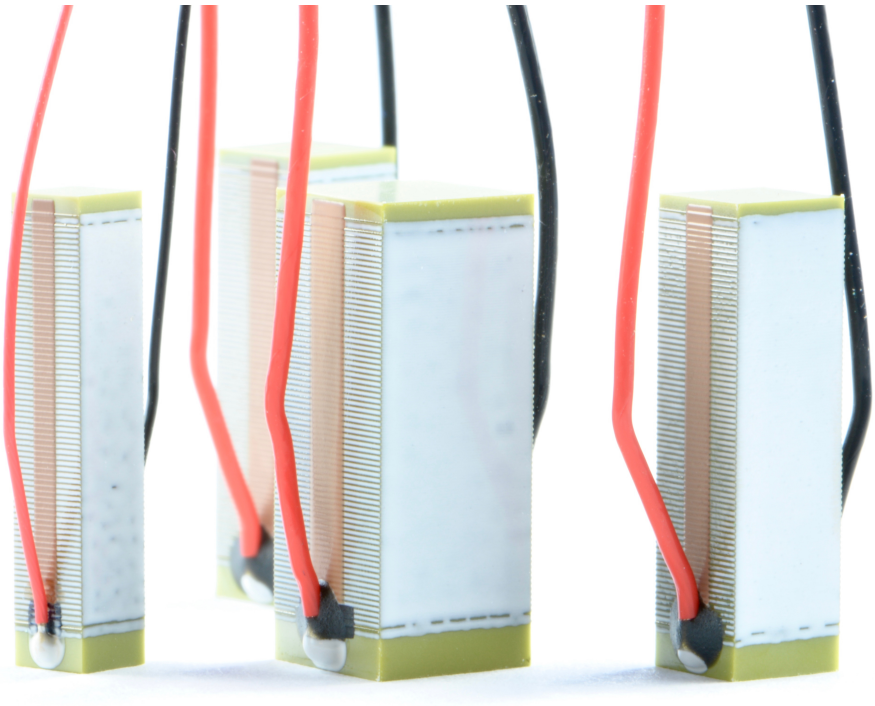
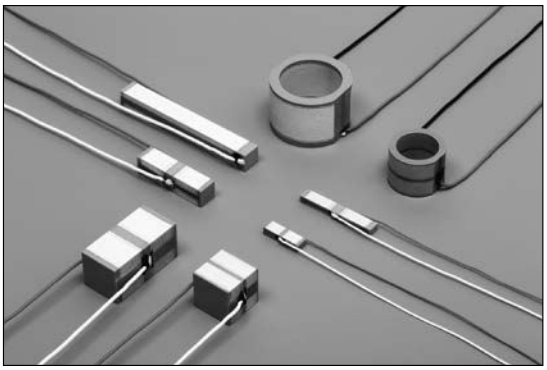


Type	Dimensions		Displacement		Electrical		Mechanical		
	Base Area	Length	0 - 150V	-30 - 150V	Capacity	Insulation	Resonanz	Stiffness	Force
	[mm^2]	[mm]	[micro meter]		[nF]	[MOhm]	[kHz]	kN/mm	[N]
PB 3.9	3,5 x 3,5	9	9	13	350	50	152	50	400
PB 3.18	3,5 x 3,5	18	20	28	800	10	76	25	400
PB 5.9	5 x 5	9	9	13	800	50	152	100	850
PB 5.18	5 x 5	18	20	28	1600	10	76	50	850
PB 5.40	5 x 5	40	42	58	3400	5	34	22	850
PB 7.18	7 x 7	18	20	28	3400	5	76	100	1700
PB 7.40	7 x 7	40	42	58	6700	5	34	40	1700
PB 10.18	10 x 10	18	20	28	6600	5	76	200	3500
PB 10.40	10 x 10	40	42	58	13600	2	34	80	3500
PB 14.18	14 x 14	18	20	28	11000	2	68	400	7000
PB 25.15	25 x 25	15	16	21	31000	0,4	68	1300	20000

Resin coated type multilayer piezoelectric actuators

Piezotechnik PB Series = TOKIN AE Series



Features

- Large generated force: 3,500 N/cm^2 (typ.)
- High-speed response: Driving up to about 1/3 of self-resonant frequency (in several ten kHz) is possible.
- Accurate positioning: Controllable in nm order.
- Low power consumption: Can be retained at the leakage current state (100 μA or less).
- Very small size: 1/10 or smaller than conventional multilayer actuators (specific volume)

