Multilayer piezoelectric actuators

Vol. 01
## 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 and AHB series (a metal-sealed type) should be based on the intended working temperature and humidity.
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TOKIN's multilayer piezoelectric actuators are available in four series.

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<th>Metal case type</th>
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<tr>
<td>General-purpose</td>
<td>High-performance</td>
</tr>
<tr>
<td></td>
<td>General-purpose</td>
</tr>
<tr>
<td>85°C rated AE series</td>
<td>85°C rated ASB series</td>
</tr>
<tr>
<td></td>
<td>150°C rated ASL series</td>
</tr>
<tr>
<td></td>
<td>High displacement model</td>
</tr>
<tr>
<td></td>
<td>AHB series</td>
</tr>
</tbody>
</table>

*AE series is resin-coated products. Therefore we recommend using metal case type, ASB, ASL and AHB series in high humidity condition.

TOKIN's multilayer piezoelectric actuators are designed using unique element structure technology and using ceramic materials with high electrostrictive factors developed by TOKIN.

*For detail information of piezoelectric ceramic material, please refer to a catalogue of "Piezoelectric ceramics".

Features

- Special ceramics developed by TOKIN are used in piezoelectric ceramic elements.
- As compared with conventional actuator elements, TOKIN's multilayer piezoelectric actuators have advantages as follows.

- Advantages over electromagnetic actuators
  - Faster response
  - High resolution for positioning
  - Large generated force
  - 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
  - Response speed (more than 100 times the response speed of the bimorph piezoelectric actuator)

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

Structure of TOKIN's Multilayer Piezoelectric Actuator

⚠️

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- Please request for a specification sheet for detailed product data prior to the purchase.
- Before using the product in this catalog, please read "Precautions" and other safety precautions listed in the printed version catalog.
Multilayer piezoelectric actuators product line up

Resin-coated type

Metal sealed type

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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.

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.

Features
- Large generated force: 3,500 N/cm² (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)

Numbering system

Example: AE 0505 D16 XXX F

- Comply with RoHS: *Compliant to RoHS directive in effect as of December, 2014
- Additional code (optional): Example: H40=Overall length is 40mm
- Nominal displacement: Indicated by two digits in micrometers [μm] in succession to D
  Example: D16=16 μm
- Ceramic cross section: Unit: Millimeters [mm]
  Example: 0505=5 mm x 5 mm
  *Coating area is not include.
- Series name: AE=Resin-coated type

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*Before using the product in this catalog, please read “Precautions” and other safety precautions listed in the printed version catalog.
### Performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>−25 to + 85°C</td>
<td>When applied with a DC voltage: Ambient temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When driven by an AC voltage: Ambient temperature + Temperature rise due to generated heat</td>
</tr>
<tr>
<td>Recommended Storage condition</td>
<td>−5 to + 40°C / less than 40% R.H</td>
<td>Recommend storage at room temperature. No condensation.</td>
</tr>
<tr>
<td>Maximum driving voltage</td>
<td>150VDC</td>
<td></td>
</tr>
<tr>
<td>Displacement</td>
<td>See the standard parts list</td>
<td></td>
</tr>
<tr>
<td>Generated force</td>
<td>At 150VDC</td>
<td></td>
</tr>
<tr>
<td>(compression resistance)</td>
<td>See the standard parts list</td>
<td></td>
</tr>
<tr>
<td>Capacitance</td>
<td>See the standard parts list</td>
<td></td>
</tr>
<tr>
<td>Capacitance allowance</td>
<td>+ / − 20 %</td>
<td>f = 1kHz, V=1Vrms ( &lt;10 μF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f = 120kHz, V=1Vrms ( &gt;10 μF)</td>
</tr>
<tr>
<td>Dissipation factor</td>
<td>5% or less</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>See the standard parts list</td>
<td>Value obtained in 1 minute at 150 VDC</td>
</tr>
<tr>
<td>Resonance frequency</td>
<td>See the standard parts list</td>
<td>With both ends of element in free state</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typical value of the element under our test conditions</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>1/10 of generated force</td>
<td>Typical value of the element under our test conditions</td>
</tr>
<tr>
<td>Young's modulus</td>
<td>4.4 × 10^10 N/m²</td>
<td>Typical value of the element under our test conditions</td>
</tr>
<tr>
<td>Temperature cycle test</td>
<td>Displacement: initial value ± 20%</td>
<td>Room temperature: (3 min)</td>
</tr>
<tr>
<td></td>
<td>Capacitance: initial value ± 30%</td>
<td>−25°C (30 min.)</td>
</tr>
<tr>
<td></td>
<td>tan δ : Less than initial rated value</td>
<td>Room temperature: (3 min)</td>
</tr>
<tr>
<td></td>
<td>Insulation resistance: 1MΩ or more</td>
<td>+85°C (30 min)</td>
</tr>
<tr>
<td></td>
<td>Appearance: No noticeable defect</td>
<td>Repetition of 10 cycles of the above</td>
</tr>
</tbody>
</table>

