AER Series Resin Coated, Ring Shape

Overview

Multilayer piezoelectric actuators are ceramic elements used to convert electrical energy into mechanical energy such as displacement or force by utilizing the piezoelectric longitudinal effect.

KEMET's multilayer piezoelectric actuators are produced based on our unique element structure design and 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.

The Resin Coated, Ring Shape AER series actuators feature compact size for applications such as ultra-fine positioning mechanism and drive sources.

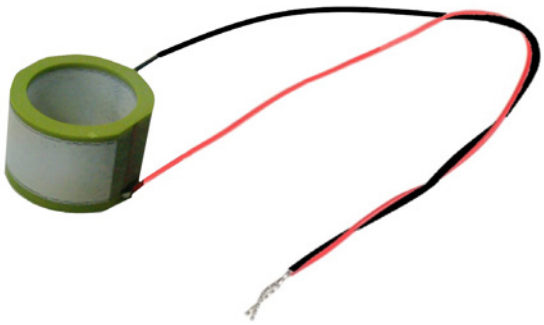
Applications

Typical applications include positioning, actuating, control and phase shift of laser. Since the laser can be passed inside the piezo ring, it can be used to adjust the phase and wavelength of the laser.

Semiconductor manufacturing system, precision machinery, mechatronics, optical equipment, communications, medical equipment and measuring instruments are just a few examples where these products can be used.

Benefits

- Ring shape
- Operating temperature range from −25°C to +85°C
- High-speed response: Driving up to about 1/3 of self-resonant frequency (in several ten kHz)
- Low power consumption: Can be retained at the leakage current state of 100 µA or less
- RoHS/REACH compliant



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Ordering Information

AER	13.6X	10X	10	D	F
Series	Outer Diameter (mm)	Inner Diameter (mm)	Height (mm)	Coating Type	Environmental Compliance
AER = Resin Coated Type, Ring Shape	13.6X = Φ13.6 mm 20X = Φ20 mm (Coating area is not included)	10X = Φ10 mm 15.4X = Φ15.4 mm (Coating area is not included)	10 = 10 mm 13.5 = 13.5 mm	D = Thin coating type	F = RoHS/REACH Compliant (See "Environmental Compliance" below)

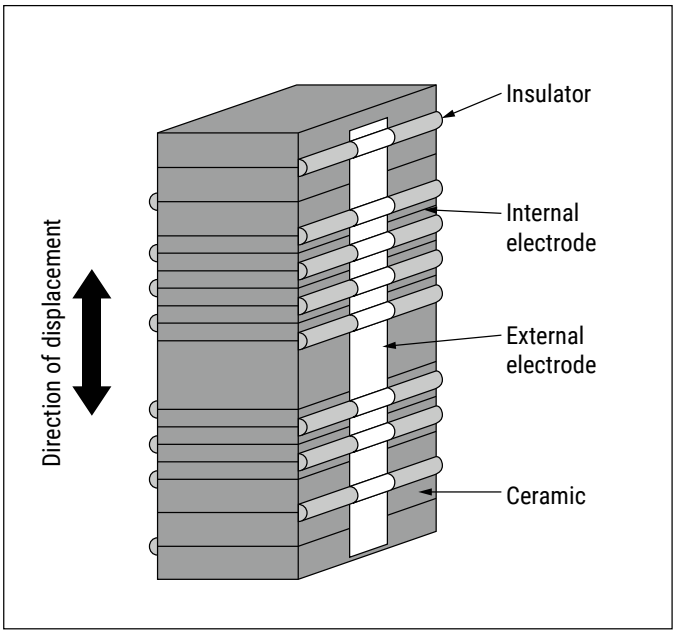
Application Examples

	Application Examples
Semiconductor manufacturing system	Actuator of shaker, positioning of light source
Precision machinery, mechatronics	Robot, positioning of equipment, pressure sensor
Optical equipment	Positioning of stage, actuator of autofocusing, actuator of shaker and damping system
Communications	Polarization control, wavelength control
Medical equipment	Micropump, ultrasonic transducer, manipulators
Measuring instrument	Fine positioning

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Element Structure

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



This particular structure and technology involved provide a unique product with below advantages compared to other similar solutions:

Against electromagnetic actuators
- Faster response
- Higher resolution for positioning
- Large generated force
- Low power consumption
- No electromagnetic noise

