ESU, +105°C

Overview

The KEMET ESU aluminum electrolytic single-ended capacitors are designed for long life (up to 12,000 hours) applications.

Applications

Typical applications include electronic lighting and power.

Benefits

- Long life, up to 12,000 hours
- Operating temperature of up to +105°C
- Safety vent on the capacitor base

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Part Number System

ESU	336	M	160	A	H8	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Single-Ended Aluminum Electrolytic	First two digits represent for capacitance values. Last digit number of zeros to be added.	M = ±20%	160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 450	A = Standard	See Dimension Table	See Ordering Options Table

Ordering Options Table

Diameter	Packaging Type	Lead Type	Lead Length (mm)	Lead and Packaging Code
Standard Bulk Packaging Options				
4 – 22	Bulk (bag)	Straight	20/15 Minimum	AA
Standard Auto-Insertion Packaging Options				
4 – 5	Tape and Reel	Formed to 2.5 mm	H_0 = 16 ±0.75	LA
6.3	Tape and Reel	2.5 mm lead spacing	H_0 = 18.5 ±0.75	KA
8	Tape and Reel	Formed to 5 mm	H_0 = 16 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16 – 18	Ammo	7.5 mm lead spacing	H_0 = 18.5 ±0.75	EA
Other Packaging Options				
4 – 8	Ammo	Formed to 5 mm	H_0 = 16 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16 ±0.75	FA
4 – 6.3	Tape and Reel	Formed to 5 mm	H_0 = 16 ±0.75	JA
4 – 10	Tape and Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other lead and packaging options				

Environmental Compliance

As an environmentally conscious company, KEMET is working continuously with improvements concerning the environmental effects of both our capacitors and their production. In Europe (RoHS Directive) and in some other geographical areas like China, legislation has been put in place to prevent the use of some hazardous materials, such as lead (Pb), in electronic

these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed

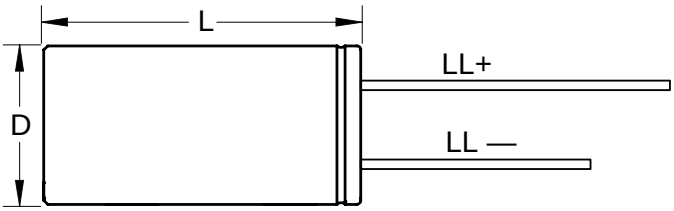
closely follow any changes in legislation world wide and make any necessary changes in its products, whenever needed.

Some customer segments such as medical, military and automotive electronics may still require the use of lead in electrode coatings. To clarify the situation and distinguish products from each other, a special symbol is used on the packaging labels for RoHS compatible capacitors.

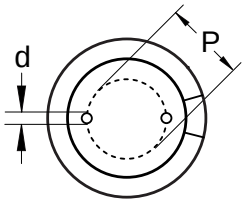
Due to customer requirements, there may appear additional markings such as lead free (LF) or lead-free wires (LFW) on the label.

Dimensions – Millimeters

SIDE VIEW



TERMINAL END VIEW



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
H8	10	±0.5	16		5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20		5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20		5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25		5	±0.5	0.6	Nominal	20/15	Minimum
M5	16	±0.5	20		7.5	±0.5	0.8	Nominal	20/15	Minimum
M7	16	±0.5	25		7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32		7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36		7.5	±0.5	0.8	Nominal	20/15	Minimum
N5	18	±0.5	25		7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32		7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36		7.5	±0.5	0.8	Nominal	20/15	Minimum
N9	18	±0.5	50		7.5	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	6.3 – 330 µF
Capacitance Tolerance	±20% at 120 Hz/20°C
Rated Voltage	160 – 450 VDC
Life Test	8,000 – 10,000 hours (see conditions in Test Methods & Performance)
Operating Temperature	
Leakage Current	
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

Impedance Z Characteristics at 120 Hz

Rated Voltage (VDC)	160	200	250	350	400	450
	3	3	3	5	5	6

Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	120 Hz	1 kHz	10 kHz	100 kHz
	0.50	0.80	0.90	1.00

Test Method & Performance

Conditions	Load Life Test		Shelf Life Test
Temperature	105°C		105°C
Test Duration	Can Ø = 10.0 mm	10,000 hours	1,000 hours
		12,000 hours	
Ripple Current			No ripple current applied
Voltage	The sum of DC voltage and the peak AC voltage must not exceed the rated voltage of the capacitor		No voltage applied
Performance	The following specifications will be satisfied when the capacitor is restored to 20°C:		
Capacitance Change	Within ±20% of the initial value		
Dissipation Factor			
Leakage Current			

Shelf Life

the leakage current will very slowly increase.