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*Please request for a specification sheet for detailed product data prior to the purchase.
*Before using the product in this catalog, please read “Precautions” and other safety precautions listed in the printed version catalog.
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

<table>
<thead>
<tr>
<th>Model</th>
<th>H</th>
<th>T1</th>
<th>W1</th>
<th>T2</th>
<th>W2</th>
<th>W3</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE0203D04DF</td>
<td>5 ± 0.1</td>
<td>2 ± 0.1</td>
<td>3 ± 0.1</td>
<td>2.4Max</td>
<td>3.4Max</td>
<td>5.5Max</td>
<td></td>
</tr>
<tr>
<td>AE0203D08H09DF</td>
<td>9 ± 0.1</td>
<td>5 ± 0.1</td>
<td>5 ± 0.1</td>
<td>5.4Max</td>
<td>5.4Max</td>
<td>7.5Max</td>
<td></td>
</tr>
<tr>
<td>AE0203D08DF</td>
<td>10 ± 0.1</td>
<td>7 ± 0.1</td>
<td>7 ± 0.1</td>
<td>7.4Max</td>
<td>7.4Max</td>
<td>9.5Max</td>
<td></td>
</tr>
<tr>
<td>AE0203D18H18DF</td>
<td>18 ± 0.1</td>
<td>10 ± 0.1</td>
<td>10 ± 0.1</td>
<td>10.4Max</td>
<td>10.4Max</td>
<td>12.5Max</td>
<td></td>
</tr>
<tr>
<td>AE0203D16DF</td>
<td>20 ± 0.1</td>
<td>14.2 ± 0.1</td>
<td>14.2 ± 0.1</td>
<td>14.6Max</td>
<td>14.6Max</td>
<td>16.7Max</td>
<td></td>
</tr>
<tr>
<td>AE0203D44H40DF</td>
<td>40 ± 0.1</td>
<td>25.1 ± 0.1</td>
<td>25.1 ± 0.1</td>
<td>25.5Max</td>
<td>25.5Max</td>
<td>27.6Max</td>
<td></td>
</tr>
</tbody>
</table>

*L = Length of lead wire
Wire diameter

- \( \phi_d \) = Diameter of lead wire
- \( \phi D \) = Outer diameter including the thickness of coating
- \( L \) = Length of lead wire

Lead wire: Copper wire with Tin plating
Coating: PTFE (Polytetrafluoroethylene)

<table>
<thead>
<tr>
<th>Model Number</th>
<th>AWG</th>
<th>( \phi_d )</th>
<th>( \phi D )</th>
<th>( L )</th>
<th>UL number</th>
</tr>
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<tbody>
<tr>
<td>AE020304DF</td>
<td>30</td>
<td>0.3</td>
<td>0.5</td>
<td></td>
<td>100</td>
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<tr>
<td>AE020308H09DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1993</td>
</tr>
<tr>
<td>AE020308DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE020318H18DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE020316DF</td>
<td></td>
<td></td>
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<tr>
<td>AE020344H40DF</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AE050508H09DF</td>
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<td></td>
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<tr>
<td>AE050516DF</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE050544H40DF</td>
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<tr>
<td>AE070708H09DF</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AE070716DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE070744H40DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE101008H09DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE101016DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE101044H40DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE141416DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE252515DF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

Example of special design parts

<table>
<thead>
<tr>
<th>Ceramic Dimension</th>
<th>AL1.65 × 1.65 × 5DF</th>
<th>AE1.65 × 1.65 × 5DF</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Operating Voltage (V)</td>
<td>± 10V</td>
<td>150VDC</td>
<td></td>
</tr>
<tr>
<td>Displacement</td>
<td>(300nm)</td>
<td>(4 μm)</td>
<td>At maximum operating voltage</td>
</tr>
<tr>
<td>Capacitance (nF)</td>
<td>90</td>
<td>43</td>
<td>f=1kHz, V=1Vrms</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-25 ~ +85°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Small size piezo actuator

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Characteristic Data

Fig-1 Voltage vs. Displacement

![Graph showing voltage vs. displacement characteristic for different piezo series.]

