Surface Mount and Radial Aluminum Electrolytic Capacitors

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Electronic Components
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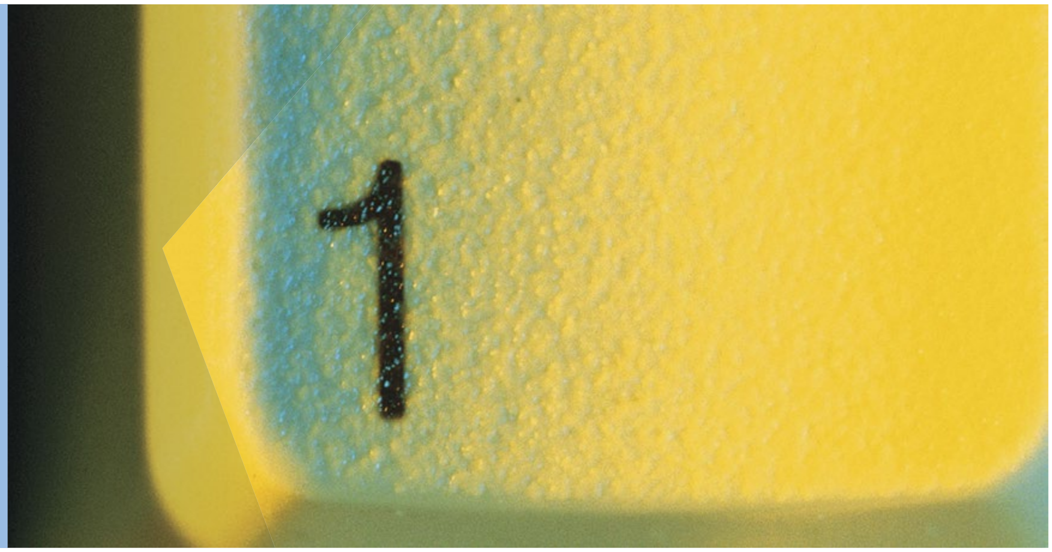

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When you partner with KEMET, our entire global organization provides you with the coordinated service you need. No bouncing from supplier to supplier. No endless phone calls and web browsing. We're your single, integrated source for electronic component solutions worldwide.

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Our commitment to product quality and on-time delivery has helped customers succeed for over 90 years. There's a reason KEMET components can be found in defense and aerospace equipment. Our reputation is built on a history of consistency, reliability and service.

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KEMET offers a level of responsiveness that far surpasses any other supplier. Our passion for customer service is evident throughout our global sales organization, which offers localized support bolstered by our worldwide logistics capabilities. Whether you need rush samples, technical assistance, in-person consultation, accelerated custom design, design collaboration or prototype services, we have a solution.

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KEMET is dedicated to economically, environmentally and socially sustainable development. We've adopted the Electronic Industry Code of Conduct (EICC) to address all aspects of corporate responsibility. Our manufacturing facilities have won numerous environmental excellence awards and recognitions, and our supply chain is certified. We believe doing the right thing is in everyone's interest.

About KEMET.

KEMET Corporation is a leading global supplier of electronic components. We offer our customers the broadest selection of capacitor technologies in the industry across multiple dielectrics, along with an expanding range of electromechanical devices, and electromagnetic compatibility solutions. Our vision is to be the preferred supplier of electronic component solutions for customers demanding the highest standards of quality, delivery and service.

EDK Series, +85ºC

Overview

KEMET's EDK Series of aluminum electrolytic surface mount capacitors are designed for high density printed circuit boards.

Applications

Typical applications include coupling, decoupling, bypass, and filtering.

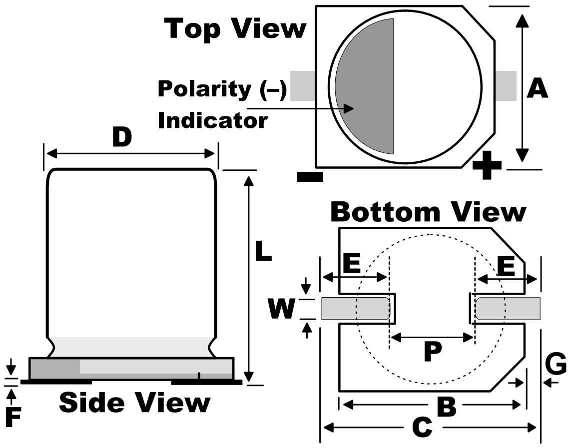
Benefits

- Surface mount lead terminals
- Low profile vertical chip
- General purpose +85°C/2,000 hours

Part Number System

EDK	226	M	004		A	9B	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)		Electrical Parameters	Size Code	Packaging
Surface Mount Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	004 = 4 6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35	050 = 50 063 = 63 100 = 100 250 = 250 400 = 400 450 = 450	A = Standard	See Dimension Table	AA = Tape & Reel

Dimensions – Millimeters



Size Code	D		L		A/B		C		E	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	4	±0.5	5.4	+0.25/-0.1	4.3	±0.2	5.5	Maximum	1.8	±0.2
9D	5	±0.5	5.4	+0.25/-0.1	5.3	±0.2	6.5	Maximum	2.2	±0.2
9G	6.3	±0.5	5.4	+0.25/-0.1	6.6	±0.2	7.8	Maximum	2.6	±0.2
9H	6.3	±0.5	7.7	±0.3	6.6	±0.2	7.8	Maximum	2.6	±0.2
9L	8	±0.5	6.2	±0.3	8.3	±0.2	9.5	Maximum	3.4	±0.2
9M	8	±0.5	10.2	±0.3	8.3	±0.2	10	Maximum	3.4	±0.2
9P	10	±0.5	10.2	±0.3	10.3	±0.2	13	Maximum	3.5	±0.2
9R	12.5	±0.5	13.5	±0.5	12.8	±0.2	15.2	Maximum	4.9	±0.2
9S	12.5	±0.5	16	±0.5	12.8	±0.2	15.2	Maximum	4.9	±0.2
9T	16	±0.5	16.5	±1.0	16.3	±0.2	18.7	Maximum	5.8	±0.2

Size Code	F		G		P		W	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	0.3	Maximum	0.35	+0.15/-0.2	1.0	±0.2	0.65	±0.1
9D	0.3	Maximum	0.35	+0.15/-0.2	1.5	±0.2	0.65	±0.1
9G	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9H	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9L	0.3	Maximum	0.35	+0.15/-0.2	2.2	±0.2	0.65	±0.1
9M	0.3	Maximum	0.70	±0.2	3.1	±0.2	0.9	±0.2
9P	0.3	Maximum	0.70	±0.2	4.6	±0.2	0.9	±0.2
9R	0.3	Maximum	1.0	±0.2	4.6	±0.2	1.25	±0.2
9S	0.3	Maximum	1.0	±0.2	4.6	±0.2	1.25	±0.2
9T	0.3	Maximum	1.0	±0.2	6.0	±0.2	2.0	±0.2

Performance Characteristics

Item	Performance Characteristics	
Capacitance Range	0.1 – 1,000 µF	4.7 – 68 µF
Rated Voltage	4 – 100 VDC	160 – 450 VDC
Operating Temperature	-40°C to +85°C	
Capacitance Tolerance	±20% at 120 Hz / 20°C	
Life Test	2,000 hours (see conditions in Test Method & Performance)	
Leakage Current	I ≤ 0.01 CV or 3 µA, whichever is greater	I = 0.04 CV +100 µA
	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)	4	6.3	10	16	25	35	50	63	100	160	200	250	400	450
Z (-25°C) / Z (20°C)	7	4	3	2	2	2	2	2	2	3	3	3	6	6
Z (-40°C) / Z (20°C)	15	8	6	4	4	3	3	3	3	6	6	6	10	10

Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	60 Hz	120 Hz	1 kHz	10 kHz
4 – 100	0.80	1.00	1.15	1.25
160 – 450	0.70	1.00	1.40	1.60

Compensation Factor of Ripple Current (RC) vs. Temperature

Rated Voltage (VDC)	50°C	75°C	85°C
4 – 100	1.36	1.25	1.00
160 – 450	1.60	1.25	1.00

Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	85°C	85°C
Test Duration	2,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 85°C	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	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

Pb

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)	RC 120 Hz 85°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
4	5	22	4 x 5.4	35	19	3	EDK226M004A9BAA
4	5	33	4 x 5.4	35	26	3	EDK336M004A9BAA
4	5	47	4 x 5.4	35	34	3	EDK476M004A9BAA
4	5	100	5 x 5.4	35	61	4	EDK107M004A9DAA
4	5	220	6.3 x 5.4	35	82	9	EDK227M004A9GAA
6.3	8	22	4 x 5.4	26	20	3	EDK226M6R3A9BAA
6.3	8	33	5 x 5.4	26	22	3	EDK336M6R3A9DAA
6.3	8	47	5 x 5.4	26	46	3	EDK476M6R3A9DAA
6.3	8	100	6.3 x 5.4	26	71	6	EDK107M6R3A9GAA
6.3	8	220	8 x 6.2	35	250	14	EDK227M6R3A9LAA
6.3	8	330	8 x 6.2	35	300	21	EDK337M6R3A9LAA
6.3	8	470	8 x 10.2	35	380	30	EDK477M6R3A9MAA
6.3	8	680	10 x 10.2	35	458	43	EDK687M6R3A9PAA
6.3	8	1000	10 x 10.2	35	700	63	EDK108M6R3A9PAA
10	13	15	4 x 5.4	30	23	3	EDK156M010A9BAA
10	13	22	4 x 5.4	30	28	3	EDK226M010A9BAA
10	13	33	4 x 5.4	30	29	3	EDK336M010A9BAA
10	13	33	5 x 5.4	20	43	3	EDK336M010A9DAA
10	13	47	5 x 5.4	30	43	5	EDK476M010A9DAA
10	13	100	6.3 x 5.4	26	70	10	EDK107M010A9GAA
10	13	220	6.3 x 7.7	26	220	22	EDK227M010A9HAA
10	13	220	8 x 6.2	26	250	22	EDK227M010A9LAA
10	13	330	8 x 10.2	26	330	33	EDK337M010A9MAA
10	13	470	10 x 10.2	26	400	47	EDK477M010A9PAA
16	20	4.7	4 x 5.4	16	20	3	EDK475M016A9BAA
16	20	10	4 x 5.4	16	28	3	EDK106M016A9BAA
16	20	22	4 x 5.4	26	27	4	EDK226M016A9BAA
16	20	22	5 x 5.4	16	39	4	EDK226M016A9DAA
16	20	33	5 x 5.4	26	45	5	EDK336M016A9DAA
16	20	33	6.3 x 5.4	16	66	5	EDK336M016A9GAA
16	20	47	6.3 x 5.4	16	70	8	EDK476M016A9GAA
16	20	100	6.3 x 5.4	20	70	16	EDK107M016A9GAA
16	20	150	6.3 x 7.7	26	109	24	EDK157M016A9HAA
16	20	220	6.3 x 7.7	20	215	35	EDK227M016A9HAA
16	20	220	8 x 10.2	20	280	35	EDK227M016A9MAA
16	20	330	10 x 10.2	20	380	53	EDK337M016A9PAA
16	20	470	8 x 10.2	20	365	75	EDK477M016A9MAA
16	20	470	10 x10.2	20	420	75	EDK477M016A9PAA
25	32	1	4 x 5.4	16	9	3	EDK105M025A9BAA
25	32	2.2	4 x 5.4	16	14	3	EDK225M025A9BAA
25	32	4.7	4 x 5.4	14	22	3	EDK475M025A9BAA
25	32	10	5 x 5.4	14	28	3	EDK106M025A9DAA
25	32	22	5 x 5.4	14	45	5	EDK226M025A9DAA
25	32	22	6.3 x 5.4	14	55	6	EDK226M025A9GAA
25	32	33	6.3 x 5.4	14	65	8	EDK336M025A9GAA
25	32	47	6.3 x 5.4	20	70	12	EDK476M025A9GAA
25	32	47	8 x 6.2	16	96	12	EDK476M025A9LAA
25	32	68	6.3 x 7.7	20	95	17	EDK686M025A9HAA
25	32	100	6.3 x 7.7	16	135	25	EDK107M025A9HAA
25	32	100	8 x 6.2	16	145	25	EDK107M025A9LAA
25	32	100	8 x 10.2	16	180	25	EDK107M025A9MAA
25	32	220	8 x 10.2	16	300	55	EDK227M025A9MAA
25	32	220	10 x 10.2	16	310	55	EDK227M025A9PAA
25	32	330	10 x 10.2	16	350	82	EDK337M025A9PAA
25	32	470	10 x 10.2	16	450	117	EDK477M025A9PAA
35	44	2.2	4 x 5.4	12	8	3	EDK225M035A9BAA
35	44	3.3	4 x 5.4	12	10	3	EDK335M035A9BAA
35	44	4.7	4 x 5.4	12	22	3	EDK475M035A9BAA
35	44	10	5 x 5.4	12	30	4	EDK106M035A9DAA
35	44	22	5 x 5.4	14	47	8	EDK226M035A9DAA
35	44	22	6.3 x 5.4	12	60	8	EDK226M035A9GAA
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**LC**	**Part Number**

