Piezo Actuators & Components
For Motion Control, Sensing, Energy Harvesting
### Selection Guide: Piezo Actuators & Components

**Great Variety: Flexure Guided, Preloaded, Stacks, Tubes, Benders, Shear Actuators**

#### Piezo Actuators Overview

PI piezo actuators are designed to combine ultra-high performance with long lifetime in industrial and scientific applications. PI’s piezo ceramic design and manufacturing division, PI Ceram, provides the capability and flexibility to offer highly engineered custom sub-assemblies at a very attractive price. The patented PICMA® multilayer long-life piezo actuators with cofired ceramic insulation provide more than 10 times higher service life than conventional actuators. Integrated position feedback sensors are available for high linearity applications in closed-loop operation. All linear drives are intended for integration into a customer’s system and feature no guidance. If off-axis motion cannot be tolerated external guidance is required.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P-601</td>
<td>Closed-loop, with flexure guidance</td>
<td>30 / 10</td>
<td>110, 300, 400</td>
<td>-20 to 120</td>
<td>SGS</td>
<td>1-68</td>
<td></td>
</tr>
<tr>
<td>P-855.20</td>
<td>Piezo tip for micrometer</td>
<td>100 / 5</td>
<td>20</td>
<td>-20 to 120</td>
<td>–</td>
<td>1-73</td>
<td></td>
</tr>
<tr>
<td>P-810–P-830</td>
<td>Only 6 mm diameter, ferromagnetic end pieces</td>
<td>50 / 1</td>
<td>15, 30, 45</td>
<td>-20 to 120</td>
<td>–</td>
<td>1-70</td>
<td></td>
</tr>
<tr>
<td>P-820</td>
<td>Smallest preloaded piezo translator</td>
<td>50 / 10</td>
<td>15, 30, 45</td>
<td>-20 to 120</td>
<td>–</td>
<td>1-72</td>
<td></td>
</tr>
<tr>
<td>P-840, P-841</td>
<td>Preloaded, optional ball tip</td>
<td>1000 / 50</td>
<td>15, 30, 45, 60, 90</td>
<td>-20 to 120</td>
<td>SGS</td>
<td>1-74</td>
<td></td>
</tr>
<tr>
<td>P-842, P-843</td>
<td>Preloaded, optional ball tip, optional water-proof case</td>
<td>800 / 300, 15, 30, 45, 60, 90</td>
<td>-20 to 120</td>
<td>SGS</td>
<td>1-76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-212, P-216, P-225, P-235</td>
<td>Preloaded, long travel ranges, very high forces</td>
<td>2000 / 300, 15 to 120, 15 to 180</td>
<td>0 to 1000 SGS</td>
<td>1-78, 1-80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL022, /033, /055</td>
<td>PICMA® Chip. Smallest multilayer piezo actuators, from 2x2x2 mm</td>
<td>to 1000 / 5</td>
<td>3</td>
<td>-20 to 120</td>
<td>–</td>
<td>1-92</td>
<td></td>
</tr>
<tr>
<td>P-882–P-888</td>
<td>PICMA® multilayer stacks, ceramic encapsulation, extreme lifetime</td>
<td>to 4000 / 20</td>
<td>5, 9, 15, 30</td>
<td>-20 to 120</td>
<td>–</td>
<td>1-82</td>
<td></td>
</tr>
<tr>
<td>P-871</td>
<td>PICMA® multilayer bender actuators, co-fired ceramic encapsulation, low operating voltage, with position sensors</td>
<td>1 / 1</td>
<td>160 to 1600</td>
<td>±30 SGS</td>
<td>–</td>
<td>1-84</td>
<td></td>
</tr>
<tr>
<td>PL112–PL140</td>
<td>PICMA® multilayer bender actuators, co-fired ceramic encapsulation, low operating voltage, open-loop</td>
<td>1 / 1</td>
<td>500, 900, 2000</td>
<td>±30</td>
<td>–</td>
<td>1-94</td>
<td></td>
</tr>
<tr>
<td>P-876</td>
<td>DuraAct™ piezoelectric patch transducers: sensor, actuator &amp; electrical charge generation</td>
<td>to 775</td>
<td>–</td>
<td>var.</td>
<td>–</td>
<td>1-96</td>
<td></td>
</tr>
<tr>
<td>P-007–P-056</td>
<td>PICMA™ Stack piezo actuators, wide variety, high-force capacity.</td>
<td>to 80000 / 300</td>
<td>5 to 300</td>
<td>0 to 1000 Opt.</td>
<td>1-86, 1-88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-010–P-056.xxP</td>
<td>PICMA™ Thru ring actuators combine the advantages of piezo tubes with the high forces of stack actuators</td>
<td>to 60000 / 250</td>
<td>5 to 300</td>
<td>0 to 1000 Opt.</td>
<td>1-90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT120–PT140</td>
<td>PT-Tube piezo tube actuators, minimum tolerances</td>
<td>0,1 / 0,1</td>
<td>4, 6, 8</td>
<td>0 to 1000</td>
<td>–</td>
<td>1-100</td>
<td></td>
</tr>
<tr>
<td>P-111–P-151</td>
<td>PICMA™ Shear shear-effect actuator: Compact, X, XY, XYZ, e.g. for scanning-microscopy, optional clear aperture</td>
<td>10 to 300</td>
<td>1 to 10x10x10 ±250</td>
<td>–</td>
<td>1-98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Relative to products in this class

---

**Options and Accessories**

- Options and Accessories see p. 1-102 ff
- More Piezo Actuators and Piezo Motors: See p. 1-3 ff & 1-23 ff
- Please follow the mounting guidelines on p. 1-67
- Notes on Specifications see p. 1-106 ff
Piezoelectric transducers are solid-state ceramic actuators which convert electrical energy directly into linear motion (mechanical energy) with virtually unlimited resolution.

Advantages of PI Piezoelectric Actuators:
- Sub-Nanometer resolution
- Large force generation (up to 50,000 N and more)
- Microsecond-range response
- No backlash, stiction or friction
- Immune to magnetic fields
- Extremely low steady-state power consumption
- No wear and tear
- Vacuum and clean-room compatibility
- Operation at cryogenic temperatures possible
Piezoelectric Actuators and Components

Quality and Selection
PI offers a comprehensive assortment of high-resolution piezoelectric actuators and drives for industrial and scientific applications. In addition to the hundreds of models presented in this catalog, PI can also deliver custom designs. All manufacturing steps from the PZT powder to the finished product are controlled by PI. PI’s proprietary PICMA® technology with ceramic encapsulation stands for high reliability and longer lifetime. Closed-loop piezo actuators and the corresponding control electronics are offered for higher linearity.

High-Force Piezo Systems
The long-established and successful high-force / high-voltage piezo system product line has been improved and completely reworked. All high-voltage piezo actuators now make exclusive use of the modern PICA™ Power piezo ceramics. For high dynamics applications, the integrated preload and low electric power requirements of the packaged PICA™ Power actuators is a special advantage.

Piezo-Electric All-Rounder—
DuraAct™ Patch Transducers
The laminated patch transducers are suitable both for actuator and sensor tasks in various fields such as adaptronics. Even in high-dynamics applications, the rugged design ensures reliability, high resistance to damage and a lifetime well over 10^9 cycles.

- High-dynamics actuators
- Adaptive systems
- Vibration and noise cancellation
- Deformation control and stabilization
- Structural health monitoring
- Energy harvesting

Applied directly to a substrate, or used as part of the structure itself, DuraAct™ patch transducers can detect and produce vibrations or contour deformations at the source, inside the structure.
PI has 4 decades of experience with piezo ceramic actuators in motion control applications in industry and research. Currently PI employs more than 100 people fully dedicated to piezo ceramic research, development and production. Extensive know-how and the most modern equipment make for the unique flexibility and worldwide leadership in piezo matters. PI piezo actuators not only show an optimal combination of travel and stiffness, but are also designed for maximum lifetime under actual operating conditions in industrial environments.

Maximum lifetime means highest possible reliability. PI's award-winning, patented PICMA® actuators are based upon the newest technology which reduces the failure rate by a factor 10 compared to conventionally designed multilayer actuators.

Long Term Tests Prove DC Reliability
PI's monolithic ceramic-encapsulated design provides better humidity protection than conventional polymer-film insulation. Diffusion of water molecules into the insulation layer is greatly reduced by the use of co-fired, outer ceramic encapsulation (fig. 2). Humidity is the main influence on the long-term reliability in low-dynamics or quasi-static operation modes, where the piezo actuator is supplied with a DC voltage to maintain a position for a long time.

Comparative tests with both PICMA® and conventional multilayer piezo actuators have proven the positive effects of the ceramic encapsulation. While polymer-coated piezos typically only survive 30 days of continuous operation - PICMA® actuators are still working after more than 4 years!
Continuous Dynamic Operation

Here, the well-known lifetime-limiting factors of conventional designs are humidity, crack formation inside the ceramic leading to rising leakage currents and delamination of electrodes under extreme dynamic conditions.

PI reduces the cracking probability by a special patented design where segmented slots take care of excessive tensile stresses. Furthermore, the special electrode design ensures excellent, stable, electric contact even after billions of cycles.

PICMA® multilayer piezo actuators show no significant decrease in displacement even after many billions of cycles.

Long-Term Test under Cryogenic Conditions

To suit an application requiring 10 years minimum lifetime under cryogenic conditions, accelerated lifetime tests with PICMA® piezo actuators have been successfully performed. Inserted in a cryogenic bath of liquid nitrogen (75 K), the piezo is placed in a vacuum chamber (2 x 10⁻³ mbar) and subjected to dynamic operation at 90% of the maximum voltage range (>105 V) with an operating frequency up to 1000 Hz. After one month of continuous operation there were no degradations in piezo performance to be measured, neither mechanical concerning the displacement, nor electrical concerning electrical capacitance or resonant frequency. (Dr. Bosotti et al., University of Milano, Italy, 2005)

Large Operating Temperature Range, Optimum UHV Compatibility - Minimum Outgassing

Another advantage of fully ceramic-encapsulation PICMA® actuators is the extended operating temperature range, up to 150 °C, a huge improvement over the 80 °C limit common for other, polymer-insulated, monolithic actuators. The heat generation in dynamic operation is proportional to the operating frequency. Thus, a higher operating temperature allows for higher operating frequencies and duty cycles. Additionally, the lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (no outgassing / high bake-out temperatures, up to 150 °C).
Adherence to the following guidelines will help you obtain maximum performance and lifetime from your piezo actuators: Do not use metal tools for actuator handling. Do not scratch the coating on the side surfaces. The following precautions are recommended during handling of piezoelectric actuators:

I. Piezoelectric stack actuators without axial preload are sensitive to pulling forces. A preload of up to 50% of the blocking force is generally recommended.

II. Piezoelectric stack actuators may be stressed in the axial direction only. The applied force must be centered very well. Tilting and shearing forces, which can also be induced by parallelism errors of the endplates, have to be avoided because they will damage the actuator. This can be ensured by the use of ball tips, flexible tips, adequate guiding mechanisms etc. An exception to this requirement is made for the PICA™Shear actuators, because they operate in the shear direction.

III. Piezoelectric stack actuators can be mounted by gluing them between even metal or ceramic surfaces by a cold or hot curing epoxy, respectively. Ground surfaces are preferred. Please, do not exceed the specified working temperature range of the actuator during curing.

IV. The environment of all actuators should be as dry as possible. PICMA® actuators are guarded against humidity by their ceramic coating. Other actuators must be protected by other measures (hermetic sealing, dry air flow, etc).

V. It is important to short-circuit the piezoelectric stack actuators during any handling operation. Temperature changes and load changes will induce charges on the stack electrodes which might result in high electric fields if the leads are not shorted: Should the stack become charged, rapid discharging—especially without a preload—might damage the stack. Use a resistor for discharging.

VI. Prevent any contamination of the piezo ceramic surfaces with conductive or corrosive substances. Iso-propanol is recommended for cleaning. Avoid acetone and excessive ultrasonic cleaning at higher temperatures.
P-601 PiezoMove™ Z-Actuator

Flexure-Guided OEM Piezo Actuator with Long Stroke to 400 μm

- Flexure Guidance for Frictionless, Ultra-Straight Motion
- Travel Ranges to 400 μm
- Resolution to 0.2 nm
- High Dynamics and Stiffness
- Custom Designs with Longer Travel or Faster Response and Non-Magnetic Versions Feasible
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- Choice of Closed-Loop and Open-Loop Models
- Ideal OEM Actuator for Precision Motion Control in Optics, Medical, Biotech and Microfluidics Applications

The flexure-guided, lever-amplified PiezoMove™ P-601 actuators provide large vertical travel ranges up to 400 μm, fast response and high positioning accuracy in a very small package. With settling times of only a few milliseconds and a resolution in the sub-nanometer range they are well suited for both static and dynamic applications.

P-601 PiezoMove™ lever-amplified actuators cover the range between direct-driven preloaded piezo translators, such as the P-840 series (see p. 1-74) and single-axis nanopositioning stages, like the P-611 series (see p. 2-20). Compared to direct-driven piezo translators, lever-amplified actuators offer larger travel ranges and much higher lateral stiffness and guiding precision. Compared to single-axis nanopositioning stages, they offer significantly smaller sizes. PiezoMove™ lever-amplified actuators feature a resolution to 0.2 nm and a repeatability to 8 nm.

OEM Actuator with Integrated Guidance
With their highly precise, frictionless flexure guidance, a very high stiffness and excellent straightness of motion are achieved. Together with their small dimensions and the cost-effective design, the P-601 lever amplified actuators are especially suited for OEM applications. Versions with strain-gauge sensors (SGS) are equipped with a full bridge circuit that is insensitive to thermal drift. Versions without sensors are also available for open-loop applications such as in high-speed switches and pumps. In addition to the standard steel models, special invar and non-magnetic versions are available on request.

Ceramic Insulated Piezo Actuators Provide Long Lifetime
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Ordering Information

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-601.1S</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 μm, SGS-Sensor</td>
</tr>
<tr>
<td>P-601.3S</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 μm, SGS-Sensor</td>
</tr>
<tr>
<td>P-601.4S</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 μm, SGS-Sensor</td>
</tr>
<tr>
<td>P-601.1SL</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 μm, SGS-Sensor, LEMO Connector</td>
</tr>
<tr>
<td>P-601.3SL</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 μm, SGS-Sensor, LEMO Connector</td>
</tr>
<tr>
<td>P-601.4SL</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 μm, SGS-Sensor, LEMO Connector</td>
</tr>
<tr>
<td>P-601.10</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 μm, Open-Loop</td>
</tr>
<tr>
<td>P-601.30</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 μm, Open-Loop</td>
</tr>
<tr>
<td>P-601.40</td>
<td>PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 μm, Open-Loop</td>
</tr>
</tbody>
</table>

Application Example
- Nanopositioning
- Imaging
- High-speed switching
- Patch clamp
- Micro-dispensing
- Semiconductor testing
- Adaptronics / Automation
- Photonics / integrated optics
- Biotechnology
### Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-601.1S</th>
<th>P-601.3S</th>
<th>P-601.4S</th>
<th>P-601.x0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active axes</td>
<td>Z</td>
<td>Z</td>
<td>Z</td>
<td>Z</td>
</tr>
<tr>
<td><strong>Motion and positioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated sensor</td>
<td>SGS</td>
<td>SGS</td>
<td>SGS</td>
<td>–</td>
</tr>
<tr>
<td>Open-loop travel, -20 to +120 V</td>
<td>100</td>
<td>250</td>
<td>400</td>
<td>as P-601,xS μm min. (+20%/-0%)</td>
</tr>
<tr>
<td>Closed-loop travel</td>
<td>100</td>
<td>250</td>
<td>400</td>
<td>– μm calibrated</td>
</tr>
<tr>
<td>Open-loop resolution</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>as P-601,xS nm typ.</td>
</tr>
<tr>
<td>Closed-loop resolution</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>– nm typ.</td>
</tr>
<tr>
<td>Linearity, closed-loop</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
<td>– % typ.</td>
</tr>
<tr>
<td>Repeatability</td>
<td>8</td>
<td>10</td>
<td>30</td>
<td>– nm typ.</td>
</tr>
<tr>
<td>Runout θx, θy</td>
<td>20 / 10</td>
<td>20 / 10</td>
<td>20 / 10</td>
<td>as P-601,xS μrad typ.</td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stiffness in motion direction</td>
<td>0.8</td>
<td>0.38</td>
<td>0.28</td>
<td>as P-601,xS N/μm ±20%</td>
</tr>
<tr>
<td>Unloaded resonant frequency</td>
<td>750</td>
<td>440</td>
<td>350</td>
<td>as P-601,xS Hz ±20%</td>
</tr>
<tr>
<td>Resonant frequency @ 30 g</td>
<td>620</td>
<td>350</td>
<td>290</td>
<td>as P-601,xS Hz ±20%</td>
</tr>
<tr>
<td>Push/pull force capacity in motion direction</td>
<td>30/10</td>
<td>20/10</td>
<td>15/10</td>
<td>as P-601,xS N Max.</td>
</tr>
<tr>
<td>Lateral force</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>as P-601,xS N Max.</td>
</tr>
<tr>
<td><strong>Drive properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceramic type</td>
<td>PICMA® P-885</td>
<td>PICMA® P-885</td>
<td>PICMA® P-885</td>
<td>as P-601,xS</td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>1.5</td>
<td>3.1</td>
<td>4.6</td>
<td>as P-601,xS μF ±20%</td>
</tr>
<tr>
<td>Dynamic operating current coefficient</td>
<td>1.9</td>
<td>1.6</td>
<td>1.4</td>
<td>as P-601,xS μA/(Hz•μm) ±20%</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-20 to 80</td>
<td>-20 to 80</td>
<td>-20 to 80</td>
<td>-20 to 80 °C</td>
</tr>
<tr>
<td>Material</td>
<td>Stainless steel</td>
<td>Stainless steel</td>
<td>Stainless steel</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Mass without cables</td>
<td>0.05</td>
<td>0.08</td>
<td>0.11</td>
<td>as P-601,xS kg ±5%</td>
</tr>
<tr>
<td>Cable length</td>
<td>S-version: 0.3 SL-version: 1.5</td>
<td>S-version: 0.3 SL-version: 1.5</td>
<td>S-version: 0.3 SL-version: 1.5</td>
<td>0.3 m ±10 mm</td>
</tr>
</tbody>
</table>

**Recommended controller / amplifier:**
- E-610 controller / amplifier (p. 2-110), E-625 bench-top controller (p. 2-114)
P-810 · P-830 Piezo Actuators
For Light and Medium Loads

The P-810 and P-830 series translators are high-resolution linear actuators for static and dynamic applications. They provide sub-millisecond response and sub-nanometer resolution.