Fig-2 Generated force vs. Displacement of AE0050D18F in Driving voltage

![Graph showing generated force vs. displacement for AE0050D18F at different driving voltages.]

Fig-3 Generated force vs. Displacement-1

![Graph showing generated force vs. displacement characteristic for different piezo series at 150VDC driving voltage.]

Fig-4 Generated force vs. Displacement-2

![Graph showing generated force vs. displacement characteristic for different piezo series at 150VDC driving voltage.]

Fig-5 Temperature vs. Displacement

![Graph showing temperature vs. displacement characteristic for different piezo series.]

* 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.

Multilayer Piezoelectric Actuators VOL.01

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Multilayer Piezoelectric Actuators VOL.01

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
Metal sealed type multilayer piezoelectric actuators

ASB Series (85°C rated), ASL series (150°C rated), AHB series (High displacement model)

Outline
Multilayer piezoelectric actuators convert electrical energy into mechanical energy such as displacement or force by making use of the piezoelectric longitudinal effect. 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 and AHB 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 which require high reliability.

Applications
Fine adjustment of various X-Y tables steppers, Mirror/prism positioning, Linear motors, Fluid flow control valve drive, Vibration source, Manipulators, etc.

Numbering system

Example: AS B 170 C 801 N P 0 -** LF

Comply with RoHS
Additional code (optional)
New design No.
Configuration of drive block
Configuration of mount
Generated force
Maximum drive voltage
Nominal displacement
Construction of housing and operating temperature range
Series name

- AS = Encapsulated in metal case
- B = Bellows (pre-load), maximum operating temperature: 85°C
- L = Bellows (pre-load), maximum operating temperature: 150°C
- C = 150VDC
- P = Plane, D = V groove
- N = Female thread type
- F = Flange type (refer to page 12 for details)
- W = Without a flange
- LF = As of December, 2014
- Example: -A0 = leads are attached straight
- Sequentially numbered starting from 0
- The first two digits are effective numerals. The last digit is an exponent of 10.
- Example: 801 = 800 N = 80 kgf
-

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

Comply with RoHS
### Standard Parts List

#### AHB series

<table>
<thead>
<tr>
<th>Model</th>
<th>Displacement (μm)</th>
<th>Maximum driving voltage (150VDC)</th>
<th>Generated force</th>
<th>Resonance frequency [kHz]</th>
<th>Capacitance [μF]</th>
<th>Insulation resistance [MΩ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHB150C301</td>
<td>55.0 ± 8</td>
<td>800</td>
<td>12</td>
<td>18</td>
<td>6.4</td>
<td>10</td>
</tr>
<tr>
<td>AHB700C301</td>
<td>70.0 ± 15</td>
<td>800</td>
<td>8</td>
<td>10</td>
<td>8.2</td>
<td>5</td>
</tr>
<tr>
<td>AHB800C301</td>
<td>80.0 ± 15</td>
<td>800</td>
<td>8</td>
<td>10</td>
<td>9.3</td>
<td>5</td>
</tr>
<tr>
<td>AHB101C301</td>
<td>103.0 ± 15</td>
<td>800</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>AHB550C172</td>
<td>52.0 ± 8</td>
<td>1,700</td>
<td>11</td>
<td>18</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>AHB550C202</td>
<td>52.0 ± 8</td>
<td>3,000</td>
<td>11</td>
<td>18</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>AHB700C302</td>
<td>68.0 ± 15</td>
<td>3,000</td>
<td>11</td>
<td>18</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>AHB101C302</td>
<td>95.0 ± 15</td>
<td>3,000</td>
<td>11</td>
<td>9</td>
<td>44</td>
<td>1</td>
</tr>
<tr>
<td>AHB101C362</td>
<td>95.0 ± 15</td>
<td>3,600</td>
<td>11</td>
<td>9</td>
<td>54</td>
<td>1</td>
</tr>
<tr>
<td>AHB151C362</td>
<td>140.0 ± 18</td>
<td>3,600</td>
<td>11</td>
<td>7</td>
<td>85</td>
<td>0.5</td>
</tr>
<tr>
<td>AHB201C362</td>
<td>240.0 ± 24</td>
<td>3,600</td>
<td>11</td>
<td>4</td>
<td>140</td>
<td>0.2</td>
</tr>
</tbody>
</table>

