

➢ Electronics from PI (p. 12)

Discharging a P-2x5 connected to the electronics

In closed-loop operation:

1. Switch off the servo mode on the electronics.
2. Set the piezo voltage to 0 V on the electronics.

In open-loop operation:

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

Discharging a P-2x5 not connected to the electronics

➢ Connect the piezo actuator’s voltage plug to the switched-off electronics from PI.
7 Maintenance

In this Chapter

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7.1 General Notes on Maintenance

The P-2x5 is maintenance-free.

7.2 Cleaning the P-2x5

**NOTICE**

Destruction of the piezo actuator by electric flashovers!
The intrusion of fluids into the case of the piezo actuator can lead to the destruction of the piezo actuator by electric flashovers.
Before cleaning the P-2x5:
1. Discharge the P-2x5 (p. 33).
2. Disconnect the voltage connection of the P-2x5 from the electronics.
3. Connect the voltage connection of the P-2x5 with the supplied shorting plug (p. 17).

**HINWEIS**

Damage from ultrasonic cleaning!
Ultrasonic cleaning can damage the P-2x5.
➢ Do **not** do any ultrasonic cleaning.

Requirements

✓ The P-2x5 is **not** connected to the electronics.
✓ The P-2x5 is discharged (p. 33) and short-circuited by the shorting plug (p. 12) provided.
Cleaning the P-2x5

Only when the piezo actuator is not used in vacuum:

➤ If necessary, clean the P-2x5 surface with a cloth dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).

Only when the piezo actuator is used in vacuum:

➤ Touch the piezo actuator only with powder-free gloves.
➤ If necessary, wipe the piezo actuator clean.
## 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>Excessive load</td>
<td></td>
<td>Do not exceed the maximum push/pull capacity according to the specifications (p. 41).</td>
</tr>
</tbody>
</table>
| The E-481 or E-482 electronics from PI has deactuated the voltage output due to overheating of the piezo actuator | If the piezo actuator is equipped with the option "PT1000 temperature sensor and purge air connector for PICA high-voltage piezo actuators" (p. 13), the E-481 and E-482 electronics evaluate the signal of the temperature sensor.  
1. Switch off the electronics. 
2. Wait a few minutes until the piezo actuator has cooled down sufficiently. 
3. Switch the electronics on again. 
Preventive measures:  
   - Reduce the operating voltage, operating frequency, and/or operating time.  
   - Cool the piezo actuator. |                                                                                  |
<p>| Zero shift of the position sensor for the following reasons: |                                                                                 | Readjust the sensor's zero-point (see manual for the electronics). | Load in direction of motion |
| Ambient/operating temperature of the piezo actuator is much higher or lower than the calibration temperature (21 °C to 24 °C) |                                                                                 |                                                                          |
| Piezo actuator is depolarized due to overheating |                                                                                 | Contact our customer service department (p. 39).                        |</p>
<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced accuracy</td>
<td>P-2x5 or controller has been replaced</td>
<td>➢ Recalibrate the axis displacement (see controller manual) or contact our customer service department (p. 39).</td>
</tr>
<tr>
<td></td>
<td>Axes were mixed up during connection</td>
<td>With calibrated systems: ➢ Pay attention to the assignment of the axes when connecting several piezo actuators to a multi-channel controller. This assignment is indicated by labels on the devices.</td>
</tr>
</tbody>
</table>
| The piezo actuator starts oscillating or positions inaccurately | Servo control parameters wrongly set because for example, the load was changed | 1. Switch off the servo mode of the corresponding axes immediately.  
2. Check the servo control parameter settings on the controller.  
3. Adjust the servo control parameters on the controller according to the load change. |
| Operating with an excessively high frequency |                                                                                 | ➢ Operate the piezo actuator at a maximum of one third of the resonant frequency (see "Data Table" (p. 41) for resonant frequency of the unloaded piezo actuator, see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 31)) resonant frequency of the loaded piezo actuator. |

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. 39).
9 Customer Service

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

➢ If you have questions concerning your system, have the following information ready:
  – Product and serial numbers of all products in the system
  – Firmware version of the controller (if available)
  – Version of the driver or the software (if available)
  – Operating system on the PC (if available)

➢ 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 ........................................................................................................................................41
Dimensions ...................................................................................................................................45
Pin Assignment ............................................................................................................................50