**Application Examples**
- Static and dynamic precision positioning
- Fiber positioning
- Laser tuning
- Patch-Clamp
- Nanotechnology

**Outstanding Lifetime Due to PICMA® Piezo Ceramics**
- Travel Range to 60 μm
- Pushing Forces to 1000 N
- Pulling Forces to 5 N
- Sub-Millisecond Response
- Sub-Nanometer Resolution

**Design**
These actuators consist of a highly reliable monolithic multilayer piezoceramic stack protected by a stainless steel case. PI offers a variety of pre-loaded translators for applications involving higher tensile loads (see the “Selection Guide” on p. 1-62).

**Ceramic Insulated Piezo Actuators Provide Long Lifetime**
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

**Mounting**
Attachment is realized via the ferromagnetic end surfaces, with epoxy or magnets. Read details in Mounting and Handling Guidelines (p. 1-67). For extensions, adapter cables and connectors, see “Accessories” (p. 1-104 ff).

**Piezo Drivers, Controllers & Amplifiers**
High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drivers / Servo Controllers” section (see p. 2-99 ff).
Technical Data and Product Order Numbers

<table>
<thead>
<tr>
<th>Order number</th>
<th>Travel range for 0 to 100 V [μm] ±20%</th>
<th>*Resolution [nm]</th>
<th>**Static large-signal stiffness [N/μm] ±20%</th>
<th>Push-/pull force capacity [N]</th>
<th>Electrical capacitance [μF] ±20%</th>
<th>Dynamic operating current coefficient [μA/(Hz·μm)]</th>
<th>Resonant frequency (unloaded) [kHz] ±20%</th>
<th>Mass [g] ±5%</th>
<th>Length L [mm] ±0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-810.10</td>
<td>15</td>
<td>0.15</td>
<td>14</td>
<td>50 / 1</td>
<td>0.3</td>
<td>3.0</td>
<td>22</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>P-810.20</td>
<td>30</td>
<td>0.3</td>
<td>7</td>
<td>50 / 1</td>
<td>0.7</td>
<td>3.0</td>
<td>15</td>
<td>6</td>
<td>38</td>
</tr>
<tr>
<td>P-810.30</td>
<td>45</td>
<td>0.45</td>
<td>4</td>
<td>50 / 1</td>
<td>1.0</td>
<td>3.0</td>
<td>12</td>
<td>8</td>
<td>56</td>
</tr>
<tr>
<td>P-830.10</td>
<td>15</td>
<td>0.15</td>
<td>57</td>
<td>1000 / 5</td>
<td>1.5</td>
<td>12.5</td>
<td>23</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>P-830.20</td>
<td>30</td>
<td>0.3</td>
<td>27</td>
<td>1000 / 5</td>
<td>3.0</td>
<td>12.5</td>
<td>14</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>P-830.30</td>
<td>45</td>
<td>0.45</td>
<td>19</td>
<td>1000 / 5</td>
<td>4.5</td>
<td>12.5</td>
<td>10</td>
<td>21</td>
<td>58</td>
</tr>
<tr>
<td>P-830.40</td>
<td>60</td>
<td>0.6</td>
<td>15</td>
<td>1000 / 5</td>
<td>6.0</td>
<td>12.5</td>
<td>8.5</td>
<td>27</td>
<td>76</td>
</tr>
</tbody>
</table>

*The resolution of piezo actuators is not limited by stiction or friction. Value given is noise equivalent motion with E-503 amplifier p. 2-144
**Dynamic small-signal stiffness is ~30% higher. Operating temperature range: -20 to 120°C. Case: non-magnetic steel; end pieces: stainless steel. Recommended preload for dynamic operation: 10–20 MPa.

Recommended amplifiers / controllers
One channel: E-831 amplifier (p. 2-164), E-610 amplifier / controller (p. 2-110)
Multi-channel: E-663 amplifier (p. 2-136)
The P-820 series piezo translators are high resolution linear actuators for static and dynamic applications. They provide sub-millisecond response and sub-nanometer resolution.

Design
These actuators consist of a friction-free, preloaded monolithic piezo ceramic stack integrated in a stainless steel housing.

Ceramic Insulated Piezo Actuators Provide Long Lifetime
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Mounting
Mounting is at the foot, with push/pull forces of less than 3 N, the actuator can be held by clamping the case. The optional ball tip (P-820.95) is intended to decouple torque and off-center forces from the piezo ceramic. The magnetic adapter P-176.30 is to be glued onto the top piece in order to provide magnetic coupling. Read details in Mounting and Handling Guidelines (p. 1-67).

Factory Installed Options
P-820.95 Ball Tip

Accessories
P-176 Magnetic Adapter (see p. 1-103) For extensions, adapter cables and connectors, see “Accessories” in the piezo electronics chapter (see p. 1-168 ff).

Piezo Drivers, Controllers & Amplifiers
High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drivers / Servo Controllers” (see p. 2-99 ff) section.

Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-820.10</th>
<th>P-820.20</th>
<th>P-820.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement at 0 to 100 V</td>
<td>15</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>*Resolution</td>
<td>0.15</td>
<td>0.3</td>
<td>0.45</td>
</tr>
<tr>
<td>**Static large-signal stiffness</td>
<td>13</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Push/pull force capacity</td>
<td>50 / 10</td>
<td>50 / 10</td>
<td>50 / 10</td>
</tr>
<tr>
<td>Max. torque limit (on tip)</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>0.3</td>
<td>0.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Dynamic operating current coefficient (DOCC)</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Unloaded resonant frequency fo</td>
<td>22</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
</tr>
<tr>
<td>Voltage connection</td>
<td>VL</td>
<td>VL</td>
<td>VL</td>
</tr>
<tr>
<td>Mass</td>
<td>8</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Material: case, end pieces</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
</tr>
<tr>
<td>Length L</td>
<td>26</td>
<td>44</td>
<td>62</td>
</tr>
</tbody>
</table>

*The resolution of piezo actuators is not limited by stiction or friction. Value given is noise equivalent motion with E-503 amplifier (p. 2-146)
**Dynamic small-signal stiffness is ~ 30% higher

Ordering Information
P-820.10 Preloaded Piezo Actuator, 15 μm Travel range
P-820.20 Preloaded Piezo Actuator, 30 μm Travel range
P-820.30 Preloaded Piezo Actuator, 45 μm Travel range

Application Examples
- Static and dynamic precision positioning
- Fiber positioning
- Laser tuning
- Nanotechnology

For Light and Medium Loads

P-820 dimensions in mm. Length L: see table

---

© Physik Instrumente (PI) GmbH & Co. KG 2008. Subject to change without notice. All data are superseded by any new release.
P-855 Miniature Piezo Actuator
Micrometer-Mountable Open-Loop Piezo Translator

Ordering Information

| P-855.20 | Piezo Actuator for Micrometer Drive |

P-855 piezo translators are high-resolution linear actuators specially designed for integration in micrometer tips. They fit the M-227 DC-Mike motorized actuators (see p. 1-42), the M-168 Stepper Mike (see p. 1-55) motorized actuators and the M-631 to M-633 manual micrometers (see p. 1-56).

The piezo translators consist of a monolithic PICMA® piezo ceramic integrated in a stainless steel housing.

P-855 actuators provide sub-millisecond response and sub-nanometer resolution.

Superior Lifetime with Ceramic-Encapsulated Piezos

Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only ceramic-encapsulated PZT actuators on the market, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Accessories

Extension cables, adapters & connectors: see in “Accessories” in the “Piezo Drivers / Servo Controllers” (see p. 2-168 ff) section.

Notes

See the “Piezo Drivers / Servo Controllers” (see p. 2-99 ff) section for our comprehensive line of low-noise modular and OEM control electronics for computer and manual control.

Read details in Mounting and Handling Guidelines (p. 1-67).

Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-855.20</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-loop travel @ -20 to 120 V</td>
<td>20 μm</td>
<td>±20 %</td>
</tr>
<tr>
<td>*Open-loop resolution</td>
<td>0.2 nm</td>
<td></td>
</tr>
<tr>
<td>**Static large-signal stiffness</td>
<td>48 N/μm</td>
<td>±20 %</td>
</tr>
<tr>
<td>Push / pull force capacity</td>
<td>100 / 5 N</td>
<td></td>
</tr>
<tr>
<td>Operating voltage range</td>
<td>-20 to 120 V</td>
<td></td>
</tr>
<tr>
<td>Piezo ceramic type</td>
<td>PICMA®</td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>1.5 μF</td>
<td>±20 %</td>
</tr>
<tr>
<td>Dynamic operating current coefficient (DOCC)</td>
<td>12.5 μA/(Hz•μm)</td>
<td></td>
</tr>
<tr>
<td>Unloaded resonant frequency</td>
<td>18 kHz</td>
<td>±20 %</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-40 bis +80 °C</td>
<td></td>
</tr>
<tr>
<td>Voltage connection</td>
<td>VL</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>28 g</td>
<td>±5 %</td>
</tr>
<tr>
<td>Recommended amplifier</td>
<td>E-610 (p. 2-110) E-500 System (p. 2-142)</td>
<td></td>
</tr>
</tbody>
</table>

*Resolution of piezo actuators is not limited by friction or sticktion.
**Dynamic small-signal stiffness -50 % higher

Application Examples

- Laser tuning
- Static and dynamic positioning of small parts
- Fiber positioning

P-855 dimensions in mm, cable length 1 m

© Physik Instrumente (PI) GmbH & Co. KG 2008. Subject to change without notice. All data are superseded by any new release.

The newest release for data sheets is available for download at www.pi.ws. Cat120E Inspirations2009 08/10.18
The P-840 and P-841 series translators are high-resolution linear actuators for static and dynamic applications. They provide sub-millisecond response and sub-nanometer resolution.

Design
These translators are equipped with highly reliable multilayer piezo ceramic stacks protected by a non-magnetic stainless steel case with internal spring preload. The preload makes them ideal for dynamic applications and for tensile loads as well.

Ceramic Insulated Piezo Actuators Provide Long Lifetime
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Outstanding Lifetime Due to PICMA® Piezo Ceramic Stacks
Travel Range to 90 μm
Compact Case
Pushing Forces to 1000 N
Pulling Forces to 50 N
Sub-Millisecond Response
Sub-Nanometer Resolution
Option: Ball Tip, Vacuum Version

Optimum UHV Compatibility - Minimum Outgassing
The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (no outgassing / high bakeout temperatures, up to 150 °C).

Mounting
Mounting is at the foot, with push/pull forces of less than 5 N, the actuator can be held by clamping the case. The optional ball tip (P-840.95) is intended to decouple torque and off-center forces from the piezo ceramic. The magnetic adapter P-176.20 is to be glued onto the top piece in order to provide magnetic coupling.

Read details in Mounting and Handling Guidelines (p. 1-67).

High Accuracy in Closed-Loop Operation
The standard model P-840 is designed for open-loop positioning. Version P-841 with integrated high-resolution strain gauge position sensors provides high precision for closed-loop operation (further details see p. 2-199).

Piezo Drivers, Controllers & Amplifiers
High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the "Piezo Drivers / Servo Controllers" (see p. 2-99) section.

Application Examples
Static and dynamic Precision positioning
Disc-drive-testing
Adaptronics
Smart structures
Active vibration control
Switches
Laser tuning
Patch-Clamp
Nanotechnology

Ordering Information
P-840.10
Preloaded Piezo Actuator, 15 μm Travel range
P-840.20
Preloaded Piezo Actuator, 30 μm Travel range
P-840.30
Preloaded Piezo Actuator, 45 μm Travel range
P-840.40
Preloaded Piezo Actuator, 60 μm Travel range
P-840.60
Preloaded Piezo Actuator, 90 μm Travel range
P-841.10
Preloaded Piezo Actuator with SGS-Sensor, 15 μm Travel range
P-841.20
Preloaded Piezo Actuator with SGS-Sensor, 30 μm Travel range
P-841.30
Preloaded Piezo Actuator with SGS-Sensor, 45 μm Travel range
P-841.40
Preloaded Piezo Actuator with SGS-Sensor, 60 μm Travel range
P-841.60
Preloaded Piezo Actuator with SGS-Sensor, 90 μm Travel range
## Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-841.10</th>
<th>P-840.10</th>
<th>P-841.20</th>
<th>P-840.20</th>
<th>P-841.30</th>
<th>P-840.30</th>
<th>P-841.40</th>
<th>P-840.40</th>
<th>P-841.60</th>
<th>P-840.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-loop travel @ 0 to 100 V</td>
<td>15</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>90</td>
<td>15</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Closed-loop / open-loop resolution**</td>
<td>0.3 / 0.15</td>
<td>0.6 / 0.3</td>
<td>0.9 / 0.45</td>
<td>1.2 / 0.6</td>
<td>1.8 / 0.9</td>
<td>nm</td>
<td>nm</td>
<td>nm</td>
<td>nm</td>
<td>nm</td>
</tr>
<tr>
<td>Static large-signal stiffness***</td>
<td>57</td>
<td>27</td>
<td>19</td>
<td>15</td>
<td>10</td>
<td>57</td>
<td>27</td>
<td>19</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Pushing forces to 1000 N</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Pulling forces to 50 N</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Max. torque limit (on tip)</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>1.5</td>
<td>3.0</td>
<td>4.5</td>
<td>6.0</td>
<td>9.0</td>
<td>1.5</td>
<td>3.0</td>
<td>4.5</td>
<td>6.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Dynamic operating current coefficient (DOCC)</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Unloaded resonant frequency fo</td>
<td>18</td>
<td>14</td>
<td>10</td>
<td>8.5</td>
<td>6</td>
<td>18</td>
<td>14</td>
<td>10</td>
<td>8.5</td>
<td>6</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
<td>-20 to +80</td>
</tr>
<tr>
<td>Voltage connection</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
</tr>
<tr>
<td>Sensor connection</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
<td>LEMO</td>
</tr>
<tr>
<td>Mass without cables</td>
<td>20</td>
<td>28</td>
<td>46</td>
<td>54</td>
<td>62</td>
<td>20</td>
<td>28</td>
<td>46</td>
<td>54</td>
<td>62</td>
</tr>
<tr>
<td>Material: case, end pieces</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
<td>N-S</td>
</tr>
<tr>
<td>Length L</td>
<td>32</td>
<td>50</td>
<td>68</td>
<td>86</td>
<td>122</td>
<td>mm ±0.3</td>
<td>mm ±0.3</td>
<td>mm ±0.3</td>
<td>mm ±0.3</td>
<td>mm ±0.3</td>
</tr>
</tbody>
</table>

*Closed-loop models can attain linearity up to 0.15% and are shipped with performance reports.

**Resolution of piezo actuators is not limited by stiction or friction. Value given is noise equivalent motion with E-503 amplifier. (p. 2-146)

***Dynamic small-signal stiffness is – 30% higher.

Recommended amplifiers / controllers

Single-channel: E-610 servo-controller / amplifier (p. 2-110), E-625 servo-controller, bench-top (p. 2-114), E-621 controller module (p. 2-160)

Single channel: modular piezo controller system E-500 (p. 2-142) with amplifier module E-505 (high-power) (p. 2-147) and E-509 controller (p. 2-152) (optional)

Multi-channel: modular piezo controller system E-500 (p. 2-142) with amplifier module E-503 (three channels) (p. 2-146) or E-505 (1 per axis, high-power) (p. 2-147) and E-509 controller (p. 2-152) (optional)
P-842 – P-845 Preloaded Piezo Actuators

For High Loads and Force Generation, Optional with Integrated Position Sensors

The P-842 / P-843 and P-844 / P-845 series piezo translators are high-resolution linear actuators for static and dynamic applications. They provide sub-millisecond response and sub-nanometer resolution.

Design

These translators are equipped with PICMA® multilayer piezo ceramic stacks protected by a non-magnetic stainless steel case with internal spring preload. The preload makes them ideal for dynamic applications (such as precision machining, active damping etc.) and for tensile loads as well.