Outline

Multilayer piezoelectric actuators are ceramic elements for converting electrical energy into mechanical energy such as displacement or force by utilizing the piezoelectric longitudinal effect d_{33}.
TOKIN's multilayer piezoelectric actuators are produced based on our unique element structure design and using originally developed piezoelectric ceramic materials with high electrostrictive factors. Compared to conventional piezoelectric actuators, they are smaller in size but can generate higher displacement and force at low voltages.
Especially, the resin-coated AE series actuators feature compact size and wide variety in shape for applications such as ultra-fine positioning mechanisms and drive sources.

Applications

Positioning, Auto focusing of optical system, Pumps, Valves, Vibration source, Vibration controls, Sensors, Image stabilization of DSC, Mirror / Prism positioning, Manipulators, Motors, Printer, etc.

Numbering system

Part Order Number
Example: **PB 5.18**

- **PB** — Series name: PB = Piezo Bare Stack
- **5** — Ceramic cross section: Example: 5 = 5 mm × 5 mm
- **18** — Overall length is 18 mm

TOKIN CODE
Example: **AE 0505 D16 XXX F**

- **AE** — Series name: AE = Resin-coated type
- **0505** — Ceramic cross section: Example: 0505 = 5 mm × 5 mm *Coating area is not include.
- **D16** — Nominal displacement: Indicated by two digits in micrometers [μm] D18 = 18μm
- **XXX** — Additional code (optional) Example: H18 = Overall length is 18 mm D = Thin coating type
- **F** — Comply with RoHS, Compliant to RoHS directive in effect as of December, 2014

Standard Parts List

Model	Cross Section [mm]	Overall length [mm]	Tokin - Label	Displacement [μm]		Generated force [N]	Stiffness (N/μm)	Resonance frequency [kHz]	Capacitance [μF]
				Unipolar voltage [150VDC]	Bipolar+ [- 30 VDC to 150VDC]				
PB2.5	2×3	5	AE0203D04DF	5.0±1.5	6.5±1.5	200	43.5	261	0.09
PB2.9		9	AE0203D08H09DF	9.0±1.5	13.0±1.5		25.0	152	0.16
PB2.10		10	AE0203D08DF	9.0±1.5	13.0±1.5		22.0	138	0.18
PB2.18		18	AE0203D18H18DF	20.0±2.0	28.0±2.0		11.1	76	0.4
PB3.9	3.5×3.5	9	AE035035D08H9DF	9.0±1.5	13.0±2.0	400	52.1	150	0.35
PB3.18		18	AE035035D18H18DF	20.0±6.6	28.0±6.6		23.3	76	0.82
PB5.9	5×5	9	AE0505D08H09DF	9.0±1.5	13.0±1.5	850	106.3	152	0.68
PB5.10		10	AE0505D08DF	9.1±1.5	13.0±1.5		93.4	138	0.75
PB5.18		18	AE0505D18H18DF	20.0±2.0	28.0±2.0		47.2	76	1.6
PB5.20		20	AE0505D16DF	17.4±2.0	22.4±2.0		48.9	69	1.4
PB5.40		40	AE0505D44H40DF	42.0±6.6	55.0±6.6		20.2	34	3.4
PB7.9	7×7	9	AE0707D08H09DF	9.0±1.5	13.0±1.5	1,700	212.5	152	1.4
PB7.10		10	AE0707D08DF	9.1±1.5	13.0±1.5		186.8	138	1.5
PB7.18		18	AE0707D18H18DF	20.0±2.0	28.0±2.0		94.4	76	3.4
PB7.20		20	AE0707D16DF	17.4±2.0	22.4±2.0		97.7	69	3.4
PB7.40		40	AE0707D44H40DF	42.0±6.6	55.0±6.6		40.5	34	6.7
PB10.9	10×10	9	AE1010D08H09DF	9.0±2.0	13.0±2.0	3,500	437.5	152	2.9
PB10.18		18	AE1010D18H18DF	20.0±3.5	28.0±3.5		194.4	76	6.6
PB10.20		20	AE1010D16DF	18.4±3.5	24.4±3.5		190.2	69	5.4
PB10.40		40	AE1010D44H40DF	42.0±6.6	55.0±6.6		83.3	34	13.6
PB14.20	14×14	20	AE1414D16DF	18.4±3.5	24.4±3.5	7,000	380.4	69	10.8
PB25.20	25×25	20	AE2525D15DF	15.6±2.0	20.6±2.0	20,000	1282.0	69	30.5

*Please contact us for the other sizes and specifications.

