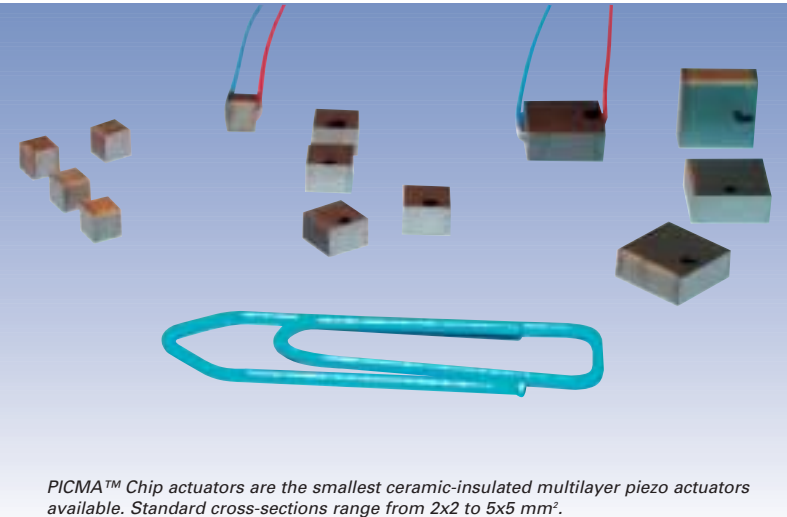


PL022
PL033
PL055

PICMA™ Chip Monolithic Multilayer Piezo Actuators



PICMA™ Chip actuators are the smallest ceramic-insulated multilayer piezo actuators available. Standard cross-sections range from 2x2 to 5x5 mm².

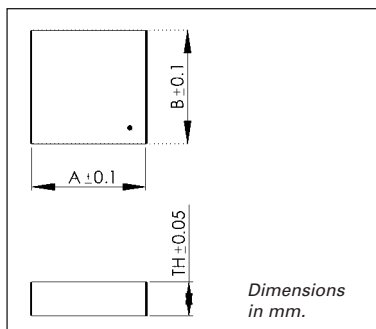
Application Examples

- Static and Dynamic NanoPositioning
- Laser Tuning
- Micro-dispensing
- Interferometry
- Life Sciences
- Photonics

- Ceramic Insulation for Extended Lifetime
- Ultra-Compact from 2x2x2 mm³
- High Curie Temperature
- Ideal for Dynamic Operation
- Sub-Millisecond Response / Sub-Nanometer Resolution
- UHV Compatible to 10⁹ hPa
- Superior Lifetime Even Under Extreme Conditions

Ultra-Compact Monolithic Piezo Actuators

PICMA™ Chip actuators are the smallest monolithic multilayer piezo actuators available. Providing sub-nanometer resolution and sub-millisecond response, they are ideally suited to high-level dynamic applications. PICMA™ actuators consist of a highly reliable ceramic-insulated PZT block (made of ~ 50 μm layers) with solderable terminations, and come in standard sizes as small as 2x2x2 mm³.



Optimized PZT Ceramics, Humidity Resistance

PICMA™ actuators are made from a ceramic material in which the piezoceramic properties such as stiffness, capacitance, displacement, temperature stability, leakage current and lifetime are optimally combined. The monolithic, ceramic-insulated design makes polymer-film insulation unnecessary. Diffusion of water molecules into the insulation layer, the major cause of dielectric breakdown, is greatly reduced by the use of cofired outer ceramic insulation.

Long Lifetime and High Performance—Ideal for Dynamic Operation

PICMA™ Chip actuators are superior to conventional actuators in high-endurance situations, where they show substantially longer lifetimes both in static and dynamic operation, even in harsh environments. Due to their high resonant frequency, these actuators are ideally suited for dynamic operation with light loads; an external preload is

recommended for dynamic operation with larger loads. The high Curie temperature of 320 °C provides a usable temperature range extending up to 150 °C, well above the 80 °C limit of conventional multilayer actuators. At the low end, operation down to a few kelvin is possible. (with some reduction in performance specifications).

Optimum UHV Compatibility—Minimal Outgassing

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

Amplifiers, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low-power drivers to multi-channel, closed-loop, digital controllers. Of course, PI also designs custom amplifiers and controllers.

Technical Data / Ordering Numbers

Ordering Number*	Dimensions A x B x TH in mm	Displacement [μm ±20% @ 100V]	Blocking Force [N]	Electrical Capacitance [nF ±20%]	Resonant Frequency [kHz]
PL022.30	2 x 2 x 2	2.2	> 250	25	> 300
PL033.20**	3 x 3 x 2	2.2	> 300	160	> 300
PL033.30	3 x 3 x 2	2.2	> 300	50	> 300
PL055.20**	5 x 5 x 2	2.2	> 500	450	> 300
PL055.30	5 x 5 x 2	2.2	> 500	250	> 300

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

Resonant frequency measured at 1 V_{pp}, capacitance measured at 1 V_{pp}, 1 kHz.

Max. operating voltage: -20 to +100 V

Max. operating temperature: 150°C (** 85°C only)

Standard Mechanical Interface: ceramic (top & bottom)

Standard Electrical Interface: solderable termination

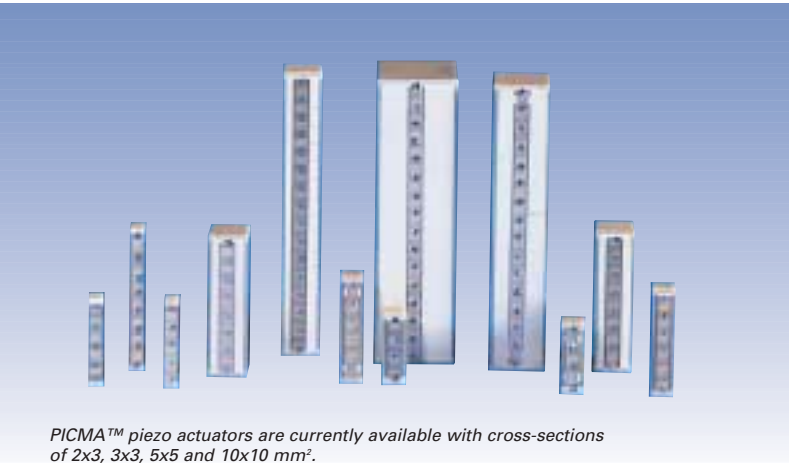
Available Options: special mechanical interfaces, etc.

Other specifications on request.

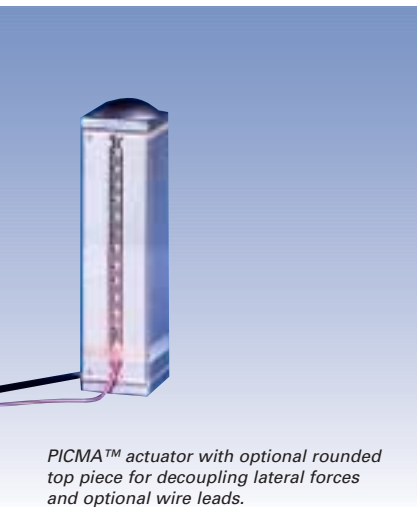
Specifications subject to change without notice.

