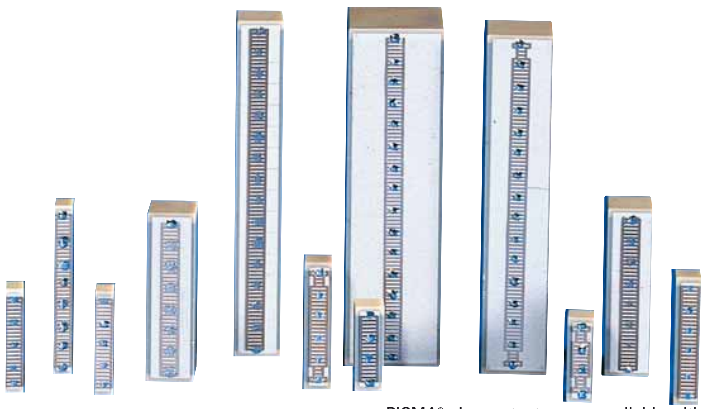
P-882 · P-888 PICMA® Multilayer Piezo Stack Actuators

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

- **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^{-9} 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.

Application Examples

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

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!

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).

PICMA® actuator with optional 0.1 m PTFE insulated wire leads and optional rounded top piece for decoupling lateral forces

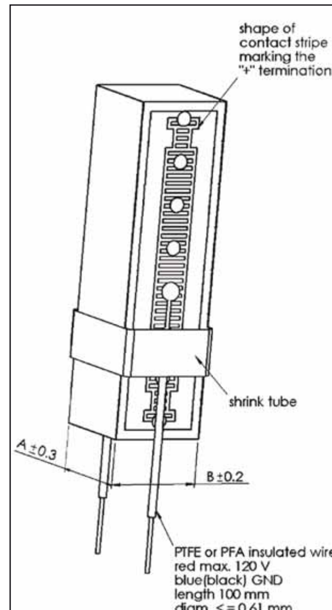
Ideal for Closed-Loop Operation

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.

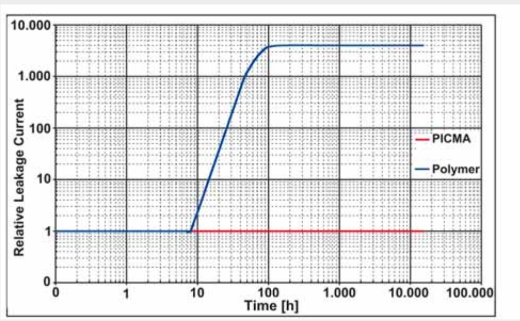
Piezo Drivers, Controllers & High-Voltage Amplifiers

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

Read more on PICMA® reliability on page 1-65 *ff.*

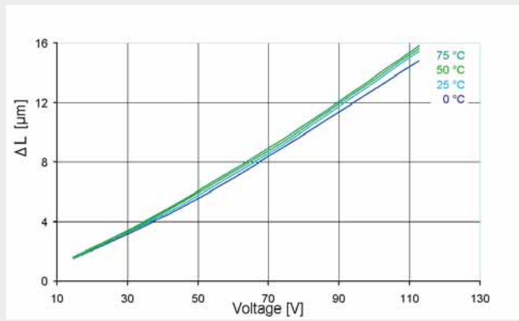


PICMA® actuators, dimensions in mm



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 %



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

Technical Data / Product Order Numbers

Order 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] ±20 %
P-882.11	3 x 2 x 9	6.5 ±20 %	8 ±20 %	190	24	0.15	135
P-882.31	3 x 2 x 13.5	11 ±20 %	13 ±20 %	210	16	0.22	90
P-882.51	3 x 2 x 18	15 ±10 %	18 ±10 %	210	12	0.31	70
P-883.11	3 x 3 x 9	6.5 ±20 %	8 ±20 %	290	36	0.21	135
P-883.31	3 x 3 x 13.5	11 ±20 %	13 ±20 %	310	24	0.35	90
P-883.51	3 x 3 x 18	15 ±10 %	18 ±10 %	310	18	0.48	70
P-885.11	5 x 5 x 9	6.5 ±20 %	8 ±20 %	800	100	0.6	135
P-885.31	5 x 5 x 13.5	11 ±20 %	13 ±20 %	870	67	1.1	90
P-885.51	5 x 5 x 18	15 ±10 %	18 ±10 %	900	50	1.5	70
P-885.91	5 x 5 x 36	32 ±10 %	38 ±10 %	950	25	3.1	40
P-887.31	7 x 7 x 13.5	11 ±20 %	13 ±20 %	1700	130	2.2	90
P-887.51	7 x 7 x 18	15 ±10 %	18 ±10 %	1750	100	3.1	70
P-887.91	7 x 7 x 36	32 ±10 %	38 ±10 %	1850	50	6.4	40
P-888.31	10 x 10 x 13.5	11 ±20 %	13 ±20 %	3500	267	4.3	90
P-888.51	10 x 10 x 18	15 ±10 %	18 ±10 %	3600	200	6.0	70
P-888.91	10 x 10 x 36	32 ±10 %	38 ±10 %	3800	100	13.0	40