*For detail information of measurement conditions and outer dimension, please refer to “Performance” and “Outer Dimension” sections.

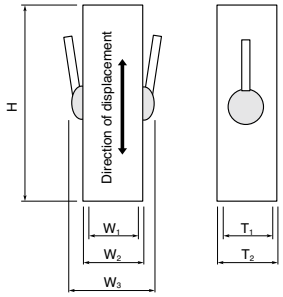
*+ Bipolar operation increases the maximum displacement of the piezo stack. It also increases the power output in transient operation and may cause heating and impact lifetime. Bipolar operation shall be carefully approved and validated before application.

Performance

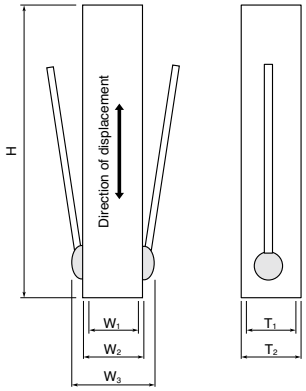
Item	Standard	Conditions
Operating temperature range	−25 to +85℃	When applied with a DC voltage: Ambient temperature When driven by an AC voltage: Ambient temperature + Temperature rise due to generated heat
Recommended Storage condition	−5 to +40℃ / less than 40%R.H	Recommend storage at room temperature. No condensation.
Maximum driving voltage	150VDC	
Displacement	See the standard parts list	At 150VDC
Generated force (compression resistance)	See the standard parts list	The force required for restricting the displacement to 0 when the maximum driving voltage is applied.
Capacitance	See the standard parts list	f＝1kHz,V=1Vrms（<10 μF） f＝120Hz,V=1Vrms（>10 μF）
Capacitance allowance	+/−20 %	
Dissipation factor	5% or less	
Insulation resistance	See the standard parts list	Value obtained in 1 minute at 150 VDC
Resonance frequency	See the standard parts list	With both ends of element in free state Typical value of the element under our test conditions
Tensile strength	1/10 of generated force	Typical value of the element under our test conditions
Young's modulus	$4.4 \times 10^{10} N/m^2$	Typical value of the element under our test conditions
Temperature cycle test	Displacement: Initial value ±20% Capacitance: Initial value ±30% tanδ : Less than initial rated value Insulation resistance: 1MΩ or more Appearance: No noticeable defect	Room temperature（3 min） −25℃（30 min.） Room temperature（3 min） +85℃（30 min） Repetition of 10 cycles of the above

Outer Dimensions

Overall length 10, 20mm Products



Overall length 5,9,18 and 40mm Products



Note:

Factory-shipped polarization : Red lead wire＝(＋) ,
White lead wire ＝(－)

Above drawings do not include dimension of wire connection area and diameter of the wire. Please contact us for details.

Unit：mm

Model	H	T1	W1	T2	W2	W3	L
PB2.5	5±0.1	2±0.1	3±0.1	2.4Max	3.4Max	5.5Max	100
PB2.9	9±0.1						
PB2.10	10±0.1						
PB2.18	18±0.1						
PB3.9	20±0.1	3.5±0.1	3.5±0.1	3.9Max	3.9Max	6Max	
PB3.18	40±0.1						
PB5.9	9±0.1	5±0.1	5±0.1	5.4Max	5.4Max	7.5Max	
PB5.10	10±0.1						
PB5.18	18±0.1						
PB5.20	20±0.1						
PB5.40	40±0.1						
PB7.9	9±0.1	7±0.1	7±0.1	7.4Max	7.4Max	9.5Max	
PB7.10	10±0.1						
PB7.18	18±0.1						
PB7.20	20±0.1						
PB7.40	40±0.1						
PB10.9	9±0.1	10±0.1	10±0.1	10.4Max	10.4Max	12.5Max	
PB10.18	18±0.1						
PB10.20	20±0.1						
PB10.40	40±0.1						
PB14.20	20±0.1	14.2±0.1	14.2±0.1	14.6Max	14.6Max	16.7Max	
PB25.20	20±0.1	25.1±0.1	25.1±0.1	25.5Max	25.5Max	27.6Max	

