Devices thru Material Innovation

NEC/TOKIN

Vol.02

Multilayer Piezoelectric Actuators

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PRECAUTIONS TO BE TAKEN WHEN USING MULTILAYER PIEZOELECTRIC ACTUATORS
(Please read these precautions before using our products)

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.

   Selection of AE series (a resin-coated type) or ASB, ASL series (a metal-sealed type) should be based on the intended working temperature and humidity.

ISO 9001	ISO 14001
JQA	JQA
JQA-0366	JQA-E-90094

CONTENTS

NEC TOKIN's multilayer piezoelectric actuators are available in three series.

Resin-coated type	Metal cased type
General-purpose	High-power General-purpose
85˚C rated AE series	85˚C rated ASB series
	150˚C rated ASL series

*AE series is resin-coated products. Therefore we recommend metallic case type, ASB or ASL series in high humidity condition.

NEC TOKIN's multilayer piezoelectric actuators were produced by our unique element structure technology using ceramic materials with high electrostrictive factors developed by NEC TOKIN.

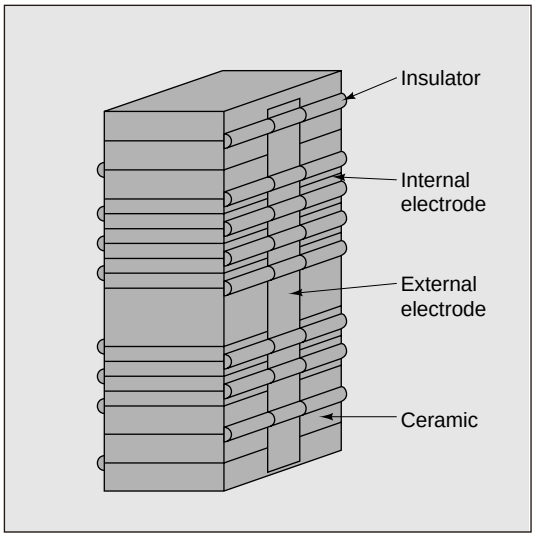
Features

☐Special ceramics developed by NEC TOKIN are used in piezoelectric ceramic elements.
☐As compared with conventional actuator elements, NEC TOKIN's multilayer piezoelectric actuators have the following advantages:

■Advantages over electromagnetic actuators
- ● Superior response
- ● High resolution for positioning
- ● Low power consumption
- ● No electromagnetic noise

■ Advantages over bimorph piezoelectric actuators
- ● High energy conversion efficiency (around 7 times the energy conversion efficiency of the bimorph type actuator), and low power consumption
- ● Large generated force
- ● Stable displacement, and reduced shift and creep phenomena
- ● Higher response speed (more than 100 times the response speed of the bimorph piezoelectric actuator)

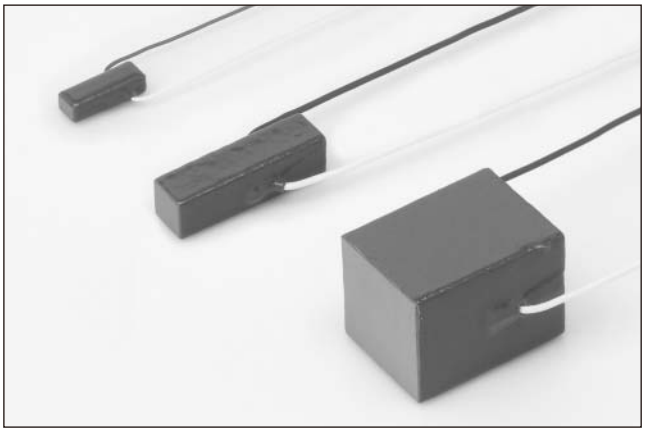
■ Advantages over stacked piezoelectric actuators
- ● Compact (less than 1/10 the specific ratio of the stacked piezoelectric actuator)
- ● Low drive voltage, and ease of use
- ● Inexpensive



Structure of NEC TOKIN's Multilayer Piezoelectric Actuator

Resin coated type multilayer piezoelectric actuators

AE Series



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.
NEC TOKIN's multilayer piezoelectric actuators are produced based on our unique element structure design by making use of 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 use in ultra-fine positioning mechanisms and drive sources for various applications.

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.
- Low power consumption: Can be retained at the leakage current (100 μA or less).
- Very small size: 1/10 or less of conventional multilayer actuators

Applications

Printer/magnetic head position adjustment, mirror/prism positioning, linear motors, pumps, vibration, valve drive, manipulators, etc.

Numbering system

Example: **AE 0505 D16 XXX F**

F	Comply with RoHS	
XXX	Additional code (optional)	
D16	Nominal displacement:	Indicated by two digits in micrometers [μm] in succession to D Example: D16 = 16 μm
0505	Cross sectional dimensions:	Unit: Millimeters [mm] Example: 0505 = 5 mm × 5 mm
AE	Series name:	AE = Resin-coated type