High Accuracy in Closed-Loop Operation

P-842 and P-844 are designed for open-loop positioning or use with external feedback. Versions P-843 and P-845 are equipped with integrated high-resolution SGS-position sensors for high precision in closed-loop operation (for further notes see the nanopositioning tutorial, see p. 2-199).

Ceramic Insulated Piezo Actuators Provide Long Lifetime

Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on

---

**Application Examples**

- Static and dynamic precision positioning
- Disc-drive-testing
- Optics
- Metrology / interferometry
- Smart structures / adaptionics
- Precision mechanics / machining
- Active vibration control
- Switches
- Laser tuning

---

### Technical Data and Product Order Numbers

<table>
<thead>
<tr>
<th>Model</th>
<th>Open-loop travel for 0 to 100 V [μm]</th>
<th>Closed-loop travel [μm]**</th>
<th>Integrated feedback sensor**</th>
<th>Closed-loop / Open-loop resolution [mm]**</th>
<th>Static large-signal stiffness [N/μm] ±20 %</th>
<th>Push/pull force capacity [N]</th>
<th>Electrical capacitance [μF] ±20 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-842.10</td>
<td>15</td>
<td>–</td>
<td>–</td>
<td>- / 0.15</td>
<td>57</td>
<td>800 / 300</td>
<td>1.5</td>
</tr>
<tr>
<td>P-842.20</td>
<td>30</td>
<td>–</td>
<td>–</td>
<td>- / 0.3</td>
<td>27</td>
<td>800 / 300</td>
<td>3.0</td>
</tr>
<tr>
<td>P-842.30</td>
<td>45</td>
<td>–</td>
<td>–</td>
<td>- / 0.45</td>
<td>19</td>
<td>800 / 300</td>
<td>4.5</td>
</tr>
<tr>
<td>P-842.40</td>
<td>60</td>
<td>–</td>
<td>–</td>
<td>- / 0.6</td>
<td>15</td>
<td>800 / 300</td>
<td>6.0</td>
</tr>
<tr>
<td>P-842.60</td>
<td>90</td>
<td>–</td>
<td>–</td>
<td>- / 0.9</td>
<td>10</td>
<td>800 / 300</td>
<td>9.0</td>
</tr>
<tr>
<td>P-843.10</td>
<td>15</td>
<td>15</td>
<td>SGS</td>
<td>0.3 / 0.15</td>
<td>57</td>
<td>800 / 300</td>
<td>1.5</td>
</tr>
<tr>
<td>P-843.20</td>
<td>30</td>
<td>30</td>
<td>SGS</td>
<td>0.6 / 0.3</td>
<td>27</td>
<td>800 / 300</td>
<td>3.0</td>
</tr>
<tr>
<td>P-843.30</td>
<td>45</td>
<td>45</td>
<td>SGS</td>
<td>0.9 / 0.45</td>
<td>19</td>
<td>800 / 300</td>
<td>4.5</td>
</tr>
<tr>
<td>P-843.40</td>
<td>60</td>
<td>60</td>
<td>SGS</td>
<td>1.2 / 0.6</td>
<td>15</td>
<td>800 / 300</td>
<td>6.0</td>
</tr>
<tr>
<td>P-843.60</td>
<td>90</td>
<td>90</td>
<td>SGS</td>
<td>1.8 / 0.9</td>
<td>10</td>
<td>800 / 300</td>
<td>9.0</td>
</tr>
<tr>
<td>P-844.10</td>
<td>15</td>
<td>–</td>
<td>–</td>
<td>- / 0.15</td>
<td>225</td>
<td>3000 / 700</td>
<td>6.0</td>
</tr>
<tr>
<td>P-844.20</td>
<td>30</td>
<td>–</td>
<td>–</td>
<td>- / 0.3</td>
<td>107</td>
<td>3000 / 700</td>
<td>12.0</td>
</tr>
<tr>
<td>P-844.30</td>
<td>45</td>
<td>–</td>
<td>–</td>
<td>- / 0.45</td>
<td>75</td>
<td>3000 / 700</td>
<td>18.0</td>
</tr>
<tr>
<td>P-844.40</td>
<td>60</td>
<td>–</td>
<td>–</td>
<td>- / 0.6</td>
<td>57</td>
<td>3000 / 700</td>
<td>24.0</td>
</tr>
<tr>
<td>P-844.60</td>
<td>90</td>
<td>–</td>
<td>–</td>
<td>- / 0.9</td>
<td>38</td>
<td>3000 / 700</td>
<td>36.0</td>
</tr>
<tr>
<td>P-845.10</td>
<td>15</td>
<td>15</td>
<td>SGS</td>
<td>0.3 / 0.15</td>
<td>225</td>
<td>3000 / 700</td>
<td>6.0</td>
</tr>
<tr>
<td>P-845.20</td>
<td>30</td>
<td>30</td>
<td>SGS</td>
<td>0.6 / 0.3</td>
<td>107</td>
<td>3000 / 700</td>
<td>12.0</td>
</tr>
<tr>
<td>P-845.30</td>
<td>45</td>
<td>45</td>
<td>SGS</td>
<td>0.9 / 0.45</td>
<td>75</td>
<td>3000 / 700</td>
<td>18.0</td>
</tr>
<tr>
<td>P-845.40</td>
<td>60</td>
<td>60</td>
<td>SGS</td>
<td>1.2 / 0.6</td>
<td>57</td>
<td>3000 / 700</td>
<td>24.0</td>
</tr>
<tr>
<td>P-845.60</td>
<td>90</td>
<td>90</td>
<td>SGS</td>
<td>1.8 / 0.9</td>
<td>38</td>
<td>3000 / 700</td>
<td>36.0</td>
</tr>
</tbody>
</table>
the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Optimum UHV Compatibility - Minimum Outgassing

The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (no outgassing / high bakeout temperatures, up to 150 °C).

Mounting

Mounting is at the foot, with push/pull forces of less than 100 N, the actuator can be held by clamping the case. The flexible tips P-176.50 / P-176.60 can be applied for protection of the ceramics from shearing forces (see p. 1-103 ff) Read details in Mounting and Handling Guidelines (p. 1-67).

Options

P-703.20
High vacuum options (see p. 1-102 ff)

Accessories

P-176.50
Flexible tip for P-842 / P-843 (see p. 1-103 ff)

P-176.60
Flexible tip for P-844 / P-845 (see p. 1-103 ff)

For extensions, adapter cables and connectors, see “Accessories” in the Piezo Actuators & Components section (p. 1-104 ff).

Piezo Drives, Controllers & Amplifiers

High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drives / Servo Controllers” section.

<table>
<thead>
<tr>
<th>Dynamic operating current coefficient [μA / (Hz · μm)]</th>
<th>Resonant frequency (unloaded) [kHz] ±20 %</th>
<th>Mass without cable [g] ±5 %</th>
<th>Length L [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5</td>
<td>18</td>
<td>31</td>
<td>37</td>
</tr>
<tr>
<td>12.5</td>
<td>14</td>
<td>42</td>
<td>55</td>
</tr>
<tr>
<td>12.5</td>
<td>10</td>
<td>53</td>
<td>73</td>
</tr>
<tr>
<td>12.5</td>
<td>8.5</td>
<td>64</td>
<td>91</td>
</tr>
<tr>
<td>12.5</td>
<td>6</td>
<td>86</td>
<td>127</td>
</tr>
<tr>
<td>12.5</td>
<td>18</td>
<td>31</td>
<td>37</td>
</tr>
<tr>
<td>12.5</td>
<td>14</td>
<td>42</td>
<td>55</td>
</tr>
<tr>
<td>12.5</td>
<td>10</td>
<td>53</td>
<td>73</td>
</tr>
<tr>
<td>12.5</td>
<td>8.5</td>
<td>64</td>
<td>91</td>
</tr>
<tr>
<td>12.5</td>
<td>6</td>
<td>86</td>
<td>127</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
<td>84</td>
<td>47</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td>108</td>
<td>65</td>
</tr>
<tr>
<td>50</td>
<td>9</td>
<td>132</td>
<td>83</td>
</tr>
<tr>
<td>500</td>
<td>7.5</td>
<td>156</td>
<td>0101</td>
</tr>
<tr>
<td>50</td>
<td>5.5</td>
<td>204</td>
<td>137</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
<td>84</td>
<td>47</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td>108</td>
<td>65</td>
</tr>
<tr>
<td>50</td>
<td>9</td>
<td>132</td>
<td>83</td>
</tr>
<tr>
<td>50</td>
<td>7.5</td>
<td>156</td>
<td>101</td>
</tr>
<tr>
<td>50</td>
<td>5.5</td>
<td>204</td>
<td>137</td>
</tr>
</tbody>
</table>

Voltage connection:
LEMO FFA.00.250 coaxial cable, RG 178, PTFE.

Sensor connector: LEMO FFA.0S.304 connector; 1 m coaxial cable with PUR-insulation.

Temperature range: -40 to 80 °C; Case / end pieces: non-magnetic steel.

*Closed-loop models can attain linearity up to 0.15 % and are shipped with performance reports.

**Resolution of piezo actuators is not limited by stiction or friction. Noise equivalent motion with E-503 amplifier (see p. 2-146).

***Dynamic small-signal stiffness is ~ 30 % higher. Recommended amplifiers / controllers
Single-channel: E-610 servo-controller / amplifier (p. 2-110), E-625 servo-controller, bench-top (p. 2-114), E-621 controller module (p. 2-160)
Single channel: modular piezo controller system E-500 (p. 2-142) with amplifier module E-505 (high-power) (p. 2-147) and E-509 controller (p. 2-152) (optional)
Multi-channel: modular piezo controller system E-500 (p. 2-142) with amplifier module E-503 (three channels) (p. 2-146) or E-505 (1 per axis, high-power, see p. 2-147) and E-509 controller (p. 2-152) (optional)

Moving the NanoWorld \_ www.pi.ws
The P-212 and P-216 series are high-resolution linear piezo actuators (translators) for static and dynamic applications. They provide sub-millisecond response and sub-nanometer resolution.

These actuators have the friction-free, preloaded PICA™ Power actuators inside. The preload makes them ideal for dynamic applications like precision machining or active damping.

### High Displacement with Ultra-High Reliability

PICA™ Power actuators are optimized for high-temperature working conditions and high-duty-cycle dynamic applications.

All PICA™ piezo ceramics are specifically designed for high-duty-cycle applications. With PI’s extensive applications knowledge, gained over several decades, performance does not come at the price of reliability. All materials used are specifically matched for robustness and lifetime. Endurance tests on PICA™ actuators prove consistent performance, even after billions (1,000,000,000) of cycles.

### Application Examples

- Optics
- Metrology / interferometry
- Adaptronics
- Precision engineering / micromechanics
- Adaptive mechanics
- Active vibration damping
- Switches
- Laser tuning
- Force generation / materials testing
- Nanotechnology

### Mechanical Mounting

Mounting is at the foot, with push/pull forces of less than 5 N, the actuator can be held by clamping the case. The optional ball tip is intended to decouple torque and off-center forces from the translator. Read details in Mounting and Handling Guidelines (p. 1-67).

### High Flexibility with PI Amplifiers, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators from low-power drivers to the high-performance amplifier / controller E-481.

For closed-loop operation PI offers a wide variety of analog and digital controllers. The E-500 modular system can be easily upgraded from an amplifier to a servo controller, including different interface / display modules.

High-resolution amplifiers and servo-control electronics, both digital and analog, see selection guide in the “Piezo Drivers / Servo Controllers” section (see p. 2-97 ff).
Technical Data

<table>
<thead>
<tr>
<th>P-212.10</th>
<th>P-212.20</th>
<th>P-212.40</th>
<th>P-212.80</th>
<th>P-216.10</th>
<th>P-216.20</th>
<th>P-216.40</th>
<th>P-216.80</th>
<th>P-216.90</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</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>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>V</td>
<td>±20%</td>
</tr>
<tr>
<td><strong>Motion and positioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed-loop travel*</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>180</td>
<td>μm</td>
</tr>
<tr>
<td>Closed-loop resolution**/***</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>2.4</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>2.4</td>
<td>3.6</td>
<td>nm</td>
</tr>
<tr>
<td>Open-open resolution**</td>
<td>0.15</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>0.15</td>
<td>0.3</td>
<td>0.6</td>
<td>1.2</td>
<td>1.8</td>
<td>nm</td>
</tr>
<tr>
<td>Linearity*</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>%</td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static large-signal stiffness***</td>
<td>90</td>
<td>60</td>
<td>34</td>
<td>18</td>
<td>210</td>
<td>140</td>
<td>80</td>
<td>50</td>
<td>32</td>
<td>N/μm</td>
</tr>
<tr>
<td>Unloaded resonant frequency</td>
<td>17</td>
<td>12</td>
<td>7</td>
<td>4.5</td>
<td>17</td>
<td>12</td>
<td>7</td>
<td>4.5</td>
<td>3</td>
<td>kHz</td>
</tr>
<tr>
<td>Shear force limit</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>60</td>
<td>36</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>N</td>
</tr>
<tr>
<td>Torque limit (on tip)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Nm</td>
</tr>
<tr>
<td><strong>Drive properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>47</td>
<td>90</td>
<td>180</td>
<td>370</td>
<td>130</td>
<td>250</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>nF</td>
</tr>
<tr>
<td>Dynamic operating current coefficient</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>μA/(Hz·μm)</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass (with cable)</td>
<td>110</td>
<td>120</td>
<td>150</td>
<td>210</td>
<td>170</td>
<td>200</td>
<td>250</td>
<td>370</td>
<td>480</td>
<td>g</td>
</tr>
</tbody>
</table>

* Requires SGS sensor. SGS versions are shipped with performance reports
** Measured with an Interferometer. The resolution of piezo actuators is not limited by stiction or friction
*** Dynamic small-signal stiffness is ~50% higher
Piezo ceramic type: PICA™ Power
Operating temperature range: -40 to +80 °C
Recommended controller/driver see p. 2-100 ff
For maximum lifetime, voltages in excess of 750 V should be applied only for short durations
See Notes (Technical Data) for further information (p. 1-106 ff)
P-225, P-235 PICA™ Power Piezo Stack Actuators

Preloaded High-Load Piezo Actuators (HVPZT) w/ Sensor Option

P-225 and P-235 are preloaded, high-load piezo actuators (translators) for static and dynamic applications. They provide sub-millisecond re-sponse and sub-nanometer resolution.

These ultra-high-force linear actuators consist of PICA™ Power piezoelectric ceramic-stacks encapsulated in a stainless steel case with stainless steel end pieces and a friction-less internal spring preload. The high load capacity and preload makes them ideal for machining applications and active vibration cancellation.

**Extremely High Stiffness**
**Pushing Forces to 30,000 N**
**Pulling Forces to 3500 N**
**Travel Ranges to 180 μm**
**Options: Versions for Vacuum, High- and Low-Temperatures and with Water-Resistant Case**

High-load piezo actuators P-235.1S, .4S and .9S, P-225.8S and .1S (from left) with CD for size comparison

---

**Application Examples**
- Precision engineering / micromechanics
- Adaptive mechanics
- Active vibration damping
- Adaptronics
- Static and dynamic precision positioning
- Force generation / materials testing

---

**High Displacement with Ultra-High Reliability**

PICA™ Power actuators are optimized for high-temperature working conditions and high-duty-cycle dynamic applications.

All PICA™ piezo ceramics are specifically designed for high-dutycycle applications. With PI’s extensive applications knowledge, gained over several decades, performance does not come at the price of reliability. All materials used are specifically matched for robustness and lifetime. Endurance tests on PICA™ actuators prove consistent performance, even after billions (1,000,000,000) of cycles.

**Open- and Closed-Loop Models for Optimum Dynamics and Linearity**

The standard models are ideal for open loop positioning applications. In this mode the actuator displacement is roughly proportional to the applied voltage.

Open-loop operation is ideal for applications where the fastest response and the highest bandwidth are essential. Here, commanding and reading the target position in absolute values is either not important or carried out by an external feedback loop.

**For highest positioning accuracy and repeatability, select the factory installed closed-loop option with integrated ultra-high-resolution strain gauge position sensors and operate with PI servo-control electronics.**

For more information, read the tutorial "Piezoelectrics in Positioning" (see p. 2-169 ff).

**High Flexibility with PI Amplifiers, Drivers & Controllers**

PI offers a wide range of control electronics for piezo actuators from economical, low-power piezo drivers to the E-481 high-performance amplifier / controller providing 2000 W of dynamic power.

For closed-loop operation a wide variety of analog and digital controllers is available. The E-500 modular system can be easily upgraded from an amplifier to a servo controller, including different interface / display modules.

Read details in Mounting and Handling Guidelines (p. 1-67).