*L＝Length of lead wire

Bold = Preference Type

Part Ordering Numbers Piezotechnik GmbH - TOKIN Code

Model	TOKIN Number
PB2.5	AE0203D04DF
PB2.9	AE0203D08H09DF
PB2.10	AE0203D08DF
PB2.18	AE0203D18H18DF
PB3.9	AE035035D08H09DF
PB3.18	AE035035D44H40DF
PB5.9	AE0505D08H09DF
PB5.10	AE0505D08DF
PB5.20	AE0505D18H18DF
PB5.18	AE0505D16DF
PB5.40	AE0505D44H40DF
PB7.9	AE0707D08H09DF
PB7.10	AE0707D08DF
PB7.18	AE0707D18H18DF
PB7.20	AE0707D16DF
PB10.5	AE0707D44H40DF
PB10.9	AE1010D08H09DF
PB10.18	AE1010D18H18DF
PB10.20	AE1010D16DF
PB10.40	AE1010D44H40DF
PB14.20	AE1414D16DF
PB25.20	AE2525D15DF

Bold = Preference Type

Special Design Parts

Non-standard parts are available per order basis. Please use the guideline below as reference regarding generated displacement and generated force.

Displacement: Roughly proportional to the element length
Generated force: Roughly proportional to the sectional area of the element
Shape: Product cross-section: 1mm×1mm square or larger

Product length: 1mm or longer can be provided in cylindrical ring or other shapes.

Please contact us for further details.