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)	RC 120 Hz 85°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
35	44	33	8 x 6.2	14	130	12	EDK336M035A9LAA
35	44	47	6.3 x 5.4	14	135	16	EDK476M035A9GAA
35	44	47	8 x 6.2	14	165	16	EDK476M035A9LAA
35	44	100	6.3 x 7.7	14	145	35	EDK107M035A9HAA
35	44	100	10 x 10.2	14	210	35	EDK107M035A9PAA
35	44	220	10 x 10.2	14	310	77	EDK227M035A9PAA
35	44	330	10 x 10.2	14	380	115	EDK337M035A9PAA
50	63	0.1	4 x 5.4	12	1	3	EDK104M050A9BAA
50	63	0.22	4 x 5.4	12	2	3	EDK224M050A9BAA
50	63	0.33	4 x 5.4	12	3	3	EDK334M050A9BAA
50	63	0.47	4 x 5.4	12	5	3	EDK474M050A9BAA
50	63	1	4 x 5.4	12	10	3	EDK105M050A9BAA
50	63	2.2	4 x 5.4	12	16	3	EDK225M050A9BAA
50	63	3.3	4 x 5.4	12	16	3	EDK335M050A9BAA
50	63	4.7	4 x 5.4	12	20	3	EDK475M050A9BAA
50	63	4.7	5 x 5.4	12	23	3	EDK475M050A9DAA
50	63	10	6.3 x 5.4	12	35	5	EDK106M050A9GAA
50	63	22	8 x 6.2	12	110	11	EDK226M050A9LAA
50	63	33	8 x 10.2	12	120	16.5	EDK336M050A9MAA
50	63	47	6.3 x 7.7	12	98	23.5	EDK476M050A9HAA
50	63	47	10 x 10.2	12	130	23.5	EDK476M050A9PAA
50	63	100	8 x 10.2	12	165	50	EDK107M050A9MAA
50	63	100	10 x 10.2	12	190	50	EDK107M050A9PAA
50	63	220	10 x 10.2	12	300	110	EDK227M050A9PAA
63	79	4.7	6.3 x 5.4	18	20	3	EDK475M063A9GAA
63	79	10	6.3 x 5.4	18	20	6	EDK106M063A9GAA
63	79	22	8 x 10.2	18	30	14	EDK226M063A9MAA
63	79	33	8 x 10.2	18	30	21	EDK336M063A9MAA
63	79	47	8 x 10.2	18	30	30	EDK476M063A9MAA
63	79	100	10 x 10.2	18	60	63	EDK107M063A9PAA
100	125	3.3	8 x 10.2	18	30	3	EDK335M100A9MAA
100	125	4.7	8 x 10.2	18	50	5	EDK475M100A9MAA
100	125	10	6.3 x 7.7	18	40	10	EDK106M100A9HAA
100	125	10	8 x 10.2	18	55	10	EDK106M100A9MAA
100	125	22	10 x 10.2	18	60	22	EDK226M100A9PAA
100	125	33	10 x 10.2	18	65	33	EDK336M100A9PAA
160	200	33	12.5 x 13.5	20	240	310	EDK336M160A9RAA
160	200	47	12.5 x 16	20	370	400	EDK476M160A9SAA
160	200	68	16 x 16.5	20	500	540	EDK686M160A9TAA
200	250	22	12.5 x 13.5	20	240	280	EDK226M200A9RAA
200	250	33	12.5 x 16	20	310	370	EDK336M200A9SAA
200	250	47	16 x 16.5	20	340	480	EDK476M200A9TAA
200	250	68	16 x 16.5	20	340	650	EDK686M200A9TAA
250	300	10	12.5 x 13.5	20	150	200	EDK106M250A9RAA
250	300	22	12.5 x 13.5	20	150	320	EDK226M250A9RAA
250	300	33	12.5 x 16	20	240	430	EDK336M250A9SAA
250	300	47	16 x 16.5	20	340	570	EDK476M250A9TAA
400	450	4.7	12.5 x 13.5	25	120	180	EDK475M400A9RAA
400	450	10	12.5 x 13.5	25	120	260	EDK106M400A9RAA
400	450	22	16 x 16.5	25	140	460	EDK226M400A9TAA
400	450	33	16 x 16.5	25	140	630	EDK336M400A9TAA
450	500	4.7	12.5 x 13.5	25	120	180	EDK475M450A9RAA
450	500	10	12.5 x 16	25	130	280	EDK106M450A9SAA
450	500	22	16 x 16.5	25	140	500	EDK226M450A9TAA
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	LC	Part Number

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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 the correct polarization of the capacitor on the board.

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

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with $V_R \leq 160$ V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

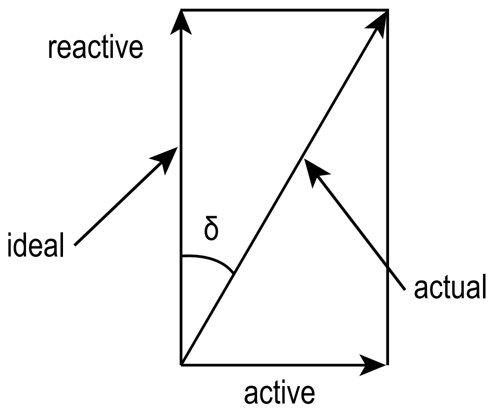
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



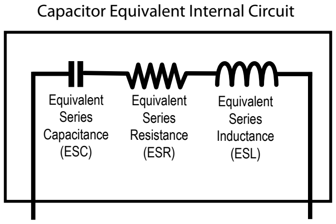
Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

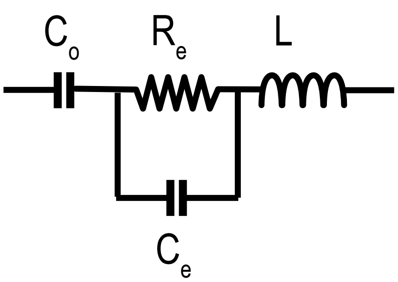
$$ESR = \frac{\tan \delta}{2\pi f \, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

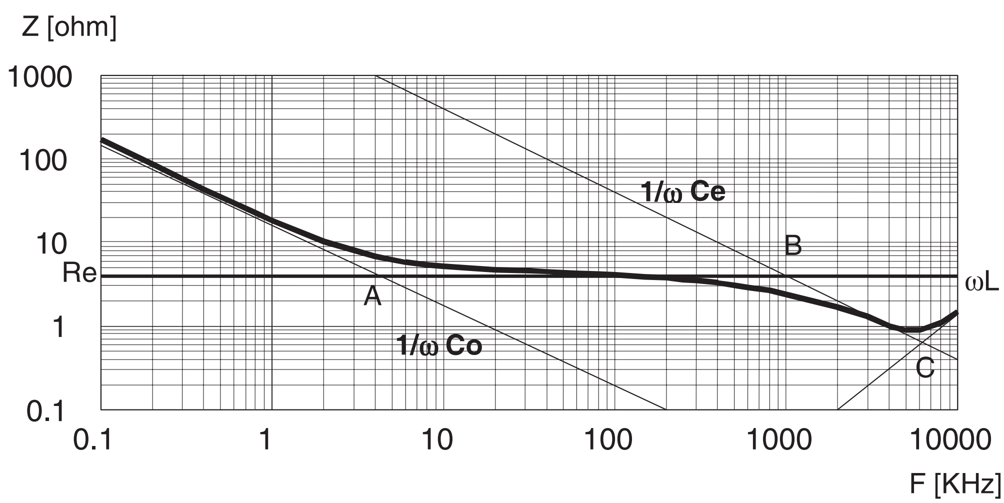
Impedance (Z)

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



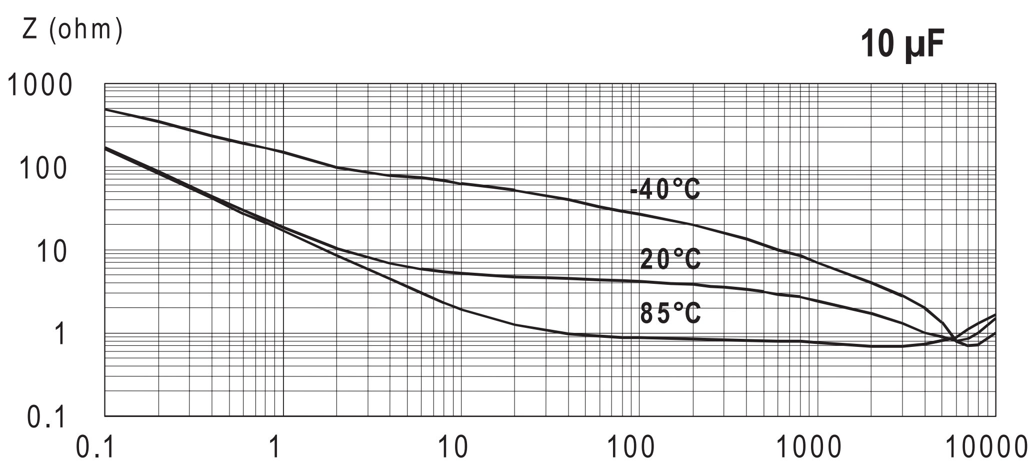
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance Xc = $1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