10.1 Specifications

10.1.1 Data Table

<table>
<thead>
<tr>
<th>Operating voltage range</th>
<th>P-225.10</th>
<th>P-225.20</th>
<th>P-225.40</th>
<th>P-225.80</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion and positioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel range, closed loop*</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>µm</td>
<td></td>
</tr>
<tr>
<td>Resolution, closed loop*</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>2.4</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Resolution, open loop**</td>
<td>0.15</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Linearity error*</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>%</td>
<td>typ.</td>
</tr>
<tr>
<td>Mechanical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static large-signal stiffness in motion direction***</td>
<td>480</td>
<td>330</td>
<td>200</td>
<td>110</td>
<td>N/µm</td>
<td>±20 %</td>
</tr>
<tr>
<td>Resonant frequency, no load</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>kHz</td>
<td>±20 %</td>
</tr>
<tr>
<td>Shear load</td>
<td>255</td>
<td>152</td>
<td>84</td>
<td>73</td>
<td>N</td>
<td>max.</td>
</tr>
<tr>
<td>Torque on tip</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>Nm</td>
<td>max.</td>
</tr>
<tr>
<td>Drive properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piezo ceramic</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>320</td>
<td>630</td>
<td>1300</td>
<td>2600</td>
<td>nF</td>
<td>±20 %</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>410</td>
<td>470</td>
<td>610</td>
<td>900</td>
<td>g</td>
<td>±5 %</td>
</tr>
</tbody>
</table>

* Requires integrated strain gauge sensor. These versions are shipped with a performance report.

** The resolution of the system is only limited by the noise of the amplifier and measuring technology because PI piezo actuators are free of friction.

*** Dynamic small-signal stiffness is approx. 50 % higher.

The operating voltage should not exceed 750 V in continuous operation.

All specifications based on room temperature (22 °C ±3 °C).

Specifications for vacuum versions can differ.
## Technical Data

<table>
<thead>
<tr>
<th></th>
<th>P-235.10</th>
<th>P-235.20</th>
<th>P-235.40</th>
<th>P-235.80</th>
<th>P-235.90</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating voltage range</strong></td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Motion and positioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel range, closed loop*</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>180</td>
<td>µm</td>
<td></td>
</tr>
<tr>
<td>Resolution, closed loop*</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>2.4</td>
<td>3.6</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Resolution, open loop**</td>
<td>0.15</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>1.8</td>
<td>nm</td>
<td>typ.</td>
</tr>
<tr>
<td>Linearity error*</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>%</td>
<td>typ.</td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static large-signal stiffness in motion direction***</td>
<td>860</td>
<td>600</td>
<td>380</td>
<td>210</td>
<td>150</td>
<td>N/µm</td>
<td>±20 %</td>
</tr>
<tr>
<td>Resonant frequency, no load</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>2.8</td>
<td>kHz</td>
<td>±20 %</td>
</tr>
<tr>
<td>Push/pull force capacity in motion direction</td>
<td>30000 / 3500</td>
<td>30000 / 3500</td>
<td>30000 / 3500</td>
<td>30000 / 3500</td>
<td>30000 / 3500</td>
<td>N</td>
<td>max.</td>
</tr>
<tr>
<td>Shear load</td>
<td>707</td>
<td>420</td>
<td>232</td>
<td>147</td>
<td>147</td>
<td>N</td>
<td>max.</td>
</tr>
<tr>
<td>Torque on tip</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Nm</td>
<td>max.</td>
</tr>
<tr>
<td><strong>Drive properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piezo ceramic</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td>PICA Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>550</td>
<td>1100</td>
<td>2400</td>
<td>5100</td>
<td>7800</td>
<td>nF</td>
<td>±20 %</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>-40 to 80</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>580</td>
<td>690</td>
<td>940</td>
<td>1400</td>
<td>1900</td>
<td>g</td>
<td>±5 %</td>
</tr>
</tbody>
</table>

* Requires integrated strain gauge sensor. These versions are shipped with a performance report.

** The resolution of the system is only limited by the noise of the amplifier and measuring technology because PI piezo actuators are free of friction.

*** Dynamic small-signal stiffness is approx. 50 % higher.

The operating voltage should not exceed 750 V in continuous operation.

All specifications based on room temperature (22 °C ±3 °C).

Specifications for vacuum versions can differ.
10.1.2 Maximum Ratings

P-2x5 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 value corresponds to one third of the resonant frequency of the unloaded piezo actuator. For further restrictions, see "Overview of Limiting Factors" (p. 30).

- 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 1000 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. For further restrictions, see "Overview of Limiting Factors" (p. 30).