Small size piezo actuator

Characteristic Data

Fig-1 Voltage vs. Displacement

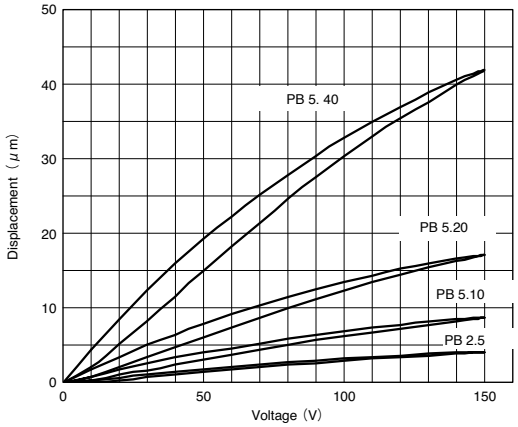


Fig-2 Generated force vs. Displacement of PB5.20 in Driving voltage

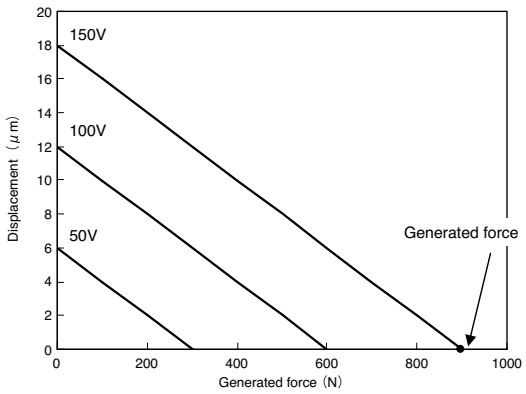


Fig-3 Generated force vs. Displacement-1

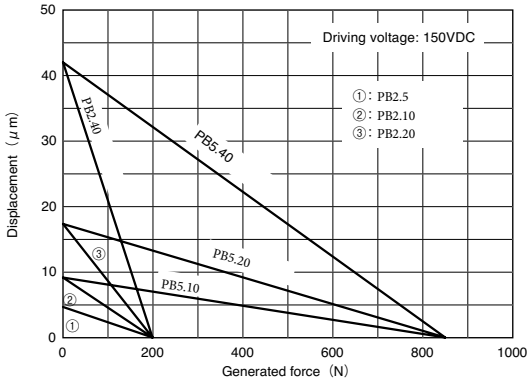


Fig-4 Generated force vs. Displacement-2

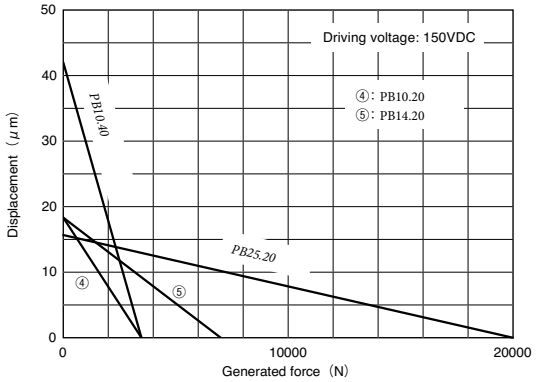
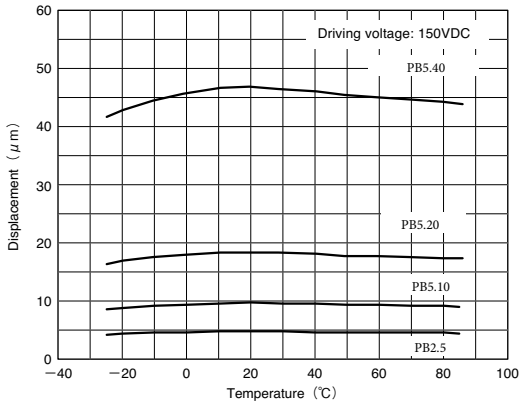


Fig-5 Temperature vs. Displacement



* Listed data are reference values. For the voltage vs. displacement characteristic, the same length of piezo series shows the same voltage vs. displacement characteristic.
* Definition of generated force for Fig-2, Fig-3 and Fig-4;
  Force is the force required for restricting the displacement to 0 when the maximum driving voltage is applied.

Fig-6 Temperature vs. displacement

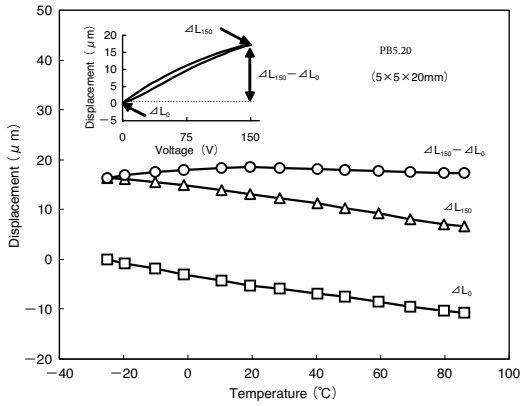


Fig-7 Voltage vs. displacement in time

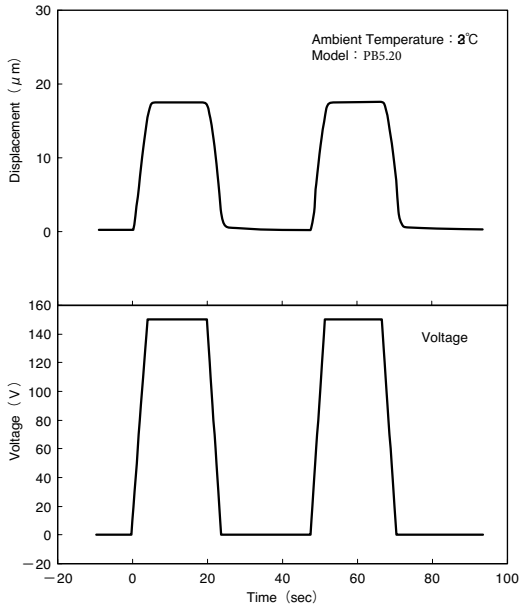


Fig-8 Heat generation vs. drive frequency-1

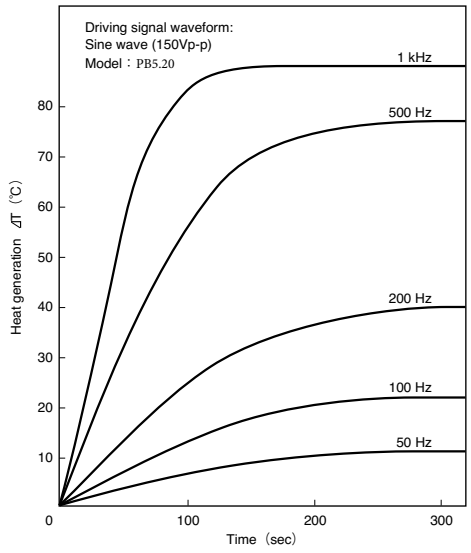
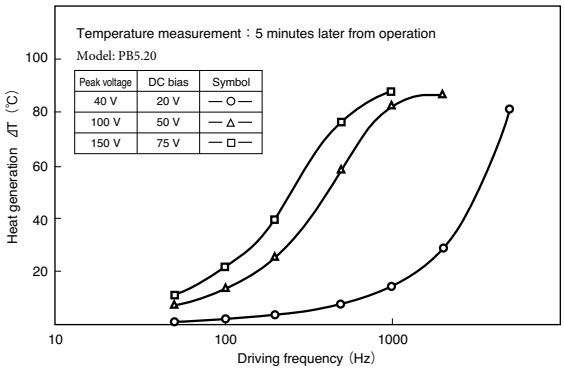


