

PT120 · PT140 PT Piezo Tube Actuators

Piezoceramic Tube Actuators with Small Tolerances and Various Options



A selection of PT piezoceramic tubes

- Standard & Custom Sizes
- Optional Quartered Electrodes for XYZ-Positioning & Scanning
- Sub-Nanometer Resolution
- Ideal for OEM-Applications

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:

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

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

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)

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

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)

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

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.



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

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)

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

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 ($\pm U$) of opposing electrodes results in bending of one of the ends, due to super-

position 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)

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

where:

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

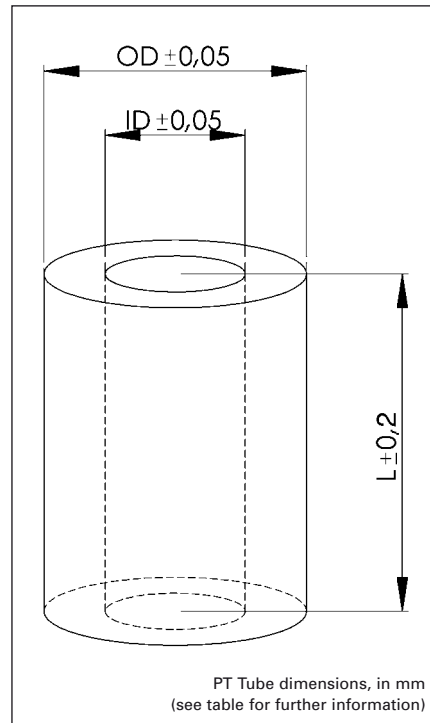
d_{31} = strain coefficient (displacement normal to polarization direction) [m/V]

U = operating voltage [V]

L = length [m]

ID = inner diameter [m]

d = wall thickness [m]



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

Linear Actuators & Motors

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

Order number	Dimensions [mm] L x OD x ID**	Max. operating voltage [V]	Electrical capacitance [nF] ±20%	Axial contraction [µm] @ max. V	Radial contraction [µm] @ max. voltage	XY deflection [µm] @ ±200 V
PT120.00	20 x 2.2 x 1.0	500	3	5	0.7	-
PT130.00	30 x 3.2 x 2.2	500	10	9	0.9	-
PT130.90	30 x 3.2 x 2.2	500	12	9	0.9	-
PT130.94*	30 x 3.2 x 2.2	±200	4 x 2.4	9	0.9	±35
PT130.10	30 x 6.35 x 5.35	500	18	9	1.8	-
PT130.14*	30 x 6.35 x 5.35	±200	4 x 3.8	9	1.8	±16
PT130.20	30 x 10.0 x 9.0	500	36	9	3	-
PT130.24*	30 x 10.0 x 9.0	±200	4 x 8.5	9	3	±10
PT130.30	30 x 10.0 x 8.0	1000	18	9	3	-
PT130.40	30 x 20.0 x 18.0	1000	35	9	6	-
PT140.70	40 x 40.0 x 38.0	1000	70	15	12	-

*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.

P-010.xxH – P-025.xxH PICA™ Thru Actuator High-Load Piezo Stack Actuators with Aperture



PICA™ Thru piezo stack actuators with clear aperture

- Clear Aperture for Transmitted-Light Applications for Mechanical Preloading
- Extreme Reliability >10⁹ Cycles
- Large Cross Sections to 56 mm Diameter
- Variety of Shapes
- Sub-Millisecond Response, Sub-Nanometer Resolution
- 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. 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 re-

duced 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:

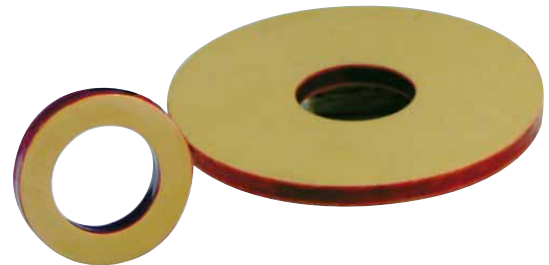
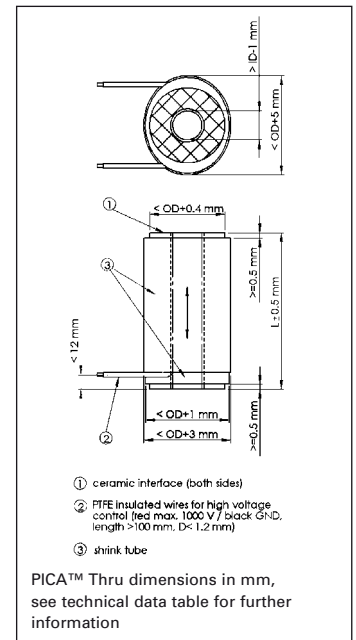
- Custom Materials
- Custom Voltage Ranges
- Custom Geometries (Circular, Rectangular, Triangular, Layer Thickness ...)
- Custom Load / Force Ranges
- Custom Flat or Spherical Endplates (Alumina, Glass, Sapphire, ...)
- Extra-Tight Length Tolerances
- Integrated Piezoelectric Sensor Discs
- Special High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

Because all piezoelectric materials used in PICA™ actuators are manufactured at PI Ceram-

ic, 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.



Customized PICA™ Thru actuator discs

Application Examples

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



Standard actuators are delivered with black heat shrink tube (shown here is the model P-010.20H)



Custom PICA™ Thru piezo actuator with 56 mm outside diameter, 8 mm inner diameter, 250 μ m displacement. Pen for size comparison

Linear Actuators & Motors

PiezoWalk® Motors / Actuators

PILine® Ultrasonic Motors

DC-Servo & Stepper Actuators

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Unpackaged Stack Actuators

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Technical Data / Product Order Numbers

Order numbers	Displacement [μ m] -10/+20 %	Diameter OD [mm]	Diameter ID [mm]	Length L [mm] \pm 0.5	Blocking force [N]	Stiffness [N/ μ m]	Capacitance [nF] \pm 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	21
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

Piezo ceramic type PIC 151
 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
 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.