High-resolution amplifiers and servo-control electronics, both digital and analog, see selection guide in the “Piezo Drivers / Servo Controllers” section (see p. 2-99 ff).
### Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-225.10</th>
<th>P-225.20</th>
<th>P-225.40</th>
<th>P-225.80</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>Operating voltage</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>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>0 to 1000</td>
<td>V</td>
<td>±20 %</td>
</tr>
<tr>
<td>Motion and positioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed-loop travel*</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>15</td>
<td>30</td>
<td>60</td>
<td>120</td>
<td>180</td>
<td>μm</td>
<td>±20 %</td>
</tr>
<tr>
<td>Closed-loop resolution**</td>
<td>0,3</td>
<td>0,6</td>
<td>1,2</td>
<td>2,4</td>
<td>0,3</td>
<td>0,6</td>
<td>1,2</td>
<td>2,4</td>
<td>3,6</td>
<td>nm typ.</td>
<td>±20 %</td>
</tr>
<tr>
<td>Open-loop resolution**</td>
<td>0,15</td>
<td>0,3</td>
<td>0,6</td>
<td>1,2</td>
<td>0,15</td>
<td>0,3</td>
<td>0,6</td>
<td>1,2</td>
<td>1,8</td>
<td>nm typ.</td>
<td>±20 %</td>
</tr>
<tr>
<td>Linearity**</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>0,2</td>
<td>% typ.</td>
<td>±20 %</td>
</tr>
<tr>
<td>Mechanical properies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static large-signal stiffness***</td>
<td>480</td>
<td>330</td>
<td>200</td>
<td>110</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>Unloaded resonant frequency</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>3,9</td>
<td>2,8</td>
<td>kHz</td>
<td>±20 %</td>
</tr>
<tr>
<td>Shear force limit</td>
<td>255</td>
<td>152</td>
<td>84</td>
<td>73</td>
<td>707</td>
<td>420</td>
<td>232</td>
<td>147</td>
<td>147</td>
<td>N</td>
<td>±20 %</td>
</tr>
<tr>
<td>Torque limit (on tip)</td>
<td>1,5</td>
<td>1,5</td>
<td>1,5</td>
<td>1,5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Nm</td>
<td>±20 %</td>
</tr>
<tr>
<td>Drive properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El. capacitance</td>
<td>320</td>
<td>630</td>
<td>1300</td>
<td>2600</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>Dynamic operating current coefficient</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>μA/(Hz • μm)</td>
<td>±20 %</td>
</tr>
</tbody>
</table>

---

*Requires SGS sensor. SGS versions are shipped with performance reports
**Measured with an interferometer. The resolution of piezo actuators is not limited by stiction or friction
***Dynamic small-signal stiffness is ~50 % higher
Piezo ceramic type: PICATM Power
Operating temperature range: -40 to +80 °C
For maximum lifetime, voltages in excess of 750 V should be applied only for short durations
See Notes (Technical Data) for further information (see p. 1-106 ff)
PICMA® piezo actuators are characterized by their high performance and reliability, even in extremely harsh environments. They are superior to conventional multilayer actuators in industrial applications and high-endurance situations, where they show substantially longer lifetimes both in static and dynamic operation.

### Application Examples

- Precision mechanics / -machining
- High-speed switching
- Active and adaptive Optics
- Active vibration damping
- Pneumatic & hydraulic valves
- Metrology / Interferometry
- Life science, Biotechnology
- Nanotechnology

### Optimum UHV Compatibility - Minimum Outgassing

The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (high bakeout temperatures, up to 150 °C).

### Increased Lifetime Through Humidity Resistance

The monolithic ceramic-encapsulated design provides better humidity protection than polymer-film insulation. Diffusion of water molecules into the insulation layer is greatly reduced by the use of cofired, outer ceramic encapsulation. Due to their high resonant frequency the actuators are suitable for highly dynamic applications with small loads; depending on the load an external preload for dynamic applications is recommended. The high Curie temperature of 320 °C gives PICMA® actuators a usable temperature range extending up to 150 °C, far beyond 80 °C as is common for conventional multilayer actuators. With conventional multilayer actuators, heat generation - which is proportional to operating frequency - either limits the operating frequency or duty cycle in dynamic operation, or makes ungainly cooling provisions necessary. At the low end, operation down to a few Kelvin is possible (with reduction in performance specifications).

### Ideal for Closed-Loop Operation

The ceramic surface of the actuators is extremely well suited for use with resistive or optical fiber strain gauge sensors. Such sensors can be easily applied to the actuator surface and exhibit significantly higher stability and linearity than with conventional polymer-insulated actuators.

### Ceramic-Insulated High-Power Actuators

PICMA® piezo actuators are available with cross-sections of 2 x 3, 3 x 3, 5 x 5, 7 x 7 and 10 x 10 mm² and feature:

- Superior Lifetime Even Under Extreme Conditions
- Very Large Operating Temperature Range
- High Humidity Resistance
- Excellent Temperature Stability
- High Stiffness
- Peak Current up to 20 A
- UHV Compatible to 10⁻⁶ hPa
- Sub-Millisecond Response / Sub-Nanometer Resolution
- Ideal for Dynamic Operation

PICMA® (PI Ceramic Monolithic Multilayer Actuator) piezo stack actuators are characterized by their high performance and reliability, even in extremely harsh environments. They are superior to conventional multilayer actuators in industrial applications and high-endurance situations, where they show substantially longer lifetimes both in static and dynamic operation.

### New Production Process, Optimized Piezo Ceramics

PICMA® piezo actuators are made from a ceramic material in which the piezoceramic properties such as stiffness, capacitance, displacement, temperature stability and lifetime are optimally combined. Thus the actuators accomplish sub-nanometer resolution in positioning and sub-millisecond response!

---

The newest release for data sheets is available for download at www.pi.ws. Cat120E Inspirations2009 08/10.18.
PICMA® piezo actuators (bottom curve) compared with conventional multilayer actuators with polymer insulation (top curve). PICMA® actuators are not affected by the high-humidity test conditions. Conventional piezo actuators exhibit increased leakage current after only a few hours. Leakage current is an indicator quality and expected lifetime.

Test conditions: U = 100 VDC, T = 25 °C, Relative Humidity = 70%

<table>
<thead>
<tr>
<th>Order number*</th>
<th>Dimensions A x B x L [mm]</th>
<th>Nominal displacement [μm @ 100 V]</th>
<th>Max. displacement [μm @ 120 V]</th>
<th>Blocking force [N @ 120 V]</th>
<th>Stiffness [N/μm]</th>
<th>Electrical capacitance [μF] ±20 %</th>
<th>Resonant frequency [kHz] ±20 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-882.10</td>
<td>2 x 3 x 9</td>
<td>6.5 ±20%</td>
<td>8 ±20%</td>
<td>190</td>
<td>24</td>
<td>0.15</td>
<td>135</td>
</tr>
<tr>
<td>P-882.30</td>
<td>2 x 3 x 13.5</td>
<td>11 ±20%</td>
<td>13 ±20%</td>
<td>210</td>
<td>16</td>
<td>0.22</td>
<td>90</td>
</tr>
<tr>
<td>P-882.50</td>
<td>2 x 3 x 18</td>
<td>15 ±10%</td>
<td>18 ±10%</td>
<td>210</td>
<td>12</td>
<td>0.31</td>
<td>70</td>
</tr>
<tr>
<td>P-883.10</td>
<td>3 x 3 x 9</td>
<td>6.5 ±20%</td>
<td>8 ±20%</td>
<td>290</td>
<td>36</td>
<td>0.21</td>
<td>135</td>
</tr>
<tr>
<td>P-883.30</td>
<td>3 x 3 x 13.5</td>
<td>11 ±20%</td>
<td>13 ±20%</td>
<td>310</td>
<td>24</td>
<td>0.35</td>
<td>90</td>
</tr>
<tr>
<td>P-883.50</td>
<td>3 x 3 x 18</td>
<td>15 ±10%</td>
<td>18 ±10%</td>
<td>310</td>
<td>18</td>
<td>0.48</td>
<td>70</td>
</tr>
<tr>
<td>P-885.10</td>
<td>5 x 5 x 9</td>
<td>6.5 ±20%</td>
<td>8 ±20%</td>
<td>800</td>
<td>100</td>
<td>0.6</td>
<td>135</td>
</tr>
<tr>
<td>P-885.30</td>
<td>5 x 5 x 13.5</td>
<td>11 ±20%</td>
<td>13 ±20%</td>
<td>870</td>
<td>67</td>
<td>1.1</td>
<td>90</td>
</tr>
<tr>
<td>P-885.50</td>
<td>5 x 5 x 18</td>
<td>15 ±10%</td>
<td>18 ±10%</td>
<td>900</td>
<td>50</td>
<td>1.5</td>
<td>70</td>
</tr>
<tr>
<td>P-885.90</td>
<td>5 x 5 x 36</td>
<td>32 ±10%</td>
<td>38 ±10%</td>
<td>950</td>
<td>25</td>
<td>3.1</td>
<td>40</td>
</tr>
<tr>
<td>P-887.30</td>
<td>7 x 7 x 13.5</td>
<td>11 ±20%</td>
<td>13 ±20%</td>
<td>1700</td>
<td>130</td>
<td>2.2</td>
<td>90</td>
</tr>
<tr>
<td>P-887.50</td>
<td>7 x 7 x 18</td>
<td>15 ±10%</td>
<td>18 ±10%</td>
<td>1750</td>
<td>100</td>
<td>3.1</td>
<td>70</td>
</tr>
<tr>
<td>P-887.90</td>
<td>7 x 7 x 36</td>
<td>32 ±10%</td>
<td>38 ±10%</td>
<td>1850</td>
<td>50</td>
<td>6.4</td>
<td>40</td>
</tr>
<tr>
<td>P-888.30</td>
<td>10 x 10 x 13.5</td>
<td>11 ±20%</td>
<td>13 ±20%</td>
<td>3500</td>
<td>267</td>
<td>4.3</td>
<td>90</td>
</tr>
<tr>
<td>P-888.50</td>
<td>10 x 10 x 18</td>
<td>15 ±10%</td>
<td>18 ±10%</td>
<td>3600</td>
<td>200</td>
<td>6.0</td>
<td>70</td>
</tr>
<tr>
<td>P-888.90</td>
<td>10 x 10 x 36</td>
<td>32 ±10%</td>
<td>38 ±10%</td>
<td>3800</td>
<td>100</td>
<td>13.0</td>
<td>40</td>
</tr>
</tbody>
</table>

Standard piezo ceramic type: 252

*For optional PTFE insulated wires, pigtail length 100 mm, change order number extension to .x1 (e.g. P-882.11).

Recommended preload for dynamic operation: 15 MPa

Maximum preload for constant force: 30 MPa

Resonant frequency at 1 Vpp, unloaded, free at both sides. The value is halved for unilateral clamping

Capacitance at 1 Vpp, 1 kHz

Operating voltage: -20 to +120 V

Operating temperature range: -40 to +150 °C

Standard Mechanical Interfaces: Ceramics

Standard Electrical Interfaces: Solderable pads

Available Options: strain gauge sensors, special mechanical interfaces, etc.

Other specifications on request.
P-871 PICMA® Piezo Bender Actuators

Low-Voltage Multilayer Piezo Bender Actuators with Position Sensor

Closed-Loop Operation for Superior Accuracy
Nanometer-Resolution
Displacement to 1.6 mm
Ceramic Encapsulation for Extended Lifetime
Ideal for Scanning Applications
Vacuum-Compatible Versions
Low Operating Voltage
Mounting Hardware Included
Special OEM- and Bench-Top Amplifiers Available

P-871 transducers are unique closed-loop piezo benders based on the open-loop PL 122 to PL 140 PICMA®-series multilayer actuators p. 1-94. Equipped with high-resolution position feedback sensors they provide better linearity, accuracy and repeatability than other piezo benders on the market. P-871 bender actuators achieve longer positioning ranges than typical piezo stack actuators, up to 1.6 mm, while still providing fast response times in the millisecond range.

Design
These multilayer piezoelectric components are manufactured from ceramic layers of only about 50 μm thickness. They feature internal silver-palladium electrodes and ceramic insulation applied in a cofiring process. Due to the thin layers the operating voltage is significantly lower than for classical parallel bimorph bender elements. For ease of installation, the units come complete with the mounting hardware, cables and connectors.

Closed-Loop Position Control for Higher Accuracy
P-871s are ideal devices for scanning, positioning and beam deflection applications and provide much better accuracy, stability and repeatability than conventional open-loop actuators. The special bender design allows the direct application of a strain gauge sensor to the surface without the need for a polymer insulation layer in between. The advantages are faster response, reduced phase lag and precise position control with non-linearity of <0.5%. The settling time for a small-signal step (up to 1% nominal travel) to an accuracy of better than 1% is between 10 ms (P-871.112) and 30 ms (P-871.140).

Ceramic Insulated Piezo Actuators Provide Long Lifetime
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

Optimum UHV Compatibility - Minimum Outgassing
The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (no outgassing / high bakeout temperatures, up to 150 °C).

Amplifiers, Drivers & Controllers
PI offers a wide range of standard amplifiers and controllers for piezo actuators. The E-651.1S and E-651.2S desktop controllers and the OEM board E-614.2BS (see p. 2-121) are specifically designed to operate P-871 bender actuators.
**Technical Data**

<table>
<thead>
<tr>
<th>Model</th>
<th>P-871.112*</th>
<th>P-871.122</th>
<th>P-871.127</th>
<th>P-871.128*</th>
<th>P-871.140</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed-loop travel</td>
<td>±80</td>
<td>±200</td>
<td>±360</td>
<td>±360</td>
<td>±800</td>
<td>μm</td>
</tr>
<tr>
<td>Integrated feedback sensor</td>
<td>SGS</td>
<td>SGS</td>
<td>SGS</td>
<td>SGS</td>
<td>SGS</td>
<td></td>
</tr>
<tr>
<td>Closed-loop linearity</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>%</td>
</tr>
<tr>
<td>Static large-signal stiffness</td>
<td>0.02</td>
<td>0.01</td>
<td>0.003</td>
<td>0.002</td>
<td>0.0007</td>
<td>N/μm</td>
</tr>
<tr>
<td>Blocking force</td>
<td>±2.0</td>
<td>±1.1</td>
<td>±1.0</td>
<td>±0.5</td>
<td>±0.5</td>
<td>N ±20%</td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>2 x 1.1</td>
<td>2 x 2.4</td>
<td>2 x 3.4</td>
<td>2 x 1.2</td>
<td>2 x 4.0</td>
<td>μF ±20%</td>
</tr>
<tr>
<td>Unloaded resonant frequency</td>
<td>2540</td>
<td>1010</td>
<td>560</td>
<td>340</td>
<td>195</td>
<td>Hz ±20%</td>
</tr>
<tr>
<td>Resonant frequency @ 6.5 g load</td>
<td>480</td>
<td>220</td>
<td>145</td>
<td>100</td>
<td>60</td>
<td>Hz ±20%</td>
</tr>
</tbody>
</table>

Operating voltage: 0 to 60 V (±30 V)
Recommended driver / controller: E-651 bench top / E-614 PCI card (p. 2-123)
Connector: 1 LEMO connector for both sensor and voltage supply
Operating temperature range: -20 to +85 °C; ** to +150 °C
Resonant frequency at 1 Vpp, capacitance at 1 Vpp, 1 kHz
All specifications depend on the real clamping conditions and on the applied mechanical load.
Other specifications on request.
P-007 – P-056 PICA™ Stack Actuator
Piezo actuator for highly dynamic applications

PICA™ Stack piezo ceramic actuators are offered in a large variety of standard shapes and sizes with additional custom designs to suit any application.

Ultra-High Reliability, High Displacement, Low Power Requirements
PICA™ piezo actuators are specifically designed for high-duty-cycle applications. With our extensive applications knowledge, gained over several decades, we know how to build performance that does not come at the price of reliability. All materials used are specifically matched for robustness and lifetime. Endurance tests on PICA™ actuators prove consistent performance, even after billions (1,000,000,000) of cycles. The combination of high displacement and low electrical capacitance provides for excellent dynamic behavior with reduced driving power requirements.

Flexibility / Short Leadtimes
All manufacturing processes at PI Ceramic are set up for flexibility. Should our standard actuators not fit your application, let us provide you with a custom design. Our engineers will work with you to find the optimum solution at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:
- Custom Materials
- Custom Voltage Ranges
- Custom Geometries (Circular, Rectangular, Triangular, Layer Thickness...)
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances
- Integrated Piezoelectric Sensor Discs
- Special High / Low Temperature Versions
- Vacuum Compatible Versions

Because all piezoelectric materials used in PICA™ actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom actuators are delivered with performance test sheets.

Piezo Drivers, Controllers & High-Voltage Amplifiers
High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the "Piezo Drivers / Servo Controllers" (see p. 2-99 ff) section.