Fig-9 Heat generation vs. drive frequency-2



Reliability

Majority of failure mode of multilayer piezoelectric actuators is the short circuit due to degraded insulation. Though the cause of degradation of insulation has not been clarified perfectly, it has been found that the failure rate varies greatly between statistic uses (DC voltage application) and dynamic uses (pulse voltage application). Like other electrical components, piezo actuators can be influenced by humidity as well as applied voltage and ambient temperature. TOKIN has added the metal sealed type piezo actuators featuring high reliability by eliminating influence of the ambient atmosphere.

This section describes reliability guidelines for static and dynamic usages of the resin-coated and metal sealed types actuators.

Reliability of our multilayer piezoelectric actuators is represented by MTTF (mean time to failure) in case of static usage. Though the number of repetitions is considered to be used to represent the reliability in the case of dynamic usage, the accurate relationship between the indicator and cause has not been determined because of various influential causes and the mutual action between them. For the present, therefore, only the obtained data and our concept are described.

MTTFr Calculation

DC voltage application

The acceleration factors have been obtained empirically for each of the drive voltage, ambient temperature and relative humidity based on many experimental result. The MTTFr in actual applications is estimated using equation (1) below with MTTFs observed under accelerated condition as the reference value.

$$MTTF_r = MTTF_s \times A_v \times A_h \times A_t \quad \cdots (1)$$

$MTTF_r$: Estimated value

$MTTF_s$: Reference value (=500h)

A_v : Acceleration factor for drive voltage $= \left(\frac{150}{V_r}\right)^{3.2}$ V_r : Actual voltage (V)

A_h : Acceleration factor for relative humidity $= \left(\frac{90}{H_r}\right)^{4.9}$ H_r : Actual relative humidity (RH%)

A_t : Acceleration factor for ambient temperature $= 1.5^{\frac{40-T_r}{10}}$ T_r : Actual ambient temperature(℃)

[Example] The following calculation is made for the case of use at 25℃, 60% RH and 100 V:

$$MTTF_r = 500 \times \left(\frac{150}{100}\right)^{3.2} \times \left(\frac{90}{60}\right)^{4.9} \times 1.5^{\frac{40-25}{10}}$$

$$= 500 \times 3.66 \times 7.29 \times 1.84$$

$$\approx 24{,}500\text{h (2.8years)}$$

Pulse voltage application

When this element is driven by a pulse voltage, temperature rises as a result of heating due to dielectric loss of ceramics. Therefore, the element is not likely to be influenced by the humidity, thus extending the service life greatly. Since this effect is affected by the element shape, pulse waveform and frequency, it cannot be calculated by an equation as in the case of DC voltage application.

In TOKIN's testing on the AE0203D08, there was no failure confirmed after 0-150 V rectangular pulse wave was applied with 500 Hz for 500 hours (equivalent to 900 million pulses were applied).
Further testing with PB7.18 proved no failure for 1KHz and 1000 hours in an environment with stabilized temperature. Please pay attention to the physical damage due to ringing phenomena caused by the dynamics of the mechanical system (mass-spring like dyanmics) and its excitation (e.g. speed of the voltage rise).

Guide to Mechanical Installation

● Carefully prevent the piezo actuators from being bent, being twisted, or being applied tensile force.

Reference: Guide for tolerance of twisting and tension

	Reference value	Remarks
Twisting force	3×10^{-1} N・m or less	For an actuator which generates a force of 800 N (compression resistance)
Tension	50 N or less	

● Install the actuator so that the center axis of generated displacement is aligned with the center axis of the load.