- Maximum power consumption:
  The value corresponds to the power consumption of the unloaded, uncooled piezo actuator that is operated at a voltage of 1000 V peak-to-peak 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></td>
<td></td>
<td>A: Without considering thermal aspects</td>
<td>B: Considering thermal aspects</td>
</tr>
<tr>
<td>P-225.1x</td>
<td>0 V to 1000 V</td>
<td>4.7 kHz</td>
<td>29 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 W</td>
</tr>
<tr>
<td>P-225.2x</td>
<td>0 V to 1000 V</td>
<td>3.3 kHz</td>
<td>25 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>84 W</td>
</tr>
<tr>
<td>P-225.4x</td>
<td>0 V to 1000 V</td>
<td>2.3 kHz</td>
<td>22 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>152 W</td>
</tr>
<tr>
<td>P-225.8x</td>
<td>0 V to 1000 V</td>
<td>1.3 kHz</td>
<td>21 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>290 W</td>
</tr>
<tr>
<td>P-235.1x</td>
<td>0 V to 1000 V</td>
<td>4.7 kHz</td>
<td>23 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>68 W</td>
</tr>
<tr>
<td>P-235.2x</td>
<td>0 V to 1000 V</td>
<td>3.3 kHz</td>
<td>20 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>115 W</td>
</tr>
<tr>
<td>P-235.4x</td>
<td>0 V to 1000 V</td>
<td>2.3 kHz</td>
<td>16 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>208 W</td>
</tr>
<tr>
<td>P-235.8x</td>
<td>0 V to 1000 V</td>
<td>1.3 kHz</td>
<td>15 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>398 W</td>
</tr>
<tr>
<td>P-235.9x</td>
<td>0 V to 1000 V</td>
<td>0.93 kHz</td>
<td>14 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>585 W</td>
</tr>
</tbody>
</table>

* The letter x in the piezo actuator's product number stands for the various models (p. 7).
## 10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-2x5 must be observed:

<table>
<thead>
<tr>
<th>Area of application</th>
<th>For indoor use only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum altitude</td>
<td>2000 m</td>
</tr>
<tr>
<td>Air pressure</td>
<td>P-2x5.xx models: 1100 hPa to 100 hPa</td>
</tr>
<tr>
<td></td>
<td>P-2x5.xxV models: 1100 hPa to 100 hPa</td>
</tr>
<tr>
<td></td>
<td>1 hPa to 10⁻⁶ hPa</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>P-2x5.xx models: –40 °C to 80 °C</td>
</tr>
<tr>
<td></td>
<td>P-2x5.xxV models: –40 °C to 150 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>–20 °C to 80 °C</td>
</tr>
<tr>
<td>Transport temperature</td>
<td>–20 °C to 80 °C</td>
</tr>
<tr>
<td>Maximum bakeout temperature (vacuum-compatible models only)</td>
<td>P-2x5.xxV piezo actuators: 150 °C</td>
</tr>
<tr>
<td></td>
<td>Vacuum feedthroughs (p. 13): 100 °C</td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>II</td>
</tr>
<tr>
<td>Protection class</td>
<td>I</td>
</tr>
<tr>
<td>Degree of pollution</td>
<td>1</td>
</tr>
<tr>
<td>Degree of protection according to IEC 60529</td>
<td>IP20</td>
</tr>
</tbody>
</table>
10.2 Dimensions

10.2.1 P-2x5 Piezo Actuator

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

<table>
<thead>
<tr>
<th></th>
<th>L [mm]</th>
<th>Ø A [mm]</th>
<th>Ø B [mm]</th>
<th>AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-225.1x</td>
<td>55</td>
<td>39.8</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>P-225.2x</td>
<td>68</td>
<td>39.8</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>P-225.4x</td>
<td>94</td>
<td>39.8</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>P-225.8x</td>
<td>147</td>
<td>39.8</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>P-235.1x</td>
<td>55</td>
<td>49.8</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>P-235.2x</td>
<td>68</td>
<td>49.8</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>P-235.4x</td>
<td>94</td>
<td>49.8</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>P-235.8x</td>
<td>147</td>
<td>49.8</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>P-235.9x</td>
<td>199</td>
<td>49.8</td>
<td>20</td>
<td>17</td>
</tr>
</tbody>
</table>

Figure 10: P-2x5

1: Sensor (only with models with position sensor and/or with P-177.50 option)
2: Piezo
10.2.2 P-2x5 with P-177.50 Option (Temperature Sensor and Purge Air Connector)

The M3-PK-2 plug nipples are provided for the purge air connector when the P-2x5 is ordered with the option "PT1000 temperature sensor and purge air connector for PICA HVPZT" (P-177.50) (p. 13).