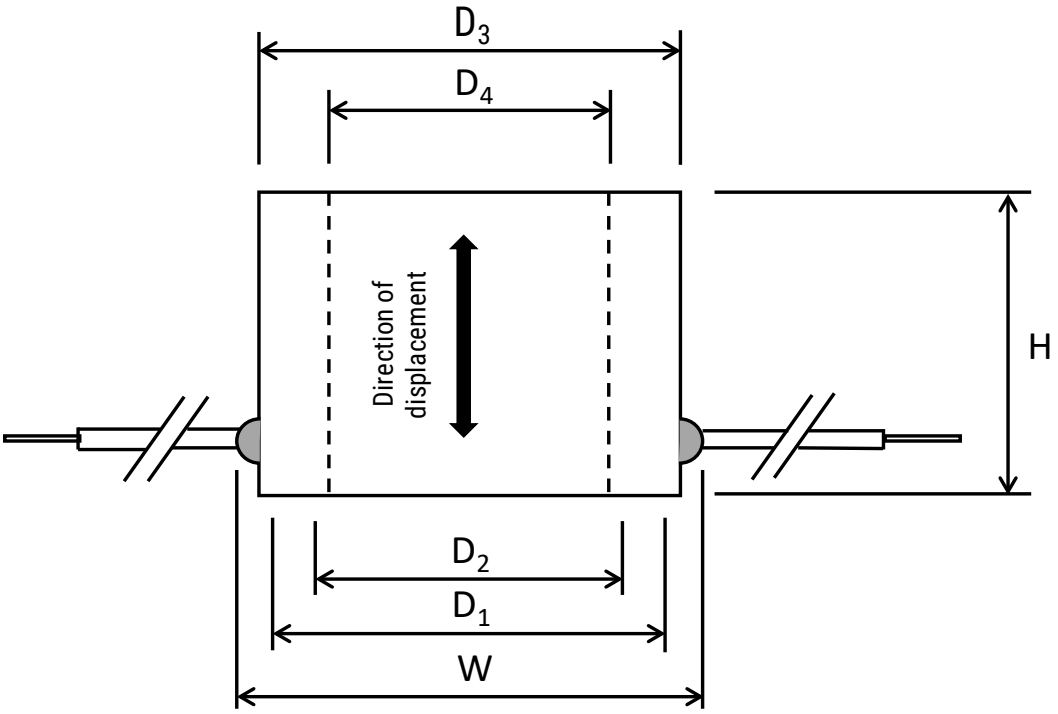
Against bimorph piezoelectric actuators
- 7 times the energy conversion efficiency of the bimorph type actuator
- Lower power consumption
- Large generated force
- Stable displacement, reduced shift and creep phenomena
- 100 times the response speed of the bimorph piezoelectric actuator

Against stacked piezoelectric actuators
- Compact size (less than 1/10 the specific volume of the stacked piezoelectric actuator)
- Low drive voltage
- Easy to use
- Inexpensive

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Dimensions in mm

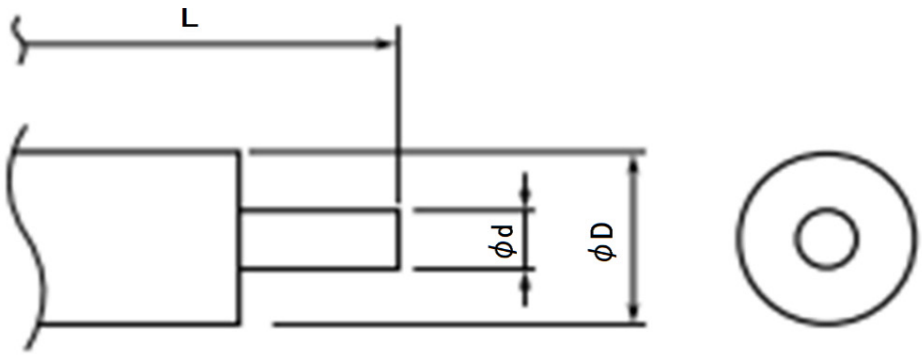
Outer dimensions in mm



Part Number	Outer Dimensions (mm)					
	H ±0.1	ØD1 ±0.1	ØD2 ±0.1	ØD3 Maximum	ØD4 Minmum	W Maximum
AER13.6X10X10DF	10.0	13.6	10.0	14.1	9.5	17.0
AER13.6X10X13.5DF	13.5	13.6	10.0	14.1	9.5	17.0
AER20X15.4X10DF	10.0	20.0	15.4	20.5	14.9	23.0
AER20X15.4X13.5DF	13.5	20.0	15.4	20.5	14.9	23.0

Dimensions in mm cont.

Wire dimensions in mm



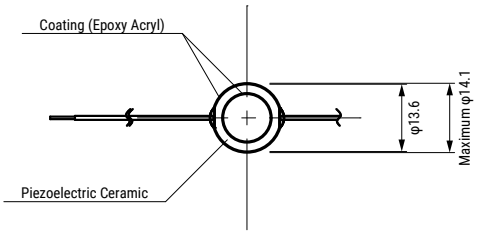
Note:
Ød = Diameter of lead wire
ØD = Outer diameter including the thickness of coating
L = Lead wire length