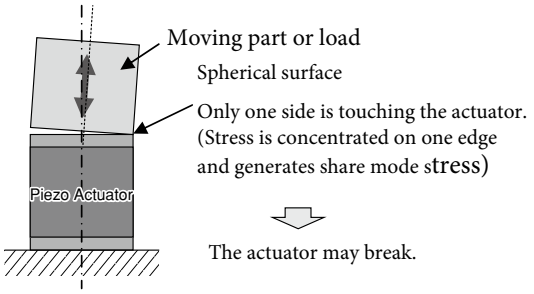
• Epoxy-based adhesives are recommended for bonding. Select adhesives that have high rigidity and allow minimum thickness so that the generation force and displacement cannot be deteriorated. Also do not form adhesives at the side of actuator.

• When thermosetting resin is used at curung temperatures higher than 150 °C perform polarizing treatment (see the caution section) again after the adhesive is settled.

• The resin-coated type is weak to tensile force because of its structure and may be broken when tensile force is applied onto the device. Using the device in the state that constantly applies compression is effective against any mechanical damage. The pressure applied to this element should be kept at 20 to 100% of the force generated by this element (compression strength).

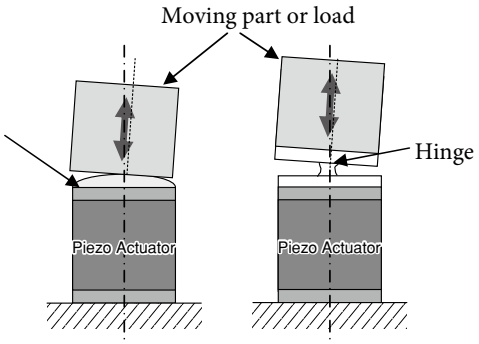
• Install the element so that the axis of generated displacement is vertical to the mounting surface. Also the axis shall be aligned to the load axis.

Example of Actuator mounting



a) Example of wrong mounting

Imperfect alignment between actuator and load
<Actuator will be broken>

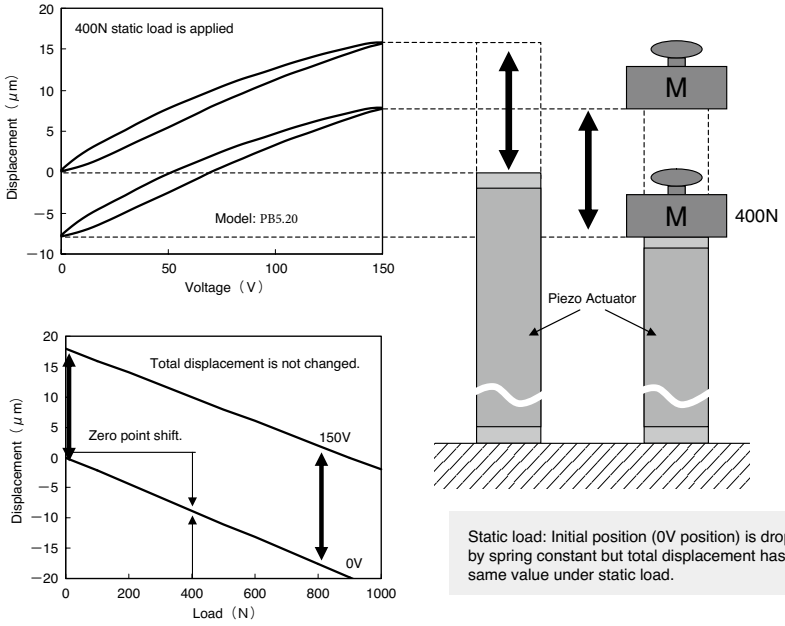


b) Example of correct mounting

Mount the device so that the load is uniformly applied by the spherical surface or the hinge