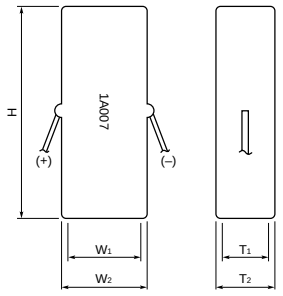
Standard Parts List

Model	Displacement [μm]		Generated force	Resonance frequency	Capacitance	Insulation resistance	Overall length
	Maximum driving voltage	Recommended driving voltage	[N]	[kHz]	[μF]	[MΩ] min.	[mm]
AE0203D04	4.6±1.5	3.0±1.5	200	261	0.09	100	5
AE0203D08	9.1±1.5	6.1±1.5	200	138	0.18	100	10
AE0203D16	17.4±2.0	11.6±2.0	200	69	0.35	50	20
AE0203D44H40	42.0±6.6	28.0±6.6	200	34	0.82	20	40
AE0505D08	9.1±1.5	6.1±1.5	850	138	0.75	50	10
AE0505D16	17.4±2.0	11.6±2.0	850	69	1.4	10	20
AE0505D44H40	42.0±6.6	28.0±6.6	850	34	3.4	5	40
AE1010D16	18.4±3.5	12.3±3.5	3,500	69	5.4	5	20
AE1010D44H40	42.0±6.6	28.0±6.6	3,500	34	13.6	2	40
AE1414D16	18.4±3.5	12.3±3.5	7,000	69	10.8	2	20
AE2525D15	15.6±2.0	10.1±2.0	20,000	69	30.5	0.4	20

Performance

Item	Standard	Conditions
Operating temperature range	–25 to +85˚C	When applied with a DC voltage: Ambient temperature When driven by an AC voltage: Ambient temperature + Temperature rise due to generated heat
Maximum driving voltage	150VDC	
Recommended driving voltage	100VDC	
Displacement	See the standard parts list	
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
Capacitance allowance	+/–20 %	
Dissipation factor	3.5 to 5.0%	
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	4.4×10^{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: 1 MΩ or more Appearance: No noticeable defect	Room temperature (3 min) –25˚C (30 min.) Room temperature (3 min) +85˚C (30 min) Repetition of 10 cycles of the above

Outer Dimensions



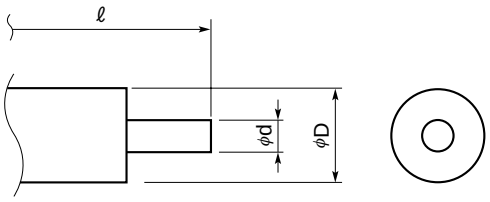
Note:
Factory-shipped polarization : Red lead wire = (+),
white lead wire = (–)

Unit : mm

Model	T_1	W_1	H	T_2	W_2	ℓ*
AE0203D04	2±0.1	3±0.1	5±0.1	3.5max.	4.5max.	100
AE0203D08	2±0.1	3±0.1	10±0.1	3.5max.	4.5max.	100
AE0203D16	2±0.1	3±0.1	20±0.1	3.5max.	4.5max.	100
AE0203D44H40	2±0.1	3±0.1	40±0.1	3.5max.	4.5max.	100
AE0505D08	5±0.1	5±0.1	10±0.1	6.5max.	6.5max.	100
AE0505D16	5±0.1	5±0.1	20±0.1	6.5max.	6.5max.	100
AE0505D44H40	5±0.1	5±0.1	40±0.1	6.5max.	6.5max.	100
AE1010D16	10±0.1	10±0.1	20±0.1	11.5max.	11.5max.	100
AE1010D44H40	10±0.1	10±0.1	40±0.1	11.5max.	11.5max.	100
AE1414D16	14.2±0.1	14.2±0.1	20±0.1	15.7max.	15.7max.	100
AE2525D15	25.1±0.1	25.1±0.1	20±0.1	26.6max.	26.6max.	100

*Length of lead wire

Wire diameter



φd = Diameter of lead wire
φD = Outer diameter including the thickness of coating
ℓ = Length of lead wire

Model Number	φd*	φD*	ℓ*
AE0203D08	0.3	0.5	100
AE0203D16	0.3	0.5	100
AE0505D08	0.3	0.5	100
AE0505D16	0.5	0.8	100
AE1010D16	0.5	0.8	100
AE1414D16	0.5	0.8	100

* Typ.

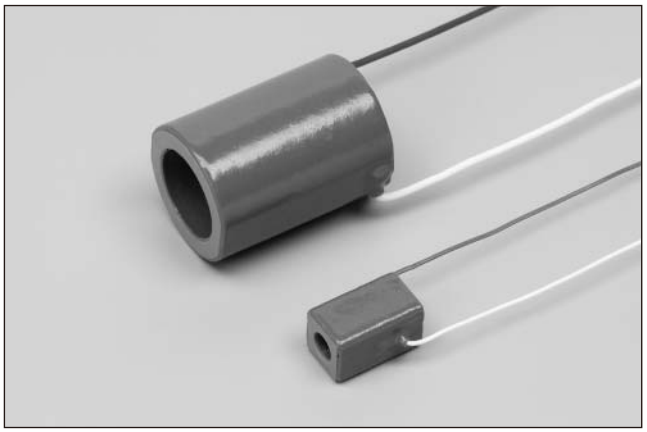
Special Design Parts

Non-standard parts may be manufactured on order. With regard to the generated displacement and generated force, use the guideline below with the performance of the standard parts as the reference.

Displacement: Roughly proportional to the element length

Generated force: Roughly proportional to the sectional area of the element

Please contact us for further details.