The KEMET E aluminum electrolytic capacitors should not be stored in high temperatures or where there is a high level of humidity. The suitable storage condition for KEMET's E aluminum electrolytic capacitors is +5 to +35°C and less than 75% in relative humidity. KEMET's E aluminum electrolytic capacitors should not be stored in damp conditions such as water, saltwater spray or oil spray. KEMET's E aluminum electrolytic capacitors should not be stored in an environment full of hazardous gas (hydrogen sulphide, sulphurous acid gas, nitrous acid, chlorine gas, ammonium, etc.) KEMET's E aluminum electrolytic capacitors should not be stored under exposure to ozone, ultraviolet rays or radiation.

If a capacitor has been stored for more than 18 months under these conditions and it shows increased leakage current, then a treatment by voltage application is recommended.

Re-Age (Reforming) Procedure

Apply the rated voltage to the capacitor at room temperature for a period of one hour, or until the leakage current has fallen

current or 5 mA (whichever is greater) is suggested.

Table 1 – Ratings & Part Number Reference

VDC	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
160	33	10 x 16	15	500	311.2	ESU336M160AH8(1)
160	47	10 x 20	15	580	400.8	ESU476M160AH4(1)
160	68	13 x 20	15	720	535.2	ESU686M160AL3(1)
160	100	13 x 25	15	970	740.0	ESU107M160AL4(1)
160	150	16 x 25	15	1120	1060.0	ESU157M160AM7(1)
160	220	16 x 32	15	1300	1508.0	ESU227M160AM2(1)
160	330	18 x 36	15	1380	2212.0	ESU337M160AN2(1)
160	560	18 x 50	15	2086	3684.0	ESU567M160AN9(1)
200	22	10 x 16	15	500	276.0	ESU226M200AH8(1)
200	33	10 x 20	15	520	364.0	ESU336M200AH4(1)
200	47	13 x 20	15	660	476.0	ESU476M200AL3(1)
200	68	13 x 25	15	720	644.0	ESU686M200AL4(1)
200	100	16 x 25	15	1120	900.0	16

(1) Insert packaging code. See Ordering Options Table for available options.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current that causes electrolysis. The oxygen produced by electrolysis will regenerate the dielectric layer but, at the same time, the hydrogen released may cause the internal pressure of the capacitor to increase. The overpressure vent (safety vent) ensures that the gas can escape when the pressure reaches a certain value. All mounting positions must allow the safety vent to work properly.

Installing

- A general principle is that lower-use temperatures result in a longer, useful life of the capacitor. For this reason, it should be ensured that electrolytic capacitors are placed away from heat-emitting components. Adequate space should be allowed between components for cooling air to circulate, particularly when high ripple current loads are applied. In any case, the maximum category temperature must not be exceeded.
- Do not deform the case of capacitors or use capacitors with a deformed case.
- Verify that the connections of the capacitors are able to insert on the board without excessive mechanical force.
- If the capacitors require mounting through additional means, the recommended mounting accessories shall be used.
- Verify the correct polarization of the capacitor on the board.
- Verify that the space around the pressure relief device is according to the following guideline:

Case Diameter	Space Around Safety Vent
	> 2 mm
	> 3 mm
> 40 mm	> 5 mm

It is recommended that capacitors always be mounted with the safety device uppermost or in the upper part of the capacitor.

value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated

R

rated voltages.

- In the case of capacitors connected in a series, a suitable voltage sharing must be used.
  In the case of balancing resistors, the approximate resistance value can be calculated as: R = 60/C.

KEMET recommends, nevertheless, to ensure that the voltage across each capacitor does not exceed its rated voltage.