PICA™ Stack piezo actuators are delivered with metal endcaps for improved robustness and reliability. For preloaded versions with steel casings (see p. 1-78, p. 1-80).
### Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order number</th>
<th>Displacement [μm] ±10/+20%</th>
<th>Diameter D [mm]</th>
<th>Length L [mm] ±0.5</th>
<th>Blocking force [N]</th>
<th>Stiffness [N/μm]</th>
<th>Capacitance [nF] ±20%</th>
<th>Resonant frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-007.00</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>650</td>
<td>130</td>
<td>11</td>
<td>126</td>
</tr>
<tr>
<td>P-007.10</td>
<td>15</td>
<td>7</td>
<td>17</td>
<td>850</td>
<td>59</td>
<td>33</td>
<td>59</td>
</tr>
<tr>
<td>P-007.20</td>
<td>30</td>
<td>7</td>
<td>29</td>
<td>1000</td>
<td>35</td>
<td>64</td>
<td>36</td>
</tr>
<tr>
<td>P-007.40</td>
<td>60</td>
<td>7</td>
<td>54</td>
<td>1150</td>
<td>19</td>
<td>130</td>
<td>20</td>
</tr>
<tr>
<td>P-010.00</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>1400</td>
<td>270</td>
<td>21</td>
<td>126</td>
</tr>
<tr>
<td>P-010.10</td>
<td>15</td>
<td>10</td>
<td>17</td>
<td>1800</td>
<td>120</td>
<td>64</td>
<td>59</td>
</tr>
<tr>
<td>P-010.20</td>
<td>30</td>
<td>10</td>
<td>30</td>
<td>2100</td>
<td>71</td>
<td>130</td>
<td>35</td>
</tr>
<tr>
<td>P-010.40</td>
<td>60</td>
<td>10</td>
<td>56</td>
<td>2200</td>
<td>38</td>
<td>260</td>
<td>20</td>
</tr>
<tr>
<td>P-010.80</td>
<td>120</td>
<td>10</td>
<td>107</td>
<td>2400</td>
<td>20</td>
<td>510</td>
<td>10</td>
</tr>
<tr>
<td>P-016.10</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>4600</td>
<td>320</td>
<td>180</td>
<td>59</td>
</tr>
<tr>
<td>P-016.20</td>
<td>30</td>
<td>16</td>
<td>29</td>
<td>5500</td>
<td>190</td>
<td>340</td>
<td>36</td>
</tr>
<tr>
<td>P-016.40</td>
<td>60</td>
<td>16</td>
<td>54</td>
<td>6000</td>
<td>100</td>
<td>680</td>
<td>20</td>
</tr>
<tr>
<td>P-016.80</td>
<td>120</td>
<td>16</td>
<td>101</td>
<td>6500</td>
<td>54</td>
<td>1300</td>
<td>11</td>
</tr>
<tr>
<td>P-016.90</td>
<td>180</td>
<td>16</td>
<td>150</td>
<td>6500</td>
<td>36</td>
<td>2000</td>
<td>7</td>
</tr>
<tr>
<td>P-025.10</td>
<td>15</td>
<td>25</td>
<td>18</td>
<td>11000</td>
<td>740</td>
<td>400</td>
<td>56</td>
</tr>
<tr>
<td>P-025.20</td>
<td>30</td>
<td>25</td>
<td>30</td>
<td>13000</td>
<td>440</td>
<td>820</td>
<td>35</td>
</tr>
<tr>
<td>P-025.40</td>
<td>60</td>
<td>25</td>
<td>53</td>
<td>15000</td>
<td>250</td>
<td>1700</td>
<td>21</td>
</tr>
<tr>
<td>P-025.80</td>
<td>120</td>
<td>25</td>
<td>101</td>
<td>16000</td>
<td>130</td>
<td>3400</td>
<td>11</td>
</tr>
<tr>
<td>P-025.90</td>
<td>180</td>
<td>25</td>
<td>149</td>
<td>16000</td>
<td>89</td>
<td>5100</td>
<td>7</td>
</tr>
<tr>
<td>P-025.150</td>
<td>250</td>
<td>25</td>
<td>204</td>
<td>16000</td>
<td>65</td>
<td>7100</td>
<td>5</td>
</tr>
<tr>
<td>P-025.200</td>
<td>300</td>
<td>25</td>
<td>244</td>
<td>16000</td>
<td>54</td>
<td>8500</td>
<td>5</td>
</tr>
<tr>
<td>P-035.10</td>
<td>15</td>
<td>35</td>
<td>20</td>
<td>20000</td>
<td>1300</td>
<td>700</td>
<td>51</td>
</tr>
<tr>
<td>P-035.20</td>
<td>30</td>
<td>35</td>
<td>32</td>
<td>24000</td>
<td>810</td>
<td>1600</td>
<td>33</td>
</tr>
<tr>
<td>P-035.40</td>
<td>60</td>
<td>35</td>
<td>57</td>
<td>28000</td>
<td>460</td>
<td>3300</td>
<td>19</td>
</tr>
<tr>
<td>P-035.80</td>
<td>120</td>
<td>35</td>
<td>104</td>
<td>30000</td>
<td>250</td>
<td>6700</td>
<td>11</td>
</tr>
<tr>
<td>P-035.90</td>
<td>180</td>
<td>35</td>
<td>153</td>
<td>31000</td>
<td>170</td>
<td>10000</td>
<td>7</td>
</tr>
<tr>
<td>P-045.20</td>
<td>30</td>
<td>45</td>
<td>33</td>
<td>39000</td>
<td>1300</td>
<td>2800</td>
<td>32</td>
</tr>
<tr>
<td>P-045.40</td>
<td>60</td>
<td>45</td>
<td>58</td>
<td>44000</td>
<td>740</td>
<td>5700</td>
<td>19</td>
</tr>
<tr>
<td>P-045.80</td>
<td>120</td>
<td>45</td>
<td>105</td>
<td>49000</td>
<td>410</td>
<td>11000</td>
<td>10</td>
</tr>
<tr>
<td>P-045.90</td>
<td>180</td>
<td>45</td>
<td>154</td>
<td>50000</td>
<td>280</td>
<td>17000</td>
<td>7</td>
</tr>
<tr>
<td>P-050.20</td>
<td>30</td>
<td>50</td>
<td>33</td>
<td>48000</td>
<td>1600</td>
<td>3400</td>
<td>32</td>
</tr>
<tr>
<td>P-050.40</td>
<td>60</td>
<td>50</td>
<td>58</td>
<td>55000</td>
<td>910</td>
<td>7000</td>
<td>19</td>
</tr>
<tr>
<td>P-050.80</td>
<td>120</td>
<td>50</td>
<td>105</td>
<td>60000</td>
<td>500</td>
<td>14000</td>
<td>10</td>
</tr>
<tr>
<td>P-050.90</td>
<td>180</td>
<td>50</td>
<td>154</td>
<td>61000</td>
<td>340</td>
<td>22000</td>
<td>7</td>
</tr>
<tr>
<td>P-056.20</td>
<td>30</td>
<td>56</td>
<td>33</td>
<td>60000</td>
<td>2000</td>
<td>4300</td>
<td>32</td>
</tr>
<tr>
<td>P-056.40</td>
<td>60</td>
<td>56</td>
<td>58</td>
<td>66000</td>
<td>1100</td>
<td>8900</td>
<td>19</td>
</tr>
<tr>
<td>P-056.80</td>
<td>120</td>
<td>56</td>
<td>105</td>
<td>76000</td>
<td>630</td>
<td>18000</td>
<td>10</td>
</tr>
<tr>
<td>P-056.90</td>
<td>180</td>
<td>56</td>
<td>154</td>
<td>78000</td>
<td>430</td>
<td>27000</td>
<td>7</td>
</tr>
</tbody>
</table>

Standard piezo ceramic type: PIC 151
Recommended preload for dynamic operation: 15 MPa
Maximum preload for constant force: 30 MPa
Resonant frequency at 1 V<sub>pp</sub>, unloaded, free at both sides.
The value is halved for unilateral clamping
Capacitance at 1 V<sub>pp</sub>, 1 kHz, blocking force at 1000 V
Operating voltage: 0 to 1000 V
Operating temperature range: -20 to +85 °C
Standard mechanical interfaces: steel plates, 0.5 to 2 mm thick (depends on model)
Standard electrical interfaces: two PTFE-insulated wires, pigtail length 100 mm
Available options: integrated piezo force sensor or strain gauge sensors, non magnetic, vacuum compatible, etc.
Other specifications on request.
P-010.xxP – P-056.xxP PICA™ Power Actuator

Piezo Stack Actuators for High-Level Dynamic Applications

Power actuators are optimized for high-temperature working conditions and high-duty-cycle dynamic applications.

High Displacement with Ultra-High Reliability

PICA™ Power actuators are optimized for high-temperature working conditions and high-duty-cycle dynamic applications.

Operating Temperature to 150 °C
High Load Capacity to 80 kN
High Force Generation to 70 kN
Large Cross Sections to 56 mm Diameter
Extreme Reliability >10⁹ Cycles
Sub-Millisecond Response, Sub-Nanometer Resolution
UHV Versions to 10⁻⁹ hPa
Non-Magnetic Versions
Temperature Sensor PT1000 Applied

Flexibility / Short Leadtimes

All manufacturing processes at PI Ceramic are set up for flexibility. Should our standard actuators not fit your application, let us provide you with a custom design. Our engineers will work with you to find the optimum solution at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:
- Custom Materials
- Custom Voltage Ranges
- Custom Geometries (Circular, Rectangular, Triangular, Layer Thickness ...)
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances
- Integrated Piezoelectric Sensor Discs
- Special High / Low Temperature Versions
- Vacuum Compatible Versions

Because all piezoelectric materials used in PICA™ actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom actuators are delivered with performance test sheets.

Piezo Drivers, Controllers & High-Voltage Amplifiers

PI offers a wide range of piezo control electronics, from low-power drivers to the ultra-high-performance E-481 power amplifier delivering 2000 W of dynamic power. For closed-loop positioning applications, a variety of analog and digital controllers is also available. The modular E-500 system can be upgraded from an amplifier to a servo-controller and offers a variety of computer interfaces. Of course, PI also designs custom amplifiers and controllers (see p. 2-98 ff.).

Application Examples

- Nanopositioning
- Active vibration damping
- High-load positioning
- Precision mechanics / -machining
- Semiconductor technology / test systems
- Laser tuning
- Switches
- Smart structures (Adaptronics)
- Nanotechnology

OEM-PICA™ Power piezo actuators are available with cross sections to 56 mm
## Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order number</th>
<th>Displacement [μm] -10/+20%</th>
<th>Diameter D [mm]</th>
<th>Length L [mm] ±0.5</th>
<th>Blocking force [N]</th>
<th>Stiffness [N/μm]</th>
<th>Capacitance [nF] ±20%</th>
<th>Resonant frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-010.00P</td>
<td>5</td>
<td>10</td>
<td>9</td>
<td>1200</td>
<td>240</td>
<td>17</td>
<td>129</td>
</tr>
<tr>
<td>P-010.10P</td>
<td>15</td>
<td>10</td>
<td>18</td>
<td>1800</td>
<td>120</td>
<td>46</td>
<td>64</td>
</tr>
<tr>
<td>P-010.20P</td>
<td>30</td>
<td>10</td>
<td>31</td>
<td>2100</td>
<td>68</td>
<td>90</td>
<td>37</td>
</tr>
<tr>
<td>P-010.40P</td>
<td>60</td>
<td>10</td>
<td>58</td>
<td>2200</td>
<td>37</td>
<td>180</td>
<td>20</td>
</tr>
<tr>
<td>P-010.80P</td>
<td>120</td>
<td>10</td>
<td>111</td>
<td>2300</td>
<td>19</td>
<td>370</td>
<td>10</td>
</tr>
<tr>
<td>P-016.10P</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>4500</td>
<td>300</td>
<td>130</td>
<td>64</td>
</tr>
<tr>
<td>P-016.20P</td>
<td>30</td>
<td>16</td>
<td>31</td>
<td>5400</td>
<td>180</td>
<td>250</td>
<td>37</td>
</tr>
<tr>
<td>P-016.40P</td>
<td>60</td>
<td>16</td>
<td>58</td>
<td>5600</td>
<td>94</td>
<td>510</td>
<td>20</td>
</tr>
<tr>
<td>P-016.80P</td>
<td>120</td>
<td>16</td>
<td>111</td>
<td>5900</td>
<td>49</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>P-016.90P</td>
<td>180</td>
<td>16</td>
<td>163</td>
<td>6000</td>
<td>33</td>
<td>1600</td>
<td>7</td>
</tr>
<tr>
<td>P-025.10P</td>
<td>15</td>
<td>25</td>
<td>20</td>
<td>9900</td>
<td>660</td>
<td>320</td>
<td>58</td>
</tr>
<tr>
<td>P-025.20P</td>
<td>30</td>
<td>25</td>
<td>33</td>
<td>12000</td>
<td>400</td>
<td>630</td>
<td>35</td>
</tr>
<tr>
<td>P-025.40P</td>
<td>60</td>
<td>25</td>
<td>60</td>
<td>13000</td>
<td>220</td>
<td>1300</td>
<td>19</td>
</tr>
<tr>
<td>P-025.80P</td>
<td>120</td>
<td>25</td>
<td>113</td>
<td>14000</td>
<td>120</td>
<td>2800</td>
<td>10</td>
</tr>
<tr>
<td>P-025.90P</td>
<td>180</td>
<td>25</td>
<td>165</td>
<td>14000</td>
<td>80</td>
<td>4000</td>
<td>7</td>
</tr>
<tr>
<td>P-035.10P</td>
<td>15</td>
<td>35</td>
<td>21</td>
<td>18000</td>
<td>1200</td>
<td>530</td>
<td>55</td>
</tr>
<tr>
<td>P-035.20P</td>
<td>30</td>
<td>35</td>
<td>34</td>
<td>23000</td>
<td>760</td>
<td>1200</td>
<td>34</td>
</tr>
<tr>
<td>P-035.40P</td>
<td>60</td>
<td>35</td>
<td>61</td>
<td>26000</td>
<td>430</td>
<td>2500</td>
<td>19</td>
</tr>
<tr>
<td>P-035.80P</td>
<td>120</td>
<td>35</td>
<td>114</td>
<td>28000</td>
<td>230</td>
<td>5200</td>
<td>10</td>
</tr>
<tr>
<td>P-035.90P</td>
<td>180</td>
<td>35</td>
<td>166</td>
<td>29000</td>
<td>160</td>
<td>7800</td>
<td>7</td>
</tr>
<tr>
<td>P-045.20P</td>
<td>30</td>
<td>45</td>
<td>36</td>
<td>36000</td>
<td>1200</td>
<td>2100</td>
<td>32</td>
</tr>
<tr>
<td>P-045.40P</td>
<td>60</td>
<td>45</td>
<td>63</td>
<td>41000</td>
<td>680</td>
<td>4300</td>
<td>18</td>
</tr>
<tr>
<td>P-045.80P</td>
<td>120</td>
<td>45</td>
<td>116</td>
<td>44000</td>
<td>370</td>
<td>8800</td>
<td>10</td>
</tr>
<tr>
<td>P-045.90P</td>
<td>180</td>
<td>45</td>
<td>169</td>
<td>45000</td>
<td>250</td>
<td>13000</td>
<td>7</td>
</tr>
<tr>
<td>P-056.20P</td>
<td>30</td>
<td>56</td>
<td>36</td>
<td>54000</td>
<td>1800</td>
<td>3300</td>
<td>32</td>
</tr>
<tr>
<td>P-056.40P</td>
<td>60</td>
<td>56</td>
<td>63</td>
<td>66000</td>
<td>1100</td>
<td>6700</td>
<td>18</td>
</tr>
<tr>
<td>P-056.80P</td>
<td>120</td>
<td>56</td>
<td>116</td>
<td>68000</td>
<td>570</td>
<td>14000</td>
<td>10</td>
</tr>
<tr>
<td>P-056.90P</td>
<td>180</td>
<td>56</td>
<td>169</td>
<td>70000</td>
<td>390</td>
<td>21000</td>
<td>7</td>
</tr>
</tbody>
</table>

**Standard piezo ceramic type:** PIC 255

**Recommended preload for dynamic operation:** 15 MPa

Maximum preload for constant force: 30 MPa

Resonant frequency at 1 V_{pp} unloaded. The value is halved for unilateral clamping

Capacitance at 1 V_{pp}, 1 kHz blocking force at 1000 V

Operating voltage: 0 to 1000 V

Operating temperature range: -20 to +150 °C

Standard mechanical interfaces: steel plates, 0.5 to 2 mm thick (depends on model)

Standard electrical interfaces: two PTFE-insulated wires, pitch length 100 mm

Available options: integrated piezo sensor or strain gauge sensors, non magnetic, vacuum compatible, etc.

Other specifications on request.
PICA™ Thru actuators are hollow piezo stack actuators, offered in a large variety of standard shapes and sizes with additional custom designs to meet all customer requirements. They combine the advantage of a clear aperture with the strength and force generation of stack actuators. These tubular devices are high-resolution linear actuators for static and dynamic applications. The clear aperture facilitates transmitted-light applications. Furthermore, the electrical consumption is reduced due to the decreased electrical capacitance.

Ultra-High Reliability, High Displacement, Low Power Requirements

PICA™ piezo actuators are specifically designed for high-duty-cycle applications. With our extensive applications knowledge, gained over several decades, we know how to build performance that does not come at the price of reliability. All materials used are specifically matched for robustness and lifetime. Endurance tests on PICA™ actuators prove consistent performance, even after billions (1,000,000,000) of cycles. The combination of high displacement and low electrical capacitance provides for excellent dynamic behavior with reduced driving power requirements.

Flexibility / Short Leadtimes

All manufacturing processes at PI Ceramic are set up for flexibility. Should our standard actuators not fit your application, let us provide you with a custom design. Our engineers will work with you to find the optimum solution at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

- Custom Materials
- Custom Voltage Ranges
- Custom Geometries (Circular, Rectangular, Triangular, Layer Thickness ...)
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances
- Integrated Piezoelectric Sensor Discs
- Special High / Low Temperature Versions
- Vacuum Compatible Versions

Because all piezoelectric materials used in PICA™ actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom actuators are delivered with performance test sheets.