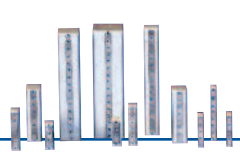
Standard piezo ceramic type: 252
Standard electrical interfaces: 100 mm wire leads
*For optional solderable contacts, change order number extension to .x0 (e. g. P-882.10).
Recommended preload for dynamic operation: 15 MPa
Maximum preload for constant force: 30 MPa
Resonant frequency at 1 V_{pp}, unloaded, free at both sides. The value is halved for unilateral clamping
Capacitance at 1 V_{pp}, 1 kHz
Operating voltage: -30 to +130 V; the lifetime depends on the voltage applied
Operating temperature range: -40 to +150 °C
Standard Mechanical Interfaces: Ceramics
Available Options: strain gauge sensors, special mechanical interfaces, etc.
Other specifications on request.

Low-cost Piezo Systems with Various Levels of Integration

For more information visit http://www.pi.ws

Piezo Actuator / Stage	Description	Travel Range up to	Guiding System	Mechanical Levels of Integrations	Positioning Sensor	Stiffness
P-882 - P-888	PICMA® Multilayer Piezo Stack Actuators	30 µm	-	-	optional SGS	up to 200 N/µm
P-871	PICMA® Piezo Bender Actuator	1600 µm	-	-	optional SGS	0.02 N/µm
P-842 - P-845	Preloaded Piezo Actuators	90 µm	-	case, mechanically preloaded	optional SGS	up to 200 N/µm
P-601	PiezoMove Linear Actuator	400 µm	flexure guiding system prevents tip and tilt	motion amplifier, mechanically preloaded	optional SGS	up to 0.8 N/µm
P-602	PiezoMove Flexure Actuator with High Stiffness	1000 µm	flexure guiding system provides straight motion with no tip and minimum tilt	motion amplifier, mechanically preloaded	optional SGS	up to 2.3 N/µm
P-603	PiezoMove Linear Actuator	500 µm	flexure guiding system prevents tip and tilt	motion amplifier, mechanically preloaded	optional SGS	up to 0.36 N/µm
P-712, P-713	Low-Profile Piezo Scanner	30 µm in X, XY	flexure guiding system provides straight motion with no tip and minimum tilt	motion amplifier, mechanically preloaded, P-713 parallel-kinematics	optional SGS	up to 0.8 N/µm
P-611	NanoCube® XYZ Piezo Stage	100 µm in up to 3 axes	flexure guiding system provides straight motion with no tip and minimum tilt	motion amplifier, mechanically preloaded, serial kinematics	optional SGS	up to 0.8 N/µm

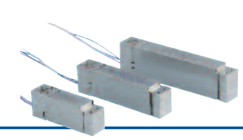
Controller	Function	Positioning Sensor	Number of Channels	Peak Output Current	Peak Output Power
E-831	Piezo Amplifier	-	1	100 mA (< 8 ms)	2 W without heat sink, 5 W with additional heat sink
E-610.00	Piezo Amplifier	-	1	180 mA (< 15 ms)	18 W (< 15 ms)
E-610.S0	Motion Controller	SGS	1	180 mA (< 15 ms)	18 W (< 15 ms)
E-621.SR	Networkable Motion Controller Module	SGS	1, networkable up to 16	120 mA (< 5 ms)	12 W (< 5 ms)