P-882-
P-888

PICMA™ High-Performance Monolithic Multilayer Piezo Actuators



PICMA™ piezo actuators are currently available with cross-sections of 2x3, 3x3, 5x5 and 10x10 mm².



PICMA™ actuator with optional rounded top piece for decoupling lateral forces and optional wire leads.

- **Low Operating Voltage**
- **Superior Lifetime Even Under Extreme Conditions**
- **Very Large Operating-Temperature Range**
- **High Humidity Resistance**
- **Excellent Temperature Stability**
- **High Stiffness**
- **UHV Compatible to 10⁻⁹ hPa**
- **Sub-Millisecond Response & Sub-Nanometer Resolution**

Increased Lifetime and Higher Performance

PICMA™ (PI Ceramic Monolithic Actuator) 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.

New Production Process, Optimized PZT Ceramics

PICMA™ piezo actuators are made from a ceramic material

in which the piezoceramic properties such as stiffness, capacitance, displacement, temperature stability, leakage current and lifetime are optimally combined. The actuators' monolithic design and special electrode structure was made possible by advances in production technology. This development is just one reflection of the more than 30 years experience of PI Ceramic with thousands of industrial PZT applications.

Increased Lifetime through Humidity Resistance

The monolithic, ceramic-insulated design makes polymer-film insulation unnecessary. Diffusion of water molecules into the insulation layer, the major cause of dielectric breakdown, is greatly reduced by the use of cofired, outer ceramic insulation.

High-Level Dynamic Performance—Very Wide Temperature Range

The high Curie temperature of 320 °C gives PICMA™ actuators a usable temperature range extending up to 150 °C. This means that they can be operated in hotter environments, or they can be driven harder in dynamic operation (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 some reduction in performance specifications).

Optimum UHV Compatibility—Minimal Outgassing

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

Ideal for Closed-Loop Operation

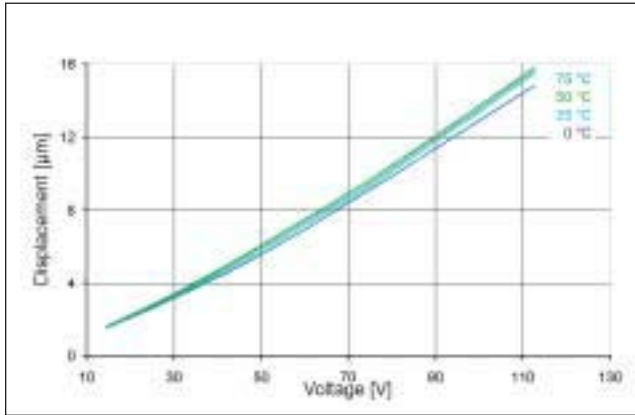
The ceramic surface of the actuators is extremely well suited for use with resistive or optical fiber strain gauge sensors. Such sensors can be easily applied to the actuator surface and exhibit significantly higher stability and linearity than with conventional polymer-insulated actuators.

Amplifiers, Drivers & Controllers

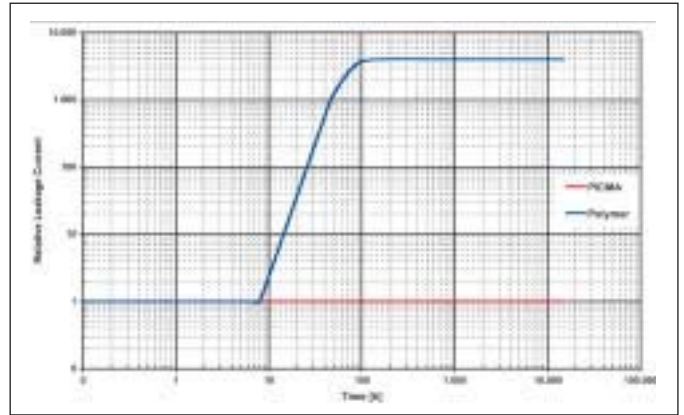
PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low-power drivers to multichannel, closed-loop, digital controllers. Of course, PI also designs custom amplifiers and controllers.

Application Examples

- Precision Mechanics and Mechanical Engineering
- NanoPositioning / High-Speed Switching
- Active and Adaptive Optics
- Vibration cancellation
- Pneumatic & Hydraulic Valves
- Metrology / Interferometry
- Life Sciences, Medicine and Biology



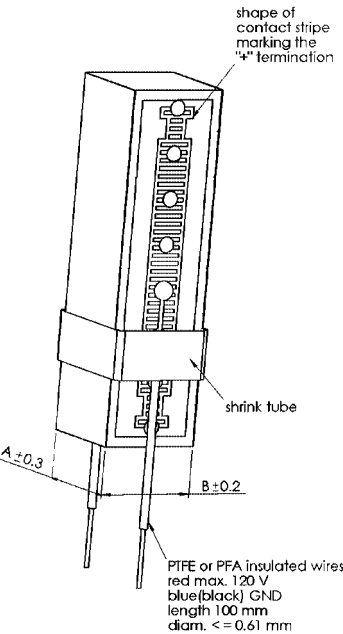
The displacement of PICMA™ actuators exhibits very low temperature dependence. This, in combination with their low heat generation, makes PICMA™ actuators optimal for dynamic operation. (Operating frequency $f = 200$ Hz)



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 indication of insulation quality and expected lifetime. Test conditions: $U = 100 V_{dc}$; $T = 25$ °C; Relative Humidity = 70%



PICMA™ actuators are also available with 100 mm leads (order number extension .x1). Shown here is the 15 µm P-885.51 (battery for size comparison).



PICMA™ dimensions, in mm

Technical Data / Ordering Numbers

Ordering Number*	Dimensions A x B x L [mm]	Nominal Displacement [µm @ 100 V]	Max. Displacement [µm @ 120 V]	Blocking Force [N @ 120 V]	Stiffness [N/µm]	Electrical Capacitance [µF] (±20%)	Resonant Frequency [kHz]
P-882.10	2 x 3 x 9	6.5 ± 20%	8 ± 20%	190	24	0.13	135
P-882.20	2 x 3 x 11	8.5 ± 20%	10.5 ± 20%	210	20	0.18	110
P-882.30	2 x 3 x 13.5	11 ± 20%	13 ± 20%	210	16	0.22	90
P-882.50	2 x 3 x 18	15 ± 10%	18 ± 10%	210	12	0.31	70
P-883.10	3 x 3 x 9	6.5 ± 20%	8 ± 20%	290	36	0.21	135
P-883.20	3 x 3 x 11	8.5 ± 20%	10.5 ± 20%	310	29	0.27	110
P-883.30	3 x 3 x 13.5	11 ± 20%	13 ± 20%	310	24	0.35	90
P-883.50	3 x 3 x 18	15 ± 10%	18 ± 10%	310	18	0.48	70
P-885.10	5 x 5 x 9	6.5 ± 20%	8 ± 20%	800	100	0.6	135
P-885.20	5 x 5 x 11	8.5 ± 20%	10.5 ± 20%	850	82	0.8	110
P-885.30	5 x 5 x 13.5	11 ± 20%	13 ± 20%	870	67	1.1	90
P-885.50	5 x 5 x 18	15 ± 10%	18 ± 10%	900	50	1.5	70
P-885.90	5 x 5 x 36	32 ± 10%	38 ± 10%	950	25	3,1	40
P-887.30	7 x 7 x 13.5		ask about availability !				
P-887.50	7 x 7 x 18		ask about availability !				
P-887.90	7 x 7 x 36		ask about availability !				
P-888.30	10 x 10 x 13.5	11 ± 20%	13 ± 20%	3500	267	4.3	90
P-888.50	10 x 10 x 18	15 ± 10%	18 ± 10%	3600	200	6.0	70
P-888.90	10 x 10 x 36	32 ± 10%	38 ± 10%	3800	100	13.0	40

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

Unloaded (longitudinal) resonant frequency measured at 1 V_{pp} , capacitance at 1 V_{pp} , 1 kHz.