Piezo Drivers, Controllers & High-Voltage Amplifiers

High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drivers / Servo Controllers” section.

Application Examples

- Optics
- Image stabilization
- Laser tuning
- Laser treatment
- Precision mechanics / -machining
- Confocal microscopy
- Nanopositioning

PICA™ Thru actuators are hol-

PICA™ Thru actuators are hollow piezo stack actuators, offered in a large variety of standard shapes and sizes with additional custom designs to meet all customer requirements. They combine the advantage of a clear aperture with the strength and force generation of stack actuators. These tubular devices are high-resolution linear actuators for static and dynamic applications. The clear aperture facilitates transmitted-light applications. Furthermore, the electrical consumption is reduced due to the decreased electrical capacitance.
PiezoWalk® Motors / Actuators
PILine® Ultrasonic Motors
DC-Servo & Stepper Actuators
Piezo Actuators & Components
Guided / Preloaded Actuators
Unpackaged Stack Actuators
Patches / Benders / Tubes / Shear...
Nanopositioning / Piezoelectrics
Nanometrology
Micropositioning
Index

Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order numbers</th>
<th>Displacement ([μm] -10/+20 %)</th>
<th>Diameter OD (mm)</th>
<th>Diameter ID (mm)</th>
<th>Length L (mm) ±0.5</th>
<th>Blocking force [N]</th>
<th>Stiffness [N/μm]</th>
<th>Capacitance [nF] ±20 %</th>
<th>Resonant frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-010.00H</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>7</td>
<td>1200</td>
<td>230</td>
<td>15</td>
<td>144</td>
</tr>
<tr>
<td>P-010.05H</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>1300</td>
<td>130</td>
<td>29</td>
<td>84</td>
</tr>
<tr>
<td>P-010.10H</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>15</td>
<td>1700</td>
<td>110</td>
<td>40</td>
<td>67</td>
</tr>
<tr>
<td>P-010.15H</td>
<td>20</td>
<td>10</td>
<td>5</td>
<td>21</td>
<td>1500</td>
<td>76</td>
<td>59</td>
<td>48</td>
</tr>
<tr>
<td>P-010.20H</td>
<td>30</td>
<td>10</td>
<td>5</td>
<td>27</td>
<td>1800</td>
<td>59</td>
<td>82</td>
<td>39</td>
</tr>
<tr>
<td>P-010.30H</td>
<td>40</td>
<td>10</td>
<td>5</td>
<td>40</td>
<td>1600</td>
<td>40</td>
<td>120</td>
<td>28</td>
</tr>
<tr>
<td>P-010.40H</td>
<td>60</td>
<td>10</td>
<td>5</td>
<td>54</td>
<td>1800</td>
<td>29</td>
<td>180</td>
<td>21</td>
</tr>
<tr>
<td>P-016.00H</td>
<td>5</td>
<td>16</td>
<td>8</td>
<td>7</td>
<td>2900</td>
<td>580</td>
<td>42</td>
<td>144</td>
</tr>
<tr>
<td>P-016.05H</td>
<td>10</td>
<td>16</td>
<td>8</td>
<td>12</td>
<td>3400</td>
<td>340</td>
<td>83</td>
<td>84</td>
</tr>
<tr>
<td>P-016.10H</td>
<td>15</td>
<td>16</td>
<td>8</td>
<td>15</td>
<td>4100</td>
<td>270</td>
<td>120</td>
<td>67</td>
</tr>
<tr>
<td>P-016.15H</td>
<td>20</td>
<td>16</td>
<td>8</td>
<td>21</td>
<td>3800</td>
<td>190</td>
<td>170</td>
<td>48</td>
</tr>
<tr>
<td>P-016.20H</td>
<td>30</td>
<td>16</td>
<td>8</td>
<td>27</td>
<td>4500</td>
<td>150</td>
<td>230</td>
<td>39</td>
</tr>
<tr>
<td>P-016.30H</td>
<td>40</td>
<td>16</td>
<td>8</td>
<td>40</td>
<td>4000</td>
<td>100</td>
<td>340</td>
<td>28</td>
</tr>
<tr>
<td>P-016.40H</td>
<td>60</td>
<td>16</td>
<td>8</td>
<td>52</td>
<td>4700</td>
<td>78</td>
<td>490</td>
<td>21</td>
</tr>
<tr>
<td>P-025.10H</td>
<td>15</td>
<td>25</td>
<td>16</td>
<td>16</td>
<td>7400</td>
<td>490</td>
<td>220</td>
<td>63</td>
</tr>
<tr>
<td>P-025.20H</td>
<td>30</td>
<td>25</td>
<td>16</td>
<td>27</td>
<td>8700</td>
<td>290</td>
<td>430</td>
<td>39</td>
</tr>
<tr>
<td>P-025.40H</td>
<td>60</td>
<td>25</td>
<td>16</td>
<td>51</td>
<td>9000</td>
<td>150</td>
<td>920</td>
<td>22</td>
</tr>
<tr>
<td>P-025.50H</td>
<td>80</td>
<td>25</td>
<td>16</td>
<td>66</td>
<td>9600</td>
<td>120</td>
<td>1200</td>
<td>17</td>
</tr>
</tbody>
</table>

Piezo ceramic type PIC 151
Recommended preload for dynamic operation: 15 MPa
Maximum preload for constant force: 30 MPa
Resonant frequency at 1 Vpp, unloaded, free at both sides.
The value is halved for unilateral clamping
Capacitance at 1 Vpp: 1 kHz
Blocking force at 1000 V
Operating voltage range: 0 to 1000 V
Operating temperature range: -20 to +85 °C
Standard mechanical interface (top & bottom): ceramic, 0.5-2 mm thick (depends on model)
Standard electrical interface: two PTFE-insulated wires, pigtail length 100 mm
Available options: integrated force piezo sensor or strain gauge sensors, non-magnetic, vacuum compatible, etc.
Ask about custom designs and further specifications.

Custom PICA™ Thru piezo actuator with 56 mm outside diameter, 8 mm inner diameter, 250 μm displacement. Pen for size comparison.
### PL022 · PL033 · PL055 PICMA® Chip Actuators

**Miniature Multilayer Piezo Stack Actuators**

![PICMA® chip miniature piezo actuators are the smallest ceramic encapsulated multilayer piezo actuators available, paper clip for size comparison](image)

- **Superior Lifetime Even Under Extreme Conditions**
- **Ultra-Compact:** from 2 x 2 x 2 mm
- **Ideal for Dynamic Operation**
- **Sub-Millisecond Response**
- **Sub-Nanometer Resolution**
- **Vacuum Compatible to 10^6 hPa**
- **High Humidity Resistance**

**Smallest Dimensions – High Performance**

PICMA® Chip actuators sized from 2 x 2 x 2 mm are the smallest monolithic multilayer piezo stack actuators available. Providing sub-nanometer resolution and sub-millisecond response, they are ideally suited to high-level dynamic applications.

**New Production Process, Optimized Piezo Ceramics**

PICMA® actuators are made from a ceramic material in which the piezoceramic properties such as stiffness, capacitance, displacement, temperature stability and lifetime are optimally combined. Thus the actuators accomplish sub-nanometer resolution in positioning and sub-millisecond response!

**Increased Lifetime Through Humidity Resistance**

The monolithic ceramic-encapsulated design provides better humidity protection than polymer-film insulation. Diffusion of water molecules into the insulation layer is greatly reduced by the use of cofired, outer ceramic encapsulation. Due to their high resonant frequency the actuators are suitable for highly dynamic applications with small loads; depending on the load an external preload for dynamic applications is recommended. The high Curie temperature of 320 °C gives PICMA® actuators a usable temperature range extending up to 150 °C, far beyond 80 °C as is common for conventional multilayer actuators. With conventional multilayer actuators, heat generation – which is proportional to operating frequency – either limits the operating frequency or duty cycle in dynamic operation, or makes ungainly cooling provisions necessary. At the low end, operation down to a few Kelvin is possible (with reduction in performance specifications).

**Optimum UHV Compatibility – Minimum Outgassing**

The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (high bakeout temperatures, up to 150 °C).

**Piezo Drivers, Controllers & High-Voltage Amplifiers**

High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the "Piezo Drivers / Servo Controllers" section.

**Technical Data / Product Order Numbers**

<table>
<thead>
<tr>
<th>Order number*</th>
<th>Dimensions A x B x TH in mm</th>
<th>Nominal displacement [μm @ 100 V] ±20 %</th>
<th>Blocking force [N]</th>
<th>Electrical capacitance [nF] ±20 %</th>
<th>Resonant frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL022.30</td>
<td>2 x 2 x 2</td>
<td>2.2</td>
<td>&gt;120</td>
<td>25</td>
<td>&gt;300</td>
</tr>
<tr>
<td>PL033.30</td>
<td>3 x 3 x 2</td>
<td>2.2</td>
<td>&gt;300</td>
<td>50</td>
<td>&gt;300</td>
</tr>
<tr>
<td>PL055.30</td>
<td>5 x 5 x 2</td>
<td>2.2</td>
<td>&gt;500</td>
<td>250</td>
<td>&gt;300</td>
</tr>
</tbody>
</table>

* For optional PTFE insulated wire leads change order number extension to .x1 (e.g. PL022.31)

Resonant frequency at 1 Vp-p unloaded, free at both sides. The value is halved for unilateral clamping.

Capacitance at 1 Vp-p, 1 kHz
- Operating voltage: -20 to +100 V
- Operating temperature range: 190 °C
- Standard electrical interfaces: Solderable pads
- Other specifications on request.
- Recommended preload for dynamic operation: 15 MPa
- Maximum preload for constant force: 30 MPa

**Application Examples**

- Static and dynamic precision positioning
- Laser tuning
- Micro-dispensing
- Metrology / Interferometry
- Life science, Biotechnology
- Photonics

---

© Physik Instrumente (PI) GmbH & Co. KG 2008. Subject to change without notice. All data are superseded by any new release. The newest release for data sheets is available for download at www.pi.ws. Cat120E Inspirations2009 08/10.18
Piezoelectric Actuators & Components from PI Ceramic—Leading in Piezo Technology

PI Ceramic—a PI Subsidiary—is a long-standing, world-class supplier of high-performance piezoelectric actuator and transducer components and subassemblies. The award-winning PICMA® actuator technology is a result of PI Ceramic’s research and development, and innovative drive solutions such as PILine® ultrasonic ceramic motors and NEXLINE® high-force ceramic motors are based on piezoelectric actuators from PIC.

PI Ceramic provides a wide range of standard piezoelectric actuator components and develops and produces all piezo ceramic drive systems employed in PI’s precision positioning systems. Apart from the standard types a multitude of application-specific and custom-engineered modifications can be delivered.

Piezoceramic Materials & Components

Variety of materials:
- lead zirconate titanate (PZT); barium titanate

Variety of shapes:
- discs (rod, block, custom design)
- rings, tubes
- shear elements (plates, rings)

Custom electrodes (material, shape)
Patch transducers, piezo composite materials

For more information on piezoceramic materials and components, see the PI Ceramic catalogs and Website (www.piceramic.de).
Pl112 · Pl140 PICMA® Bender Actuators
Multilayer Piezo Bender Actuators with High Travel and Low Operating Voltage

PICMA® multilayer bender piezo actuators provide a deflection of up to 2 mm, forces up to 2 N and response times in the millisecond range. These multilayer piezoelectric components are manufactured from ceramic layers of only about 50 μm thickness. They feature internal silver-palladium electrodes and ceramic insulation applied in a cofiring process. The benders have two outer active areas and one central electrode network dividing the actuator in two segments of equal capacitance, similar to a classical parallel bimorph.

Advantages
PICMA® Bender piezo actuators offer several advantages over classic bimorph components manufactured by gluing together two ceramic plates (0.1 to 1 mm thick): faster response time and higher stiffness. The main advantage, however, is the drastically reduced (by a factor of 3 to 10) operating voltage of only 60 V. The reduced voltage allows smaller drive electronics and new applications, such as in medical equipment. Additionally, these devices offer improved humidity resistance due to the ceramic encapsulation.

Application Examples
- Wire bonding
- Pneumatic valves
- Fiber optic switches
- (Laser)-Beam steering
- Micropositioning
- Acceleration sensors

Increased Lifetime Through Humidity Resistance
The monolithic ceramic-encapsulated design provides better humidity protection than polymer-film insulation. Diffusion of water molecules into the insulation layer is greatly reduced by the use of cofired, outer ceramic encapsulation. Due to their high resonant frequency the actuators are suitable for highly dynamic applications with small loads; depending on the load an external preload for dynamic applications is recommended. The high Curie temperature of 320 °C gives PICMA® actuators a usable temperature range extending up to 150 °C, far beyond 80 °C as is common for conventional multilayer actuators. With conventional multilayer actuators, heat generation – which is proportional to operating frequency – either limits the operating frequency or duty cycle in dynamic operation, or makes ungainly cooling provisions necessary. At the low end, operation down to a few Kelvin is possible (with reduction in performance specifications).

Optimum UHV Compatibility – Minimum Outgassing
The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (high bakeout temperatures, up to 150 °C).

Closed-Loop Version
For closed-loop positioning the versions P-871 with integrated strain gauge sensors are available (see p. 1-84).

Drivers and Controllers
PI offers a wide selection of low noise amplifiers and controllers for piezo actuators (see section „Piezo Electronics“). Customized piezo electronics are developed on request.

The E-650.00 and E-650.0E piezo amplifiers (see p. 2-122) are especially designed for operating the PICMA® bender actuators.
Recommended clamping: non-conducting material with rounded clamping end face for protection of ceramics (not included). See table for dimensions.

Differential control of PICMA® bender actuators
Pin Assignments:
1: -30 V [or GND]
2: -30 V to +30 V [or 0 to 60 V]
3: +30 V [or +60 V]
Dimensions in mm

Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order number*</th>
<th>Operating voltage [V]</th>
<th>Nominal displacement [μm] ±20 %</th>
<th>Free length [mm]</th>
<th>Dimensions L x W x T [mm]</th>
<th>Blocking force [N]</th>
<th>Electrical capacitance [μF] ±20 %</th>
<th>Resonant frequency [Hz] ±20 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL112.10**</td>
<td>0 - 60 (±30)</td>
<td>±80</td>
<td>12</td>
<td>17.8 x 9.6 x 0.65</td>
<td>±2.0</td>
<td>2 x 1.1</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>PL122.10</td>
<td>0 - 60 (±30)</td>
<td>±250</td>
<td>22</td>
<td>25.0 x 9.6 x 0.65</td>
<td>±1.1</td>
<td>2 x 2.4</td>
<td>660</td>
</tr>
<tr>
<td>PL127.10</td>
<td>0 - 60 (±30)</td>
<td>±450</td>
<td>27</td>
<td>31.0 x 9.6 x 0.65</td>
<td>±1.0</td>
<td>2 x 3.4</td>
<td>380</td>
</tr>
<tr>
<td>PL128.10**</td>
<td>0 - 60 (±30)</td>
<td>±450</td>
<td>28</td>
<td>35.5 x 6.3 x 0.75</td>
<td>±0.5</td>
<td>2 x 1.2</td>
<td>360</td>
</tr>
<tr>
<td>PL140.10</td>
<td>0 - 60 (±30)</td>
<td>±1000</td>
<td>40</td>
<td>45.0 x 11.0 x 0.60</td>
<td>±0.5</td>
<td>2 x 4.0</td>
<td>160</td>
</tr>
</tbody>
</table>

*For optional PTFE insulated wire leads change order number extension to .x 1 (e.g. PL112.11)
Operating temperature range: -20 to +85 °C
**to +150 °C Resonant frequency at 1 Vpp capacitance at 1 Vpp, 1 kHz

All parameters depend on actual clamping conditions and applied load.
Ask about custom designs and further specifications.
P-876 DuraAct™

Piezoelectric Patch Transducers

P-876 DuraAct™ patch transducers offer the functionality of piezoceramic materials as sensors and actuators as well as for electrical charge generation and storage. Used as bender actuators, they allow high deflections of up to 0.8 mm with high force and high precision. Other possible operation modes of DuraAct™ transducers are as high-dynamics sensors (e.g. for structural health monitoring) or for energy harvesting.

Integration into Adaptive Systems

With their compact design, DuraAct™ transducers can be applied to structure areas where deformations are to be generated or detected. For this purpose the transducers can be affixed to the surfaces of structures or integrated as structural elements themselves. Whole areas can be monitored effectively by applying an array of several modules to a surface.

DuraAct™ patch transducers are ideally suited for active and adaptive systems. Embedded in a servo-control loop, they can reduce vibrations and control structures in the nanometer range.

Robust and Cost-Effective Design for Industrial Applications

The laminated design with piezoceramic plate and polymers provide a mechanically preloaded and electrically insulated device for easy handling. P-876 patch transducers feature a rugged design with the mechanical stability of a structural material.

Energy Harvesting: Self-Sustaining Systems in a Small Package

One possible application of DuraAct™ patch transducers is in the field of energy harvesting. Transformation of mechanical vibrations of up to some kilohertz into the corresponding potential difference can yield electrical power in the milliwatt range. This power can supply miniature electronic devices like diodes, sensors or even radio transmitters for remote data control.