Characteristic Data

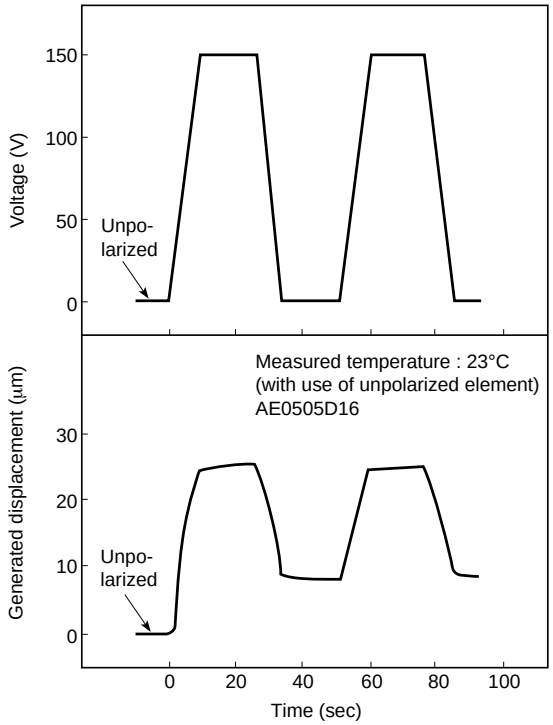


Fig. 1 Voltage and generated displacement vs time characteristics

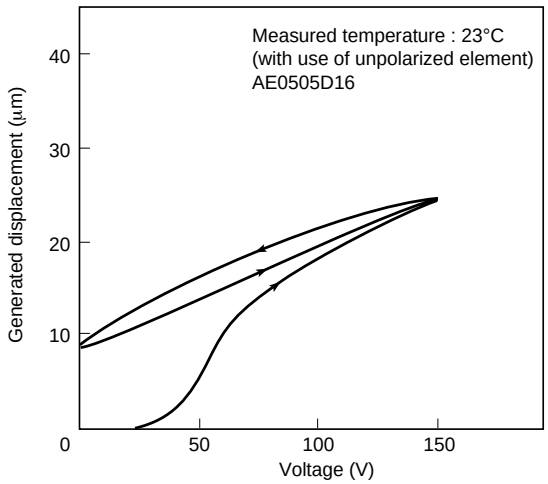


Fig. 2 Voltage vs generated displacement characteristics

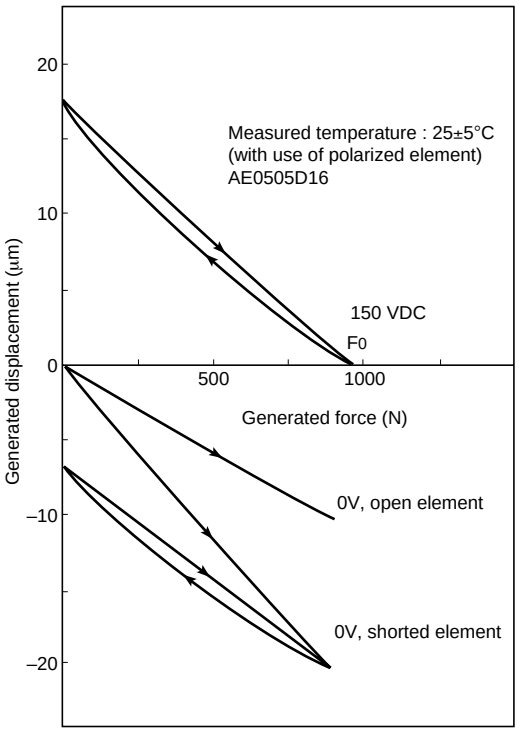


Fig. 3 Generated Force vs Generated Displacement Characteristics

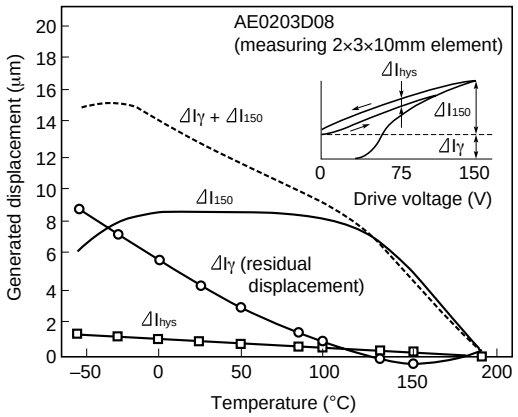


Fig. 4 Temperature characteristics of generated displacement

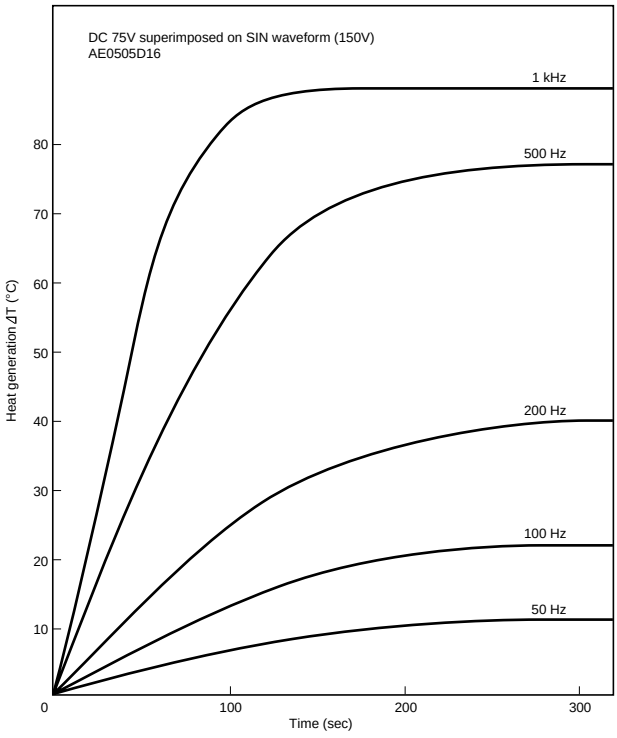


Fig. 5 Heat development characteristics

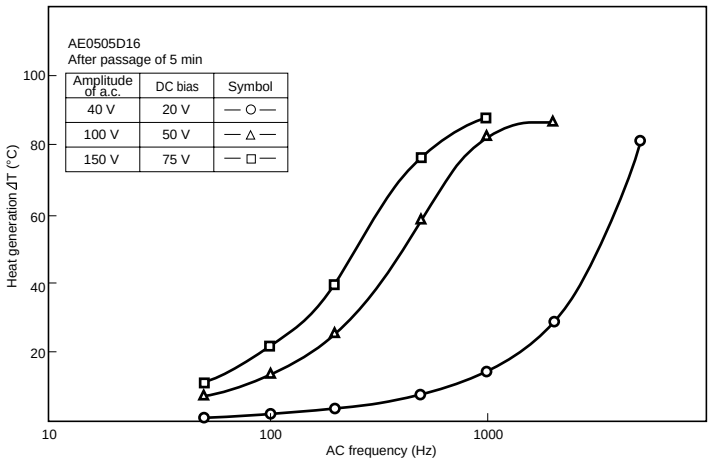
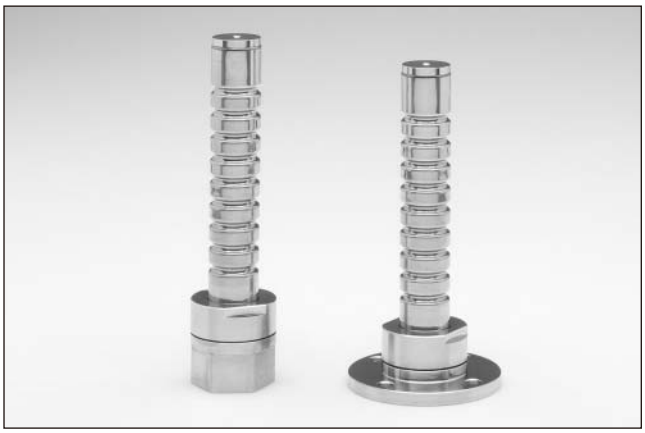


Fig. 6 Heat generation vs frequency characteristics

Metal sealed type multilayer piezoelectric actuators

ASB Series (85˚C rated), ASL series (150˚C rated)



Outline

Multilayer piezoelectric actuators convert electrical energy into mechanical energy such as displacement or force by making use of the piezoelectric longitudinal effect. NEC TOKIN's multilayer piezoelectric actuators are produced based on our unique element structure design by making use of originally developed piezoelectric ceramic materials with high electrostrictive factors. Compared to conventional piezoelectric actuators, they are smaller in size but can generate higher displacements and forces at low voltages.
Especially, the metal sealed ASB/ASL series actuators are much less influenced by ambient humidity because of insulation from the atmosphere. As a result, long service life and high performance never experienced in the past have been attained to allow use in various applications such as semiconductor device production equipment and optical communication equipment requiring high reliability.