Standard PZT ceramic type: PIC 252 (see page 40)

Max. operating voltage: -20 to +120 V
 Max. operating temperature: -40 to +150 °C
 Recommended preload 15 to 30 MPa

Standard Mechanical Interface: ceramic (top & bottom)
 Standard Electrical Interface: solderable termination

Available Options: Strain Gauge Sensors, special mechanical interfaces, etc.
 Other specifications on request.
 Specifications subject to change without notice.

P-007-
P-056

PICA-Stack Piezoceramic Actuators Versatile Piezoelectric Power



Variety of standard and custom PICA-Stack piezo actuators.

Application Examples

- NanoPositioning
- High-load positioning
- Precision mechanics
- Semiconductor manufacturing and testing
- Laser tuning
- Switching
- Smart structures (adaptronics)

Notes

PICA-Stack actuators are delivered with metal endcaps for improved robustness and reliability. Adherence to the mounting and handling guidelines on page 50 will help you obtain maximum performance and lifetime from your piezo actuators. Please contact a PI Ceramic applications engineer for additional technical support.

- High Load Capacity to 100 kN
- High Force Generation to 80 kN
- Large Cross Sections (to 56 mm Diameter)
- Variety of Shapes
- Extreme Reliability >10⁹ Cycles
- Proven and Flexible Design
- Sub-Nanometer-Resolution / Sub-Millisecond-Settling-Time
- Vacuum-Compatible Versions

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-Stack 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: PI Ceramic's Strength

All manufacturing processes at PI Ceramic are setup 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 for your application 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 Displacement
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances

- Custom-Molded Versions
- Integrated Piezoelectric Sensor Discs
- Special High / Low Temperature Versions
- Vacuum Compatible Versions

Short Leadtime, Standard & Custom Designs

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

Amplifiers, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low-power drivers to multi-channel, closed-loop, digital controllers. Of course, PI also designs custom amplifiers and controllers.



Custom PICA-Stack actuator with 350 μ m displacement.

Technical Data / Ordering Numbers

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

Unloaded (longitudinal) resonant frequency measured at $1 V_{pp}$, capacitance at $1 V_{pp}$, 1 kHz. Blocking force at 1000 V.

Standard PZT ceramic type: PIC 151 (see page 40)

Operating voltage range: 0 to 1000 V

Operating temperature range: -20 to +85 °C

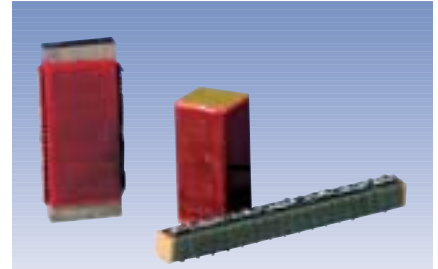
Standard mechanical interface (top & bottom): steel plates, 0.5 - 2 mm thick (depends on model)

Standard electrical interface: two PTFE insulated wires, pigtail length 100 mm

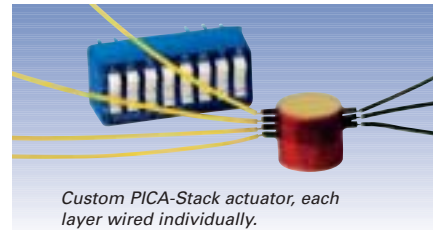
Available options: integrated piezo force sensor or strain gauge sensors, non magnetic, vacuum compatible, etc.

Other specifications on request.

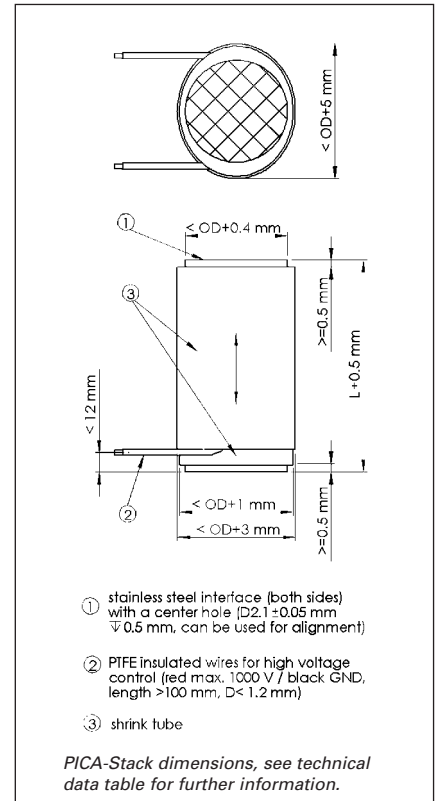
Specifications subject to change without notice.



Custom PICA-Stack actuators with rectangular cross-sections.

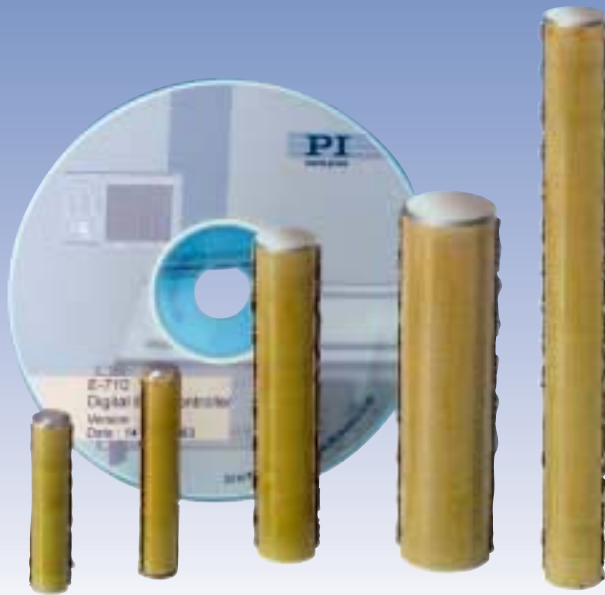


Custom PICA-Stack actuator, each layer wired individually.



P-007.xxP
P-056.xxP

PICA-Power High-Level Dynamics Piezo Actuators



Variety of PICA-Power piezo stack actuators from 5 μ m to 180 μ m travel range.

