

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 displacement and force at low voltages.

The Resin Coated AE series actuators feature compact size and a wide variety of shapes for applications such as ultra-fine positioning mechanism and drive sources.

Benefits

- Large generated force of 3,500 N/cm²
- 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
- Very small size: 1/10 or smaller than conventional multilayer actuators
- RoHS/REACH compliant



Applications

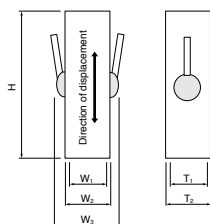
Typical applications include positioning, auto focusing of optical systems, pumps, mass-flow valves, vibration source, vibration controls, sensors, image stabilization of DSC, mirror/prism positioning, manipulators, motors and printers.

Ordering Information

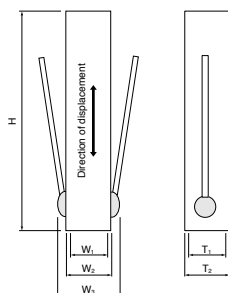
AE	0505	D44	H40	D	F
Series	Ceramic Cross Section (mm)	Nominal Displacement (µm)	Overall Length (mm)	Coating Type	Environmental Compliance
AE = Resin Coated Type	0505 = 5 mm X 5 mm (Coating area is not included)	The last two digits specify the displacement values. Example: D44 = 44 µm	Blank = Standard overall lengths of 5, 10 or 20 H40 = 40	D = Thin coating type	F = RoHS/REACH Compliant (See "Environmental Compliance" below)

Outer Dimensions in mm

Overall length 10,20mm Products



Overall length 5,9,18 and 40mm Products



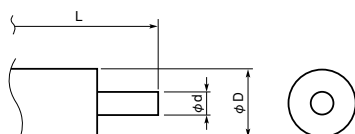
Note:

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.

Part Number	H	T ₁	W ₁	T ₂	W ₂	W ₃	L
AE0203D04DF	5 ±0.1	2 ±0.1	3 ±0.1	2.4 Maximum	3.4 Maximum	5.5 Maximum	100
AE0203D08DF	10 ±0.1						
AE0203D16DF	20 ±0.1						
AE0203D44H40DF	40 ±0.1						
AE0505D08DF	10 ±0.1	5 ±0.1	5 ±0.1	5.4 Maximum	5.4 Maximum	7.5 Maximum	
AE0505D16DF	20 ±0.1						
AE0505D44H40DF	40 ±0.1						
AE1010D16DF	20 ±0.1	10 ±0.1	10 ±0.1	10.4 Maximum	10.4 Maximum	12.5 Maximum	
AE1010D44H40DF	40 ±0.1						

Wire Diameter



φ d =Diameter of lead wire

φ D =Outer diameter including the thickness of coating

L =Length of lead wire

Lead wire: Copper wire with Tin plating

Coating: PTFE (Polytetrafluoroethylene)

Part Number	AWG	Ød	ØD	L	UL Number
AE0203D04DF	30	0.3	0.5	100	1993
AE0203D08DF					
AE0203D16DF					
AE0203D44H40DF					
AE0505D08DF	26	0.5	0.8		
AE0505D16DF					
AE0505D44H40DF					
AE1010D16DF	26	0.5	0.8		
AE1010D44H40DF					

Resin Coated Type Multilayer Piezoelectric Actuators

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	$f = 1 \text{ kHz}, V = 1 V_{\text{rms}} (< 10 \mu\text{F})$ $f = 120 \text{ Hz}, V = 1 V_{\text{rms}} (> 10 \mu\text{F})$
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 series and ASB Series)
2. Report for content of REACH SVHC list: The product(s) above contain a substance that is listed in the 8th update of the REACH SVHC 54 substances (December 19, 2012) which is included in the 14th update of the REACH SVHC 161 substances (December 17, 2015) by more than 0.1wt% per product weight.
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