P-882 · P-888 PICMA® Multilayer Piezo Stack Actuators

P-871 PICMA® Piezo Bender Actuator

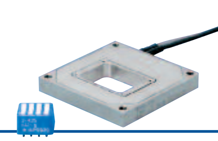
P-842 · P-845 Preloaded Piezo Actuators



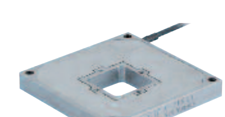
P-601 PiezoMove Linear Actuator

P-602 PiezoMove Flexure Actuator with High Stiffness

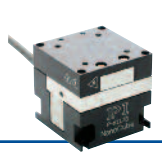
P-603 PiezoMove Linear Actuator



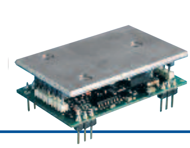
P-712 Low-Profile Piezo Scanner



P-713 Low-Profile Piezo Scanner



P-611 NanoCube® XYZ Piezo Stage



E-831 Piezo Amplifier

E-610 Piezo Amplifier/ Motion Controller

E-621.SR Motion Controller Module

Page numbers on the following pages refer to the hardbound 2009 PI catalog

PiezoMove: Moving, Positioning, Scanning

Microfluidics, Biotechnology, Medical Engineering, Adaptronics

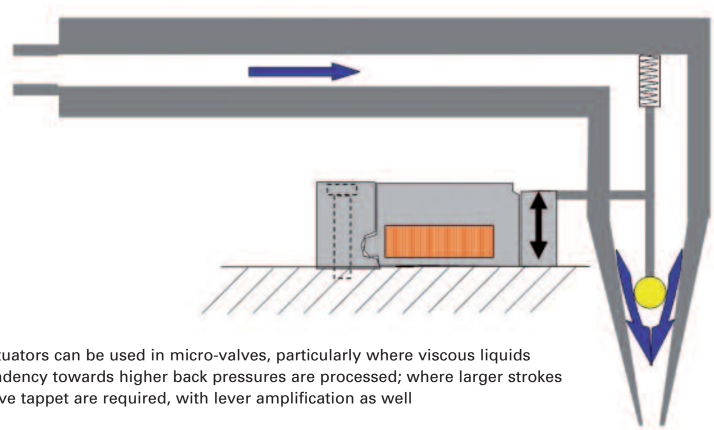
Piezo = nano = expensive?

Piezo actuators can do a lot more than "just" precision. Their excellent dynamics and high force play a crucial role in many areas, while the (nanometer) precision is of lesser importance: e.g. for fast switching, vibration cancellation, or to adjust tools in machines.

In these applications the piezo actuator is one – if not the only – solution and in the case of the new PiezoMove OEM actuators, at a very attractive price.

PiezoMove OEM actuators: Apply motion, how and where it is required

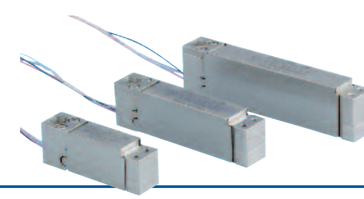
PiezoMove actuators combine guided motion and long travel ranges up to 1 mm and provide precision in the 10 nm range if ordered with the position sensor option. They are very compact, easy to integrate, require no maintenance and provide service life of Billions (10^9) of cyles.



Linear actuators can be used in micro-valves, particularly where viscous liquids with a tendency towards higher back pressures are processed; where larger strokes of the valve tappet are required, with lever amplification as well

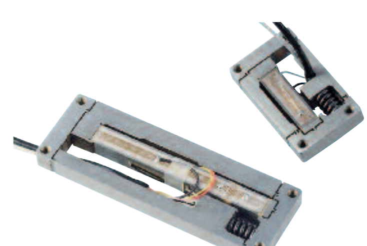
PI supplies a variety of standard integration levels and also customized versions: From simple piezo stack components and preloaded linear actuators through to 6-axis positioning systems with sub-nanometer precision.

3 Actuator Families



P-601: Travel ranges to 400 µm, slight tilt

P-602: Travel ranges to 1000 µm, slight tip and tilt, high stiffness



P-603: Travel ranges to 500 µm, slight tilt, cost-optimized for high quantities

For more information visit http://www.pi.ws

Application fields

Microfluidics:

Valves, pumps, microliter and nanoliter dosing

Biotechnology:

Cell manipulation, patch-clamp, microarrays, nanoliter dosing, dispensers, microstructuring with imprint processes

Medical engineering:

Diaphragm pumps, valves, dosing, injection, sample handling

Mechatronics, adaptronics:

Active structures, vibration isolation, active tools, structure deformation

Laser technology, metrology:

Cavity tuning, adjustment of optics or slit widths, sample positioning, beam control