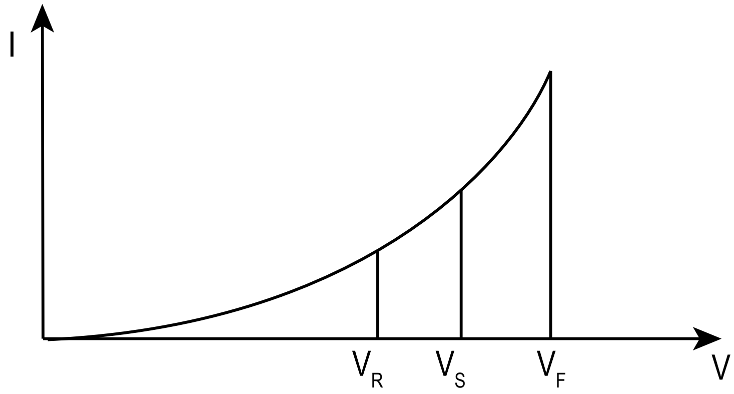
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

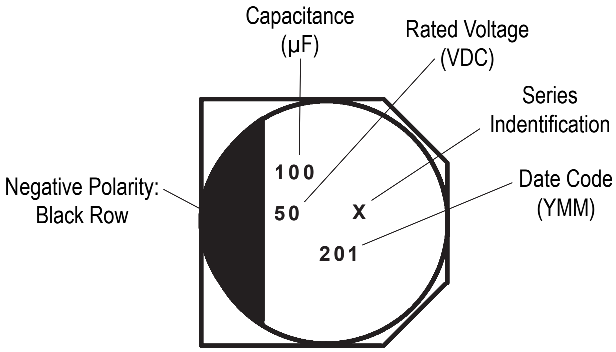
Expected Life Calculation

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 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)	Reel Quantity	Box Quantity (4 Reels per box)
9B	4	5.4	2000	20000
9D	5	5.4	1000	10000
9G	6.3	5.4	1000	10000
9H	6.3	7.7	1000	10000
9L	8	6.2	1000	10000
9M	8	10.2	500	4000
9P	10	10.2	500	4000
9R	12.5	13.5	200	800
9S	12.5	16	150	600
9T	16	16.5	125	500

Standard Marking for Surface Mount Types



Note: 6.3 V rated voltage shall be marked as 6 V, but 6.3 V shall be assured.

- Series
- Rated voltage (VDC)
- Capacitance (µF)
- Negative polarity: black line

EEV Series, +105ºC

Overview

KEMET's EEV Series of aluminum electrolytic surface mount capacitors are designed for applications requiring ultra-low impedance and a low profile vertical chip.

Applications

Typical applications include audio/visual (AV), computer/monitor, communications, and switch mode power supplies (SMPS).

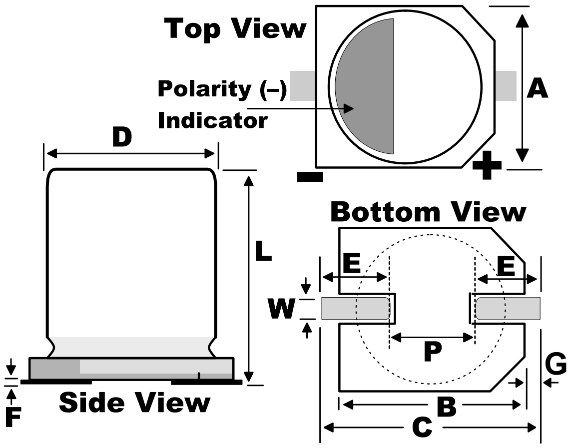
Benefits

- Surface mount lead terminals
- Low profile vertical chip
- Ultra-low impedance
- +105°C/2,000 hours

Part Number System

EEV	226	M	6R3	A	9B	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Surface Mount Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35	A = Standard	See Dimension Table	AA = Tape & Reel

Dimensions – Millimeters



Size Code	D		L		A/B		C		E	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	4	±0.5	5.4	+0.25/-0.1	4.3	±0.2	5.5	Maximum	1.8	±0.2
9D	5	±0.5	5.4	+0.25/-0.1	5.3	±0.2	6.5	Maximum	2.2	±0.2
9G	6.3	±0.5	5.4	+0.25/-0.1	6.6	±0.2	7.8	Maximum	2.6	±0.2
9H	6.3	±0.5	7.7	±0.3	6.6	±0.2	7.8	Maximum	2.6	±0.2
9L	8	±0.5	6.2	±0.3	8.3	±0.2	9.5	Maximum	3.4	±0.2
9M	8	±0.5	10.2	±0.3	8.3	±0.2	10	Maximum	3.4	±0.2
9P	10	±0.5	10.2	±0.3	10.3	±0.2	13	Maximum	3.5	±0.2

Size Code	F		G		P		W	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	0.3	Maximum	0.35	+0.15/-0.2	1.0	±0.2	0.65	±0.1
9D	0.3	Maximum	0.35	+0.15/-0.2	1.5	±0.2	0.65	±0.1
9G	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9H	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9L	0.3	Maximum	0.35	+0.15/-0.2	2.2	±0.2	0.65	±0.1
9M	0.3	Maximum	0.70	±0.2	3.1	±0.2	0.9	±0.2
9P	0.3	Maximum	0.70	±0.2	4.6	±0.2	0.9	±0.2

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	4.7 – 1,500 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 35 VDC
Life Test	2,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

Compensation Factor of Ripple Current (RC) vs. Frequency

Frequency	120 Hz	1 kHz	10 kHz	100 kHz
Coefficient	0.70	0.80	0.90	1.00

Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	105°C	105°C
Test Duration	2,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 85°C	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	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	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)	Z 100 kHz 20°C (Ω)	Part Number
6.3	8	22	4 x 5.4	26	90	1.93	EEV226M6R3A9BAA
6.3	8	33	4 x 5.4	26	90	1.93	EEV336M6R3A9BAA
6.3	8	47	4 x 5.4	26	90	1.93	EEV476M6R3A9BAA
6.3	8	47	5 x 5.4	26	160	1.00	EEV476M6R3A9DAA
6.3	8	100	5 x 5.4	26	160	1.00	EEV107M6R3A9DAA
6.3	8	100	6.3 x 5.4	26	240	0.52	EEV107M6R3A9GAA
6.3	8	150	6.3 x 7.7	26	240	0.30	EEV157M6R3A9HAA
6.3	8	220	6.3 x 7.7	26	240	0.30	EEV227M6R3A9HAA
6.3	8	330	6.3 x 7.7	26	280	0.34	EEV337M6R3A9HAA
6.3	8	330	8 x 6.2	26	300	0.26	EEV337M6R3A9LAA
6.3	8	470	8 x 10.2	26	600	0.16	EEV477M6R3A9MAA
6.3	8	680	8 x 10.2	26	600	0.16	EEV687M6R3A9MAA
6.3	8	1000	8 x 10.2	26	600	0.16	EEV108M6R3A9MAA
6.3	8	1500	10 x 10.2	26	850	0.08	EEV158M6R3A9PAA
10	13	22	4 x 5.4	19	90	1.93	EEV226M010A9BAA
10	13	33	4 x 5.4	19	90	1.93	EEV336M010A9BAA
10	13	33	5 x 5.4	19	160	1.00	EEV336M010A9DAA
10	13	47	6.3 x 5.4	19	190	0.52	EEV476M010A9GAA
10	13	100	6.3 x 5.4	19	190	0.52	EEV107M010A9GAA
10	13	150	6.3 x 7.7	19	240	0.34	EEV157M010A9HAA
10	13	220	6.3 x 7.7	19	280	0.34	EEV227M010A9HAA
10	13	220	8 x 6.2	19	300	0.26	EEV227M010A9LAA
10	13	330	8 x 10.2	19	600	0.16	EEV337M010A9MAA
10	13	470	8 x 10.2	19	600	0.16	EEV477M010A9MAA
10	13	470	10 x 10.2	19	600	0.12	EEV477M010A9PAA
10	13	1000	10 x 10.2	19	850	0.08	EEV108M010A9PAA
16	20	22	4 x 5.4	16	90	1.93	EEV226M016A9BAA
16	20	22	5 x 5.4	16	160	1.00	EEV226M016A9DAA
16	20	33	5 x 5.4	16	160	1.00	EEV336M016A9DAA
16	20	47	5 x 5.4	16	160	1.00	EEV476M016A9DAA
16	20	47	6.3 x 5.4	16	240	0.52	EEV476M016A9GAA
16	20	100	6.3 x 5.4	16	240	0.52	EEV107M016A9GAA
16	20	150	6.3 x 7.7	16	280	0.34	EEV157M016A9HAA
16	20	340	6.3 x 7.7	16	280	0.22	EEV227M016A9HAA
16	20	340	8 x 6.2	16	280	0.22	EEV227M016A9LAA
16	20	220	8 x 10.2	16	370	0.22	EEV227M016A9MAA
16	20	330	8 x 10.2	16	600	0.16	EEV337M016A9MAA
16	20	470	8 x 10.2	16	600	0.16	EEV477M016A9MAA
16	20	470	10 x 10.2	16	850	0.08	EEV687M016A9PAA
25	32	10	4 x 5.4	14	90	1.93	EEV106M025A9BAA
25	32	22	5 x 5.4	14	160	1.00	EEV226M025A9DAA
25	32	33	5 x 5.4	14	160	1.00	EEV336M025A9DAA
25	32	33	6.3 x 5.4	14	240	0.52	EEV336M025A9GAA
25	32	47	6.3 x 5.4	14	240	0.52	EEV476M025A9GAA
25	32	68	6.3 x 5.4	14	240	0.52	EEV686M025A9GAA
25	32	100	6.3 x 7.7	14	280	0.34	EEV107M025A9HAA
25	32	150	8 x 10.2	14	600	0.16	EEV157M025A9MAA
25	32	220	8 x 10.2	14	600	0.16	EEV227M025A9MAA
25	32	330	10 x 10.2	14	600	0.16	EEV337M025A9PAA
25	32	470	10 x 10.2	14	850	0.08	EEV477M025A9PAA
35	44	3.3	4 x 5.4	12	90	1.93	EEV335M035A9BAA
35	44	10	4 x 5.4	12	90	1.93	EEV106M035A9BAA
35	44	10	5 x 5.4	12	160	1.00	EEV106M035A9DAA
35	44	22	5 x 5.4	12	160	1.00	EEV226M035A9DAA
35	44	33	6.3 x 5.4	12	240	0.52	EEV336M035A9GAA
35	44	47	6.3 x 5.4	12	240	0.52	EEV476M035A9GAA
35	44	68	6.3 x 7.7	12	280	0.34	EEV686M035A9HAA
35	44	100	6.3 x 7.7	12	280	0.34	EEV107M035A9HAA
35	44	100	8 x 10.2	12	600	0.16	EEV107M035A9MAA
35	44	150	8 x 10.2	12	600	0.16	EEV157M035A9MAA
35	44	220	8 x 10.2	12	600	0.16	EEV227M035A9PAA
35	44	330	10 x 10.2	12	850	0.08	EEV337M035A9PAA
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Z**	**Part Number**

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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 the correct polarization of the capacitor on the board.