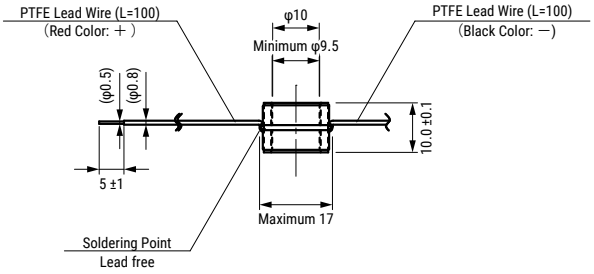
Lead wire : Copper wire with Tin plating
Coating : PTFE (Polytetrafluoroethylene)

Part Number	Wire Dimensions (mm)				
	AWG	Ød	ØD	L	UL Number
AER13.6X10X10DF	26	0.5	0.8	100	1993
AER13.6X10X13.5DF					
AER20X15.4X10DF					
AER20X15.4X13.5DF					

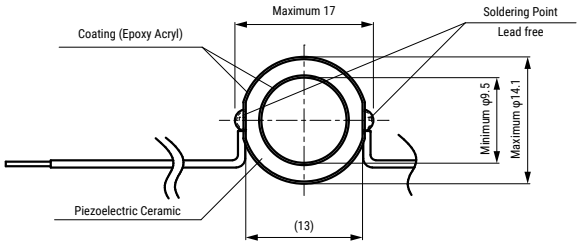
Dimensions in mm cont.

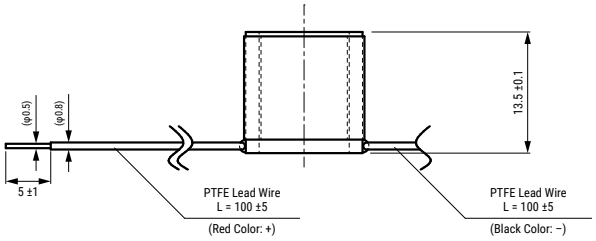
AER13.6X10X10DF



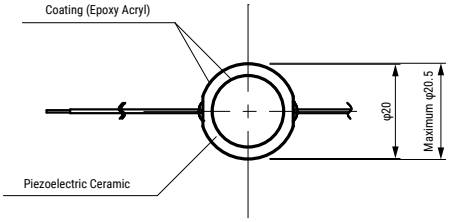


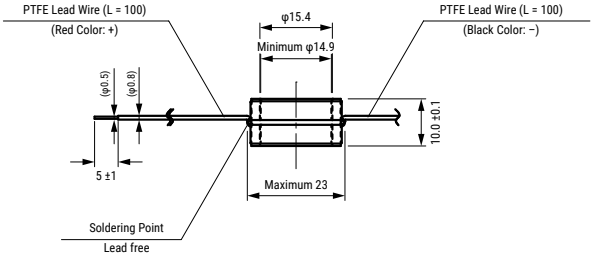
AER13.6X10X13.5DF



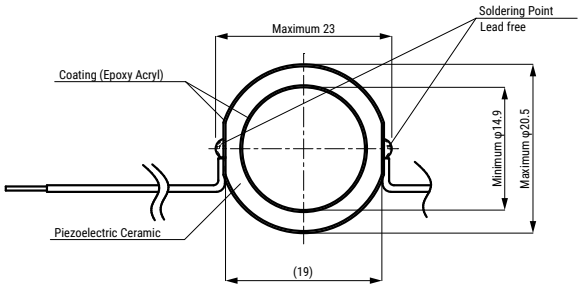


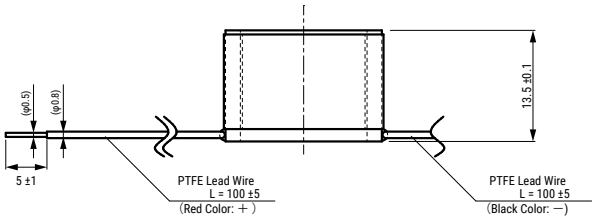
AER20X15.4X10DF





AER20X15.4X13.5DF





Performance Characteristics

Item	Performance Characteristics	Conditions
Operating Temperature Range	−25 to +85°C	When applied with a DC voltage at ambient temperature. When driven by an AC voltage at ambient temperature plus temperature rise due to heat generation.
Recommended Storage Condition	−5 to +40°C / less than 40% R.H.	No condensation. Recommended storage to be at room temperature.
Maximum Driving Voltage	150 VDC	
Displacement	See Table 1 - Ratings & Part Number Reference	At 150 VDC
Generated Force (Compression Resistance)	See Table 1 - Ratings & Part Number Reference	The force required for restricting the displacement to zero when the maximum driving voltage is applied.
Capacitance	See Table 1 - Ratings & Part Number Reference	f = 1 kHz, V = 1 V_{rms} (< 10 µF) f = 120 Hz, V = 1 V_{rms} (> 10 µF)
Capacitance Tolerance	±20%	
Dissipation Factor	5% or less	
Insulation Resistance	See Table 1 - Ratings & Part Number Reference	Value obtained in one minute at 150 VDC.
Resonance Frequency	See Table 1 - Ratings & Part Number Reference	Both ends of the element are in free state. Typical values of the element under our test conditions.
Tensile Strength	1/10 of generated force	Typical values of the element under our test conditions.
Young's Modulus	4.4 X 10^{10} N/m^2	Typical values of the element under our test conditions.
Temperature Cycle Test	Displacement: Initial value ±20% Capacitance: Initial value ±30% tan δ: Less than initial rated value Insulation Resistance: 1 MΩ or more	Room temperature (3 minutes) At −25°C for 30 minutes Room temperature (3 minutes) At +85°C for 30 minutes Repetition of 10 cycles of the above