- Position of the purge air inlet: In the base of the piezo actuator across from the cable exit, 20 mm above the lower edge of the base
- Position of the purge air outlet: In the housing tube of the piezo actuator above the cable exit; exact position on request

➢ Contact our customer service department (p. 39) for details on the position of the plug nipples.

10.2.3 P-2x5 with the P-706.00 Option (Water-Resistant Housing)

The dimensions of the P-2x5 with water-resistant case are supplied on request.

➢ Contact our customer service department (p. 39).

10.2.4 Ball Tip P-176.B25

![Figure 11: P-176.B25 (1 = plane hardened and polished)](image)

Figure 11: P-176.B25 (1 = plane hardened and polished)
10.2.5 Flat Tips P-176.F25 and P-176.F35

Figure 12: P-176.F25 (1 = Plane hardened and polished)

Figure 13: P-176.F35 (1 = Plane hardened and polished)
### 10.2.6 Vacuum Feedthrough for High-Voltage Piezo Actuators

LEMO SJG.0B.701.CJA.1173 (part of the P-203.VA option for high-voltage piezo actuators)

![Vacuum feedthrough LEMO SJG.0B.701.CJA.1173](image)

#### Designation Description

<table>
<thead>
<tr>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Outer body</td>
</tr>
<tr>
<td>2</td>
<td>O-ring, Ø 12x1.5</td>
</tr>
<tr>
<td>3</td>
<td>LEMO device socket, &quot;J&quot; coded, EGJ.0B.701.CJA, flange side (atmosphere)</td>
</tr>
<tr>
<td>4</td>
<td>LEMO device socket, &quot;G&quot; coded, EGG.0B.701.CJL, vacuum side</td>
</tr>
<tr>
<td>PZT m</td>
<td>High-voltage contact, male, vacuum side</td>
</tr>
<tr>
<td>GND w</td>
<td>Female contact, GND, vacuum side</td>
</tr>
<tr>
<td>PZT w</td>
<td>High-voltage contact, female, flange side (atmosphere)</td>
</tr>
<tr>
<td>GND m</td>
<td>Male contact, GND, flange side (atmosphere)</td>
</tr>
</tbody>
</table>
10.2.7 Vacuum Feedthroughs for Sensors

The dimensions of the following vacuum feedthroughs are identical:

- LEMO SWH.0S.304.CLLSV (part of the P-892.VA option for SGS)
- LEMO SWH.0S.303.CLLSV (part of the P-899.VA option for temperature sensor)

![Figure 15: LEMO SWH.0S.30x.CLLSV](image)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>e</th>
<th>E</th>
<th>L</th>
<th>M</th>
<th>S1</th>
<th>S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 mm</td>
<td>13.8 mm</td>
<td>M10x0.75</td>
<td>17 mm</td>
<td>34 mm</td>
<td>2.0 mm</td>
<td>9.0 mm</td>
<td>12 mm</td>
</tr>
</tbody>
</table>
10.3 Pin Assignment

10.3.1 Voltage Connection

LEMO FGG.0B.701.CJA.1173

<table>
<thead>
<tr>
<th>Connector (front view)</th>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W (female)</td>
<td>Input</td>
<td>Piezo voltage 1000 V</td>
</tr>
<tr>
<td></td>
<td>M (male)</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>

The connector shell is connected with the cable shield.

10.3.2 Connection of the Position Sensor

LEMO FFA.0S.304.CLA

<table>
<thead>
<tr>
<th>Connector (front view)</th>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Input</td>
<td>Supply voltage for strain gauge sensor</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Output</td>
<td>Sensor signal 1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Output</td>
<td>Sensor signal 2</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>

The connector shell is connected with the cable shield.

10.3.3 Connection of the Temperature Sensor

LEMO FFA.0S.303.CLA

<table>
<thead>
<tr>
<th>Connector (front view)</th>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Output</td>
<td>Temp_SA</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Output</td>
<td>Temp_S</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>

The connector shell is connected with the cable shield.
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
For the P-2x5, an EU Declaration of Conformity has been issued in accordance with the following European directives:

- Low Voltage Directive
- EMC Directive
- RoHS Directive

The applied standards certifying the conformity are listed below.

- Safety (Low Voltage Directive): EN 61010-1
- EMC: EN 61326-1
- RoHS: EN 50581