Application and Operation Guidelines

Electrical Ratings:
Capacitance (ESC)

7MQTPM¼ IH IUYMZEPIRX GMVGYMX HMEKVEQ SJ ER IPIGXVSP]XMG GETEGMXSV

The capacitive component of the equivalent series circuit, (equivalent series capacitance - ESC), is determined by applying

Temperature Dependence of the Capacitance

Capacitance of an electrolytic capacitor depends upon temperature: with decreasing temperature the viscosity of the electrolyte increases, thereby reducing its conductivity.
Capacitance will decrease if temperature decreases. Furthermore, temperature drifts cause armature dilatation and, therefore, capacitance changes (up to 20% depending on the series considered, from 0 to 80°C). This phenomenon is more evident for electrolytic capacitors than for other types.

Frequency Dependence of the Capacitance

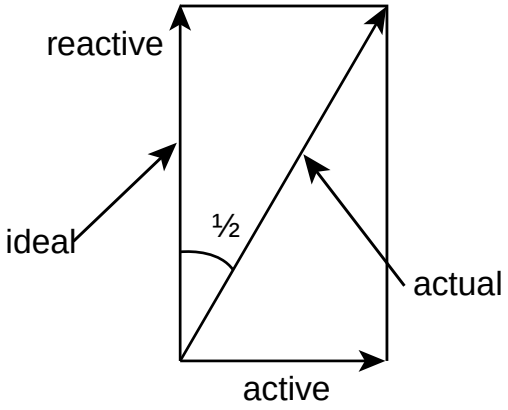
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{}$$

C = capacitance (F)
f = frequency (Hz)

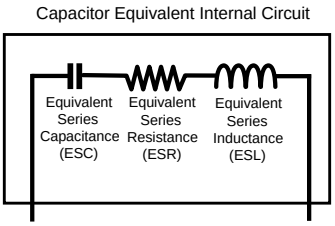
Dissipation Factor tan δ (DF)

thought of as a measurement of the gap between an actual and ideal capacitor.



ESC = Equivalent series capacitance
ESR = Equivalent series resistance

Equivalent Series Inductance (ESL)



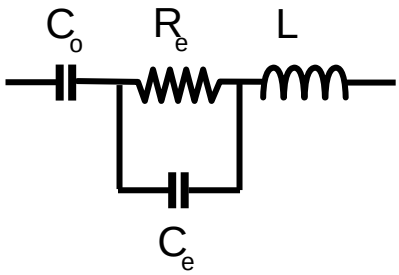
Equivalent Series Resistance (ESR)
Equivalent series resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and

$$ESR = \frac{\quad}{\quad}$$

ESC = Equivalent series capacitance (F)
f = Frequency (Hz)

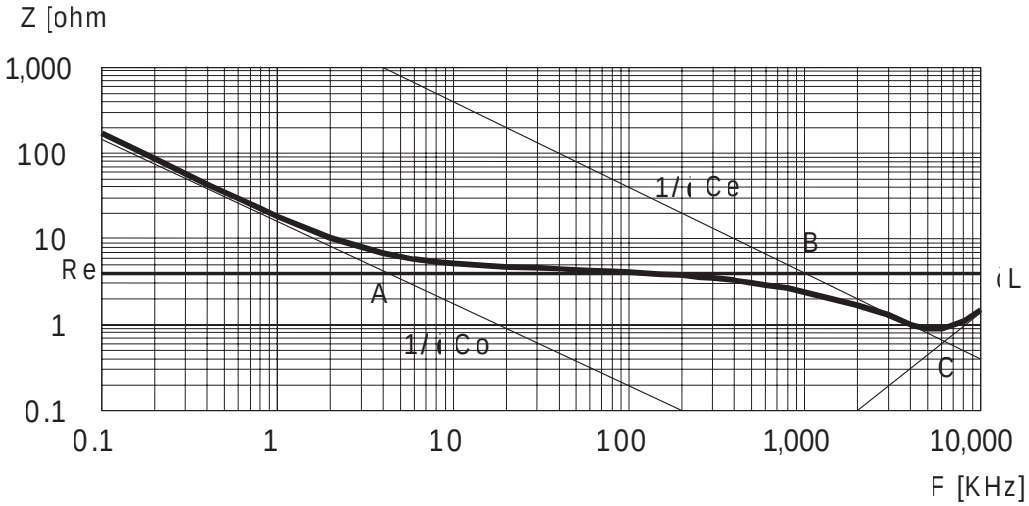
Tolerance limits of the rated capacitance must be taken into account when calculating this value.