Environmental Compliance

All KEMET Multilayer Piezoelectric Actuators are RoHS and REACH Compliant.

Article 33(1) of the REACH Regulation states that manufacturers and importers of articles (products) are required to notify their customers of the presence of any Substances of Very High Concern (SVHC) in their products exceeding 0.1% by weight and provide instructions on safe use of the product.

KEMET Corporation reports regarding the Article 33(1) of REACH Regulation as follows:

1. Applicable Product:
Multilayer piezoelectric actuators (AE, AER, ASB, ASL and AHB Series).

2. Report for content of REACH SVHC list:
The product(s) above contain a substance by more than 0.1wt% per product weight that was published in the 8th update of the REACH SVHC substances (December 19, 2012).

3. Regarding safety of the multilayer piezoelectric actuators (Piezoceramic products):
The Piezoceramic that is used in this product becomes ceramic by sintering powder containing PZT as a main ingredient. It is chemically stable, with minimum risks toward the human body or environment within the intended use of the product. Please note that risks could occur in the case of inhalation or accidental oral uptake of powder ceramics.

4. Technical product information on the multilayer piezoelectric actuators (Piezoceramic products):
The manufacturing technique of the “piezoceramic products” whose main ingredient is Lead Titanium Zirconium Oxide (PZT) has been established, and there is no alternative material that can exhibit superior performance than PZT at this moment. Please note that the piezoceramic is listed as an exempt on RoHS (2011/65/EU) Annex III (7c.1).

5. Responsibility of piezoceramic manufacturers:
Piezoceramic manufacturers report information regarding PZT containment in their products to the customers to obey the article 33 of the REACH regulation.



Table 1 – Ratings & Part Number Reference

Part Number	Electrical			Energy/ Power	Physical				
	Capacitance (µF)	Resonance Frequency (kHz)	Insulation Resistance (MΩ)	Generated Force (N)	Cross Section (mm)	Overall Length (mm)	Displacement (µm) at Maximum Voltage of 150 VDC	Stiffness (N/µm)	Weight (g)
AER13.6X10X10DF	2.1	138	10	2,200	OD13.6/ID10	10.0	9.1 ±1.5	241.8	6.8
AER13.6X10X13.5DF	2.8	102	10	2,200	OD13.6/ID10	13.5	13.2 ±2.0	166.7	7.4
AER20X15.4X10DF	3.7	138	2	4,200	OD13.6/ID10	10.00	9.1 ±1.5	461.5	10.4
AER20X15.4X13.5DF	5.3	102	2	4,200	OD13.6/ID10	13.5	13.2 ±2.0	318.2	14.0

Custom Design Parts

Customized parts are available on request. Please contact KEMET.
Below guidelines can be used as reference regarding generated displacement and generated force.

Item	Characteristics
Displacement	Roughly proportional to the length of the element
Generated Force	Roughly proportional to the sectional area of the element
Product Cross Section	1 x 1 mm square or larger
Product Length	1 mm or longer
Product Shape	Available in cylindrical ring or other shapes