1. In model number has “N” or “F”, “W” letter.
2. In model number has “P” or “O” letter.
3. ▲ in model number has New design No.
   Example: AHB800C301NP0LF

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

#### ASB series

<table>
<thead>
<tr>
<th>Model</th>
<th>Displacement (μm)</th>
<th>Maximum driving voltage (150VDC)</th>
<th>Generated force</th>
<th>Resonance frequency [kHz]</th>
<th>Capacitance [μF]</th>
<th>Insulation resistance [MΩ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASB170C201</td>
<td>20.0 ± 3</td>
<td>200</td>
<td>24</td>
<td>37</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>ASB170C301</td>
<td>17.0 ± 3</td>
<td>800</td>
<td>14</td>
<td>32</td>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td>ASB340C301</td>
<td>34.0 ± 6</td>
<td>800</td>
<td>12</td>
<td>18</td>
<td>3.0</td>
<td>15</td>
</tr>
<tr>
<td>ASB510C301</td>
<td>51.0 ± 9</td>
<td>800</td>
<td>10</td>
<td>12</td>
<td>4.5</td>
<td>10</td>
</tr>
<tr>
<td>ASB610C301</td>
<td>68.0 ± 12</td>
<td>800</td>
<td>8</td>
<td>9</td>
<td>6.0</td>
<td>5</td>
</tr>
<tr>
<td>ASB600C301</td>
<td>44.0 ± 6</td>
<td>3,000</td>
<td>11</td>
<td>18</td>
<td>18.0</td>
<td>1</td>
</tr>
<tr>
<td>ASB600C302</td>
<td>84.0 ± 15</td>
<td>3,000</td>
<td>11</td>
<td>8</td>
<td>34.0</td>
<td>1</td>
</tr>
</tbody>
</table>

1. In model number has “N” or “F”, “W” letter.
2. ▲ in model number has “P” or “O” letter.
   Example: ASB1710C01NP0LF, ASB510C301W01AOLF

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

#### ASL series

<table>
<thead>
<tr>
<th>Model</th>
<th>Displacement (μm)</th>
<th>Maximum driving voltage (150VDC)</th>
<th>Generated force</th>
<th>Resonance frequency [kHz]</th>
<th>Capacitance [μF]</th>
<th>Insulation resistance [MΩ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASL170C201</td>
<td>19.0 ± 3</td>
<td>800</td>
<td>14</td>
<td>32</td>
<td>1.3</td>
<td>30</td>
</tr>
<tr>
<td>ASL240C301</td>
<td>39.0 ± 6</td>
<td>800</td>
<td>12</td>
<td>18</td>
<td>2.6</td>
<td>15</td>
</tr>
<tr>
<td>ASL310C301</td>
<td>58.0 ± 9</td>
<td>800</td>
<td>10</td>
<td>12</td>
<td>3.9</td>
<td>10</td>
</tr>
<tr>
<td>ASL610C301</td>
<td>77.0 ± 12</td>
<td>800</td>
<td>8</td>
<td>9</td>
<td>5.1</td>
<td>5</td>
</tr>
</tbody>
</table>

1. In model number has “N” or “F”, “W” letter.
2. ▲ in model number has “P” or “O” letter.
   Example: ASL1710C01FP0LF

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

---

![Multilayer Piezoelectric Actuators VOL.01](13)
Product appearance example
## Performance