Electrical Characteristics

Fig-1 Voltage vs. Displacement

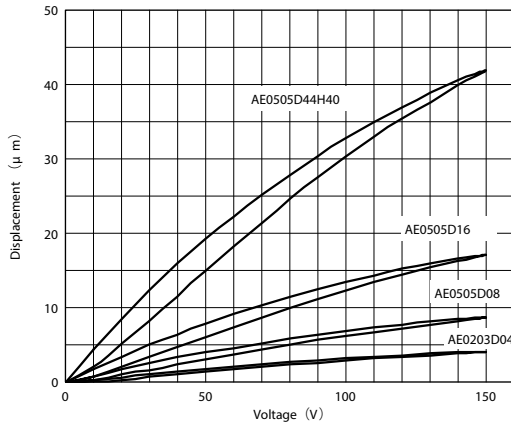


Fig-2 Generated force vs. Displacement of AE0505D16F in Driving voltage

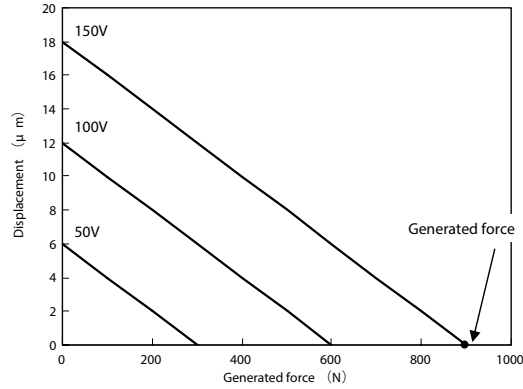


Fig-3 Generated force vs. Displacement-1

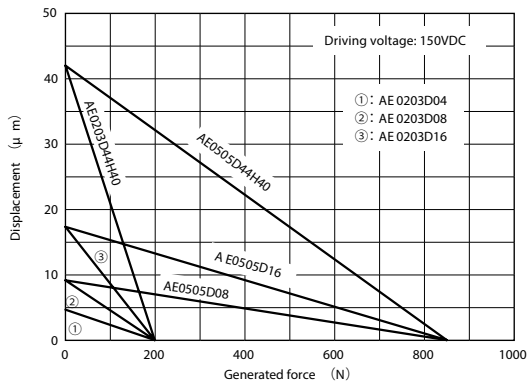


Fig-4 Generated force vs. Displacement-2

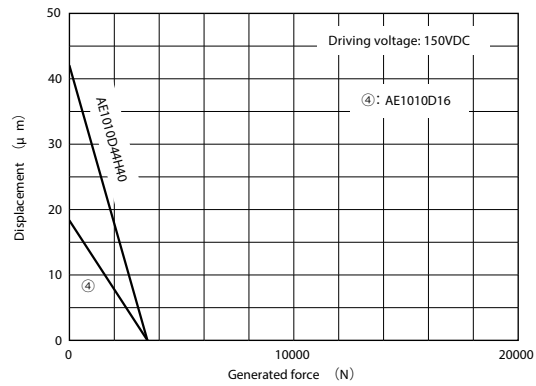
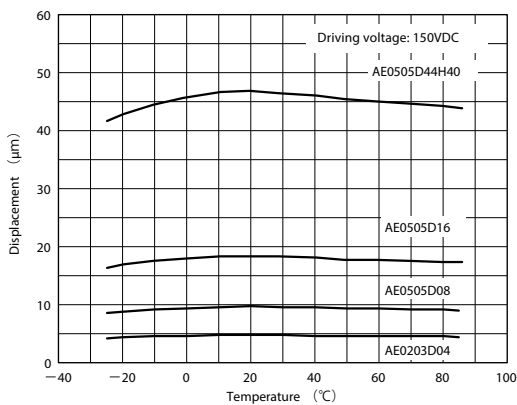


Fig-5 Temperature vs. Displacement



* Listed data are reference values. For the voltage vs. displacement characteristic, the same length of piezo series shows the same voltage vs. displacement characteristic.

* Definition of generated force for Fig-2, Fig-3 and Fig-4;

Force is the force required for restricting the displacement to 0 when the maximum driving voltage is applied.