Impedance (Z)
Impedance of an electrolytic capacitor results from a circuit formed by the following individual equivalent series components:



C_o = Aluminum oxide capacitance (surface and thickness of the dielectric.)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance.
L = Inductive reactance of the capacitor winding and terminals.
Impedance of an electrolytic capacitor is not a constant quantity that retains its value under all conditions; it changes depending on frequency and temperature.
Impedance as a function of frequency (sinusoidal waveform) for a certain temperature can be represented as follows:

Impedance (Z) cont'd



- Capacitive reactance predominates at low frequencies.

  $_o$ decreases until it reaches the order of magnitude of electrolyte resistance R_e(A)
- At even higher frequencies, resistance of the electrolyte predominates: $Z = R_e$ (A - B)

  $_0$), capacitive and inductive reactance mutually cancel each other

  $_e$ $_0$ = 1/SQR(LC_e)

  an increase in impedance

Generally speaking, it can be estimated that C_e $_o$.

Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):

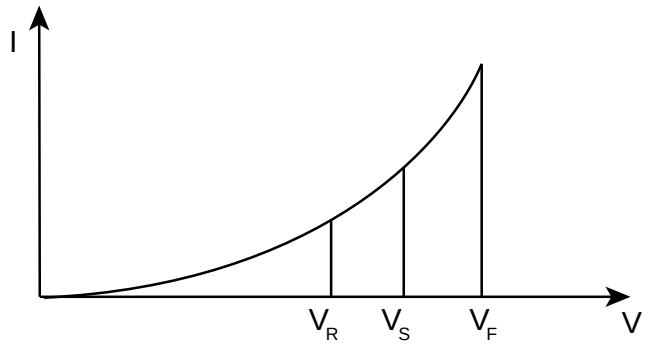
Leakage Current (LC)

been applied for long periods. This current is called leakage current.

prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease and reach an almost constant value.

After a voltage-free storage the oxide layer may deteriorate, especially at a high temperature. Since there are no leakage currents to transport oxygen ions to the anode, the oxide layer is not regenerated. The result is that a higher than normal

As the oxide layer is regenerated in use, the leakage current will gradually decrease to its normal level.
The relationship between the leakage current and voltage applied at constant temperature can be shown schematically as follows:



Where:
V_F = Forming voltage
If this level is exceeded, a large quantity of heat and gas will be generated and the capacitor could be damaged.
V_R = Rated voltage
This level represents the top of the linear part of the curve.
V_S = Surge voltage
This lies between V_R and V_F. The capacitor can be subjected to V_S for short periods only.

Electrolytic capacitors are subjected to a reforming process before acceptance testing. The purpose of this preconditioning is to ensure that the same initial conditions are maintained when comparing different products.

Ripple Current (RC)
The maximum ripple current value depends on:
- Ambient temperature
- Surface area of the capacitor (heat dissipation area)

- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

a function of the frequency.

Temperature Dependence of the Ripple Current

Expected Life Calculation

Expected life depends on operating temperature according to the following formula: $L = Lo \times 2^{(To-T)/10}$

Where:

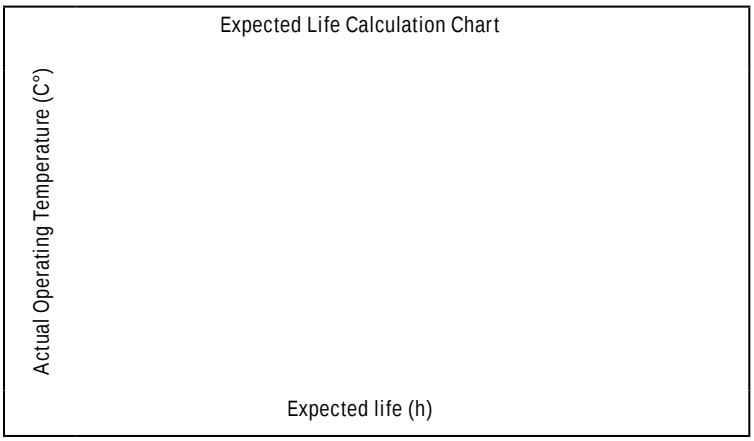
L: Expected life

Lo: Load life at a maximum permissible operating temperature

T: Actual operating temperature

To: Maximum permissible operating temperature

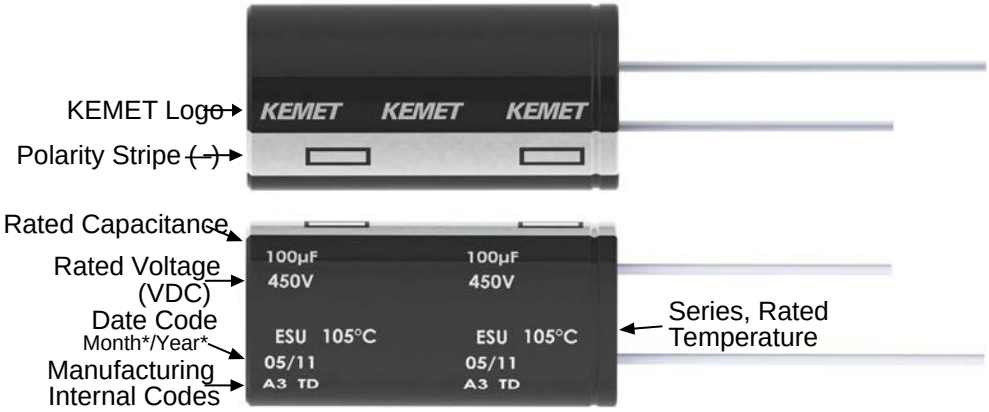
This formula is applicable between 40°C and To.



Packaging Quantities

Size Code	Diameter (mm)	Length (mm)	Bulk		Auto-insertion	
			Standard Leads	Cut Leads	Ammo	Tape & Reel
H8	10	16	3000	4000	700	1200
H4	10	20	2400	3000	700	1200
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M5	16	20	1000	500	300	
M7	16	25	1000	500	300	
M2	16	32	800	500	300	
M3	16	36	600	500	300	
N5	18	25	800	500	300	
N1	18	32	500	500		
N2	18	36	500	500		
N9	18	50	500	500		