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| **Operating temperature range** | ASB/AHB: -25 to +85°C  
                           ASL: -40 to +150°C | When applied with DC voltage: Ambient temperature  
When driven by pulse: Ambient temperature + Temperature rise due to generated heat |
| **Recommended Storage condition** | -5 to +40°C             |                                                                                                                                  |
| **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 |                                                                                                                                  |
| **Capacitance tolerance**   | +/− 20%                    | f = 1kHz, V=1Vrms (<10 μF)  
                        f = 120kHz, V=1Vrms (>10 μF) |
| **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 | Typical value of the element under our test conditions                                                                           |
| **Airtightness**            | $1 \times 10^{-4}$ atm co/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, AHB  
Room temperature (3 min): 25°C (30 min)  
-40°C (30 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, AHB: 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 |

---

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Dimensions (Common to ASB, ASL and AHB Series)

● Female thread type

![Female thread type diagram]

- **TOP VIEW**
  - 17
  - \(\phi 11.5 \pm 0.5\)
  - Section A
  - Direction of displacement
  - Width: \(2.0 \pm 0.3\)
  - Height: \(2.5 \pm 0.2\)
  - Length: \(L \geq 0.5\)
  - \(9 \pm 0.2\)

- **BOTTOM VIEW**
  - \(\phi 19.6 \pm 0.5\)
  - \(17\)
  - \(\phi\ 2.2\)
  - \(90^\circ\)
  - M4 screw of min. 3 deep
  - Prepared hole of max. 5 deep

- **Enlarged of section A**
  - **P type**
  - **D type**

- **Model L (mm)**
  - ASB170C801NP0LF 38.4
  - ASL170C801NP0LF 38.4
  - ASB340C801NP0LF 58.4
  - ASL340C801NP0LF 58.4
  - ASB510C801NP0LF 78.4
  - ASL510C801NP0LF 78.4
  - ASB680C801NP0LF 98.4
  - ASL680C801NP0LF 98.4

Both P type and D type have the same overall lengths

● Flange type

![Flange type diagram]

- **TOP VIEW**
  - 17
  - \(\phi 11.5 \pm 0.5\)
  - Section A
  - Direction of displacement
  - Width: \(2.5 \pm 0.2\)
  - Height: \(3.0 \pm 0.2\)
  - Length: \(L \geq 0.5\)
  - \(13.0 \pm 0.5\)

- **BOTTOM VIEW**
  - \(\phi 35 \pm 0.5\)
  - \(90^\circ\)

- **Enlarged of section A**
  - **P type**
  - **D type**

- **Model L (mm)**
  - ASB170C801FP0LF 32.4
  - ASL170C801FP0LF 32.4
  - ASB340C801FP0LF 52.4
  - ASL340C801FP0LF 52.4
  - ASB510C801FP0LF 72.4
  - ASL510C801FP0LF 72.4
  - ASB680C801FP0LF 92.4
  - ASL680C801FP0LF 92.4

Both P type and D type have the same overall lengths

- **Lead wire: AWG26, UL1993**
  - Red color: (+)
  - White color: (−)
Without flange type

**TOP VIEW**

**BOTTOM VIEW**

### Enlarged of section A

- **P type**
- **D type**

- **Section A**
  - **φ11.5±0.5**
  - **L±1**
  - **22±0**
  - **7±0.2**

- **Lead wire: AWG26, UL1993**
- **Red color:** (+)
- **White color:** (−)

---

**ASB170C201WP1-A0LF**

**TOP VIEW**

- **MAX1.5**
- **24±0.05**
- **0.2±0.1**

- **Lead wire**
  - **2.0±0.1**
  - **0.6±0.3**

- **L±1**

- **L±0.1**

- **φ16±0.3**

---

**AHB550C172WD1-A0LF**

**TOP VIEW**

- **φ13.1±0.5**
- **24±0.05**
- **0.2±0.1**

- **Lead wire**
  - **4.4±0.5**
  - **1.5±0.2**

- **10±1**

- **9.2±0.15**

---

### Specifications

- **Model**
- **L (mm)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASB170C801W ● 1-A0LF</td>
<td>24.4</td>
</tr>
<tr>
<td>ASL170C801W ● 1-A0LF</td>
<td>24.4</td>
</tr>
<tr>
<td>ASB340C801W ● 1-A0LF</td>
<td>44.4</td>
</tr>
<tr>
<td>ASL340C801W ● 1-A0LF</td>
<td>44.4</td>
</tr>
<tr>
<td>ASB510C801W ● 1-A0LF</td>
<td>64.4</td>
</tr>
<tr>
<td>ASL510C801W ● 1-A0LF</td>
<td>64.4</td>
</tr>
<tr>
<td>ASB680C801W ● 1-A0LF</td>
<td>84.4</td>
</tr>
<tr>
<td>ASL680C801W ● 1-A0LF</td>
<td>84.4</td>
</tr>
</tbody>
</table>