Electrical Characteristics cont'd

Fig-6 Temperature vs. Displacement

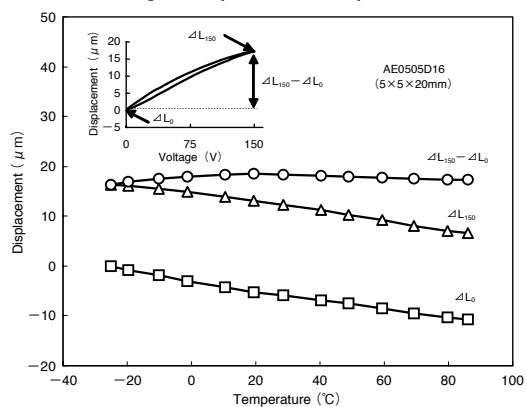


Fig-7 Voltage vs. Displacement in time

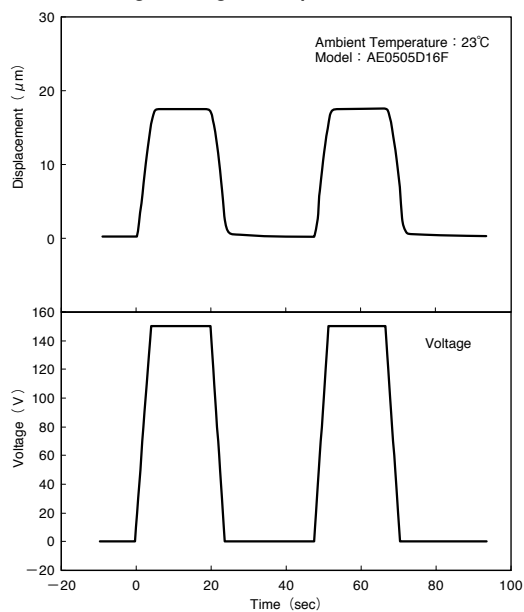


Fig-8 Heat generation vs. Drive frequency-1

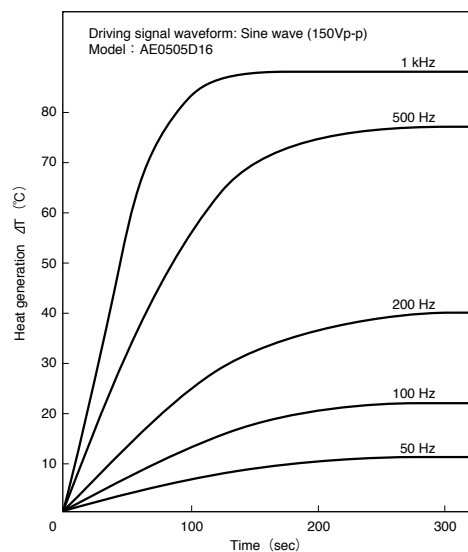


Fig-9 Heat generation vs. Drive frequency-2

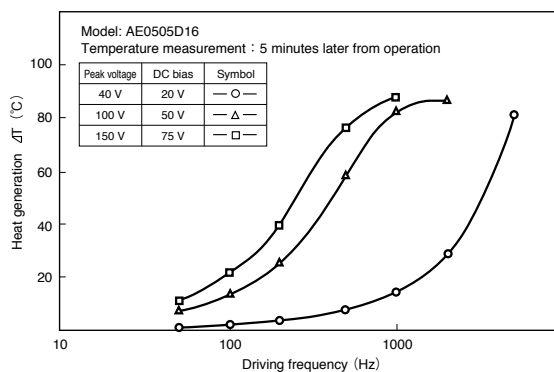


Table 1 – Ratings & Part Number Reference

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)
AE0203D04DF	0.09	261	100	200	2X3	5	4.6 +/- 1.5	43.5
AE0203D08DF	0.18	138	100	200	2X3	10	9.1 +/- 1.5	22
AE0203D16DF	0.35	69	50	200	2X3	20	17.4 +/- 2.0	11.5
AE0203D44H40DF	0.82	34	20	200	2X3	40	42.0 +/- 6.6	4.8
AE0505D08DF	0.75	138	50	850	5X5	10	9.1 +/- 1.5	93.4
AE0505D16DF	1.4	69	10	850	5X5	20	17.4 +/- 2.0	48.9
AE0505D44H40DF	3.4	34	5	850	5X5	40	42.0 +/- 6.6	20.2
AE1010D16DF	5.4	69	5	3,500	10X10	20	18.4 +/- 3.5	190.2
AE1010D44H40DF	13.6	34	2	3,500	10X10	40	42.0 +/- 6.6	83.3

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. KEMET has added the metal sealed piezoelectric actuators featuring high reliability by eliminating the effects of the ambient atmosphere.

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.