Application Examples

- NanoPositioning
- Active vibration damping and cancellation
- High-load positioning
- Precision machining
- Semiconductor manufacturing and testing
- Laser tuning
- Switching
- Smart structures (adaptronics)

- **Operating Temperature to 150 °C**
- **Temperature Sensor PT1000 applied**
- **High Load Capacity to 80 kN**
- **Large Cross-Sections (to 56 mm Diameter)**
- **Extreme Reliability >10⁹ Cycles**
- **Sub-Nanometer Resolution / Sub-Millisecond Settling Time**
- **Ultra-High-Vacuum-Compatible Versions to 10⁻⁹ hPa**
- **Non-Magnetic Versions**

PICA-Power-series piezoceramic stack actuators are offered in a large variety of standard shapes and sizes, with additional custom designs to suit any application. Based on the PIC 255 material, these actuators are especially well-suited for industrial, high-level dynamic applications.

Extra-High Reliability for High-Level Dynamics, High-Temperature Applications

PICA-Power actuators are optimized for high-temperature working conditions and high-duty-cycle dynamic 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-Power actuators prove consistent performance, even after billions (1,000,000,000) of cycles.

Flexibility: PI Ceramic's Strength

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 for your application 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 Displacement
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (alumina, glass, sapphire, ...)
- Extra-Tight Length Tolerances
- Custom-Molded Versions
- Integrated Piezoelectric Sensors

- Custom UHV Versions (10⁻⁹ h Pa)
- Clear Aperture Available

Short Leadtime for Standard & Custom Designs

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

Amplifiers, Drivers & Controllers

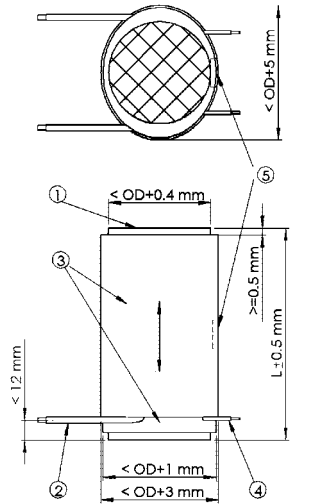
PI offers a wide range of piezo control electronics (see page 28 and www.pi.ws), from low-power drivers to the ultra-high-performance E-480 power amplifier delivering 2000 W of dynamic power (see PI catalog).

For closed-loop positioning applications, a variety of analog and digital controllers is also available. The modular E-500 system (see PI catalog) 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.



PICA-Power actuators are available with cross sections to 56 mm!



- ① stainless steel interface (both sides) with a center hole (D2.1 ±0.05 mm ∇ 0.5 mm, can be used for alignment)
- ② PTFE insulated wires for high voltage control (red max. 1000 V / black GND, length >100 mm, D < 1.2 mm)
- ③ shrink tube
- ④ temperature sensor wires (PTFE insulated, yellow/yellow, length >100 mm, D < 0.7 mm)
- ⑤ temperature sensor PT 1000 (centered)

PICA-Power actuator dimensions, see technical data table for further information.

Technical Data / Ordering Numbers

Ordering Number	Displacement [μm -10/+20%]	Diameter D [mm]	Length L [mm ± 0.5]	Blocking force [N]	Stiffness [N/ μm]	Capacitance [nF $\pm 20\%$]	Resonant Frequency [kHz]
P-010.00P	5	10	9	1200	240	17	129
P-010.10P	15	10	18	1800	120	46	64
P-010.20P	30	10	31	2100	68	90	37
P-010.40P	60	10	58	2200	37	180	20
P-010.80P	120	10	111	2300	19	370	10
P-016.10P	15	16	18	4500	300	130	64
P-016.20P	30	16	31	5400	180	250	37
P-016.40P	60	16	58	5600	94	510	20
P-016.80P	120	16	111	5900	49	1000	10
P-016.90P	180	16	163	6000	33	1600	7
P-025.10P	15	25	20	9900	660	320	58
P-025.20P	30	25	33	12000	400	630	35
P-025.40P	60	25	60	13000	220	1300	19
P-025.80P	120	25	113	14000	120	2600	10
P-025.90P	180	25	165	14000	80	4000	7
P-035.10P	15	35	21	18000	1200	530	55
P-035.20P	30	35	34	23000	760	1200	34
P-035.40P	60	35	61	26000	430	2500	19
P-035.80P	120	35	114	28000	230	5200	10
P-035.90P	180	35	166	29000	160	7800	7
P-045.20P	30	45	36	36000	1200	2100	32
P-045.40P	60	45	63	41000	680	4300	18
P-045.80P	120	45	116	44000	370	8800	10
P-045.90P	180	45	169	45000	250	13000	7
P-056.20P	30	56	36	54000	1800	3300	32
P-056.40P	60	56	63	66000	1100	6700	18
P-056.80P	120	56	116	68000	570	14000	10
P-056.90P	180	56	169	70000	390	21000	7

Unloaded (longitudinal) resonant frequency measured at $1 V_{pp}$, capacitance at $1 V_{pp}$, 1 kHz. Blocking force at 1000 V.

Standard PZT ceramic type: PIC 255 (see page 40)
 Operating voltage range: 0 to 1000 V
 Operating temperature range: -20 to +150 °C
 Standard mechanical interface (top & bottom): steel plates, 0.5 to 2 mm thick (depends on model)
 Standard electrical interfaces: PTFE insulated wires, pigtail length 100 mm
 Available options: integrated piezo sensor or strain gauge sensors, non-magnetic, UHV, etc.

Other specifications on request.
 Specifications subject to change without notice.



Custom preloaded PICA-Power piezo actuator with forced-air cooling.

P-010.xxH

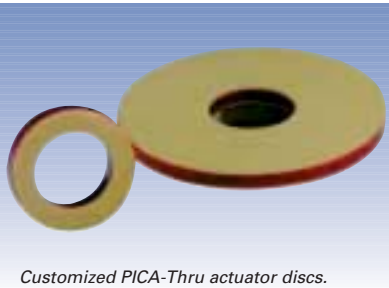
P-016.xxH

P-025.xxH

PICA-Thru Piezo Stack Actuators with Aperture



PICA-Thru piezo stack actuators with clear aperture.



Customized PICA-Thru actuator discs.

- **Clear Aperture for Transmitted-Light Applications**
- **Large Cross-Sections Available (to 56 mm Diameter)**
- **Variety of Shapes**
- **Extreme Reliability >10⁹ Cycles**
- **Proven and Flexible Design**
- **Sub-Nanometer Resolution / Sub-Millisecond Settling-Time**
- **Vacuum Compatible Versions**

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.

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: PI Ceramic's Strength

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 for your application at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

- Custom Materials
- Custom Voltage Ranges
- Custom Geometries
- Custom Displacement
- Custom Load / Force Ranges
- Custom Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances
- Custom-Molded Versions
- Integrated Piezoelectric Sensor Discs
- Low Temperature Versions
- Vacuum Versions

Short Leadtime for Standard & Custom Designs

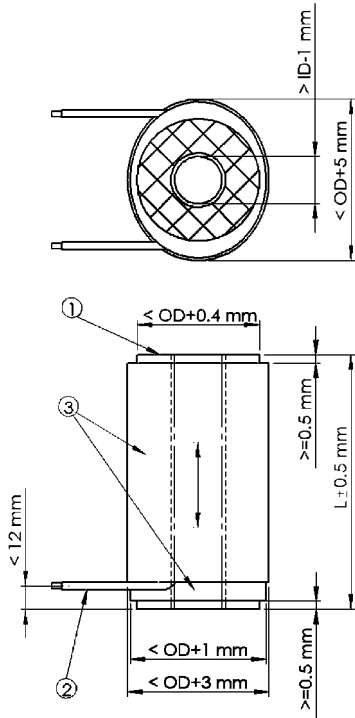
Because all piezoelectric materials used in PICA actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom PICA actuators are delivered with performance test sheets.