*Note: ● in model number has “P” or “D” letter.*

---

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---

Multilayer Piezoelectric Actuators VOL.01

17
ASB***C302WD1-A0LF
AHB***C302WD1-A0LF, AHB***C362WD1-A0LF

Top View

Bottom View

<table>
<thead>
<tr>
<th>Model</th>
<th>L (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASB400C302W●-1-A0LF</td>
<td>45.4</td>
</tr>
<tr>
<td>ASB800C302W●-1-A0LF</td>
<td>85.0</td>
</tr>
<tr>
<td>AHB550C302W●-1-A0LF</td>
<td>45.4</td>
</tr>
<tr>
<td>AHB700C302W●-1-A0LF</td>
<td>64.4</td>
</tr>
<tr>
<td>AHB101C302W●-1-A0LF</td>
<td>85.6</td>
</tr>
<tr>
<td>AHB101C362W●-1-A0LF</td>
<td>85.6</td>
</tr>
<tr>
<td>AHB151C362W●-1-A0LF</td>
<td>125.4</td>
</tr>
<tr>
<td>AHB201C362W●-1-A0LF</td>
<td>217.7</td>
</tr>
</tbody>
</table>

*Note: ● in model number has "P" or "D" letter.

*Lead wire: AWS26, UL1993
Red color: (+)
White color: (−)

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Example of fixing method for without flange type

Metal sealed actuator (Without flange type)

Lead wire

The base of the actuator should be settled to pedestal. Keep caution on the electrical insulation for the lead wire.

More than 4mm

More than 6mm

Characteristic Data

- ASB series

![Graphs and data tables showing various characteristics of ASB series actuators](image-url)
- ASL series performance compare with ASB series

Fig-16 Temperature vs. Displacement

Fig-17 Temperature vs. Capacitance

- AHB series

Fig-18 Voltage vs. Displacement

Fig-19 Compression load vs. Displacement

Fig-20 Heat generation vs. Drive frequency

\[\text{Driving waveform: SIN wave 0~Vp-p} \]
\[\text{Temperature measurement : 10 minutes after the device is in operation}\]

\[\text{Surface temperature (℃)}\]
\[\text{Driving frequency (Hz)}\]

**Multilayer Piezoelectric Actuators VOL.01**

20
## Application Example

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision machinery, Mechatronics</td>
<td>Sewing machine, Robot, Vibration of parts feeder, Positioning of equipment, Pressure sensor</td>
</tr>
<tr>
<td>Home appliance, Audio equipment</td>
<td>Actuator of pump, Speaker</td>
</tr>
<tr>
<td>Imaging equipment</td>
<td>Actuator of resolution improvement, Actuator of autofocus, Actuator of damping</td>
</tr>
<tr>
<td>Computer, OA equipment</td>
<td>Pressure sensor, Positioning of memory device (data storage or others)</td>
</tr>
<tr>
<td>Optical equipment</td>
<td>Positioning of stage, Actuator of autofocus, Actuator of shaker and damping system</td>
</tr>
<tr>
<td>Communications</td>
<td>Polarization control, Wavelength control</td>
</tr>
<tr>
<td>Medical equipment</td>
<td>Micropump, Ultrasonic transducer, Manipulators</td>
</tr>
<tr>
<td>Measuring instrument</td>
<td>Pressure sensor, Acceleration sensor, Fine positioning</td>
</tr>
<tr>
<td>Automobile</td>
<td>Vibration control</td>
</tr>
</tbody>
</table>

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⚠️ Before using the product in this catalog, please read "Precautions" and other safety precautions listed in the printed version catalog.
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, piezoe 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.