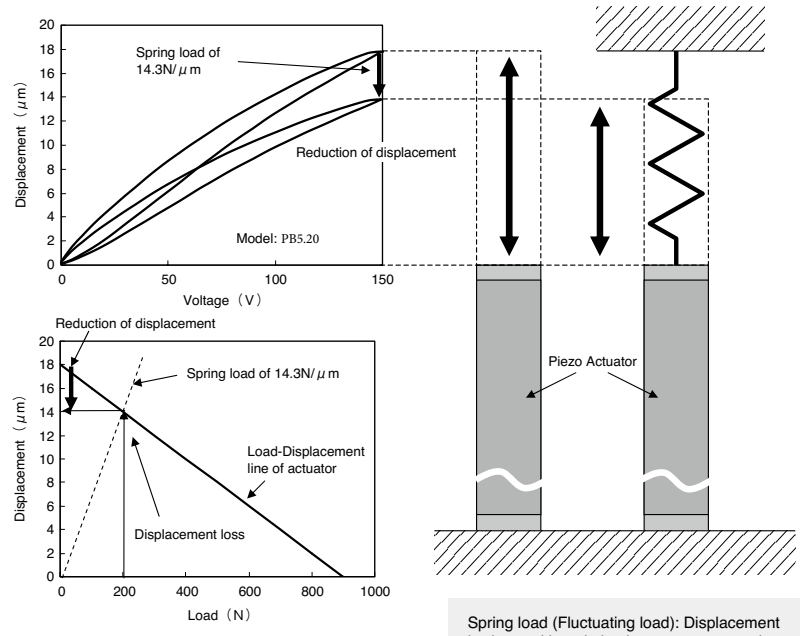
Load Cases - Generated force and load relation:

Static loads e.g. mass load: Constant displacement for different masses .



Static load: Initial position (0V position) is dropped by spring constant but total displacement has the same value under static load.

Sping-type load: Load value changes by spring reaction when actuator moves.



Spring load (Fluctuating load): Displacement is changed by relation between generated force and spring constant of actuator.

PRECAUTIONS TO BE TAKEN WHEN USING MULTILAYER PIEZOELECTRIC ACTUATORS

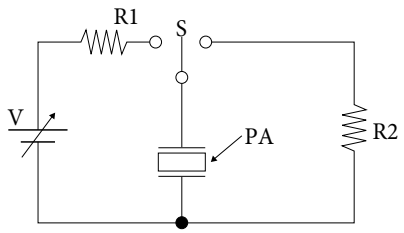
1. Before using our products or designing a system using our products, read the precautions and specifications （such as level of quality） for the products you intend to use on the last page of this manual.

2. The main failures with multilayer piezoelectric actuators are deterioration of insulation resistance, short-circuit, and open-circuit. Before using the products, design systems carefully to ensure redundancy, prevention of the spread of fire, and prevention of faulty operation allowing for the occurrence of failures.

3. Use the products after checking the working conditions and rated performance of each of the multilayer piezoelectric actuator series. For operation in environment with high humidity and other media such as dust or oil spray select a hermetically series and contact Piezotechnik GmbH.

Precautions

- Connect the red lead wire to the positive (+)terminal of the power supply.
- Carefully avoid electric shock since a high voltage is in use.
- Never apply excessive tension to a lead wire. Do not handle the product by picking up or moving the lead wire.
- Do not disassemble the case of the metal sealed type.
- Machining of the actuator element and replacement of the lead wire are prohibited.
- Do not handle the resin-coated type（AE series）with bare hands. Otherwise, the reliability of the element would be degraded.
- Do not wash resin-coated type （AE series） by organic solvant.
- Avoid excessive physical shock resulting from, for example, dropping. Otherwise, the internal piezoelectric ceramic element may be damaged.
- I f the actuator is exposed to high temperature above 100℃ or if it is used after long storage period （more
- than three months）, it should be polarized by using the circuit configuration and conditions shown below.



Protective resistor R1＝1kΩ Protective resistor R2＝1kΩ

Polarizing conditions: DC voltage application 0V→150±0.2V (to be retained for 10 seconds) →0

- Do not apply voltage exceeding maximum rating voltage, or do not do rapid charging and discharging. These might lead to degradation of the reliability or mechanical fracture.
- Do not use the actuator in high concentration of highly infl ammable gas. Otherwise, ignition may occur. Use the actuator so as not to cause bending, twisting or tension. Furthermore, align the center axis of displacement
- of the actuator with the center axis of the mechanical load.
- Drive the actuator so that the rising speed is more than three times as much as the resonance period in order to prevent the device from damaging by ringing.
- Store the resin-coated type （AE series） preferably in a dry atmosphere （desirably below 40% RH） at ordinary temperatures （−5 to ＋40˚C）. Avoid condensation on the product surface.
- Store actuators where there is no vibration.
- Piezo actuator is industrial wastes, make sure disposal method under the laws.