Features

- High reliability: Realization of MTTF = 36,000 hours (at 85˚C and 100 V)
- Easier installation n equipment thanks to the built-in pre-load mechanism and mounting attachment
- Minimum mechanical abrasion
- Large generated force: 800 N
- Accurate positioning: Controllable in nm

Applications

Fine adjustment of various X-Y tables steppers, mirror/prism positioning, linear motors, fluid flow control valve drive, vibration, manipulators, etc.

Numbering system

Example: **AS B 170 C 801 N P 0 F**

F	Comply with RoHS	
0	New design No.	Sequentially numbered starting from 0
P	Configuration of drive block	P = Plane
N	Configuration of mount	N = Female thread type F = Flange type
801	Generated force	Unit: Newton [N] The first two digits are effective numerals. The last digit is an exponent of 10. Example: 801 = 800 N ≒ 80 kgf
C	Maximum drive voltage	C = 150 V
170	Nominal displacement	Unit: Micrometers (μm) The first two digits are effective numerals. The last digit is an exponent of 10. Example: 170 = 17 μm
B	Construction of housing and operating temperature range	B = Bellows ((pre-load), maximum operating temperature: 85˚C L = Bellows (pre-load), maximum operating temperature: 150˚C
AS	Series name	AS = Encapsulated in metal case

Standard Parts List

• ASB series

Model	Displacement [μm]		Generated force	Resonance frequency	Capacitance	Insulation resistance
	Maximum driving voltage	Recommended driving voltage	[N]	[kHz]	[μF]	[MΩ] min.
ASB170C801*P0	17.0± 3	12.0± 3	800	14	1.5	30
ASB340C801*P0	34.0± 6	24.0± 6	800	12	3.0	15
ASB510C801*P0	51.0± 9	36.0± 9	800	10	4.5	10
ASB680C801*P0	68.0±12	48.0±12	800	8	6.0	5