(1) Resin-coated Type (AE Series)

a. 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.

\[
MTTF_r = MTTF_s \times A_v \times A_h \times A_t \quad (1)
\]

- \(MTTF_r\) : Estimated value
- \(MTTF_s\) : Reference value (=500h)

\[A_v = \left(\frac{150}{V_r}\right)^{3.2}\]

- \(A_v\) : Acceleration factor for drive voltage
- \(V_r\) : Actual voltage (V)

\[A_h = \left(\frac{90}{H_r}\right)^{4.9}\]

- \(A_h\) : Acceleration factor for relative humidity
- \(H_r\) : Actual relative humidity (RH%)

\[A_t = \left(\frac{40-T_r}{10}\right)^{1.5}\]

- \(A_t\) : Acceleration factor for ambient temperature
- \(T_r\) : Actual ambient temperature(°C)

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

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

\[
= 500 \times 3.66 \times 7.29 \times 1.84
\]

\[
= 24,500h \ (2.8yea)
\]

b. 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).

Please pay attention to the physical damage due to ringing phenomenon caused by the fixed method of the element and the speed of the voltage rise.

Please refer to the separately printed literature, “TOKIN Multilayer Piezoelectric Actuators User’s Manual” for more detail.
(2) Metal Sealed Type (ASB, ASL and AHB 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.

\[
MTTF_r = MTTF_s \times A_v \times A_t \neq (2)
\]

- \( MTTF_r \): Estimated value
- \( MTTF_s \): Reference value (=36,000h)
- \( A_v \): Acceleration factor for drive voltage = \( \frac{100}{V_r} \)
- \( V_r \): Actual operating voltage (V)
- \( A_t \): Acceleration factor for ambient temperature = 1.5\( \frac{T_r}{85} \)
- \( T_r \): Actual operating temperature (°C)

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

\[
MTTF_r = 36,000 \times \left( \frac{100}{150} \right)^2 \times 1.5 \times \frac{85}{85-25} = 36,000 \times 0.44 \times 11.3 = 179,000h \text{ (20.4 years)}
\]

b. Pulse voltage application

Like the resin-coated type, it is extremely difficult to estimate reliability by using an equation in the metal sealed type because of the influence of the pulse waveform, frequency, etc. in addition to the voltage and ambient temperature.

In TOKIN’s testing on the ASB170C801NP0, there was no failure confirmed up to 1000 hours (equivalent to 100 million pulses were applied) under the conditions below.

[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 the piezo actuators from being bent, being twisted, or being applied tensile force.
- Reference: Guide for tolerance of twisting and tension

<table>
<thead>
<tr>
<th>Reference value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisting force</td>
<td>$3 \times 10^{-3}$ N \cdot m or less</td>
</tr>
<tr>
<td>Tension</td>
<td>50 N or less</td>
</tr>
</tbody>
</table>

- 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 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, 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 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 that the generated force and displacement cannot be deteriorated.
  - Connect the driven item at the displacement generating end after securing the mounting portion so that it avoids unnecessary stress applied 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 usages that cause bending, twisting, or tension force when the device is in use.

Example of Actuator mounting:

![Diagram of Actuator mounting](attachment:image)

a) Example of wrong mounting
   - Imperfect alignment between actuator and load
   - The actuator may break.

b) Example of correct mounting
   - Mount the device so that the load is uniformly applied by the spherical surface or the hinge

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 literature, "TOKIN Multilayer Piezoelectric Actuators User’s Manual"
Generated force and load relation:

Static load: No load value change when actuator moves.

- 400N static load is applied

- Zero point shift.

- Total displacement is not changed.

- 100N static load is applied.

- Load-Displacement line of actuator

- Displacement loss

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

- Spring load (Fluctuating load): Displacement is changed by relation between generated force and spring constant of actuator.
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.
- If the actuator is exposed to high temperature above 100°C 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.

![Diagram]

**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 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 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.
- These products must be handled properly as industrial waste. When disposing, please contact your local waste disposal service.
- Piezo actuator is industrial wastes, make sure disposal method under the laws.

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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. 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 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.

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 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 May 2017, and they may be changed without notice. If our products are used for mass-production design, please consult 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 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, TOKIN assumes no responsibility for problems other than problems directly associated with the constitution and manufacturing method of the products.

(6) Export Control

For customers outside Japan
TOKIN products should not be used or sold for use in the development, production, stockpiling or utilization of any conventional weapons or mass-destructive weapons (nuclear weapons, chemical or biological weapons, or missiles), or any other weapons.

For customers in Japan
For products which are controlled items subject to the "Foreign Exchange and Foreign Trade Law" of Japan, the export license specified by the law is required for export.