Electrical Characteristics

Figure 1 - Voltage vs. Displacement

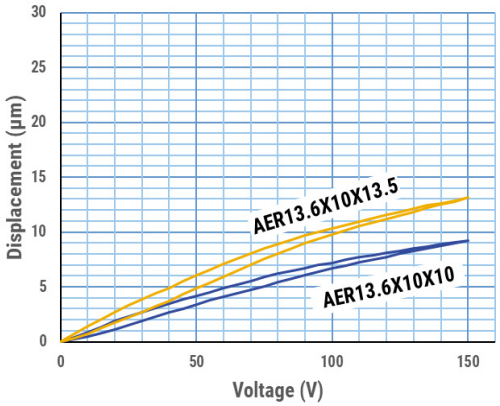


Figure 2 - Generated Force vs. Displacement

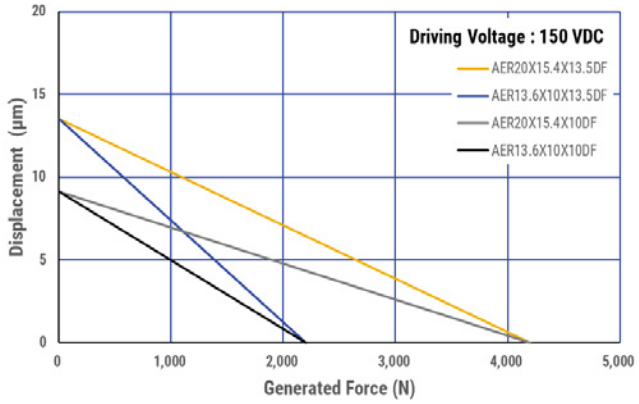
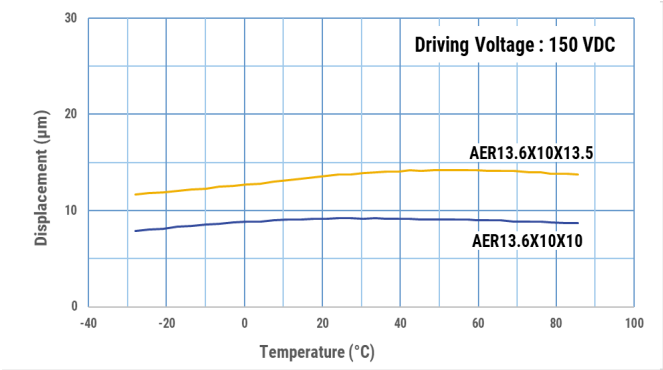
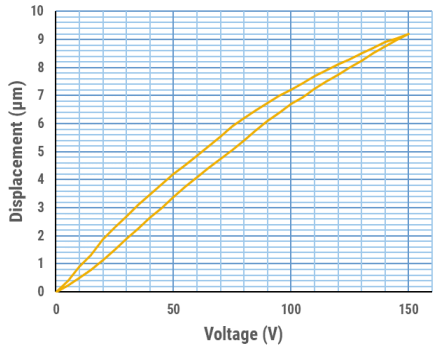
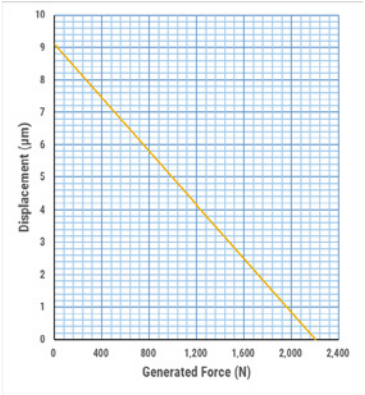
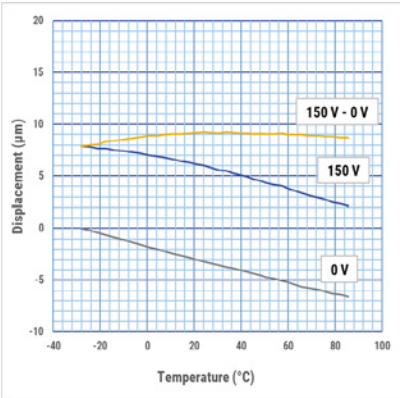
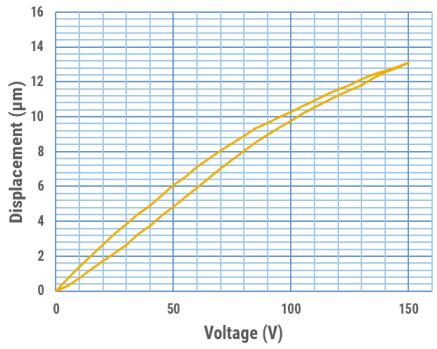
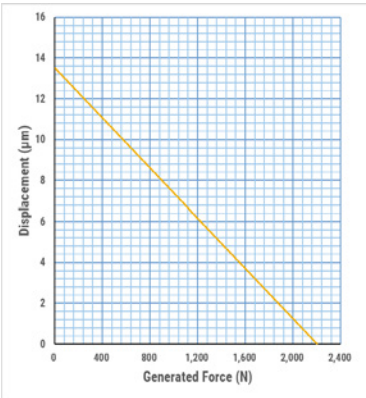
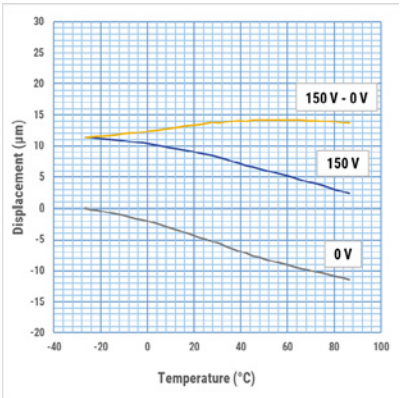