DuraAct™ transducers can be offered in highly customized versions:

- **Actuator, Sensor or Energy Source**
- **Highly Formable Ceramics**
- **Can be Applied to Curved Surfaces**
- **Customized Solutions on Request**
- **Cost-Effective**

P-876.A12 and .A15 actuators. Golf ball for size comparison

### Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-876.A11</td>
<td>61 x 35 x 0.4 mm</td>
</tr>
<tr>
<td>P-876.A12</td>
<td>61 x 35 x 0.5 mm</td>
</tr>
<tr>
<td>P-876.A15</td>
<td>61 x 35 x 0.8 mm</td>
</tr>
</tbody>
</table>

Ask for custom designs!

### Application Examples

- High-dynamics actuators
- Adaptive systems
- Vibration and noise cancellation
- Deformation control and stabilization
- Damage monitoring
- Energy harvesting

### Dimensions of the P-876 in mm

![Dimensions of the P-876 in mm](image)

Lateral contraction of a DuraAct™ patch transducer when voltage is applied
### Technical Data

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating voltage</strong></td>
<td>-50 to +200 V</td>
<td>-100 to +400 V</td>
<td>-250 to +1000 V</td>
<td></td>
</tr>
<tr>
<td><strong>Motion and positioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral contraction, open-loop</td>
<td>400 μm/m</td>
<td>650 μm/m</td>
<td>800 μm/m</td>
<td>min.</td>
</tr>
<tr>
<td></td>
<td>1.6 μm/m/V</td>
<td>1.3 μm/m/V</td>
<td>0.64 μm/m/V</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blocking force</td>
<td>90 N</td>
<td>265 N</td>
<td>775 N</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>61 mm</td>
<td>61 mm</td>
<td>61 mm</td>
<td>±0.5 mm</td>
</tr>
<tr>
<td>Width</td>
<td>35 mm</td>
<td>35 mm</td>
<td>35 mm</td>
<td>±0.5 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.4 mm</td>
<td>0.5 mm</td>
<td>0.8 mm</td>
<td>±0.05 mm</td>
</tr>
<tr>
<td>Bending radius</td>
<td>12 mm</td>
<td>20 mm</td>
<td>70 mm</td>
<td>max.</td>
</tr>
<tr>
<td><strong>Drive properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piezo ceramic type</td>
<td>PIC 252</td>
<td>PIC 255</td>
<td>PIC 255</td>
<td></td>
</tr>
<tr>
<td>Layer thickness: 100 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer thickness: 200 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer thickness: 500 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical capacitance</td>
<td>150 nF</td>
<td>90 nF</td>
<td>45 nF</td>
<td>±20 %</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-20 to +150 (180) °C</td>
<td>-20 to +150 (180) °C</td>
<td>-20 to +150 (180) °C</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>2.1 g</td>
<td>3.5 g</td>
<td>7.2 g</td>
<td>±5 %</td>
</tr>
<tr>
<td>Voltage connection</td>
<td>Solder pads</td>
<td>Solder pads</td>
<td>Solder pads</td>
<td></td>
</tr>
<tr>
<td>Recommended controller/driver</td>
<td>E-413.D2</td>
<td>E-413.D2 (p. 2-120)</td>
<td>E-508 (p. 2-150)</td>
<td>E-835 (p. 2-166)</td>
</tr>
</tbody>
</table>
P-111 · P-151 PICA™ Shear Actuators

Compact Multi-Axis Actuators Based on the Piezo Shear Effect

The unique PICA™ Shear piezo actuator series are exclusively available from PI. These devices are extremely compact and feature sub-nanometer resolution and ultra-fast response. They come in a variety of geometries providing displacements to 10 μm. Possible applications for these devices are e.g. scanning microscopy, or in motor drives.

High Stiffness and High Displacement

PICA™ Shear actuators exhibit high stiffness, both parallel and perpendicular to the motion direction. Based on the piezoelectric shear effect, the PICA™ Shear X and XY actuators show almost twice the displacement amplitudes of conventional piezo actuators at the same electric field. Consequently they can be made smaller and have higher resonant frequencies. This results in reduced power requirements for a given induced displacement in dynamic X- and Y-axis operation.

High Reliability under High Duty Cycles, Low Power Requirements

PICA™ Shear actuators are specifically designed for high-duty-cycle applications. All materials used are specifically matched for robustness and lifetime. Endurance tests proved consistent performance, even after billions (1,000,000,000) of cycles. The combination of high displacement and low electrical capacitance provides for excellent dynamic behavior with reduced driving power requirements.

Short Leadtime for Standard & Custom Designs

All manufacturing processes at PI Ceramic are set up for maximum flexibility. Should our standard actuators not fit your application, let us provide you with a custom design. Our engineers will work with you to find the optimum solution at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

- Custom Materials
- Custom Voltage Range / Custom Displacement
- Clear Aperture
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Metal, Ceramics, Glass, Sapphire, ...) / Optical Surface Quality

Application Examples

- Nanopositioning
- Precision mechanics / -machining
- Active vibration damping
- Semiconductor technology / test systems
- Laser tuning
- Atomic force microscopy
- Switches
- Scanning applications
- Linear motors
- Nanotechnology

Compact Single- and Multi-Axis Actuators

X-, XY-, XZ- and XYZ-Versions

High Resonant Frequencies

Extreme Reliability >10⁹ Cycles

Picometer-Resolution / Sub-Millisecond Response

UHV Versions to 10⁻⁹ hPa

Non-Magnetic and Clear Aperture Versions

The standard actuator P-151.10 is delivered with a 10 cm lead
- Extra-Tight Length Tolerances
- Combination with Piezoelectric Shear Sensors (no Pyroelectric Effect)
- Low-Temperature Designs, Down to Liquid-He
- Vacuum Compatible and Non-Magnetic Versions

Because all piezoelectric materials used in these actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom actuators are delivered with performance test sheets.

**Amplifiers and Controllers**

The E-413.OE bipolar piezo driver is recommended for operating these actuators. Other high-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drivers / Servo Controllers” section.

---

### Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order number</th>
<th>Active axes</th>
<th>Displacement [μm] -10/+20% for -250 to 250 V</th>
<th>Cross section A x B / ID (mm)</th>
<th>Length L [mm] ±0.3</th>
<th>Max. shear load [N]</th>
<th>Axial Stiffness [N/μm]</th>
<th>Capacitance [pF] ±20%</th>
<th>Resonant frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-111.01</td>
<td>X 1*</td>
<td>3 x 3</td>
<td>3.5</td>
<td>20</td>
<td>70</td>
<td>0.5</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>P-111.03</td>
<td>X 3*</td>
<td>3 x 3</td>
<td>5.5</td>
<td>20</td>
<td>45</td>
<td>1.5</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>P-111.05</td>
<td>X 5</td>
<td>3 x 3</td>
<td>7.5</td>
<td>20</td>
<td>30</td>
<td>2.5</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-121.01</td>
<td>X 1*</td>
<td>5 x 5</td>
<td>3.5</td>
<td>50</td>
<td>190</td>
<td>1.4</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>P-121.03</td>
<td>X 3*</td>
<td>5 x 5</td>
<td>5.5</td>
<td>50</td>
<td>120</td>
<td>4.2</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>P-121.05</td>
<td>X 5</td>
<td>5 x 5</td>
<td>7.5</td>
<td>40</td>
<td>90</td>
<td>7</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-141.03</td>
<td>X 3*</td>
<td>10 x 10</td>
<td>5.5</td>
<td>200</td>
<td>490</td>
<td>17</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>P-141.05</td>
<td>X 5</td>
<td>10 x 10</td>
<td>7.5</td>
<td>200</td>
<td>360</td>
<td>28</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-141.10</td>
<td>X 10</td>
<td>10 x 10</td>
<td>12</td>
<td>200</td>
<td>230</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>P-151.03</td>
<td>X 3*</td>
<td>16 x 16</td>
<td>5.5</td>
<td>300</td>
<td>1300</td>
<td>43</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>P-151.05</td>
<td>X 5</td>
<td>16 x 16</td>
<td>7.5</td>
<td>300</td>
<td>920</td>
<td>71</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-151.10</td>
<td>X 10</td>
<td>16 x 16</td>
<td>12</td>
<td>300</td>
<td>580</td>
<td>130</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>P-112.01</td>
<td>XY 1 x 1*</td>
<td>3 x 3</td>
<td>5</td>
<td>20</td>
<td>50</td>
<td>0.5 / 0.5</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>P-112.03</td>
<td>XY 3 x 3*</td>
<td>3 x 3</td>
<td>9.5</td>
<td>10</td>
<td>25</td>
<td>1.5 / 1.5</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>P-122.01</td>
<td>XY 1 x 1*</td>
<td>5 x 5</td>
<td>5</td>
<td>50</td>
<td>140</td>
<td>1.4 / 1.4</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>P-122.03</td>
<td>XY 3 x 3*</td>
<td>5 x 5</td>
<td>9.5</td>
<td>40</td>
<td>70</td>
<td>4.2 / 4.2</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>P-122.05</td>
<td>XY 5 x 5</td>
<td>5 x 5</td>
<td>14</td>
<td>30</td>
<td>50</td>
<td>7 / 7</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>P-142.03</td>
<td>XY 3 x 3*</td>
<td>10 x 10</td>
<td>9.5</td>
<td>200</td>
<td>280</td>
<td>17 / 17</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>P-142.05</td>
<td>XY 5 x 5</td>
<td>10 x 10</td>
<td>14</td>
<td>100</td>
<td>190</td>
<td>28 / 28</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>P-152.03</td>
<td>XY 10 x 10</td>
<td>16 x 16</td>
<td>9.5</td>
<td>300</td>
<td>730</td>
<td>43 / 43</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>P-152.05</td>
<td>XY 5 x 5</td>
<td>16 x 16</td>
<td>14</td>
<td>300</td>
<td>490</td>
<td>71 / 71</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>P-152.10</td>
<td>XY 10 x 10</td>
<td>16 x 16</td>
<td>23</td>
<td>100</td>
<td>300</td>
<td>130 / 130</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P-123.01</td>
<td>XYZ 1 x 1 x 1*</td>
<td>5 x 5</td>
<td>7.5</td>
<td>40</td>
<td>90</td>
<td>1.4 / 1.4 / 2.9</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-123.03</td>
<td>XYZ 3 x 3 x 3*</td>
<td>5 x 5</td>
<td>15.5</td>
<td>10</td>
<td>45</td>
<td>4.2 / 4.2 / 7.3</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>P-143.01</td>
<td>XYZ 1 x 1 x 1*</td>
<td>10 x 10</td>
<td>7.5</td>
<td>200</td>
<td>360</td>
<td>5.6 / 5.6 / 11</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-143.03</td>
<td>XYZ 3 x 3 x 3*</td>
<td>10 x 10</td>
<td>15.5</td>
<td>100</td>
<td>170</td>
<td>17 / 17 / 29</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>P-143.05</td>
<td>XYZ 5 x 5</td>
<td>10 x 10</td>
<td>23</td>
<td>50</td>
<td>120</td>
<td>28 / 28 / 47</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P-153.03</td>
<td>XYZ 3 x 3 x 3*</td>
<td>16 x 16</td>
<td>15.5</td>
<td>300</td>
<td>450</td>
<td>43 / 43 / 73</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>P-153.05</td>
<td>XYZ 5 x 5</td>
<td>16 x 16</td>
<td>23</td>
<td>100</td>
<td>300</td>
<td>71 / 71 / 120</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P-153.10</td>
<td>XYZ 10 x 10</td>
<td>16 x 16</td>
<td>40</td>
<td>60</td>
<td>170</td>
<td>130 / 130 / 230</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>P-153.10H</td>
<td>XYZ 10 x 10</td>
<td>16 x 16 / 10</td>
<td>40</td>
<td>20</td>
<td>120</td>
<td>89 / 89 / 160</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>P-151.03H</td>
<td>X 3*</td>
<td>16 x 10 / 10</td>
<td>5.5</td>
<td>200</td>
<td>870</td>
<td>30</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>P-151.05H</td>
<td>X 5</td>
<td>16 x 16 / 10</td>
<td>7.5</td>
<td>200</td>
<td>640</td>
<td>49</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>P-151.10H</td>
<td>X 10</td>
<td>16 x 16 / 10</td>
<td>12</td>
<td>200</td>
<td>460</td>
<td>89</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Standard piezo ceramic type: 255
* Tolerances ±30%
Unloaded (longitudinal) resonant frequency measured at 1 Vpp, capacitance at 1 Vpp, 1 kHz, unloaded, free at both sides
Capacitance at 1 Vpp, 1 kHz
Operating voltage: -250 V to +250 V
Operating temperature range: -20 to +85 °C
Standard mechanical interfaces: Ceramics
PTFE-insulated wires, pigtail length 100 mm
Available options: integrated piezo force sensors, non magnetic, vacuum compatible, free aperture etc.
Other specifications on request.
PT120 · PT140 PT Piezo Tube Actuators

Piezoceramic Tube Actuators with Small Tolerances and Various Options

PT-series piezoceramic tubes are used in a wide range of applications from microdispensing to scanning microscopy. These monolithic components contract laterally (radially) and longitudinally when a voltage is applied between their inner and outer electrodes. Multi-electrode tubes are available to provide XYZ motion for use in manipulation and scanning microscopy applications. PI also provides ultra-high linearity, closed-loop scanning stages for SPM and nanomanipulation.

Precision and Flexibility

PT piezo tubes are manufactured to the tightest tolerances. We can provide tubes with diameters as small as 0.8 mm and tolerances as tight as 0.05 mm. All manufacturing processes at PI Ceramic are set up for maximum flexibility. Should our standard actuators not fit your application, let us provide you with a custom design. Our engineers will work with you to find the optimum solution at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

- Custom Materials
- Custom Voltage Ranges / Displacement
- Custom Geometries
- Extra-Tight Tolerances
- Applied Sensors
- Special High / Low Temperature Versions

Application Examples

- Micropositioning
- Scanning microscopy (AFM, STM, etc.)
- Fiber stretching / modulation
- Micropumps
- Micromanipulation
- Ultrasonic and sonar applications

Short Leadtime

Because all piezoelectric materials used in PT tube actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding.

Dimensions

max. L: 50 mm
max. OD: 80 mm
min. d: 0.30 mm

Electrodes

Fired silver-plated inside and outside as standard; thin film electrodes (e.g. copper-nickel or gold) as outer electrodes optional.

Options

Single or double wrapped, circumferential bands or quartered outer electrodes.

Polarization

Inner electrode positive potential

Tube actuators are not designed to withstand large forces (see PICA™ Thru actuators p. 1-90), but their high resonant frequencies make them especially suitable for dynamic operation with light loads.

Application examples are micro pumps, scanning microscopy, ink-jet printing, ultrasonic and sonar applications.

Piezo Drivers, Controllers & High-Voltage Amplifiers

High-resolution amplifiers and servo-control electronics, both digital and analog, are described in the “Piezo Drivers / Servo Controllers” section.

Equations

The axial contraction and radial displacement of piezo tubes can be calculated as follows:

(Equation 1)

\[ \Delta L \approx \frac{d_{31} \cdot L \cdot U}{d} \]

where:

- \( d_{31} \) = strain coefficient (displacement normal to polarization direction) [m/V]
- \( L \) = length of ceramic tube [m]
- \( U \) = operating voltage [V]
- \( d \) = wall thickness [m]

(Equation 2)

\[ \Delta d \approx \frac{d_{33} \cdot U}{d} \]

where:

- \( d \) = change in wall thickness [m]
- \( d_{33} \) = strain coefficient (field and displacement in polarization direction) [m/V]
- \( U \) = operating voltage [V]

Typical values for \( d_{31} \) and \( d_{33} \) are -200 pm/V and 500 pm/V, respectively.
The radial contraction is the superposition of the increase in wall thickness and the tangential contraction; it can be estimated by the following equation:

(Equation 3)

\[
\Delta r = \frac{d_{31}}{r} \left( \frac{U}{d} \right)
\]

where:

- \( r \) = radius of piezo tube
- \( d_{31} \) = strain coefficient (displacement normal to polarization direction) [m/V]
- \( U \) = operating voltage [V]
- \( d \) = wall thickness [m]

For a given division of the outer electrode of a piezo tube into four 90° sections the differential control (±U) of opposing electrodes results in bending of one of the ends, due to superposition of radial and axial contraction. Such tubes are applied as XY scanner in scanning-probe microscopes such as atomic force microscopes. The scanning range can be evaluated as follows:

(Equation 4)

\[
\Delta x = 2 \sqrt{2} \cdot d_{31} \cdot L^2 \cdot \frac{U}{\pi \cdot ID \cdot d}
\]

where:

- \( \Delta x \) = scanning range in X and Y (for symmetrical electrodes) [m]
- \( d_{31} \) = strain coefficient (displacement normal to polarization direction) [m/V]
- \( U \) = operating voltage [V]
- \( L \) = length [m]
- \( ID \) = inner diameter [m]
- \( d \) = wall thickness [m]

Technical Data / Product Order Numbers

<table>
<thead>
<tr>
<th>Order number</th>
<th>Dimensions [mm] L x OD x ID**</th>
<th>Max. operating voltage [V]</th>
<th>Electrical capacitance [nF] ±20%</th>
<th>Axial contraction [µm] @ max. V</th>
<th>Radial contraction [µm] @ max. voltage</th>
<th>XY deflection [µm] @ ±200 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT120.00</td>
<td>20 x 2.2 x 1.0</td>
<td>500</td>
<td>3</td>
<td>5</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>PT130.00</td>
<td>30 x 3.2 x 2.2</td>
<td>500</td>
<td>10</td>
<td>9</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td>PT130.90</td>
<td>30 x 3.2 x 2.2</td>
<td>500</td>
<td>12</td>
<td>9</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td>PT130.94*</td>
<td>30 x 3.2 x 2.2 ±200</td>
<td>4 x 2.4</td>
<td>9</td>
<td>0.9</td>
<td>±35</td>
<td></td>
</tr>
<tr>
<td>PT130.10</td>
<td>30 x 6.39 x 5.35</td>
<td>500</td>
<td>18</td>
<td>9</td>
<td>1.8</td>
<td>-</td>
</tr>
<tr>
<td>PT130.14*</td>
<td>30 x 6.39 x 5.35 ±200</td>
<td>4 x 3.8</td>
<td>9</td>
<td>1.8</td>
<td>±16</td>
<td></td>
</tr>
<tr>
<td>PT130.20</td>
<td>30 x 10.0 x 9.0</td>
<td>500</td>
<td>36</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>PT130.24*</td>
<td>30 x 10.0 x 9.0 ±200</td>
<td>4 x 8.5</td>
<td>9</td>
<td>3</td>
<td>±10</td>
<td></td>
</tr>
<tr>
<td>PT130.30</td>
<td>30 x 10.0 x 8.0</td>
<td>1000</td>
<td>18</td>
<td>9</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>PT130.40</td>
<td>30 x 20.0 x 18.0</td>
<td>1000</td>
<td>35</td>
<td>9</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>PT140.70</td>
<td>40 x 40.0 x 38.0</td>
<td>1000</td>
<td>70</td>
<td>15</td>
<td>12</td>
<td>-</td>
</tr>
</tbody>
</table>

*Quartered electrodes for XY deflection
**OD (outer diameter), ID (inner diameter) ±0.05 mm. PT120 / PT130.00: ID ±0.1 mm

Other specifications on request.
Options and Accessories

Factory Installed Options

Notes
The following options must be installed in the piezo translators during the manufacturing process. They must be ordered with the piezo actuator and cannot be added later. If necessary contact your local PI office for details on how to order modified translators.