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

MTTFr : Estimated value

MTTFs : Reference value (= 500 hours)

A_v : Acceleration factor for drive voltage = $(150/V_R)^{3.2}$

A_h : Acceleration factor for relative humidity = $(90/H_R)^{4.9}$

A_t : Acceleration factor for ambient temperature = $1.5^{(40 - T_R)/10}$

V_R : Actual voltage (V)

H_R : Actual relative humidity (RH%)

T_R : Actual ambient temperature (°C)

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

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

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

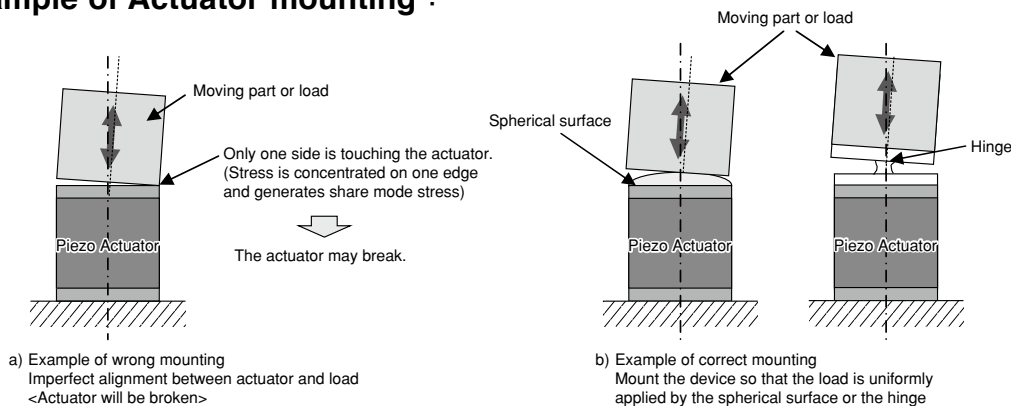
- Carefully prevent the piezoelectric actuators from being bent, twisted or applied tensile force.

Reference: Twisting and Tension Tolerance

	Reference Value	Remarks
Twisting Force	$3 \times 10^{-1} \text{ N} \cdot \text{m}$ 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 :



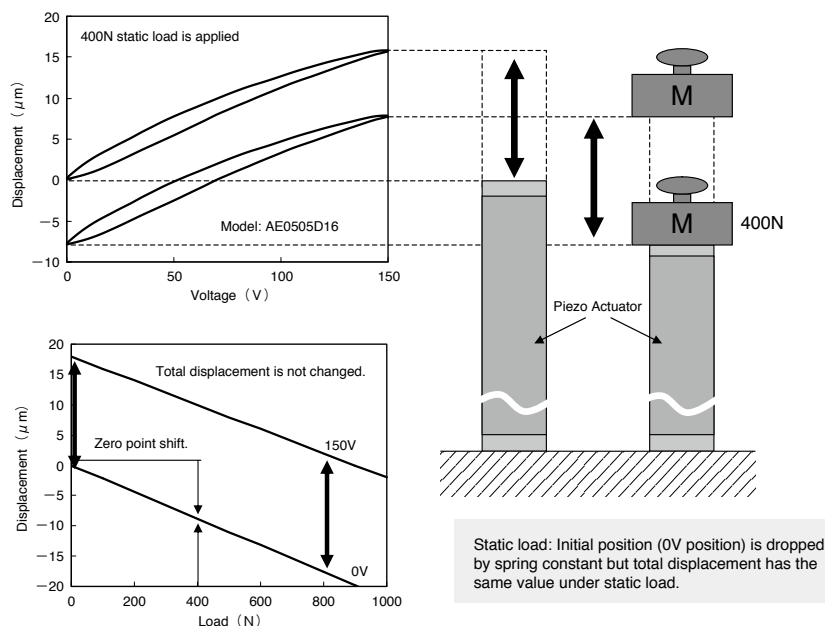
Driving Method

- 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 phenomena. For pulse driving, it is also necessary to be aware of self-heat generation, charge/discharge current, and the power supply's impedance.