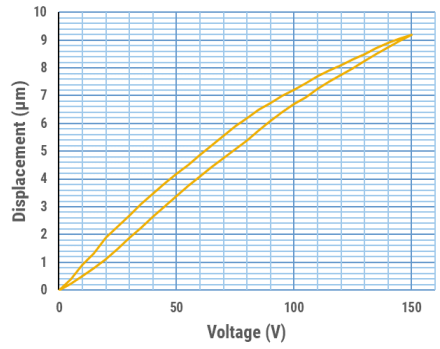
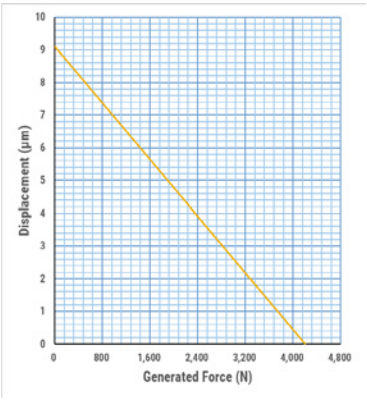
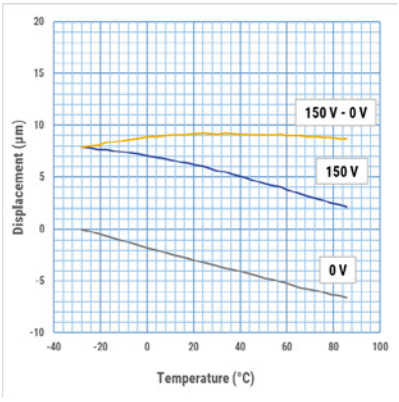
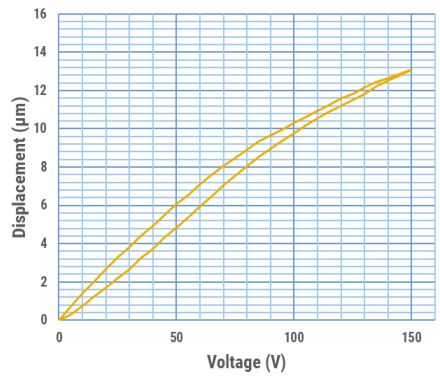
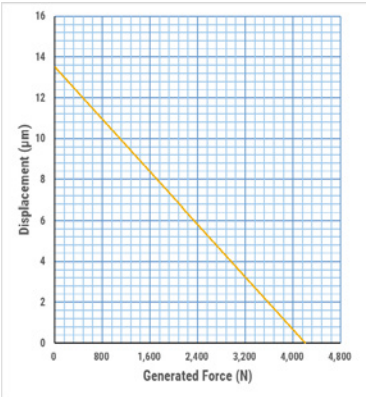
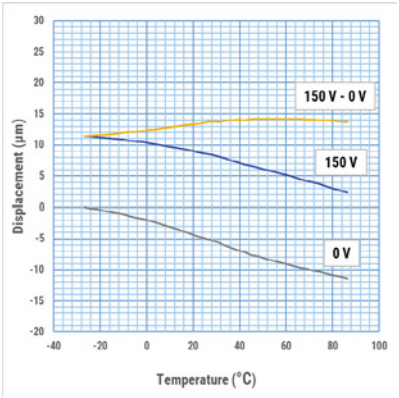
Figure 3 - Temperature vs. Displacement



Electrical Characteristics cont.

Voltage vs. Displacement	Generated Force vs. Displacement	Temperature vs. Displacement
AER13.6X10X10DF		
		
AER13.6X10X13.5DF		
		

Electrical Characteristics cont.

Voltage vs. Displacement	Generated Force vs. Displacement	Temperature vs. Displacement
AER20X15.4X10DF		
		
AER20X15.4X13.5DF		
		

Packaging

Series	Packaging Type	Pieces
AER	Bulk	1

Reliability

The majority of failure modes on multilayer piezoelectric actuators are short-circuits due to degraded insulation. Although the cause of degradation of insulation has not been clarified, it has been found that the failure rate varies greatly between static uses (DC voltage application) and dynamic uses (pulse voltage application). Like other electrical components, piezoelectric actuators can be affected by humidity as well as applied voltage and ambient temperature.

This section describes reliability guidelines for static and dynamic usage of the resin coated type actuators. Reliability of our multilayer piezoelectric actuators is represented by MTTF (mean time to failure) in case of static usage.

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 results. The MTTFr in actual applications is estimated using equation (1) below with MTTFs observed under accelerated conditions as the reference value.

(1) $MTTFr = MTTFs \times A_v \times A_h \times A_t$

MTTFr : Estimated value
MTTFs : Reference value (= 500 hours)

A_v: Acceleration factor for drive voltage = $(150/V_r)^{3.2}$ — V_r: Actual voltage (V)
A_h: Acceleration factor for relative humidity = $(90/H_r)^{4.9}$ — H_r: Actual relative humidity (RH%)
A_t: Acceleration factor for ambient temperature = $1.5^{(40\ -Tr)/10}$ — T_r: Actual ambient temperature (°C)

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

$MTTFr = 500 \times (150/100)^{3.2} \times (90/60)^{4.9} \times 1.5^{(40-25)/10}$
$= 500 \times 3.66 \times 7.29 \times 1.84$
$\approx$ 24,500 hours (2.8 years)

Pulse Voltage Application

In driving dynamic applications, temperature rises as a result of self-heating allowing the component not to be affected by the humidity, thus extending the operational lifetime. This phenomenon is explained as a result of the humidity factor elimination caused by the self-heating.