Amplifiers, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low-power drivers to multi-channel, closed-loop, digital controllers. Of course, PI also designs custom amplifiers and controllers.

Application Examples

- Optics
- Image stabilization
- Laser tuning
- Laser treatment
- Precision mechanics
- Confocal microscopy
- Micropositioning



- ① ceramic interface (both sides)
- ② PTFE insulated wires for high voltage control (red max. 1000 V / black GND, length >100 mm, D< 1.2 mm)
- ③ shrink tube

PICA-Thru piezo actuator dimensions, see technical data table for further information.

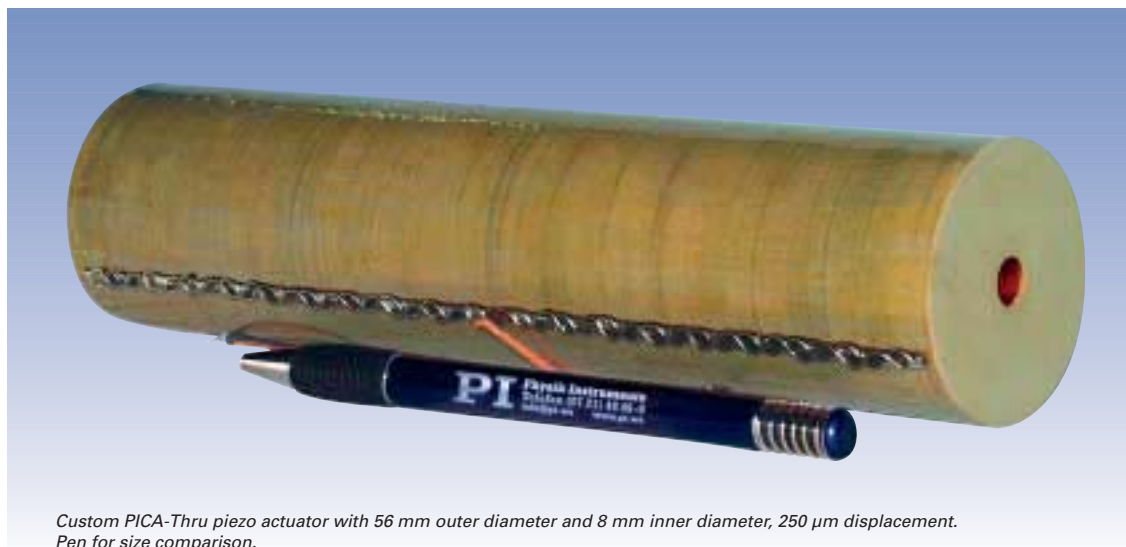
Technical Data / Ordering Numbers

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

Unloaded (longitudinal) resonant frequency measured at 1 V_{pp}, capacitance at 1 V_{pp}, 1 kHz. Blocking force at 1000 V.

Standard PZT ceramic type: PIC 151 (see page 40)
 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
 Standard electrical interface: two PTFE insulated wires, pigtail length 100 mm
 Available options: integrated piezo sensor or strain gauge sensors, vacuum compatible, etc.

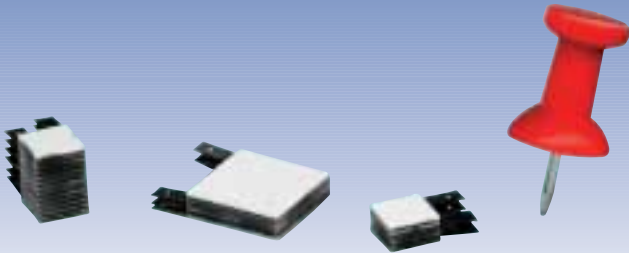
Other specifications on request.
 Specifications subject to change without notice.



Custom PICA-Thru piezo actuator with 56 mm outer diameter and 8 mm inner diameter, 250 µm displacement. Pen for size comparison.

P-111-
P-151

PICA-Shear Piezo Actuators—Compact Multiaxis Motion



PICA-Shear actuators are available in cross-sections from 3 mm x 3 mm to 16 mm x 16 mm.

- **Compact Multiaxis Actuators**
- **X, XY, XZ and XYZ Versions**
- **High Resonant Frequencies**
- **Extreme Reliability >10⁹ Cycles**
- **Picometer-Resolution / Sub-Millisecond Settling Time**
- **Ultra-High-Vacuum-Compatible Versions to 10⁻⁹ hPa**
- **Non-Magnetic and Clear Aperture Versions**

PICA-Shear series multi-axis piezo actuators are only available from PI Ceramic. These devices are extremely compact and feature sub-nanometer resolution and ultra-fast response. They are available in a variety of geometries providing displacements to 10 µm.

High Stiffness under High Duty Cycles

PICA-Shear actuators exhibit high stiffness, both parallel and perpendicular to the motion direction. Based on the piezoelectric shear effect, PICA-Shear X and XY actuators show almost twice the displacement amplitudes of conventional piezo actuators at the same electric field. Con-

sequently 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.

Ultra-High Reliability, High Displacement, Low Power Requirements

PICA 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.

Flexibility: PI Ceramic's Strength

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 for your application, at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

- Vacuum Versions to 10⁻⁹ hPa
- Non-Magnetic Designs
- Clear Aperture
- Custom Endplates (Alumina, Glass, ...)
- Extra-Tight Length Tolerances, to 0.02 mm
- Optical Surface Quality
- Custom Geometries
- Custom Displacement
- Custom Load / Force Ranges
- Low-Temperature Designs, Down to L-He
- Combination with Piezoelectric Shear Sensors (no Pyroelectric Effect)

Short Leadtime for Standard & Custom Designs

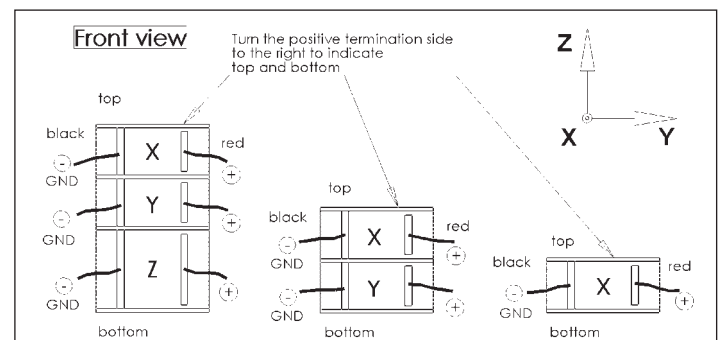
Because all piezoelectric materials used in PICA actuators are manufactured at PI Ceramic, leadtimes are short and quality is outstanding. All standard and custom PICA actuators are delivered with performance test sheets.

Amplifiers, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low power drivers to multi-channel, closed-loop, digital controllers. Of course, PI also designs custom amplifiers and controllers.