PiezoMove: Travel Ranges to 1 mm

Easy Integration and Adaptation

Systems Thinking

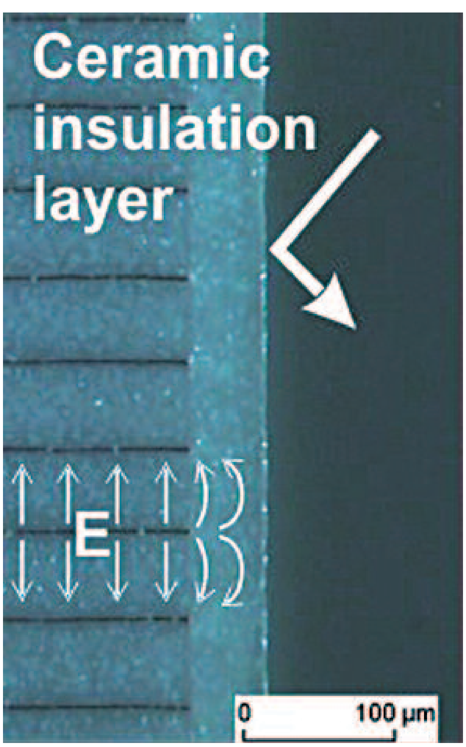
PI provides a range of different control electronics for PiezoMove actuators.
These range from solderable OEM piezo driver modules to advanced digital motion controllers.
PI's wide range of actuators and control electronics allows for an optimum match of performance and cost for any application.
In addition to standard products, modified or completely custom engineered solutions are available at competitive prices. The following parameters can be modified to suit an application:

- Travel range
- Dynamics
- Force
- Precision

Levels of Integration: From Stack Actuator to 6-Axis Stage

	Stack actuators	Lever-amplified actuators	Positioning systems
Travel ranges	up to approx. 150 µm	up to 1 mm	up to 2 mm
Axes moved	one	one	up to three linear axes and three tip/ tilt axes
Sensors	SGS optional	SGS optional	SGS or direct measuring capacitive sensors
Linearity	up to 99.8 %	up to 99.8 %	over 99.9 %
Guidance	none	flexures for rotations <10"	flexures for rotations <2"
Space required	low	low	depends on features
Price	low	low	depends on features
Integration effort	high	low	low

PI Actuators Offer Longer Service Life



The ceramic insulating layer prevents the penetration of water molecules and reliably protects the sensitive internal electrodes from mechanical damage and dirt

Different Piezo Solutions: Simple Piezo Components to Complex (Nano) Positioning Systems

Actuator: Piezo ceramic stack actuators are the driving force in many of PI's motion systems. Piezo actuators can move very rapidly due to their high stiffness; response times are as short as microseconds and scan frequencies up to several tens of kilohertz are feasible. The resolution is virtually unlimited, depending only on the electrical noise of the driver, making piezo actuators predestined for precision motion applications. The displacement of basic actuators is limited to a few tens of micrometers, however, and they need to be handled with care.

Preloading and Decoupling Against Lateral Forces: Encased piezo stacks can handle higher forces. The housing can decouple the piezo ceramics from lateral forces. Integrated mechanical preloading allows dynamic operation with higher loads.

Guiding System: Piezo ceramic stacks do not move in perfectly straight lines. For precise linear motion, a guiding system is required. Flexures guarantee the best performance because they provide frictionless, backlash-free motion and unlimited lifetime. If designed well, preloading and decoupling of unwanted forces can also be integrated without negative effects on the system stiffness.

Lever Amplification for Longer Travel Ranges: The guiding system can be designed in such a way that it acts like a mechanical lever and increases the displacement of the piezo ceramic stack. Lever amplifiers reduce the system stiffness and this is where experience pays off. PI uses CAD modeling, FEA analysis and laser vibrometry for design optimization and testing. Based on 3 decades of experience with piezo flexure design PI actuators provide the best combination of lifetime, stiffness, precision and size.

Sensor: Position feedback sensors are available when absolute position information is required. Strain gauge sensors (lower cost, accuracy to 0.5%) and capacitive sensors (higher precision to 0.01 %) are available.

Controller: The higher the demands placed on the system precision, the larger the role played by the motion controller. Open-loop actuators can be controlled directly via a voltage amplifier. To achieve maximum positional accuracy and scanning linearity, however, closed-loop control and digital control algorithms are indispensable.

Multi-Axis Positioners are constructed as parallel-kinematic systems for the highest possible precision, and controlled by advanced digital nanopositioning controllers.