Since the self-heating value is affected by multiple factors such as the element's shape, pulse waveform and frequency, it is difficult to estimate the actual rising value. Therefore, the life of the actuator cannot be determined by using an equation, unlike the case of DC voltage applications. When testing the AE0203D08DF part, there was no failure confirmed after 500 hours end of the pulse driving test. (500 Hz, 0 – 150 V rectangular pulse).

Users should be careful about the influence of physical damage which can be caused by the fixing method of the element and/or the driving conditions.

User's Guide

Fixing Method

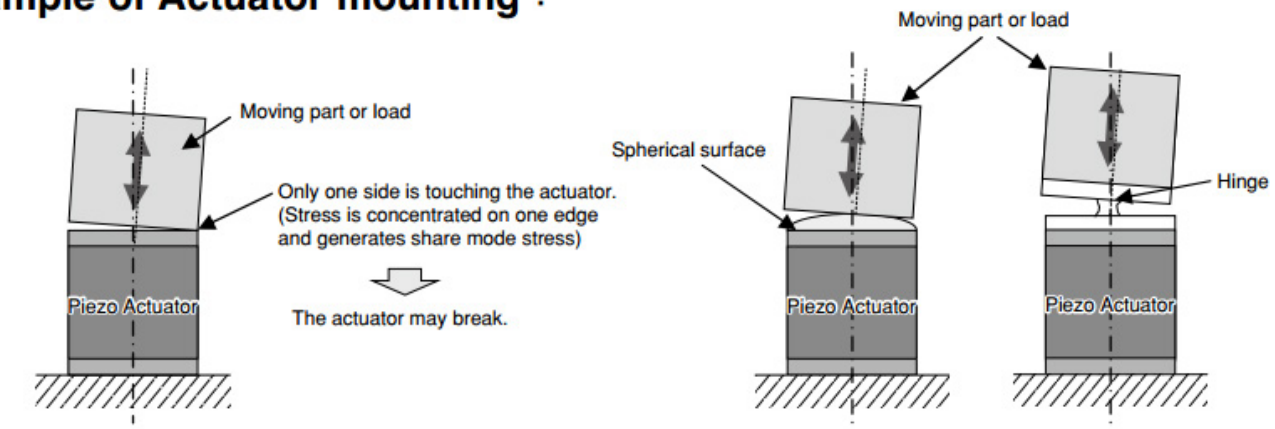
- Carefully prevent the piezoelectric actuators from being bent, twisted or applied tensile force.

Reference: Twisting and Tension Tolerance

	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 the 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 for medium thickness so that the generation force and displacement cannot be deteriorated. Also, do not form adhesives on the side of the actuator.
- When thermosetting resin is used, perform polarizing treatment (see caution section) after the adhesive is settled.
- The resin coated type is weak to the tensile force due to its structure and may be broken when tensile forces are 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.