Application Examples

- NanoPositioning
- Precision mechanics
- Active vibration cancellation
- Semiconductor manufacturing and testing
- Laser tuning
- Atomic force microscopy
- Switching
- Scanning applications
- Micro-stepper motors



Technical Data / Ordering Numbers

Ordering Number	Active Axes	Displacement [μm -10/+20%]	Cross section A x B / ID [mm]	Length L [mm ± 0.3]	Max. Shear Load [N]	Axial Stiffness [N/ μm]	Capacitance [nF $\pm 20\%$]	Resonant Frequency [kHz]
P-111.01	X	1*	3 x 3	3.5	20	70	0.5	330
P-111.03	X	3*	3 x 3	5.5	20	45	1.5	210
P-111.05	X	5	3 x 3	7.5	20	30	2.5	155
P-121.01	X	1*	5 x 5	3.5	50	190	1.4	330
P-121.03	X	3*	5 x 5	5.5	50	120	4.2	210
P-121.05	X	5	5 x 5	7.5	40	90	7	155
P-141.03	X	3*	10 x 10	5.5	200	490	17	210
P-141.05	X	5	10 x 10	7.5	200	360	28	155
P-141.10	X	10	10 x 10	12	200	230	50	100
P-151.03	X	3*	16 x 16	5.5	300	1300	43	210
P-151.05	X	5	16 x 16	7.5	300	920	71	155
P-151.10	X	10	16 x 16	12	300	580	130	100
P-112.01	XY	1 x 1*	3 x 3	5	20	50	0.5 x 0.5	230
P-112.03	XY	3 x 3*	3 x 3	9.5	10	25	1.5 x 1.5	120
P-122.01	XY	1 x 1*	5 x 5	5	50	140	1.4 x 1.4	230
P-122.03	XY	3 x 3*	5 x 5	9.5	40	70	4.2 x 4.2	120
P-122.05	XY	5 x 5	5 x 5	14	30	50	7 x 7	85
P-142.03	XY	3 x 3*	10 x 10	9.5	200	280	17 x 17	120
P-142.05	XY	5 x 5	10 x 10	14	100	190	28 x 28	85
P-142.10	XY	10 x 10	10 x 10	23	50	120	50 x 50	50
P-152.03	XY	3 x 3*	16 x 16	9.5	300	730	43 x 43	120
P-152.05	XY	5 x 5	16 x 16	14	300	490	71 x 71	85
P-152.10	XY	10 x 10	16 x 16	23	100	300	130 x 130	50
P-123.01	XYZ	1 x 1 x 1*	5 x 5	7.5	40	90	1.4 x 1.4 x 2.9	155
P-123.03	XYZ	3 x 3 x 3*	5 x 5	15.5	10	45	4.2 x 4.2 x 7.3	75
P-143.01	XYZ	1 x 1 x 1*	10 x 10	7.5	200	360	5.6 x 5.6 x 11	155
P-143.03	XYZ	3 x 3 x 3*	10 x 10	15.5	100	170	17 x 17 x 29	75
P-143.05	XYZ	5 x 5 x 5	10 x 10	23	50	120	28 x 28 x 47	50
P-153.03	XYZ	3 x 3 x 3*	16 x 16	15.5	300	450	43 x 43 x 73	75
P-153.05	XYZ	5 x 5 x 5	16 x 16	23	100	300	71 x 71 x 120	50
P-153.10	XYZ	10 x 10 x 10	16 x 16	40	60	170	130 x 130 x 230	30
P-153.10H	XYZ	10 x 10 x 10	16 x 16 / 10	40	20	120	89 x 89 x 160	30
P-151.03H	X	3*	16 x 16 / 10	5.5	200	870	30	210
P-151.05H	X	5	16 x 16 / 10	7.5	200	640	49	155
P-151.10H	X	10	16 x 16 / 10	12	200	460	89	100

* Tolerances $\pm 30\%$

Unloaded (longitudinal) resonant frequency measured at $1 V_{pp}$, capacitance at $1 V_{pp}$, 1 kHz.

Standard PZT ceramic type: PIC 255 (see page 40). For more information on the shear effect see p. 42.

Operating voltage range: -250 V to +250 V

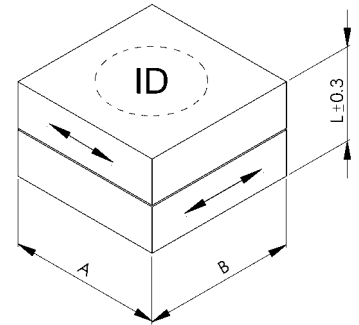
Operating temperature range: -20 to +85 °C

Standard mechanical interface (top & bottom): ceramic plates

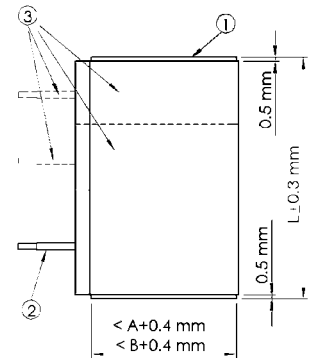
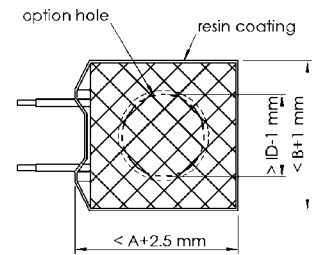
Available options: integrated piezo sensor, non-magnetic, UHV, low temperature, clear aperture etc.

Other specifications on request.

Specifications subject to change without notice.



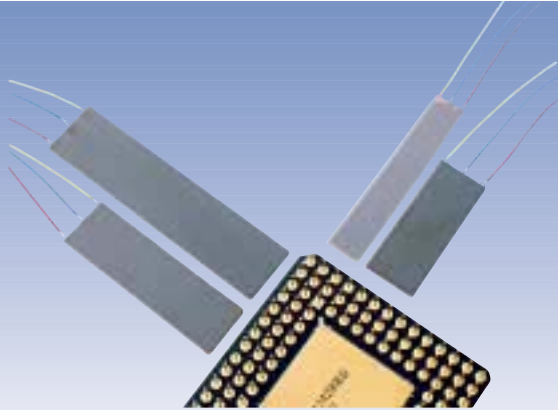
PICA-Shear actuator dimensions, in mm. See technical data table for explanation of A, B, L.



- ① ceramic interface (both sides)
- ② PTFE insulated wires for high voltage control (red +250 V / black GND, length >100 mm, D < 0.7 mm), axial position centered at the termination line of the stack element
- ③ number of axis elements and wires is dependent on stack type

PL112-
PL140

PICMA™ Multilayer Bender Actuators



Bender actuators with optional wire leads (order number extension .x1); microprocessor for size comparison.

- For OEM Applications
- Ceramic Insulation
- Positioning Range up to 2 mm
- Fast Response (< 10 msec)
- Nanometer-Range Resolution
- Low Operating Voltage
- Vacuum-Compatible Versions
- Available with Integrated Position Sensor
- Special OEM and Bench-Top Amplifiers/Drivers Available

PICMA™-series multilayer bender piezo actuators provide a deflection of up to 2 mm, forces up to 2 N (200 grams) and response times in the millisecond range. These multilayer piezoelectric components are manufactured from ceramic layers of only about 25 μm thickness. They feature internal silver-palladium electrodes and ceramic insulation applied in a co-firing process. The bender 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 60 V only. The reduced voltage allows smaller drive electronics and new applications, such as in medical equipment. Additionally these devices offer an improved humidity resistance due to the 100 % ceramic insulation.