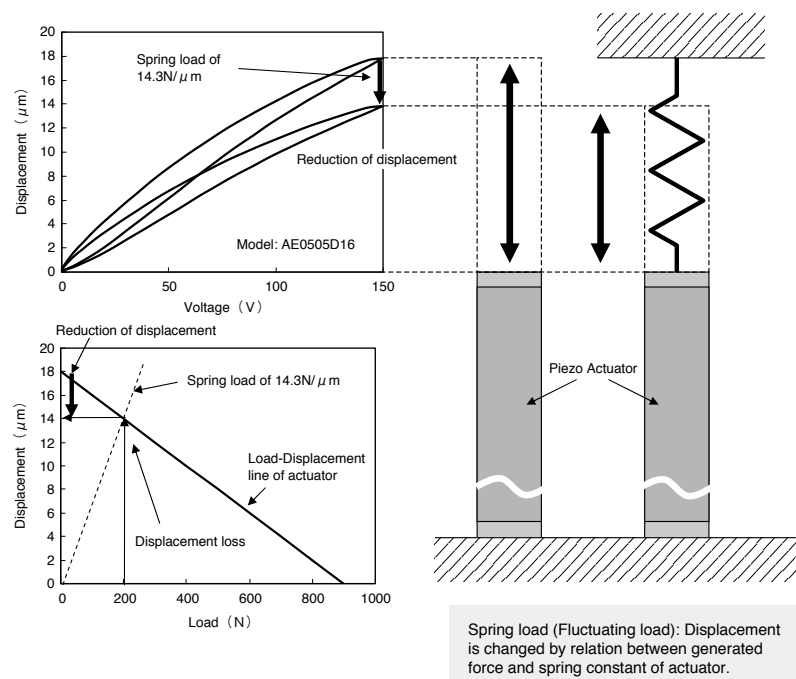
User's Guide cont'd

Generated force and load relation

Static load: No load value change when actuator moves.

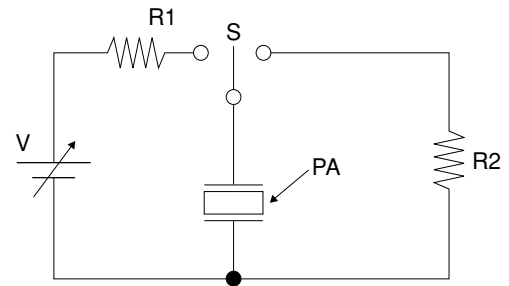


Fluctuating load: Load value changes by spring reaction when actuator moves.



Precautions

- 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.
- 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 (AE series) 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.



Protective resistor R1=1kΩ

Protective resistor R2=1kΩ

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

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

1. Safety designs allowing for failures of electronic components used in the system. In general, failures will occur in electronic components at a certain probability. KEMET 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 KEMET's electronic component products, systems should be carefully designed to ensure the prevention of faulty operation and redundancy in the event of an accident which would result in injury or death, fire, or social damage. Please refer to Precautions when using multilayer piezoelectric actuators for more details of failures.
2. Quality level of various kinds of parts and equipment in which the parts can be utilized as electronic components have a standard quality level unless otherwise specified. KEMET classifies the level of quality of electronic component products into three levels: 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 KEMET representative before using the electronic parts.

Precautions cont'd

Standard Quality Level: Computers, office automation equipment, communication equipment, measuring instruments, AV equipment, household electrical appliances, machine tools, personal equipment and industrial robots.

Special Quality Level: Transportation equipment (automobiles, railways, shipping), traffic signals, disaster prevention/crime prevention systems, a variety of safety devices and medical equipment which are not directly intended for life-support purposes.

Custom Quality Level: Equipment for airplanes, aerospace equipment, nuclear power control systems, medical equipment and apparatus or systems for life-support purposes.

Unless otherwise specified, the quality level of KEMET's electronic component products shown in documents such as catalogs, datasheets or technical books are the standard quality level.

3. This manual is subject to change without notice. The content of this manual is based on data which is correct as of December, 2014 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.
4. Reprinting and copying of this manual without prior written permission from KEMET Electronics Corporation is not permitted.
5. In the event of any problems associated with industrial property of a third party arising as a result of the use of our products, KEMET assumes no responsibility for problems other than directly associated with the constitution and manufacturing methods of the product.
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.

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 (such as level of quality) for the products you intend to use.
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 multilayer piezoelectric actuator series. Selection of AE series (resin coated type) or ASB series (metal sealed type) should be based on the intended working temperature and humidity.

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Although KEMET designs and manufactures its products to the most stringent quality and safety standards, given the current state of the art, isolated component failures may still occur. Accordingly, customer applications which require a high degree of reliability or safety should employ suitable designs or other safeguards (such as installation of protective circuitry or redundancies) in order to ensure that the failure of an electrical component does not result in a risk of personal injury or property damage.

Although all product-related warnings, cautions and notes must be observed, the customer should not assume that all safety measures are indicated or that other measures may not be required.