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

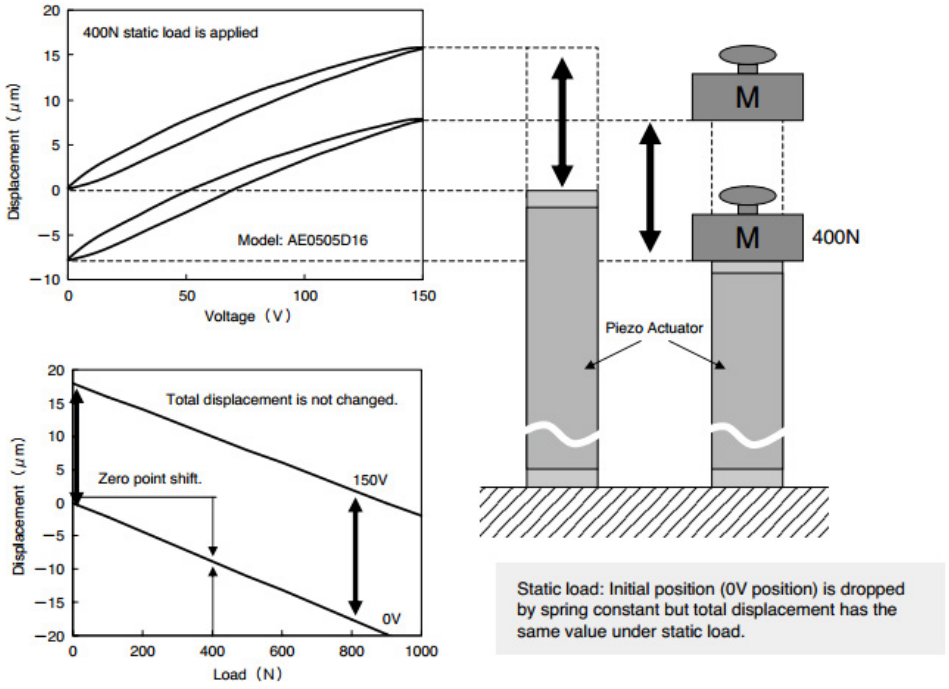
Driving Method

- Connect the red lead wire to the positive (+) terminal of the power supply. Also prevent reverse voltage application.
- In driving applications, it is necessary to take consideration of hysteresis, ringing, creep, and other similar phenomenons.
- For pulse driving, it is also necessary to be aware of self-heat generation, charge/discharge current, and the power supply's impedance.

User's Guide cont.

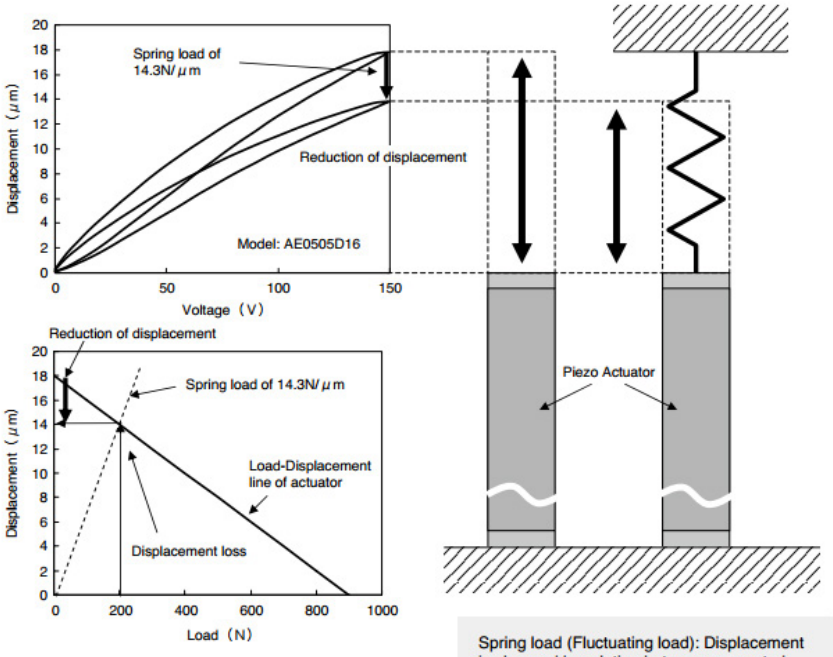
Generated Force and Load Relation

Static load: No load value changes when actuator moves.



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

Fluctuating 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.

Handling Precautions

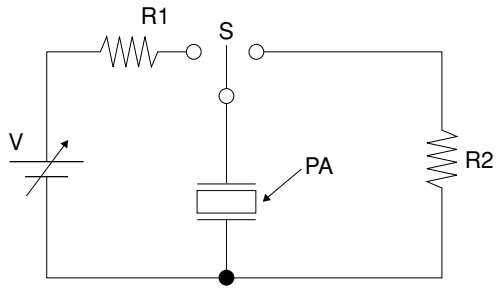
Precautions to be taken when using multilayer piezoelectric actuators
(Please read these precautions before using our products)

1. Before using or designing a system using our products, read the precautions and specifications listed below.

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

3. Use the products after checking the working conditions and rated performance of each multilayer piezoelectric actuator series. Selection of AE or AER Series (resin coated type) or ASB, ASL or AHB Series (metal sealed type) should be based on the intended working temperature and humidity.

- Connect the red lead wire to the positive (+) terminal of the power supply.
- Avoid electric shocks 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.
- 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.
- Do not wash the resin coated type (AE series) with organic solvents.
- Avoid excessive physical shock. Otherwise, the internal piezoelectric ceramic element may be damaged.
- If the actuator is exposed to high temperatures above 100°C or if used after long storage periods (more than three months), the device should be polarized by using the circuit configuration and conditions shown at right.



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 rapid charging and discharging.
- Do not use the actuator in high concentrations of highly inflammable gas.
- Align the center axis of displacement of the actuator with the center axis of the mechanical load.
- When operated, the transient response time of the actuator should be less than 1/3 of the resonant frequency in order to prevent damage by ringing.
- Store the resin coated type preferably in a dry atmosphere (desirably below 40% RH) at ordinary temperatures (-5°C to +40°C). Avoid condensation on the product's surface.
- Store actuators where there is no vibration.
- Handle products properly as industrial waste. When disposing, please contact your local waste disposal service and make sure the disposal methods meet all legal requirements.

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