• ASL series

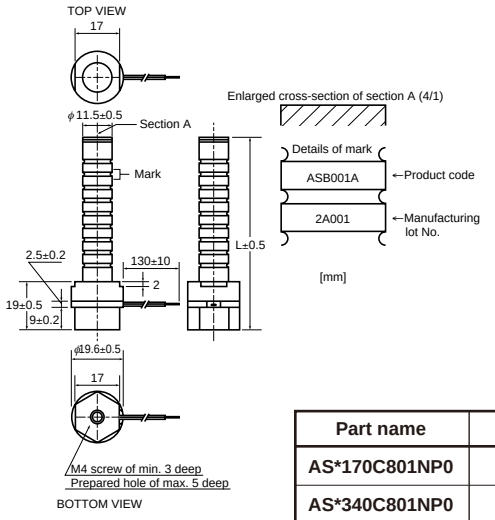
Model	Displacement [μm]		Generated force	Resonance frequency	Capacitance	Insulation resistance
	Maximum driving voltage	Recommended driving voltage	[N]	[kHz]	[μF]	[MΩ] min.
ASL170C801*P0	17.0± 3	12.0± 3	800	14	1.12	30
ASL340C801*P0	34.0± 6	24.0± 6	800	12	2.23	15
ASL510C801*P0	51.0± 9	36.0± 9	800	10	3.35	10
ASL680C801*P0	68.0±12	48.0±12	800	8	4.47	5

Performance

Item	Standard	Conditions
Operating temperature range	ASB : –25 to +85˚C ASL : –40 to +150˚C	When applied with DC voltage: Ambient temperature When driven by pulse: Ambient temperature + Rise by generated heat
Maximum driving voltage	$150V_{DC}$	
Recommended driving voltage	$100V_{DC}$	
Displacement	See the standard parts list	
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
Capacitance tolerance	+/– 20 %	
Dissipation factor	3.5 to 5.0%	
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
Airtightness	1 × 10–8 atm cc/sec or less	
Temperature cycle test	Displacement: Initial value ±30% Capacitance: Initial value ±30% tan δ: Less than initial rated value Insulation resistance: 1 MΩ or more Appearance: No noticeable defect	ASB / ASL Room temperature (3 min) / Room temperature (3 min) –25˚C (30 min) / –40˚C (30 min) Room temperature (3 min) / Room temperature (3 min) +85˚C (30 min) / +150˚C (30 min) Repetition of 10 cycles of the above
High-temperature shelf test	Displacement: Initial value ±30% Capacitance: Initial value ±30% tan δ: Less than initial rated value Insulation resistance: 1 MΩ or more Appearance: No noticeable defect	Temperature: ASB: 85±2˚C / ASL: 150±2˚C Time: 1,000±48 h
Solvent resistance test	Displacement: Initial value ±30% Capacitance: Initial value ±30% tan δ: Less than initial rated value Insulation resistance: 1 MΩ or more Appearance: No noticeable defect Mark: Easily legible	Solvent: Isopropyl alcohol Temperature: 23±5˚C Time: Immersion for 1 min
Heat resistance test	Displacement: Initial value ±30% Capacitance: Initial value ±30% tan δ: Less than initial rated value Insulation resistance: 1 MΩ or more Appearance: No noticeable defect Mark: Easily legible	Temperature: 150±3˚C Time: 96±4 h

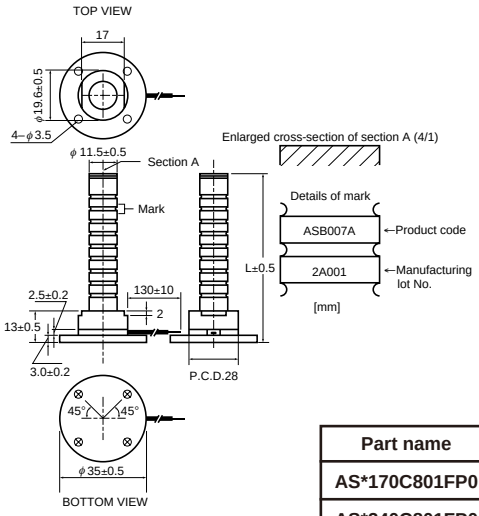
Outer Dimensions (Common to ASB and ASL Series)

● Female thread type



Part name	L
AS*170C801NP0	38.4
AS*340C801NP0	58.4
AS*510C801NP0	78.4
AS*680C801NP0	98.4