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

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with $V_R \leq 160$ V (5 W resistor) .
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

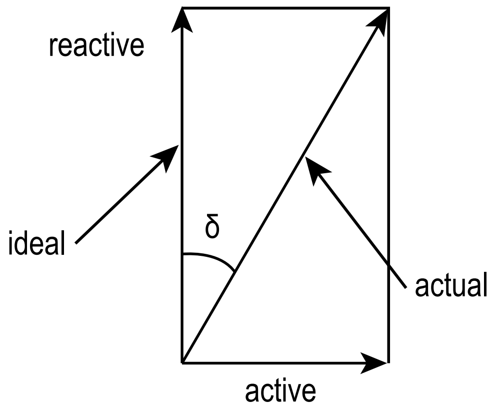
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



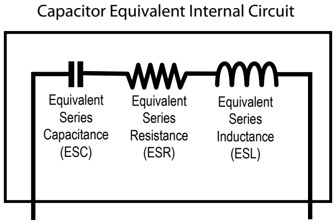
Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

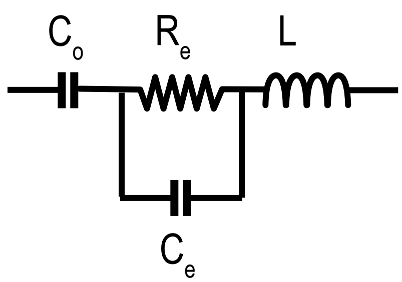
$$ESR = \frac{\tan \delta}{2\pi f\, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

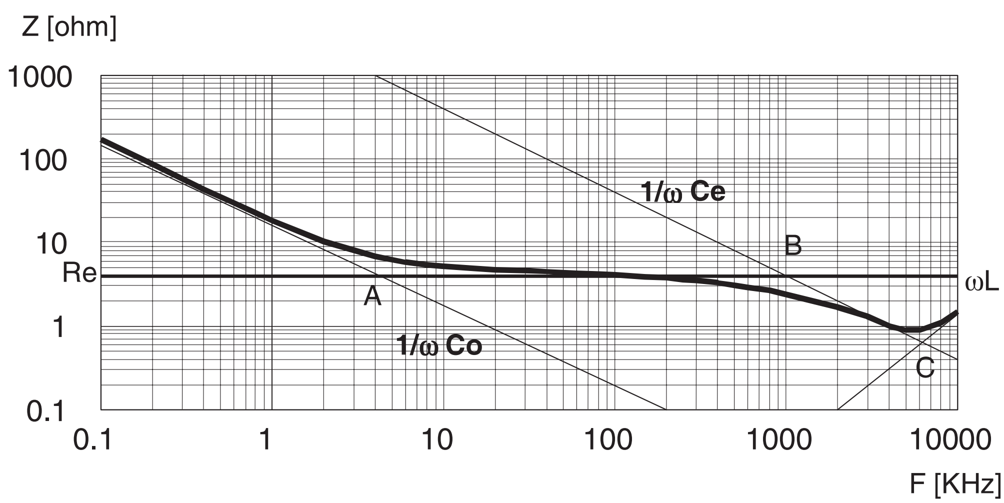
Impedance (Z)

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



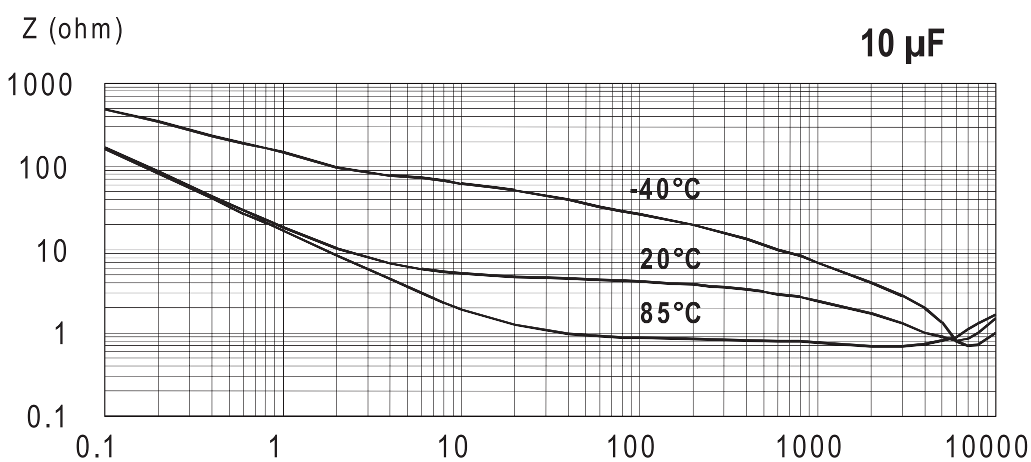
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

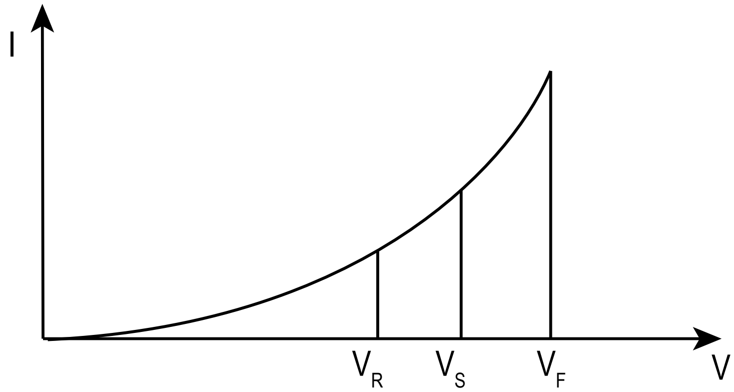
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

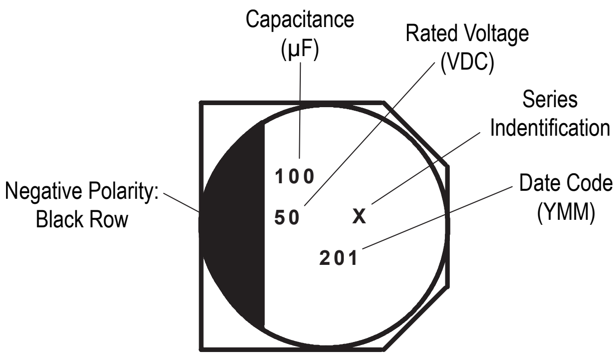
Expected Life Calculation

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 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)	Reel Quantity	Box Quantity (4 Reels per box)
9B	4	5.4	2000	20000
9D	5	5.4	1000	10000
9G	6.3	5.4	1000	10000
9H	6.3	7.7	1000	10000
9L	8	6.2	1000	10000
9M	8	10.2	500	4000
9P	10	10.2	500	4000

Standard Marking for Surface Mount Types



Note: 6.3 V rated voltage shall be marked as 6 V, but 6.3 V shall be assured.

- Series
- Rated voltage (VDC)
- Capacitance (µF)
- Negative polarity: black line

EXV Series, +105ºC

Overview

KEMET's EXV Series of aluminum electrolytic surface mount capacitors are designed for applications requiring ultra-low impedance and a low profile vertical chip.

Applications

Typical applications include audio/visual (AV), computer/monitor, communications, and switch mode power supplies (SMPS).

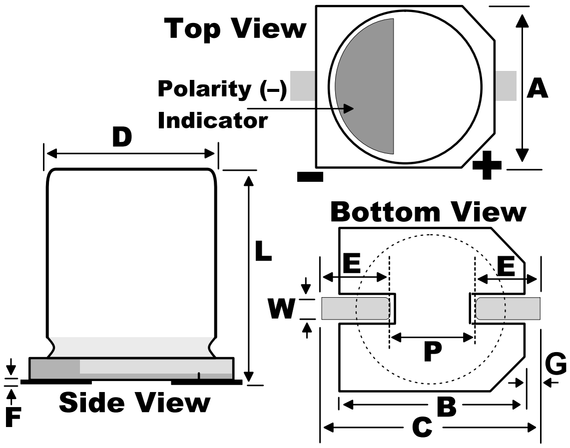
Benefits

- Surface mount lead terminals
- Low profile vertical chip
- Ultra-low impedance
- +105°C/3,000 – 5,000 hours

Part Number System

EXV	226	M	6R3	A	9B	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Surface Mount Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50	A = Standard	See Dimension Table	AA = Tape & Reel

Dimensions – Millimeters



Size Code	D		L		A/B		C		E	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	4	±0.5	5.4	+0.25/-0.1	4.3	±0.2	5.5	Maximum	1.8	±0.2
9D	5	±0.5	5.4	+0.25/-0.1	5.3	±0.2	6.5	Maximum	2.2	±0.2
9G	6.3	±0.5	5.4	+0.25/-0.1	6.6	±0.2	7.8	Maximum	2.6	±0.2
9H	6.3	±0.5	7.7	±0.3	6.6	±0.2	7.8	Maximum	2.6	±0.2
9L	8	±0.5	6.2	±0.3	8.3	±0.2	9.5	Maximum	3.4	±0.2
9M	8	±0.5	10.2	±0.3	8.3	±0.2	10	Maximum	3.4	±0.2
9P	10	±0.5	10.2	±0.3	10.3	±0.2	13	Maximum	3.5	±0.2

Size Code	F		G		P		W	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
9B	0.3	Maximum	0.35	+0.15/-0.2	1.0	±0.2	0.65	±0.1
9D	0.3	Maximum	0.35	+0.15/-0.2	1.5	±0.2	0.65	±0.1
9G	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9H	0.3	Maximum	0.35	+0.15/-0.2	1.8	±0.2	0.65	±0.1
9L	0.3	Maximum	0.35	+0.15/-0.2	2.2	±0.2	0.65	±0.1
9M	0.3	Maximum	0.70	±0.2	3.1	±0.2	0.9	±0.2
9P	0.3	Maximum	0.70	±0.2	4.6	±0.2	0.9	±0.2

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	1.0 – 1,000 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 50 VDC
Life Test	3,000 – 5,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