Long Lifetime and High Performance—Ideal for Dynamic Operation

PICMA™ Bender actuators are superior to conventional actuators in high-endurance situations. They show substantially longer lifetimes both in static and dynamic operation, even in harsh environments. The monolithic, ceramic-insulated design makes polymer-film insulation unnecessary. Diffusion of water molecules into the insulation layer, the major cause of dielectric breakdown, is greatly reduced by the use of cofired, outer ceramic insulation.

The high Curie temperature of 320 °C gives PICMA™ actuators a usable temperature range extending up to 150 °C, well above the 80 °C limit of conventional multilayer actuators. At the low end, operation down to a few kelvin is possible (with some reduction in performance specifications).

Optimum UHV Compatibility—Minimal Outgassing

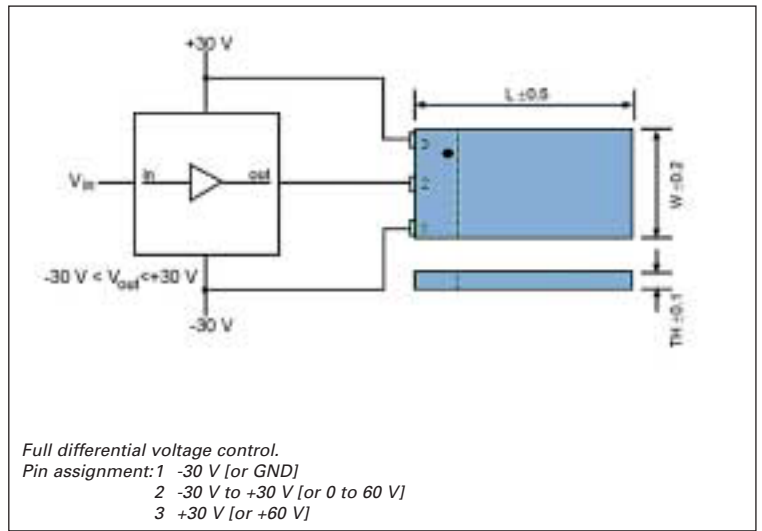
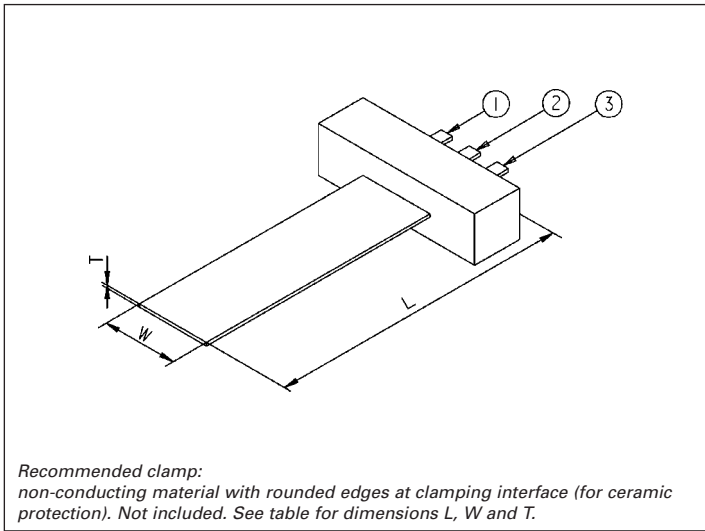
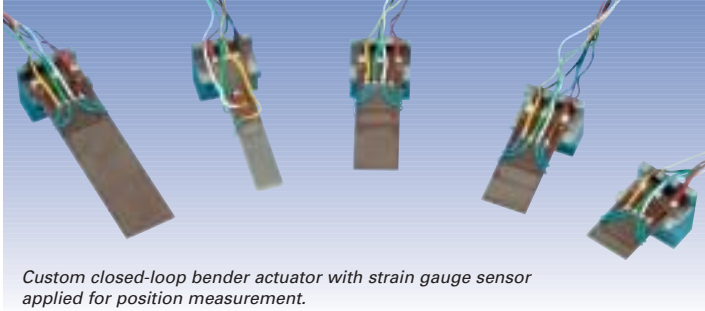
The lack of polymer insulation and the high Curie temperature make for optimal ultra-high-vacuum compatibility (no measurable outgassing / high bakeout temperatures, up to 150 °C).

Amplifiers, Drivers & Controllers

PI offers a wide range of standard amplifiers and controllers for piezo actuators (see page 28 and www.pi.ws). The E-650.00 and E-650.OE drivers were specifically designed to operate PICMA™ Bender actuators. For closed-loop positioning applications, a variety of analog and digital controllers are available. Of course, PI also designs custom amplifiers and controllers.

Application Examples

- Wire bonding
- Pneumatic valves
- Fiber optic switches
- Beam deflection
- Micropositioning
- Acceleration sensors



Technical Data / Ordering Numbers

Ordering Number*	Operating Voltage [V]	Nominal displacement [$\mu\text{m} \pm 20\%$]	Free length [mm]	Dimensions L x W x T [mm]	Blocking Force [N]	El. capacitance [$\mu\text{F} \pm 20\%$]	Resonant Frequency [Hz]
PL112.10**	0 - 60	± 80	12	17.8 x 9.6 x 0.65	2.0	2 x 1.1	> 1000
PL122.10	0 - 60	± 250	22	25.0 x 9.6 x 0.65	1.1	2 x 2.4	660
PL127.10	0 - 60	± 450	27	31.0 x 9.6 x 0.65	1.0	2 x 3.4	380
PL128.10**	0 - 60	± 450	28	35.5 x 6.3 x 0.75	0.5	2 x 1.2	360
PL140.10	0 - 60	± 1000	40	45.0 x 11.0 x 0.6	0.5	2 x 4.0	160

* For optional 100 mm wire leads change order number extension to .x1 (e.g. PL 112.11).

All parameters depend on actual clamping conditions and applied load.

Operating Temperature: -20 °C to +85 °C (** max. 150 °C)

Low temperature option available

Closed-loop option on request (strain-gauge-sensor)

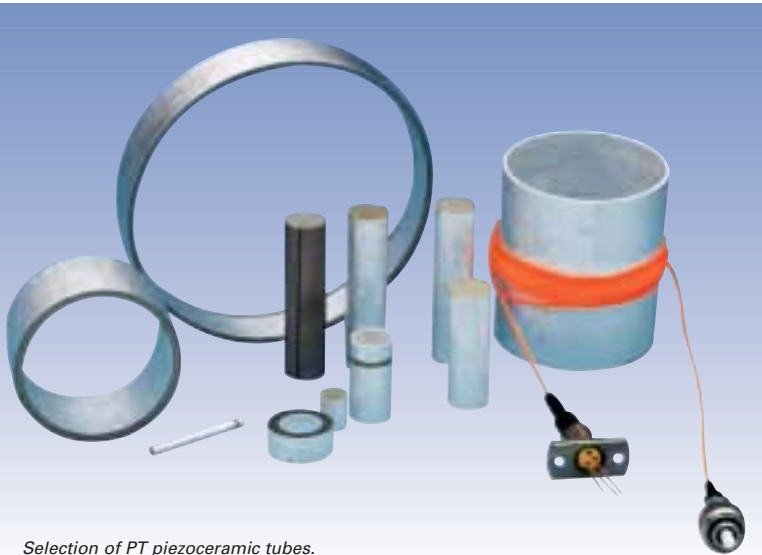
Other specifications on request.