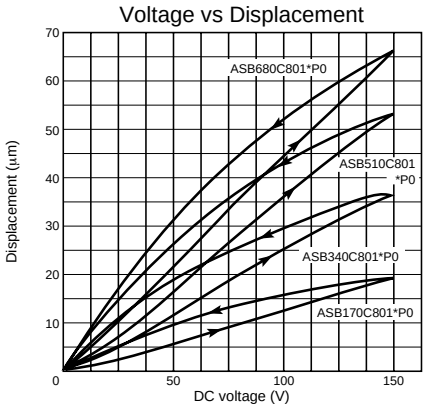
● Flange type

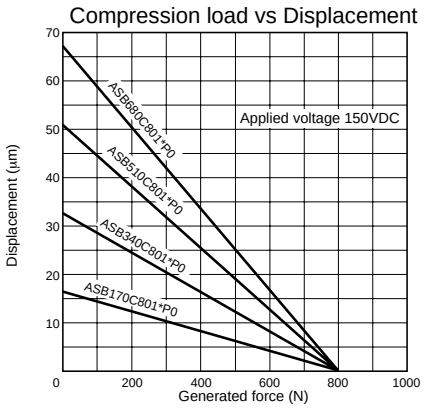


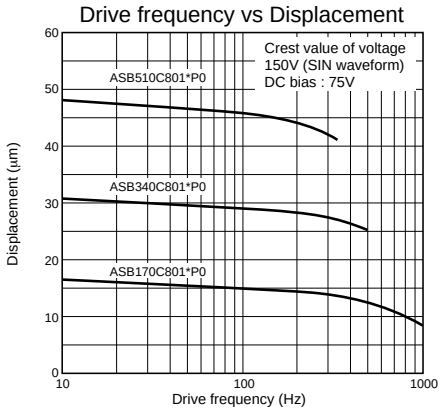
Part name	L
AS*170C801FP0	32.4
AS*340C801FP0	52.4
AS*510C801FP0	72.4
AS*680C801FP0	92.4