Compensation Factor of Ripple Current (RC) vs. Frequency

Frequency	120 Hz	1 kHz	10 kHz	100 kHz
Coefficient	0.70	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 = 4, 5, 6.3 mm	3,000 hours	1,000 hours
	Can Ø = 8, 10 mm	5,000 hours	
Ripple Current	Maximum ripple current specified at 120 Hz 85°C		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	Does not exceed 200% of the specified value		
Leakage Current	Does not exceed specified value		

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	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)	Z 100 kHz 20°C (Ω)	Part Number
6.3	8	22	4x5.4	26	90	1.93	EXV226M6R3A9BAA
6.3	8	33	4x5.4	26	90	1.93	EXV336M6R3A9BAA
6.3	8	47	5x5.4	26	160	1	EXV476M6R3A9DAA
6.3	8	100	6.3x5.4	26	240	0.52	EXV107M6R3A9GAA
6.3	8	150	6.3x7.7	26	240	0.3	EXV157M6R3A9HAA
6.3	8	220	6.3x7.7	26	240	0.3	EXV227M6R3A9HAA
6.3	8	330	8x10.2	26	600	0.16	EXV337M6R3A9MAA
6.3	8	470	8x10.2	26	600	0.16	EXV477M6R3A9MAA
6.3	8	680	10x10.2	26	850	0.12	EXV687M6R3A9PAA
6.3	8	1000	10x10.2	26	850	0.12	EXV108M6R3A9PAA
10	13	22	4 x 5.4	19	90	1.93	EXV226M010A9BAA
10	13	33	5 x 5.4	19	160	1	EXV336M010A9DAA
10	13	47	6.3 x 5.4	19	190	0.52	EXV476M010A9GAA
10	13	100	6.3 x 5.4	19	190	0.52	EXV107M010A9GAA
10	13	150	6.3 x 7.7	19	240	0.34	EXV157M010A9HAA
10	13	220	8 x 10.2	19	600	0.16	EXV227M010A9MAA
10	13	330	8 x 10.2	19	600	0.16	EXV337M010A9MAA
10	13	470	10 x 10.2	19	850	0.12	EXV477M010A9PAA
10	13	680	10 x 10.2	19	850	0.12	EXV687M010A9PAA
16	20	22	5 x 5.4	16	160	1	EXV226M016A9BAA
16	20	33	6.3 x 5.4	16	240	0.52	EXV336M016A9GAA
16	20	47	6.3 x 5.4	16	240	0.52	EXV476M016A9GAA
16	20	100	6.3 x 7.7	16	280	0.34	EXV107M016A9HAA
16	20	150	8 x 10.2	16	370	0.22	EXV157M016A9MAA
16	20	220	8 x 10.2	16	370	0.22	EXV227M016A9MAA
16	20	330	8 x 10.2	16	600	0.16	EXV337M016A9MAA
16	20	470	10 x 10.2	16	850	0.12	EXV477M016A9PAA
25	32	10	4 x 5.4	14	90	1.93	EXV106M025A9BAA
25	32	22	5 x 5.4	14	160	1	EXV226M025A9DAA
25	32	33	6.3 x 5.4	14	240	0.52	EXV336M025A9GAA
25	32	47	6.3 x 5.4	14	240	0.52	EXV476M025A9GAA
25	32	68	6.3 x 7.7	14	280	0.34	EXV686M025A9HAA
25	32	100	6.3 x 7.7	14	300	0.26	EXV107M025A9HAA
25	32	150	8 x 10.2	14	600	0.16	EXV157M025A9MAA
25	32	220	8 x 10.2	14	600	0.16	EXV227M025A9MAA
25	32	330	10 x 10.2	14	850	0.12	EXV337M025A9PAA
35	44	4.7	4 x 5.4	12	90	1.93	EXV475M035A9BAA
35	44	10	5 x 5.4	12	160	1	EXV106M035A9DAA
35	44	22	5 x 5.4	12	160	1	EXV226M035A9DAA
35	44	33	6.3 x 5.4	12	240	0.52	EXV336M035A9GAA
35	44	47	6.3 x 7.7	12	280	0.34	EXV476M035A9HAA
35	44	68	6.3 x 7.7	12	280	0.34	EXV686M035A9HAA
35	44	100	8 x 10.2	12	600	0.16	EXV107M035A9MAA
35	44	150	10 x 10.2	12	850	0.12	EXV157M035A9PAA
35	44	220	10 x 10.2	12	850	0.12	EXV227M035A9PAA
50	63	1	4 x 5.4	12	60	5	EXV105M050A9BAA
50	63	2.2	4 x 5.4	12	60	5	EXV225M050A9BAA
50	63	3.3	4 x 5.4	12	60	5	EXV335M050A9BAA
50	63	4.7	5 x 5.4	12	95	4	EXV475M050A9DAA
50	63	10	6.3 x 5.4	12	140	2.6	EXV106M050A9GAA
50	63	22	6.3 x 7.7	12	230	1.3	EXV226M050A9HAA
50	63	33	8 x 10.2	12	350	0.5	EXV336M050A9MAA
50	63	47	10 x 10.2	12	670	0.34	EXV476M050A9PAA
50	63	68	10 x 10.2	12	670	0.34	EXV686M050A9PAA
50	63	100	10 x 10.2	12	670	0.34	EXV107M050A9PAA
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Z**	**Part Number**

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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 the correct polarization of the capacitor on the board.

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

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with $V_R \leq 160$ V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

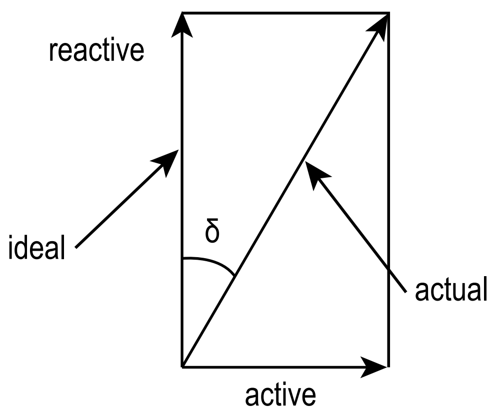
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



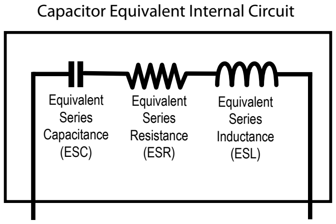
Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

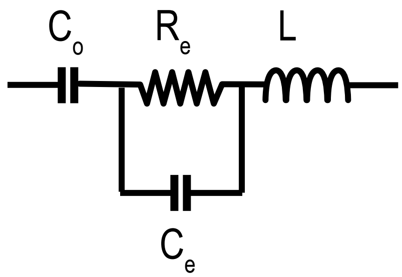
$$ESR = \frac{\tan \delta}{2\pi f\, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

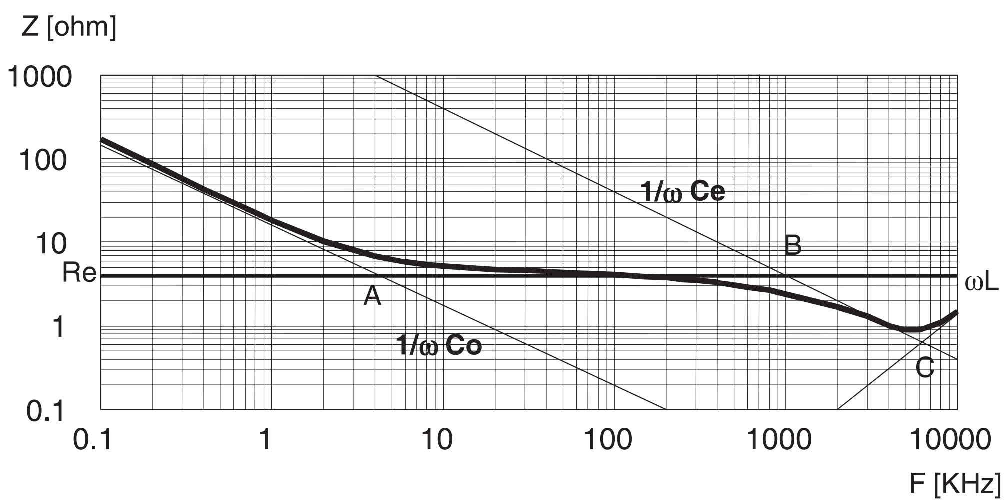
Impedance (Z)

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



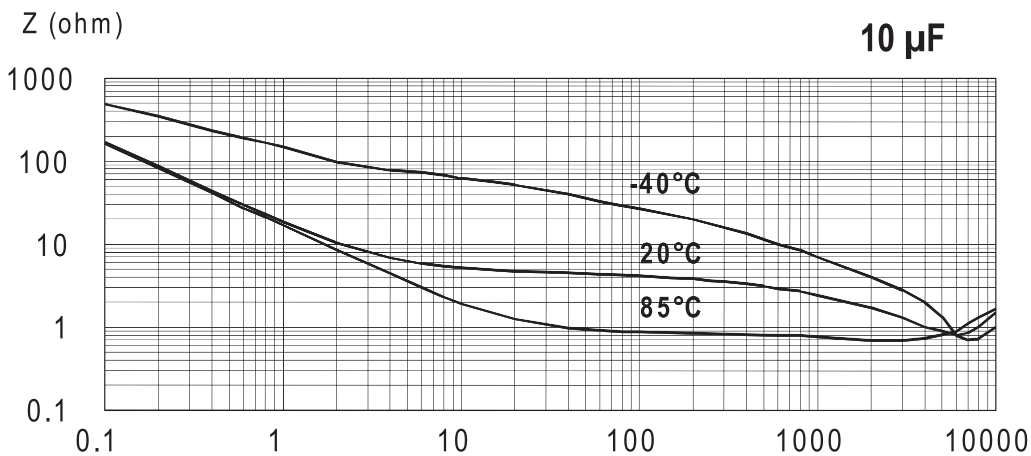
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

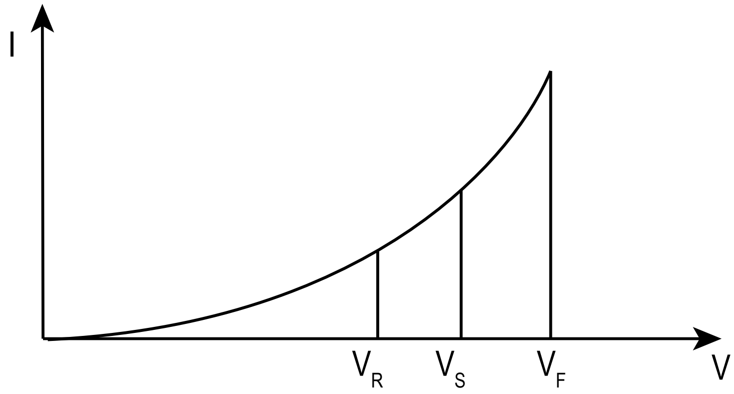
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

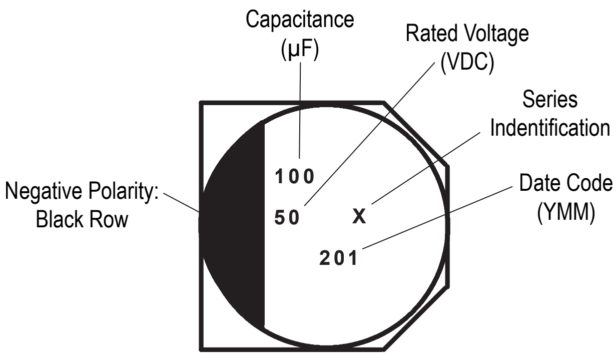
Expected Life Calculation

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 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)	Reel Quantity	Box Quantity (4 Reels per box)
9B	4	5.4	2000	20000
9D	5	5.4	1000	10000
9G	6.3	5.4	1000	10000
9H	6.3	7.7	1000	10000
9L	8	6.2	1000	10000
9M	8	10.2	500	4000
9P	10	10.2	500	4000

Standard Marking for Surface Mount Types



Note: 6.3 V rated voltage shall be marked as 6 V, but 6.3 V shall be assured.