Strain Gauge Position Sensor for HVPZT Stack Actuators
For positioning requiring high repeatability and accuracy, the strain gauge position sensor is available. See page 2-187 ff. and page 2-199 ff., for more information on position sensors and closed-loop operation of piezos. Piezos with strain gauge sensors are equipped with a 1 m PUR cable with FFA.0S.304.CLAC32 LEMO connector in addition to the voltage cable.

Vacuum Options
All PI piezo translators can be safely used in a vacuum outside the range from 100 to 0.1 hPa (100 to 0.1 torr). See the tutorial “Piezoelectrics in Positioning” section, page 2-205 for discussion. For applications that require reduced outgassing, the P-703.10 and P-703.20 high-vacuum configurations are available.

P-703.10 High Vacuum (for preloaded PZTs)
The translators are delivered as bare ceramic stacks without a case. The PZTs can be baked up to 150 °C. The electrical connection is via two 50 cm long Teflon leads without connector. The nominal displacement of the PZT is reduced by about 20% (due to the stiff insulation materials).

P-703.20 High Vacuum (for preloaded PZTs)
The piezo ceramics are enclosed in a stainless steel case with vent holes. The PZTs can be baked to 150 °C. The electrical connection is via two 50 cm Teflon leads without connector. The nominal displacement of the PZT is reduced by about 20% (due to the stiff insulation materials).

This option includes factory calibration of any PI servo-controller (see “Piezo Drivers & Nanopositioning Controllers” section) delivered along with the sensor-equipped piezo translator.

P-177.50 Dynamic applications (with E-481): temperature sensor and protective air for PICA™ HVPZT
The option for dynamic applications is recommended for high operation with the E-481 HVPZT Piezo Amplifier / Controller with energy recovery. Protective air and integrated temperature sensor prevent damage to the piezo ceramic by overtemperature.

P-706.00 Water-Resistant Case
The water-resistant case is recommended if PZTs are used in applications where spray of coolants, oil, water, etc. might damage the piezo ceramics. It consists of a specially sealed steel case with integrated flexure zones. Please call for dimensions and further details. The following translators are available with water-resistant cases: P-844.xx, P-845.xx, P-225.xx, P-235.xx.

P-176.30 Magnetic Adapter
To attach P-820 translators to various positioning units the P-176.30 magnetic adapters are available. The P-176.30 can be glued on the top piece of the P-820.

Cables and Cable Adapters
A variety of cables, extension cables and adapters are available. See “Accessories” page 2-168 ff. in the “Piezo Drivers / Servo Controllers” section for further details.

Extended Temperature Range
Standard HVPZTs work in the temperature range from -40 °C to 80 °C (-40 °F to +176 °F). For applications requiring an extended temperature range the following options are available:

High-Temperature Range and High Vacuum (only for HVPZTs)
-40 °C to +150 °C / -40 °F to +302 °F / 233 K to 423 K
The piezo ceramics are enclosed in a stainless steel case with vent holes. Special electrical insulation materials are used. The nominal displacement of the PZT is reduced by about 20% (due to the stiff insulation materials). The electrical connection is via two 1.5 m Kapton leads with LEMO connector.

Low-Temperature Range
-273 °C to +80 °C / -459 °F to +176 °F / 0 K to 353 K
Generally all PZT ceramics function down to zero kelvin. However, piezo translators are constructed of a combination of materials (ceramics, metal, insulating materials...) which makes the situation more complex.

To qualify the piezoelectric translators for cryogenic temperatures, special insulation material and adhesives must be used. The low-temperature translators are delivered as bare ceramic stacks without case and mechanical preload. The electrical connection is via two 50 cm Teflon leads without connectors.
Accessories

Accessories can be installed after manufacture.

P-176.Bxx Ball Tips
To avoid bending moments and shear forces on the PZT ceramics, a ball tip is available that can be screwed into the top piece of the individual translators.
- P-176.B12 Ball tip for P-212
- P-176.B16 Ball tip for P-216
- P-176.B25 Ball tip for P-225 and P-235

P-176.Fxx Flat Tips
Flat Tips are available and can be screwed into the top piece of the individual translators.
- P-176.F12 Flat tip for P-212
- P-176.F16 Flat tip for P-216
- P-176.F25 Flat tip for P-225
- P-176.F35 Flat tip for P-235

P-176.10/20 Magnetic Adapter
To attach P-840/1 and P-212 translators to various positioning units the P-176.10/20 magnetic adapters are available. The P-176.20 can be screwed into the top piece of the P-840/1. The P-176.10 can be screwed into the top piece of the P-212.

P-176.50/60 Flexible Tip
PZT ceramic stacks cannot withstand bending forces. The P-176.50/60 flexible tips are available for applications where it is not possible to avoid those forces. They can be screwed into the standard top pieces of the P-842/3 and P-844/5 translators. See drawing.

Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-176.50</th>
<th>P-176.60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thread</td>
<td>M5/M5</td>
<td>M8/M8</td>
</tr>
<tr>
<td>Ø [mm]</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>L [mm]</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Tilting angle [deg]</td>
<td>±0.5</td>
<td>±0.5</td>
</tr>
<tr>
<td>Axial stiffness [N/μm]</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Bending stiffness [Nm/rad]</td>
<td>22</td>
<td>40</td>
</tr>
</tbody>
</table>
Accessories (cont.)

Cables, Connectors & Adapters for PICA™ HVPZT Piezo Translators and Nanopositioning Systems

Notes

Unless stated otherwise, PI’s preloaded PICA™ HVPZT piezo translators and nanopositioners are equipped with LEMO connectors and 1 m PVC cables. The voltage connector is an FGG.0B.701.CJL.1173. With integrated P-177.10 strain gauge, an additional sensor cable is installed. The length of the sensor cable is 1 m, the material PUR and the connector a LEMO FFA.0S.304.CLAC32 as shown on the P-892 cable.

P-202.xx PICA™ HVPZT Cable
LEMO plug / solderable end
Plug: FGG.0B.701.CJL.1173 (fits PICA™ HVPZT amplifiers, e.g. E-508.00)
Cable with PUR insulation, 2-conductor, shielded

This cable can be soldered to PZTs with pigtails

- P-202.06 0.6 m
- P-202.10 1 m
- P-202.12 2 m
- P-202.13 3 m
- P-202.15 5 m

P-203.xx PICA™ HVPZT
Extension Cable
Plug: FGG.0B.701.CJL.1173
Socket: PHG.0B.701.CJL.1173
Cable: PUR-insulation, 2-conductor, shielded

- P-203.01 1 m
- P-203.02 2 m
- P-203.03 3 m
- P-203.05 5 m
- P-203.10 10 m
- P-203.15 15 m
Sensor Extension Cables

**P-892.xx Sensor Extension Cable**

For strain gauge sensors or LVDTs.
Plug (right):
FFA.0S.304.CLAC32
Socket (left):
PCA.0S.304.CLLC32
Cable: 4 wires; = Ø 0.20 mm;
#32 AWG (American)
= #35 SWG (British)
PVC-Isolation

<table>
<thead>
<tr>
<th>P-892.xx</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-892.01</td>
<td>1 m</td>
</tr>
<tr>
<td>P-892.02</td>
<td>2 m</td>
</tr>
<tr>
<td>P-892.03</td>
<td>3 m</td>
</tr>
<tr>
<td>P-892.05</td>
<td>5 m</td>
</tr>
<tr>
<td>P-892.10</td>
<td>10 m</td>
</tr>
</tbody>
</table>

**D-892 Sensor Extension Cable Set**

For capacitive sensors.
Set of two.
Plug (e.g., far left)
FFA.00.250.CTLC20
Socket (e.g., far right)
PCA.00.250.CTAC22
Cable: LSM 75 (Teflon)

<table>
<thead>
<tr>
<th>D-892.xx</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-892.01</td>
<td>1 m</td>
</tr>
<tr>
<td>D-892.02</td>
<td>2 m</td>
</tr>
<tr>
<td>D-892.03</td>
<td>3 m</td>
</tr>
</tbody>
</table>
Notes on Specifications for Piezo Actuators and Components

Operating voltage
For PICMA® ceramic equipped piezo actuators: 0 to 100 V typ. Max. recommended operating voltage range is -20 to +120 V (extremes for short durations only).

For PICA™ ceramic equipped piezo actuators: 0 to 1000 V typ. Voltages in excess of +750 V should not be applied for long durations. Operation in the range of -200 to +750 V is recommended for maximum lifetime and displacement.

For shear and bender type piezo actuators, bipolar voltage is applied, ranging from ±30 V up to ±250 V typ.

Motion and Positioning
Performance specifications are valid for room temperature (22 ±3 °C) and closed-loop systems are calibrated at this temperature (specifications for different operating temperatures on request). Recalibration is recommended for operation at a significantly higher or lower temperature. Custom designs for ultra-low or ultra-high temperatures on request.

Integrated feedback sensor
Absolute measuring capacitive and SGS sensors are used to provide position information to the controller. For details see the tutorial “Piezoelectrics in Positioning” Section (see p. 2-187 ff).

Open-loop travel for PICMA® Ceramic Equipped Piezo Stages and Actuators
Minimum open-loop travel at 0 to 100 V operating voltage.

Open-loop travel for PICA™ Ceramic Equipped Piezo Actuators
Minimum open-loop travel of high-voltage piezo actuators at 0 to +1000 V operating voltage.

Closed-loop travel for PICMA® Ceramic Equipped Piezo Stages and Actuators
Travel provided in closed-loop operation. PI piezo amplifiers have an output voltage range of -20 to +120 V or -30 to +135 V to provide enough margin for the servo-controller to compensate for load changes, etc.

Open-loop / closed-loop resolution
Resolution of piezo actuators is basically infinitesimal because it is not limited by stiction or friction. Instead of resolution, the noise-equivalent motion is specified. Values are typical results (RMS, 1 σ), measured with E-503/E-508 amplifier module in E-500/501 chassis.

Mechanical Properties

Static large-signal stiffness
Typical tolerance ±20%. Static large-signal stiffness of the stage in operating direction at room temperature. Small-signal stiffness and dynamic stiffness may differ because of effects caused by the active nature of piezoelectric material, compound effects, etc. For details see the tutorial “Piezoelectrics in Positioning” Section (see p. 2-189 ff).

Unloaded resonant frequency
Typical tolerance ±20%. Lowest resonant frequency in operating direction (does not specify the maximum operating frequency). For details see the tutorial “Piezoelectrics in Positioning” Section (see p. 2-192 ff).

Push/pull force capacity (in operating direction)
Specifies the maximum forces that can be applied to the system along the active axis. Limited by the piezo ceramic material and the flexure design. If larger forces are applied, damage to the piezo ceramic, the flexures or the sensor can occur. The force limit must also be considered in dynamic applications.

Example: the dynamic forces generated by sinusoidal operation at 500 Hz, 20 μm peak-to-peak, 1 kg moved mass, are approximately ±100 N. For details see the tutorial “Piezoelectrics in Positioning” Section (see p. 2-192 ff).

Torque limit (on tip)
Maximum torque that can be applied before damage occurs. Limited by the piezo ceramics.

Shear force limit
Maximum lateral force orthogonal to the operating direction. Limited by the piezo ceramics.
Drive Properties

Electrical capacitance
Typical tolerance ±20%. The piezo capacitance values indicated in the technical data tables are typical small-signal values (measured at 1 V, 1000 Hz, 20 °C, no load). Large-signal values at room temperature are 30 to 50% higher. The capacitance of piezo ceramics changes with amplitude, temperature, and load, up to 200% of the unloaded, small-signal capacitance at room temperature. For detailed information on power requirements, refer to the amplifier frequency-response graphs in the Piezo Drivers / Servo Controllers (p. 2-99 ff) Section of this catalog.

Dynamic Operating Current Coefficient (DOCC)
Typical tolerance ±20%. Average electrical current (supplied by the amplifier) required to drive a piezo actuator per unit frequency and unit displacement (sine-wave operation). For example to find out if a selected amplifier can drive a given piezo stage at 50 Hz with 30 μm amplitude, multiply DOC coefficient by 50 x 30 and check if the result is smaller or equal to the output current of the selected amplifier. For details see the tutorial “Piezoelectrics in Positioning” Section (p. 2-195 ff).

Miscellaneous

Operating temperature range
The temperature range indicates where the piezo actuator may be operated without damage. Nevertheless, recalibration or zero-point-adjustment may be required if the system is operated at different temperatures. Performance specifications are valid for room temperature range.

Material
Housings are usually made of stainless steel. Small amounts of other materials may be used internally (for spring preload, piezo coupling, mounting, thermal compensation, etc.).

Al: Aluminum
N-S: Non-magnetic stainless steel
S: Ferromagnetic stainless steel
I: Invar
T: Titanium

See also “Options and Accessories” (p. 1-102 ff).
# Headquarters

**GERMANY**

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstr. 1  
76228 Karlsruhe/Palmbach  
Tel: +49 (721) 4846-0  
Fax: +49 (721) 4846-100  
info@pi.ws · www.pi.ws

PI Ceramic GmbH  
Lindenstr.  
07589 Lederhose  
Tel: +49 (36604) 882-0  
Fax: +49 (36604) 882-25  
info@piceramic.de  
www.piceramic.de

---

# Subsidiaries

**USA (East) & CANADA**

PI (Physik Instrumente) L.P.  
16 Albert St.  
Auburn, MA 01501  
Tel: +1 (508) 832 3456  
Fax: +1 (508) 832 0506  
info@pi-usa.us  
www.pi-usa.us

---

**USA (West) & MEXICO**

PI (Physik Instrumente) L.P.  
5420 Trabuco Rd., Suite 100  
Irvine, CA 92620  
Tel: +1 (949) 679 9191  
Fax: +1 (949) 679 9292  
info@pi-usa.us  
www.pi-usa.us

---

**JAPAN**

PI Japan Co., Ltd.  
Akebono-cho 2-38-5  
Tachikawa-shi  
Tokyo 190  
Tel: +81 (42) 526 7300  
Fax: +81 (42) 526 7301  
info@pi-japan.jp  
www.pi-japan.jp

---

**CHINA**

Physik Instrumente (PI Shanghai) Co., Ltd.  
Building No. 7-301  
Longdong Avenue 3000  
201203 Shanghai, China  
Tel: +86 (21) 687 900 08  
Fax: +86 (21) 687 900 98  
info@pi-china.cn  
www.pi-china.cn

---

**UK & IRELAND**

PI (Physik Instrumente) Ltd.  
Lambda House  
Batford Mill  
Harpenden, Hertfordshire  
AL5 5BZ  
Tel: +44 (1582) 711 650  
Fax: +44 (1582) 712 084  
uk@pi.ws  
www.physikinstrumente.co.uk

---

**FRANCE**

PI France S.A.S.  
32 rue Delizy  
93694 Pantin Cedex  
Tel: +33 (1) 57 14 07 10  
Fax: +33 (1) 41 71 18 98  
info@pifrance.fr  
www.pifrance.fr

---

**ITALY**

Physik Instrumente (PI) S.r.l.  
Via G. Marconi, 28  
20091 Bresso (MI)  
Tel: +39 (02) 665 011 01  
info@pionline.it  
www.pionline.it