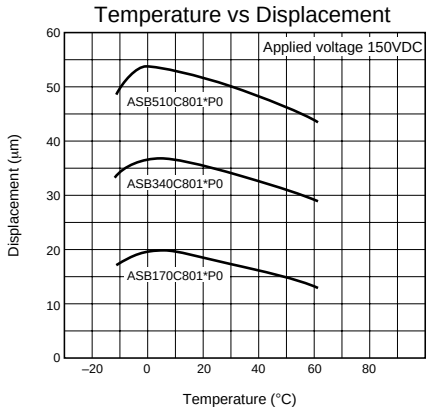
Characteristic Data

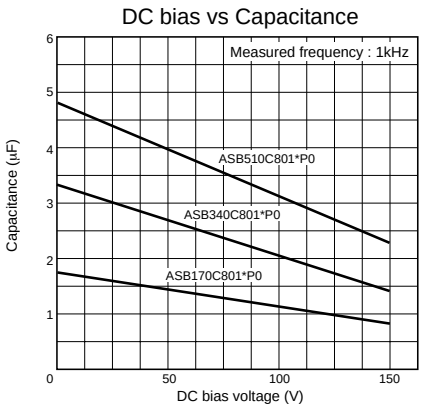
• ASB series

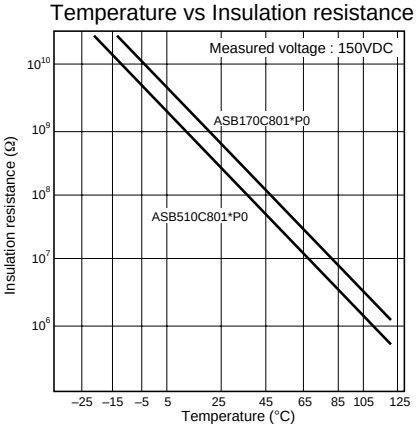




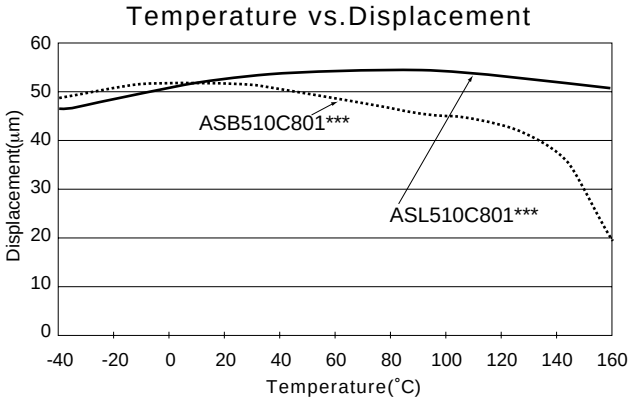


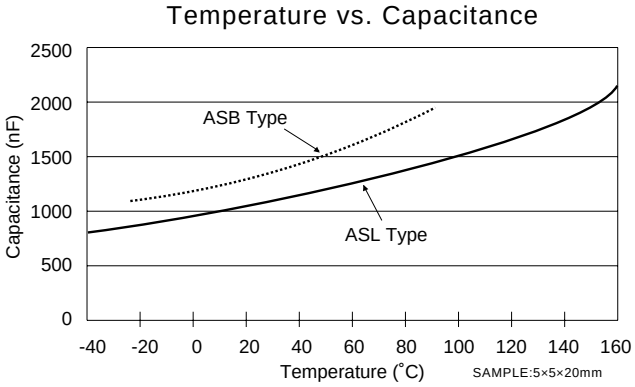






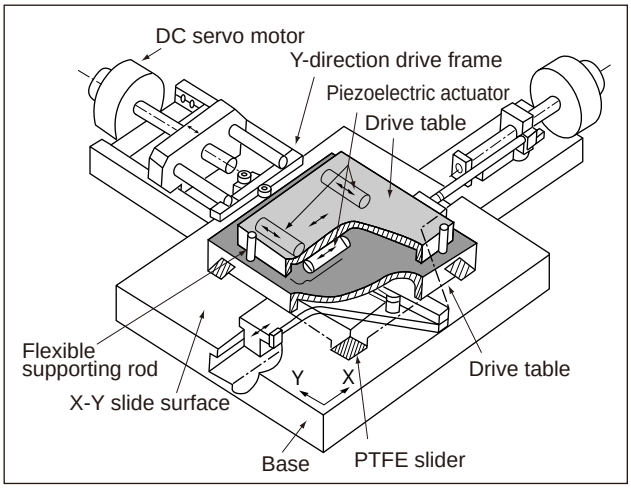
• ASL series

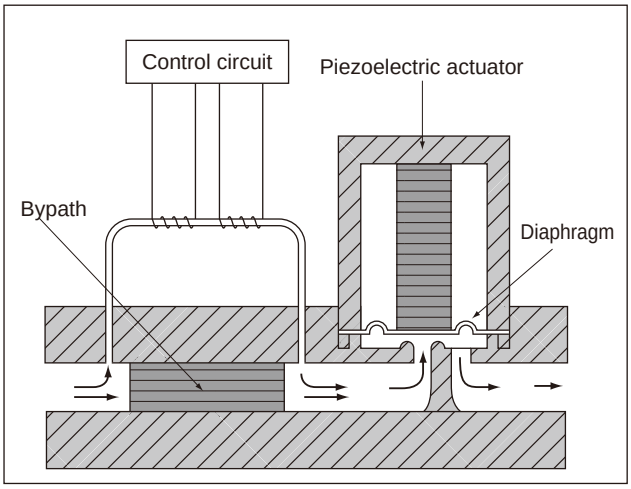


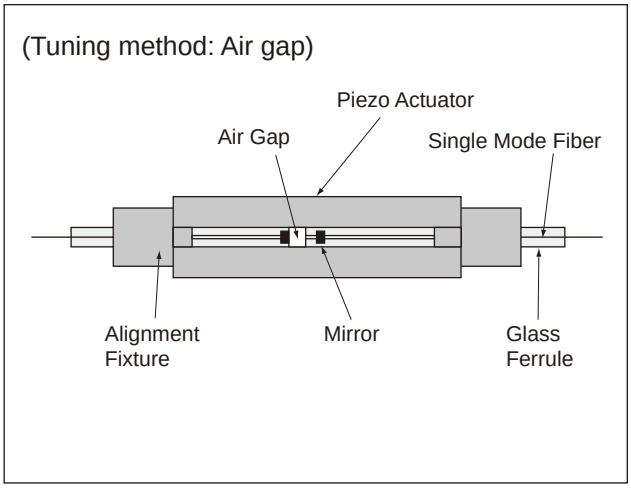


Shall be added as required in the same way as for the ASB series in the future

Application Examples







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). Since it has been found that the influence of humidity is great in addition to the ambient temperature as in the case of other general electronic parts, the metal sealed type featuring high reliability by elimination of the influence of the atmosphere has been added in the product line.
This section describes the reliability guidelines for static and dynamic uses for each of the resin-coated and metal sealed types.
Reliability of our multilayer piezoelectric actuators is represented by MTTF (mean time to failure) on assumption of static uses. Though the number of repetitions is considered to be used to represent the reliability in the case of dynamic uses, the accurate relationship between the indicator and cause has not been obtained because of various influential causes and the mutual action between them. For the present, therefore, only the obtained data and our concept are described.

(1) Resin-coated Type (AE Series)

a. DC voltage application

The acceleration factor has been obtained empirically for each of the drive voltage, ambient temperature and relative humidity based on many experimental result data. The MTTFr in an actual application 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) • • • Typical value as of the year 1990

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(˚C)

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

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

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

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

b. Pulse voltage application

When this element is driven by a pulse voltage, temperature rise occurs 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.
It has been seen that no failure occurred after application of 0 to 150-V rectangular pulse wave at 500 Hz to the AE0203D08 for 500 hours (equivalent to 900 million pulses).
On the other hand, physical damage due to ringing phenomenon due to element fixing method and voltage rising speed may arise, so attention should be paid.
Please refer to the separately printed "Guide to Multilayer Actuator" for more detailed data.

(2) Metal Sealed Type (ASB/ASL Series)

a. DC voltage application

MTTFr of the metal sealed type under the actual operating conditions is calculated/estimated from the reference MTTFs and the acceleration factor as in the case of the resin-coated type. However since the internal element is sealed from the atmosphere, it is not influenced by the atmospheric humidity. Therefore, equation (2) below is used.

$$MTTF_r = MTTF_s \times A_v \times A_t \quad \cdots (2)$$

$MTTF_r$: Estimated value

$MTTF_s$: Reference value (=36,000h) • • • Typical value as of 1990

A_v : Acceleration factor for drive voltage= $\left(\frac{100}{V_r}\right)^2$ V_r : Actual operating voltage (V)

A_t :Acceleration factor for ambient temperature= $1.5^{\frac{85-T_r}{10}}$ T_r : Actual operating temperature (˚C)

[Example] The following calculation is made for use at 25(c and 150 V:

$$MTTF_r = 36{,}000 \times \left(\frac{100}{150}\right)^2 \times 1.5^{\frac{85-25}{10}}$$

$$= 36{,}000 \times 0.44 \times 11.3$$

$$\approx 179{,}000\text{h (20.4years)}$$

b. Pulse voltage application

Estimation by an equation is extremely difficult because of the influence of the pulse waveform, frequency, etc. in addition to the voltage and ambient temperature as in the case of the resin-coated type.