Marking



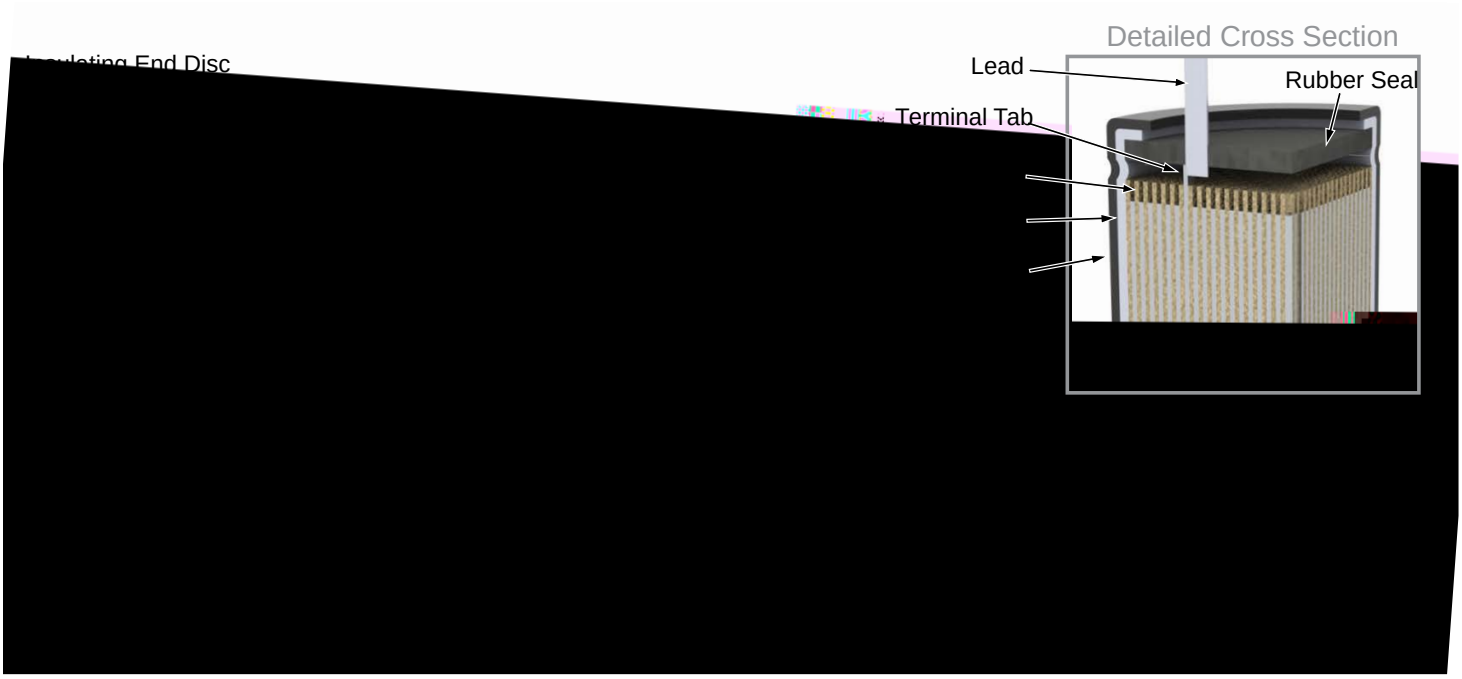
*Y = Year

Code	01	02	03	04	05	06	07	08	09
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019

*M = Month

Code	01	02	03	04	05	06	07	08	09	10	11	12
Month	1	2	3	4	5	6	7	8	9	10	11	12

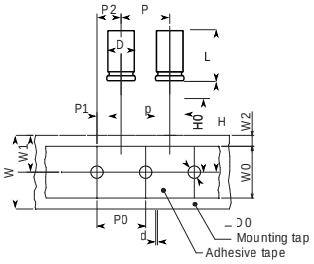
Construction



Taping for Automatic Insertion Machines

Formed to 2.5 mm
(Lead and packaging code LA and FA)

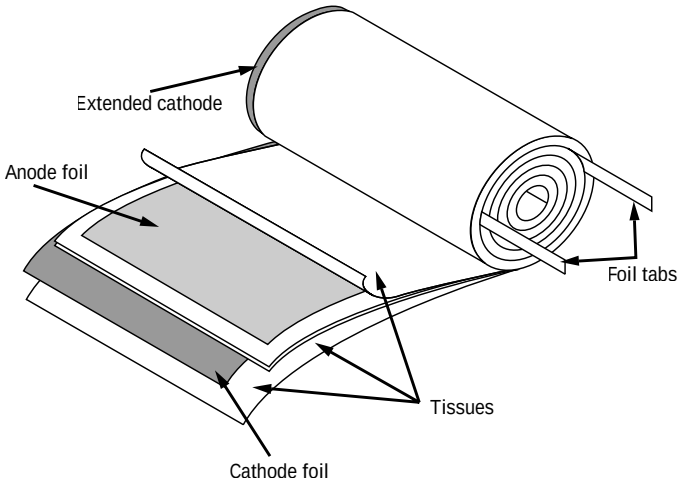
Formed to 5 mm
(Lead and packaging code JA and DA)

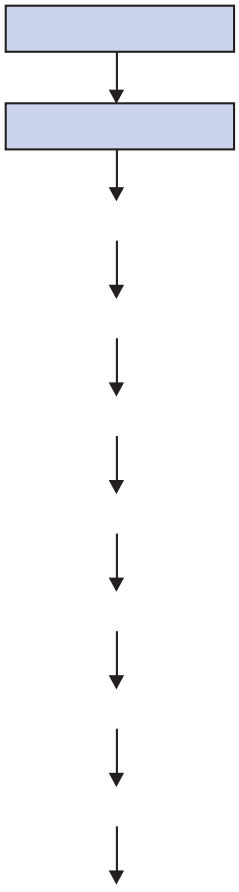


Straight Leads (Diameter: 4 – 8 mm)
Lead and packaging code EA and KA

Straight Leads (Diameter > 8)
Lead and packaging code EA and KA

Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	I	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1 .0	±0 .3	±0 .7	±1 .3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5		2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
Formed to 5 mm	4	5-7	5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	5		5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	6		5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	8		5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
Straight leads	4	5-7	1.5	0.45	12.7	12.7	5.6	6.35	18	12	11	3	18.5			4	0.7
	5		2	0.45	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
		>7	2	0.5	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
	6		2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
	8		3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
		>7	3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
	10	12-25	5	0.6	12.7	12.7	3.85	6.35	18	12	11	3	18.5		1	4	1
	12		5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
	13		5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
		15-25	5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
	16		7.5	0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1
	18		7.5	0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1


Extended cathode
Anode foil
Foil tabs
Tissues
Cathode foil



KEMET Electronics Corporation Sales O ces

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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 indicted or that other measures may not be required.