Specifications subject to change without notice.

Capacitance measured at 1 V_{pp} , 1 kHz. Unloaded ("free bending") resonant frequency measured at 1 V_{pp} .

PT120- PT140

Piezoceramic Tubes



Selection of PT piezoceramic tubes.

- Standard & Custom Sizes
- For OEM Applications
- XYZ- Positioning
- Sub-Nanometer Resolution

PT series piezoceramic tubes are used in a wide range of applications from microdispensing to scanning microscopy. These monolithic components contract laterally (radi-

ally) 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: PI Ceramic's Strength

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 0.025 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 for your application, at a very attractive price, even for small quantities. Some of our custom capabilities are listed below:

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

Short Leadtime for Standard & Custom Designs

Because all piezoelectric materials used in PT tube 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, Drivers & Controllers

PI offers a wide range of control electronics for piezo actuators (see page 28 and www.pi.ws) from low power drivers to multi-channel, closed-loop, digital controllers.

Application Examples

- Micropositioning
- Scanning Microscopy (STM, AFM, etc.)
- Fiber Stretching / Modulation of Optical Path Length
- Micro Pumps / Ink-Jet Printing
- Micromanipulators
- Ultrasonic and Sonar Applications

Technical Data / Ordering Numbers

Ordering Number	Dimensions L x OD x ID**	Max. Operating Voltage [V]	Electrical Capacitance [nF ±20%]	Axial Contraction µm @ max. V	Radial Contraction µm @ max. V	XY Deflection [µm]
PT120.00	20 x 2.2 x 1.0	500	3	4		n/a
PT130.00	30 x 3.2 x 2.2	500	10	8	0.5	n/a
PT130.90	30 x 3.2 x 2.2	500	12	8	0.6	n/a
PT130.94*	30 x 3.2 x 2.2	±200	4 x 2.4	8	0.6	±6
PT130.10	30 x 6.35 x 5.35	500	18	6	1.0	n/a
PT130.14*	30 x 6.35 x 5.35	±200	4 x 3.8	6	1.0	±8
PT130.20	30 x 10.0 x 9.0	500	36	8	4	n/a
PT130.24*	30 x 10.0 x 9.0	±200	4 x 8.5	8	4	±14
PT130.30	30 x 10.0 x 8.0	1000	18	8	3	n/a
PT130.40	30 x 20.0 x 18.0	1000	35	8	5	n/a
PT140.70	40 x 40.0 x 38.0	1000	70	15	10	n/a

All models available with 40 mm length, except PT120.00

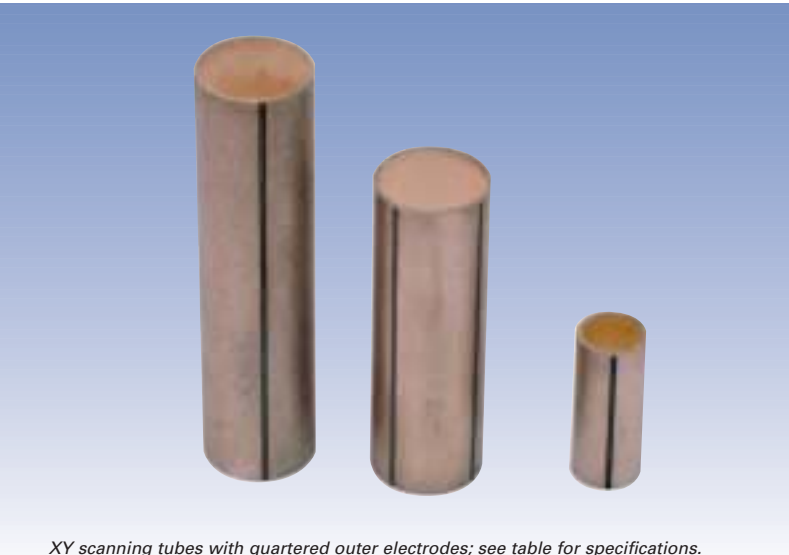
* Quartered electrodes for XY deflection

All standard PT Tubes are made of PIC151 PZT material (see page 40).

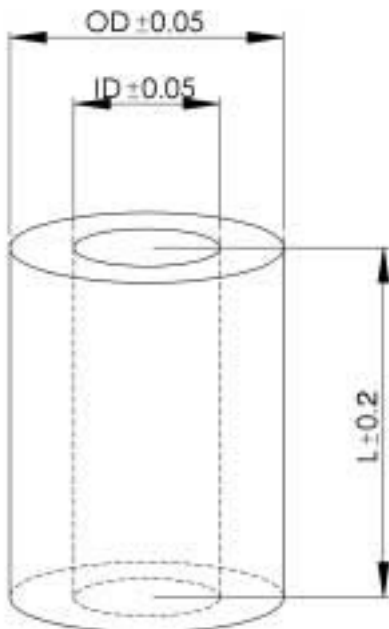
** OD, ID ±0.05 mm all models except PT120 / PT 130.00 (±0.1 mm)

Other specifications on request.

Specifications subject to change without notice.



XY scanning tubes with quartered outer electrodes; see table for specifications.



PT Tube dimensions, in mm (see table for further information).

Design

Dimensions: max. L: 50 mm
max. OD: 80 mm
min. wall thickness: 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 axial segmenting (quartered outer electrodes)

Polarization: inner electrode, positive potential

Useful Equations

Axial contraction and radial displacement of piezo tube actuators can be estimated by the following equations:

(Equation 1)

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

where:

d_{31} = strain coefficient (displacement normal to polarization direction) [m/V]

L = length of the ceramic tube [m]

U = operating voltage [V]

d = wall thickness [m]

(Equation 2)

$$\Delta d \approx d_{33} \cdot U$$

where:

Δd = change in wall thickness [m]

d_{33} = strain coefficient (field and displacement in polarization direction) [m/V]

U = operating voltage [V]

The radial contraction is the superposition of the increase in wall thickness and the tangential contraction; it can be estimated by the following equation:

$$\frac{\Delta r}{r} \approx d_{31} \frac{U}{d}$$

where:

r = tube radius

d_{31} = strain coefficient (displacement normal to polarization direction) [m/V]

U = operating voltage [V]

d = wall thickness [m]

The quartered electrodes option makes XY scanning possible — employing the superposition of the axial and radial contraction, similar to bending devices. These scanner tubes, which flex in X and Y, are widely used in scanning-probe microscopes. The scan range of these components is estimated by:

(Equation 3)

$$\Delta x \approx \frac{2\sqrt{2} \cdot d_{31} \cdot L^2 \cdot U}{\pi \cdot ID \cdot d}$$

where:

Δx = scan range in X and Y (for symmetrical electrodes) [m]

d_{31} = strain coefficient (displacement normal to polarization direction) [m/V]

U = symmetric operating voltage [V]

L = length [m]

ID = inner diameter [m]

d = wall thickness [m]

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

PT Tubes are also used as transducers in ultrasonic and sonar applications.