- Series
- Rated voltage (VDC)
- Capacitance (µF)
- Negative polarity: black line

ESK Series, +85ºC

Overview

KEMET's ESK Series of aluminum electrolytic radial capacitors are designed for high-density printed circuit boards.

Applications

Typical applications include general purpose coupling, decoupling, bypass and filtering.

Benefits

- Operating temperature of up to 85°C
- 2,000 hour operating life
- Case diameters 5 – 22 mm
- Safety vent on the capacitor base

Part Number System

ESK	226	M	6R3		A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)		Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63	100 = 100 160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 450 500 = 500	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

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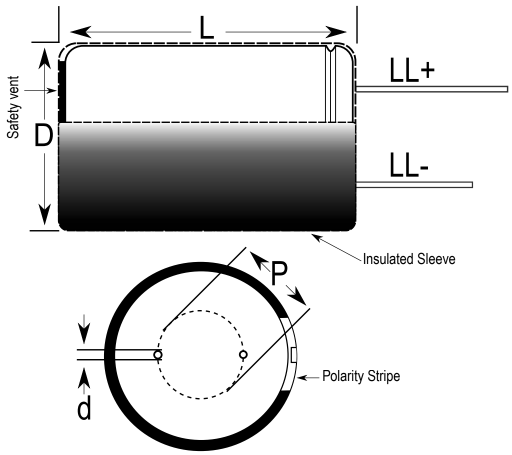
Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.5	Nominal	20/15	Minimum
G4	8	±0.5	15	+2.0/-0	3.5	±0.5	0.5	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N4	18	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
Q3	22	±0.5	35	+2.0/-0	10	±0.5	0.8	Nominal	20/15	Minimum
Q4	22	±0.5	40	+2.0/-0	10	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics	
Capacitance Range	0.1 – 22,000 µF	0.47 – 470 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C	
Rated Voltage	6.3 – 100 VDC	160 – 450 VDC
Life Test	2,000 hours (see conditions in Test Methods & Performance)	
Operating Temperature	-40°C to +85°C	-25°C to +85°C
Leakage Current	I ≤ 0.01 CV (µA) or 3 µA, whichever is greater	I = 0.03 CV (µA) + 10 µA
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.	

Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	Capacitance Range (µF)	50 Hz	120 Hz	300 Hz	1 kHz	10 to 100 kHz
6.3 – 100	0.1 – 68	0.75	1.00	1.20	1.30	1.45
6.3 – 100	100 – 680	0.75	1.00	1.10	1.15	1.25
6.3 – 100	1,000 – 22,000	0.75	1.00	1.05	1.10	1.15
160 – 450	0.47 – 220	0.80	1.00	1.25	1.40	1.40
160 – 450	330 – 470	0.80	1.00	1.10	1.13	1.15

Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	50°C	70°C	85°C
Coefficient	1.30	1.15	1.00

Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	85°C	85°C
Test Duration	2,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 85°C	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	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
6.3	8	22	5 x 11	22	35	ESK226M6R3AC3(1)
6.3	8	33	5 x 11	22	55	ESK336M6R3AC3(1)
6.3	8	47	5 x 11	22	75	ESK476M6R3AC3(1)
6.3	8	100	5 x 11	22	130	ESK107M6R3AC3(1)
6.3	8	220	5 x 11	22	200	ESK227M6R3AC3(1)
6.3	8	220	6 x 11	22	240	ESK227M6R3AE3(1)
6.3	8	330	6 x 11	22	260	ESK337M6R3AE3(1)
6.3	8	330	8 x 11	22	300	ESK337M6R3AG3(1)
6.3	8	470	6 x 11	22	330	ESK477M6R3AE3(1)
6.3	8	470	8 x 11	22	380	ESK477M6R3AG3(1)
6.3	8	1000	8 x 11	22	460	ESK108M6R3AG3(1)
6.3	8	1000	10 x 12	22	580	ESK108M6R3AH1(1)
6.3	8	2200	10 x 20	22	840	ESK228M6R3AH4(1)
6.3	8	2200	13 x 20	22	1050	ESK228M6R3AL3(1)
6.3	8	3300	10 x 20	22	1000	ESK338M6R3AH4(1)
6.3	8	3300	13 x 20	22	1250	ESK338M6R3AL3(1)
6.3	8	4700	13 x 20	22	1300	ESK478M6R3AL3(1)
6.3	8	4700	16 x 25	22	1700	ESK478M6R3AM7(1)
6.3	8	6800	16 x 25	22	1900	ESK688M6R3AM7(1)
6.3	8	10000	16 x 25	22	1900	ESK109M6R3AM7(1)
6.3	8	10000	16 x 32	22	2250	ESK109M6R3AM2(1)
6.3	8	15000	16 x 36	22	2500	ESK159M6R3AM3(1)
6.3	8	15000	18 x 36	22	2880	ESK159M6R3AN2(1)
6.3	8	22000	18 x 40	22	3650	ESK229M6R3AN3(1)
10	13	4.7	5 x 11	19	20	ESK475M010AC3(1)
10	13	10	5 x 11	19	35	ESK106M010AC3(1)
10	13	22	5 x 11	19	55	ESK226M010AC3(1)
10	13	33	5 x 11	19	80	ESK336M010AC3(1)
10	13	47	5 x 11	19	95	ESK476M010AC3(1)
10	13	100	5 x 11	19	180	ESK107M010AC3(1)
10	13	220	5 x 11	19	230	ESK227M010AC3(1)
10	13	220	6 x 11	19	250	ESK227M010AE3(1)
10	13	330	8 x 11	19	330	ESK337M010AG3(1)
10	13	470	6 x 11	19	360	ESK477M010AE3(1)
10	13	470	8 x 11	19	400	ESK477M010AG3(1)
10	13	680	8 x 15	19	430	ESK687M010AG4(1)
10	13	680	10 x 16	19	460	ESK687M010AH2(1)
10	13	1000	10 x 12	19	580	ESK108M010AH1(1)
10	13	1000	10 x 16	19	630	ESK108M010AH2(1)
10	13	2200	10 x 20	19	880	ESK228M010AH4(1)
10	13	2200	13 x 20	19	1100	ESK228M010AL3(1)
10	13	3300	13 x 20	19	1250	ESK338M010AL3(1)
10	13	3300	13 x 25	19	1400	ESK338M010AL4(1)
10	13	4700	13 x 25	19	1500	ESK478M010AL4(1)
10	13	4700	16 x 25	19	1800	ESK478M010AM7(1)
10	13	6800	16 x 25	19	1900	ESK688M010AM7(1)
10	13	6800	16 x 32	19	2150	ESK688M010AM2(1)
10	13	10000	16 x 36	19	2500	ESK109M010AM3(1)
10	13	10000	18 x 36	19	2500	ESK109M010AN2(1)
10	13	15000	18 x 36	19	2950	ESK159M010AN2(1)
10	13	22000	22 x 40	19	3700	ESK229M010AQ4(1)
16	20	1.0	5 x 11	16	9.3	ESK105M016AC3(1)
16	20	4.7	5 x 11	16	25	ESK475M016AC3(1)
16	20	10	5 x 11	16	40	ESK106M016AC3(1)
16	20	22	5 x 11	16	75	ESK226M016AC3(1)
16	20	33	5 x 11	16	110	ESK336M016AC3(1)
16	20	47	5 x 11	16	130	ESK476M016AC3(1)
16	20	100	5 x 11	16	185	ESK107M016AC3(1)
16	20	100	6 x 11	16	185	ESK107M016AE3(1)
16	20	220	6 x 11	16	320	ESK227M016AE3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
16	20	220	8 x 11	16	320	ESK227M016AG3(1)
16	20	330	8 x 11	16	360	ESK337M016AG3(1)
16	20	470	8 x 11	16	400	ESK477M016AG3(1)
16	20	470	10 x 12	16	470	ESK477M016AH1(1)
16	20	680	10 x 16	16	560	ESK687M016AH2(1)
16	20	1000	10 x 16	16	630	ESK108M016AH2(1)
16	20	1000	10 x 20	16	790	ESK108M016AH4(1)
16	20	2200	13 x 20	16	1100	ESK228M016AL3(1)
16	20	2200	13 x 25	16	1350	ESK228M016AL4(1)
16	20	3300	13 x 25	16	1400	ESK338M016AL4(1)
16	20	3300	16 x 25	16	1700	ESK338M016AM7(1)
16	20	4700	16 x 25	16	1800	ESK478M016AM7(1)
16	20	4700	16 x 32	16	2100	ESK478M016AM2(1)
16	20	6800	16 x 36	16	2200	ESK688M016AM3(1)
16	20	6800	18 x 36	16	2500	ESK688M016AN2(1)
16	20	10000	18 x 36	16	2700	ESK109M016AN2(1)
16	20	15000	22 x 40	16	3150	ESK159M016AQ4(1)
16	20	22000	22 x 40	16	3800	ESK229M016AQ4(1)
25	32	4.7	5 x 11	14	30	ESK475M025AC3(1)
25	32	10	5 x 11	14	50	ESK106M025AC3(1)
25	32	22	5 x 11	14	90	ESK226M025AC3(1)
25	32	33	5 x 11	14	115	ESK336M025AC3(1)
25	32	47	5 x 11	14	135	ESK476M025AC3(1)
25	32	100	6 x 11	14	200	ESK107M025AE3(1)
25	32	220	8 x 11	14	290	ESK227M025AG3(1)
25	32	220	10 x 12	14	340	ESK227M025AH1(1)
25	32	330	8 x 15	14	380	ESK337M025AG4(1)
25	32	330	10 x 12	14	420	ESK337M025AH1(1)
25	32	330	10 x 16	14	420	ESK337M025AH2(1)
25	32	470	10 x 12	14	460	ESK477M025AH1(1)
25	32	470	10 x 16	14	540	ESK477M025AH2(1)
25	32	1000	10 x 20	14	760	ESK108M025AH4(1)
25	32	1000	13 x 20	14	950	ESK108M025AL3(1)
25	32	2200	13 x 25	14	1300	ESK228M025AL4(1)
25	32	2200	16 x 25	14	1550	ESK228M025AM7(1)
25	32	3300	16 x 25	14	1660	ESK338M025AM7(1)
25	32	3300	16 x 32	14	1950	ESK338M025AM2(1)
25	32	4700	16 x 32	14	1950	ESK478M025AM2(1)
25	32	4700	18 x 36	14	2360	ESK478M025AN2(1)
25	32	6800	18 x 36	14	2550	ESK688M025AN2(1)
25	32	10000	22 x 40	14	2800	ESK109M025AQ4(1)
25	32	15000	22 x 40	14	3200	ESK159M025AQ4(1)
35	44	4.7	5 x 11	12	35	ESK475M035AC3(1)
35	44	10	5 x 11	12	60	ESK106M035AC3(1)
35	44	22	5 x 11	12	95	ESK226M035AC3(1)
35	44	33	5 x 11	12	120	ESK336M035AC3(1)
35	44	47	5 x 11	12	120	ESK476M035AC3(1)
35	44	47	6 x 11	12	140	ESK476M035AE3(1)
35	44	100	6 x 11	12	200	ESK107M035AE3(1)
35	44	100	8 x 11	12	230	ESK107M035AG3(1)
35	44	220	8 x 11	12	290	ESK227M035AG3(1)
35	44	220	10 x 12	12	370	ESK227M035AH1(1)
35	44	330	10 x 12	12	420	ESK337M035AH1(1)
35	44	330	10 x 16	12	490	ESK337M035AH2(1)
35	44	470	10 x 16	12	480	ESK477M035AH2(1)
35	44	470	10 x 20	12	510	ESK477M035AH4(1)
35	44	470	13 x 20	12	640	ESK477M035AL3(1)
35	44	1000	13 x 20	12	950	ESK108M035AL3(1)
35	44	1000	13 x 25	12	1100	ESK108M035AL4(1)
35	44	2200	16 x 25	12	1600	ESK228M035AM7(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
35	44	2200	16 x 32	12	1800	ESK228M035AM2(1)
35	44	3300	16 x 36	12	1970	ESK338M035AM3(1)
35	44	3300	18 x 36	12	2220	ESK338M035AN2(1)
35	44	4700	18 x 36	12	2400	ESK478M035AN2(1)
35	44	6800	22 x 40	12	2600	ESK688M035AQ4(1)
50	63	0.1	5 x 11	10	1	ESK104M050AC3(1)
50	63	0.22	5 x 11	10	2	ESK224M050AC3(1)
50	63	0.33	5 x 11	10	3	ESK334M050AC3(1)
50	63	0.47	5 x 11	10	5	ESK474M050AC3(1)
50	63	1	5 x 11	10	10	ESK105M050AC3(1)
50	63	2.2	5 x 11	10	23	ESK225M050AC3(1)
50	63	3.3	5 x 11	10	35	ESK335M050AC3(1)
50	63	4.7	5 x 11	10	40	ESK475M050AC3(1)
50	63	10	5 x 11	10	65	ESK106M050AC3(1)
50	63	22	5 x 11	10	100	ESK226M050AC3(1)
50	63	33	6 x 11	10	125	ESK336M050AE3(1)
50	63	47	6 x 11	10	140	ESK476M050AE3(1)
50	63	47	8 x 11	10	150	ESK476M050AG3(1)
50	63	100	8 x 11	10	230	ESK107M050AG3(1)
50	63	100	10 x 12	10	250	ESK107M050AH1(1)
50	63	220	10 x 12	10	360	ESK227M050AH1(1)
50	63	220	10 x 16	10	440	ESK227M050AH2(1)
50	63	330	10 x 16	10	490	ESK337M050AH2(1)
50	63	330	10 x 20	10	580	ESK337M050AH4(1)
50	63	470	10 x 20	10	610	ESK477M050AH4(1)
50	63	470	13 x 20	10	760	ESK477M050AL3(1)
50	63	1000	13 x 25	10	1100	ESK108M050AL4(1)
50	63	1000	16 x 25	10	1350	ESK108M050AM7(1)
50	63	2200	16 x 36	10	1850	ESK228M050AM3(1)
50	63	2200	18 x 36	10	2090	ESK228M050AN2(1)
50	63	3300	18 x 36	10	2170	ESK338M050AN2(1)
50	63	3300	18 x 40	10	2400	ESK338M050AN3(1)
50	63	4700	22 x 35	10	2500	ESK478M050AQ3(1)
50	63	4700	22 x 40	10	2500	ESK478M050AQ4(1)
63	79	0.47	5 x 11	9	5	ESK474M063AC3(1)
63	79	1.0	5 x 11	9	10	ESK105M063AC3(1)
63	79	2.2	5 x 11	9	29	ESK225M063AC3(1)
63	79	3.3	5 x 11	9	40	ESK335M063AC3(1)
63	79	4.7	5 x 11	9	45	ESK475M063AC3(1)
63	79	10	5 x 11	9	70	ESK106M063AC3(1)
63	79	22	6 x 11	9	115	ESK226M063AE3(1)
63	79	33	6 x 11	9	130	ESK336M063AE3(1)
63	79	33	8 x 11	9	140	ESK336M063AG3(1)
63	79	47	6 x 11	9	190	ESK476M063AE3(1)
63	79	47	8 x 11	9	190	ESK476M063AG3(1)
63	79	100	10 x 12	9	300	ESK107M063AH1(1)
63	79	220	10 x 16	9	410	ESK227M063AH2(1)
63	79	220	10 x 20	9	490	ESK227M063AH4(1)
63	79	330	10 x 20	9	540	ESK337M063AH4(1)
63	79	330	13 x 20	9	680	ESK337M063AL3(1)
63	79	470	13 x 25	9	880	ESK477M063AL4(1)
63	79	1000	16 x 25	9	1310	ESK108M063AM7(1)
63	79	1000	16 x 32	9	1550	ESK108M063AM2(1)
63	79	2200	18 x 40	9	2200	ESK228M063AN3(1)
63	79	3300	22 x 40	9	2500	ESK338M063AQ4(1)
100	125	1.0	5 x 11	8	21	ESK105M100AC3(1)
100	125	2.2	5 x 11	8	30	ESK225M100AC3(1)
100	125	3.3	5 x 11	8	45	ESK335M100AC3(1)
100	125	4.7	5 x 11	8	50	ESK475M100AC3(1)
100	125	10	6 x 11	8	75	ESK106M100AE3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
100	125	22	8 x 11	8	130	ESK226M100AG3(1)
100	125	33	8 x 11	8	140	ESK336M100AG3(1)
100	125	33	10 x 12	8	170	ESK336M100AH1(1)
100	125	47	10 x 12	8	190	ESK476M100AH1(1)
100	125	47	10 x 16	8	230	ESK476M100AH2(1)
100	125	100	10 x 20	8	400	ESK107M100AH4(1)
100	125	220	13 x 25	8	710	ESK227M100AL4(1)
100	125	330	13 x 25	8	720	ESK337M100AL4(1)
100	125	330	16 x 25	8	860	ESK337M100AM7(1)
100	125	470	16 x 25	8	1100	ESK477M100AM7(1)
100	125	1000	16 x 32	8	1350	ESK108M100AM2(1)
100	125	1000	18 x 40	8	1680	ESK108M100AN3(1)
100	125	2200	22 x 40	8	2300	ESK228M100AQ4(1)
160	200	0.47	5 x 11	15	12	ESK474M160AC3(1)
160	200	1.0	5 x 11	15	17	ESK105M160AC3(1)
160	200	2.2	6 x 11	15	26	ESK225M160AE3(1)
160	200	3.3	6 x 11	15	30	ESK335M160AE3(1)
160	200	3.3	8 x 11	15	35	ESK335M160AG3(1)
160	200	4.7	6 x 11	15	32	ESK475M160AE3(1)
160	200	4.7	8 x 11	15	40	ESK475M160AG3(1)
160	200	10	8 x 11	15	50	ESK106M160AG3(1)
160	200	10	10 x 12	15	65	ESK106M160AH1(1)
160	200	22	10 x 16	15	110	ESK226M160AH2(1)
160	200	33	10 x 20	15	150	ESK336M160AH4(1)
160	200	47	13 x 20	15	180	ESK476M160AL3(1)
160	200	100	13 x 25	15	250	ESK107M160AL4(1)
160	200	100	16 x 25	15	300	ESK107M160AM7(1)
160	200	220	16 x 32	15	450	ESK227M160AM2(1)
160	200	220	16 x 36	15	510	ESK227M160AM3(1)
160	200	330	18 x 36	15	540	ESK337M160AN2(1)
160	200	330	18 x 40	15	600	ESK337M160AN3(1)
160	200	470	22 x 40	15	900	ESK477M160AQ4(1)
200	250	0.47	5 x 11	15	14	ESK474M200AC3(1)
200	250	1.0	5 x 11	15	19	ESK105M200AC3(1)
200	250	2.2	6 x 11	15	22	ESK225M200AE3(1)
200	250	2.2	8 x 11	15	27	ESK225M200AG3(1)
200	250	3.3	6 x 11	15	30	ESK335M200AE3(1)
200	250	3.3	8 x 11	15	37	ESK335M200AG3(1)
200	250	4.7	8 x 11	15	36	ESK475M200AG3(1)
200	250	4.7	10 x 12	15	45	ESK475M200AH1(1)
200	250	10	10 x 12	15	57	ESK106M200AH1(1)
200	250	10	10 x 16	15	70	ESK106M200AH2(1)
200	250	22	10 x 16	15	120	ESK226M200AH2(1)
200	250	33	10 x 20	15	160	ESK336M200AH4(1)
200	250	47	13 x 20	15	160	ESK476M200AL3(1)
200	250	47	13 x 25	15	190	ESK476M200AL4(1)
200	250	100	16 x 25	15	330	ESK107M200AM7(1)
200	250	220	18 x 32	15	600	ESK227M200AN1(1)
200	250	220	18 x 36	15	600	ESK227M200AN2(1)
200	250	330	18 x 36	15	800	ESK337M200AN2(1)
200	250	330	18 x 40	15	800	ESK337M200AN3(1)
200	250	470	18 x 40	15	1000	ESK477M200AN3(1)
250	300	0.47	5 x 11	15	14	ESK474M250AC3(1)
250	300	1.0	6 x 11	15	19	ESK105M250AE3(1)
250	300	2.2	6 x 11	15	24	ESK225M250AE3(1)
250	300	2.2	8 x 11	15	30	ESK225M250AG3(1)
250	300	3.3	8 x 11	15	30	ESK335M250AG3(1)
250	300	3.3	10 x 12	15	38	ESK335M250AH1(1)
250	300	4.7	8 x 11	15	36	ESK475M250AG3(1)
250	300	4.7	10 x 12	15	45	ESK475M250AH1(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
250	300	10	10 x 12	15	70	ESK106M250AH1(1)
250	300	10	10 x 16	15	70	ESK106M250AH2(1)
250	300	22	10 x 20	15	130	ESK226M250AH4(1)
250	300	33	13 x 20	15	140	ESK336M250AL3(1)
250	300	33	13 x 25	15	160	ESK336M250AL4(1)
250	300	47	13 x 25	15	210	ESK476M250AL4(1)
250	300	100	16 x 32	15	310	ESK107M250AM2(1)
250	300	220	18 x 40	15	600	ESK227M250AN3(1)
350	400	0.47	5 x 11	20	14	ESK474M350AC3(1)
350	400	1.0	6 x 11	20	19	ESK105M350AE3(1)
350	400	2.2	8 x 11	20	33	ESK225M350AG3(1)
350	400	3.3	8 x 11	20	33	ESK335M350AG3(1)
350	400	3.3	10 x 12	20	39	ESK335M350AH1(1)
350	400	4.7	10 x 12	20	39	ESK475M350AH1(1)
350	400	4.7	10 x 16	20	45	ESK475M350AH2(1)
350	400	10	10 x 16	20	70	ESK106M350AH2(1)
350	400	22	13 x 20	20	130	ESK226M350AL3(1)
350	400	33	13 x 25	20	170	ESK336M350AL4(1)
350	400	47	16 x 25	20	220	ESK476M350AM7(1)
350	400	100	18 x 36	20	360	ESK107M350AN2(1)
400	450	0.47	6 x 11	20	14	ESK474M400AE3(1)
400	450	1.0	6 x 11	20	19	ESK105M400AE3(1)
400	450	1.0	8 x 11	20	19	ESK105M400AG3(1)
400	450	2.2	8 x 11	20	26	ESK225M400AG3(1)
400	450	2.2	10 x 12	20	33	ESK225M400AH1(1)
400	450	3.3	10 x 12	20	40	ESK335M400AH1(1)
400	450	4.7	10 x 16	20	45	ESK475M400AH2(1)
400	450	10	10 x 20	20	56	ESK106M400AH4(1)
400	450	10	13 x 20	20	70	ESK106M400AL3(1)
400	450	22	13 x 25	20	110	ESK226M400AL4(1)
400	450	22	16 x 25	20	130	ESK226M400AM7(1)
400	450	33	16 x 25	20	170	ESK336M400AM7(1)
400	450	33	18 x 20	20	130	ESK336M400AN4(1)
400	450	47	16 x 25	20	180	ESK476M400AM7(1)
400	450	47	16 x 32	20	220	ESK476M400AM2(1)
400	450	100	18 x 36	20	360	ESK107M400AN2(1)
450	500	0.47	6 x 11	20	14	ESK474M450AE3(1)
450	500	1.0	8 x 11	20	19	ESK105M450AG3(1)
450	500	2.2	10 x 12	20	33	ESK225M450AH1(1)
450	500	3.3	10 x 16	20	42	ESK335M450AH2(1)
450	500	4.7	10 x 16	20	50	ESK475M450AH2(1)
450	500	10	13 x 20	20	60	ESK106M450AL3(1)
450	500	10	13 x 25	20	75	ESK106M450AL4(1)
450	500	22	16 x 25	20	130	ESK226M450AM7(1)
450	500	33	16 x 32	20	160	ESK336M450AM2(1)
450	500	33	16 x 36	20	180	ESK336M450AM3(1)
450	500	47	18 x 40	20	230	ESK476M450AN3(1)
450	500	47	18 x 36	20	200	ESK476M450AN2(1)
450	500	100	22 x 40	20	370	ESK107M450AQ4(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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.
- 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