It has been seen that no failure occurred under the following conditions up to 1,000 hours (equivalent to 100 million pulses) in the case of the ASB170C801NP0:

[Conditions for evaluation]
Temperature: 85±2˚C
Humidity: 90 to 95% RH
Load: 200 N to 500 N (20 kgf to 50 kgf)
Drive voltage waveform: Rectangular wave, 30 Hz, 0 V to 100 V, duty ratio at 30%

Guide to Use

Fixing Method:

● Carefully prevent any bending, twisting or tensile force from being applied to this product.
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.

a. Resin-coated type

- Epoxy-based adhesives are usable for bonding. Select a type featuring high rigidity and minimum thickness so that the generation force and displace ment would not be spoiled.
- When thermosetting resin is used, perform polarizing treatment (see the caution section) again after setting.
- This type is weak to a tensile force because of its structure and may be broken when applied with tension. Use in the state constantly applied with compression is effective in preventing any mechanical damage. The pressure applied to this element should be kept at 20 to 50% of the force generated by this element (compression resistance).
- Install the element so that the axis of generated displacement is vertical to the mounting surface.

b. Metal sealed type

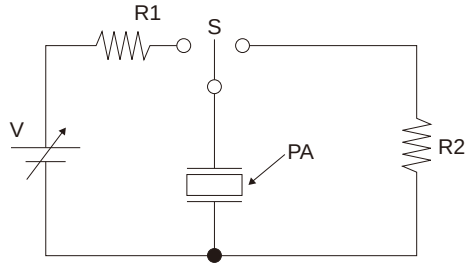
- Select the mounting bracket (female thread type or flange type) according to the mounting method, and install the element utilizing the bracket.
- Fix the element securely so as not to damp the generated force or displacement.
- Connect the driven item at the displacement generating end after securing the mounting portion so as to avoid unnecessary stress application at the time of installation.
- Though this product is designed to apply a compressive force to the internal element by the metal case, avoid any usage causing application of bending, twisting or tension at the time of driving.

Driving Method:

● Connect the red lead wire to the positive (+) terminal of the power supply. Also prevent reverse voltage application.
● Basically the voltage controls the aimed displacement and generated force. In driving, however, it is also necessary to take ringing due to the resonance or hysteresis of the element itself into consideration. In pulse driving, it is further necessary to pay sufficient attention to heat generation due to dielectric loss, charge/discharge current due to the capacitive component and the power output impedance as well. Please refer to the separately printed Guide for Use of Multilayer Piezoelectric Actuators".

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 an 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.
- If exposed to high temperatures above 100˚C or for use after long storage (for more than three months), the actuator should be used after being polarized using the following circuit configuration and conditions shown below.



Protective resistor R1 = 1 kΩ
Protective resistor R2 = 1 kΩ
Polarizing conditions: DC voltage application
0 V →150±0.2 V (to be retained for 10 seconds) →0

- Do not apply voltage exceeding MAX. driving voltage value to the actuator. Otherwise, degraded reliability or mechanical fracture may arise.
- Do not use the actuator in a high concentration of highly inflammable 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 at an initial speed exceeding three times the resonance cycle to prevent damage caused 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).
- Store actuators where there is no vibration.

When using our products, the following precautions should be taken.

(1) Safety designing of an apparatus or a system allowing for failures of electronic components used in the system

In general, failures will occur in electronic components at a certain probability. NEC TOKIN makes every effort to improve the quality and reliability of electronic component products. However, it is impossible to completely eliminate the probability of failures. Therefore, when using NEC TOKIN's electronic component products, systems should be carefully designed to ensure redundancy in the event of an accident which would result in injury or death, fire, or social damage, to ensure the prevention of the spread of fire, and the prevention of faulty operation. (Please refer to precautions to be taken when using multilayer piezoelectric actuators for the details of failures.)

(2) Quality level of various kinds of parts, and equipment in which the parts can be utilized
Electronic components have a standard quality level unless otherwise specified.

NEC TOKIN classifies the level of quality of electronic component products into three levels, in order from a lower level, a standard quality level, a special quality level, and a custom quality level in which a customer individually specifies a quality assurance program. Each of the quality levels has recommended applications.
If a user wants to use the electronic parts having a standard quality level in applications other than the applications specified for the standard quality level, they should always consult a member of our company's sales staff before using the electronic parts.

Standard quality level	:	Computers, office automation equipment, communications equipment, measuring instruments, AV equipment, household electrical appliances, machine tools, personal equipment, industrial robots
Special quality level	:	Transportation equipment (automobiles, railways, shipping, or the like), traffic signals, disaster prevention/crime prevention systems, a variety of safety devices, and medical equipment which is not directly intended for life-support purposes
Custom quality level	:	Equipment for airplanes, aerospace equipment, nuclear power control systems, and medical equipment, apparatus or system for life-support purposes

Unless otherwise shown, the quality level of NEC TOKIN's electronic component products included in documents such as catalogues, data sheets or data books is the standard quality level.

(3) This manual is subject to change without notice.

The contents of this manual are based on data which is correct as of September 2005, and they may be changed without notice. If our products are used for mass-production design, please cousult with a member of our company's sales staff by way of precaution.

(4) Reprinting and copying of this manual without prior written permission from NEC TOKIN Corporation are not permitted.

(5) Industrial property problems

In the event any problems associated with industrial property of a third party arising as a result of the use of our products, NEC TOKIN assumes no responsibility for problems other than problems directly associated with the constitution and manufacturing method of the products.

(6) Should any of these products come under the category of strategic goods or services (according to Japan's foreign trade and foreign exchange regulations), the sender must obtain an export license from the Japanese Government before said products can be exported outside Japan.