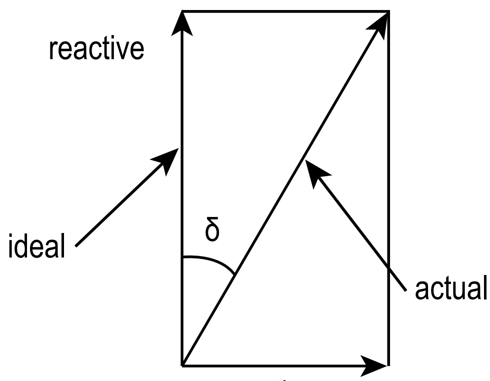
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.

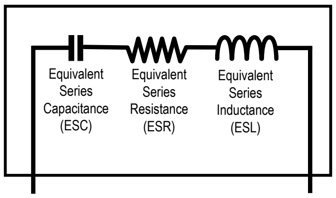


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:
ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

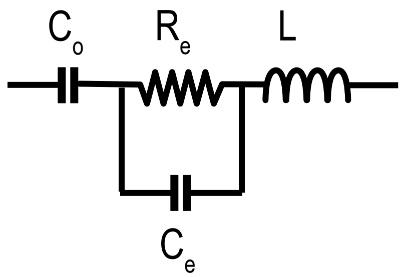
$$ESR = \frac{\tan \delta}{2\pi f\ ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

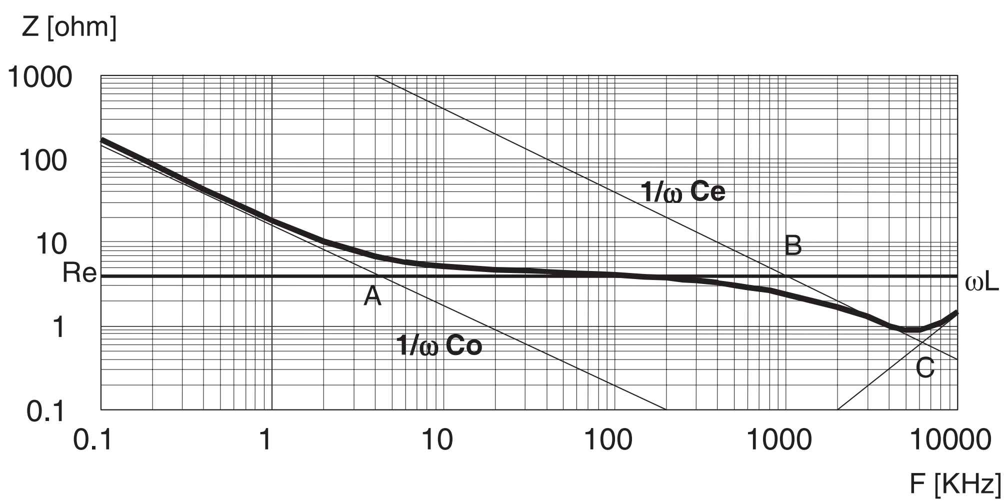
Impedance (Z)

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



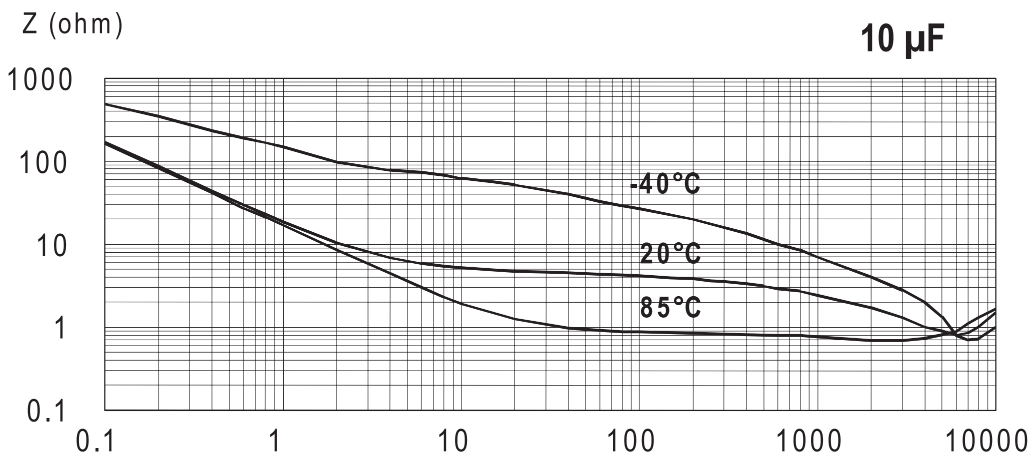
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

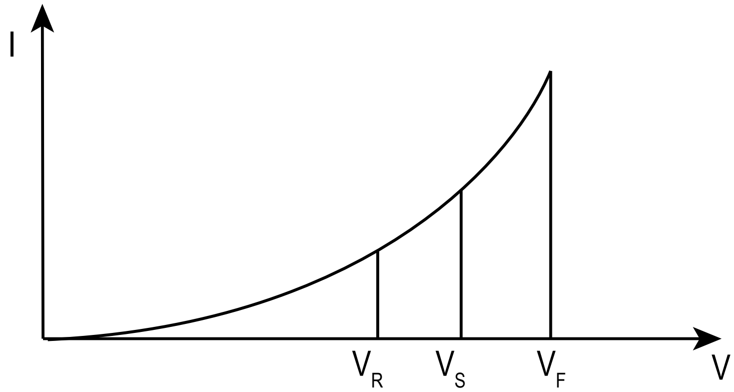
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Cut Leads	Auto-insertion	
					Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
N4	18	20	800	1000		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		
Q3	22	35	400			
Q4	22	40	300	400		

Standard Marking for Radial Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: white line
- Date code

ESH Series, +105ºC

Overview

KEMET's ESH Series of aluminum electrolytic radial capacitors are designed for high quality, high reliability applications.

Applications

Typical applications include general purpose coupling, decoupling, bypass and filtering.

Benefits

- Suited for high quality, high reliability applications
- 2,000 hour operating life
- Operating temperature of up to +105°C
- Case diameters 5 – 18 mm
- Safety vent on the capacitor base

Part Number System

ESH	107	M	6R3		A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)		Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63	100 = 100 160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 450 500 = 500	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 & Reel	Formed to 2.5 mm	$H_0 = 16.5 \pm 0.75$	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	KA
8	Tape & Reel	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	JA
10 – 13	Ammo	5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
16	Ammo	7.5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
Other Packaging Options				
4 – 8	Ammo	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	DA
10	Ammo	5 mm Lead Spacing	$H_0 = 16.5 \pm 0.75$	DA
4 – 8	Ammo	Straight	$H_0 = 18.5 \pm 0.75$	EA
4 – 5	Ammo	Formed to 2.5 mm	$H_0 = 16.5 \pm 0.75$	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	$H_0 = 16.5 \pm 0.75$	JA
4 – 5, 8 – 16	Tape & Reel	Straight	$H_0 = 18.5 \pm 0.75$	KA
Contact KEMET for other Lead and Packaging options				

Environmental Compliance

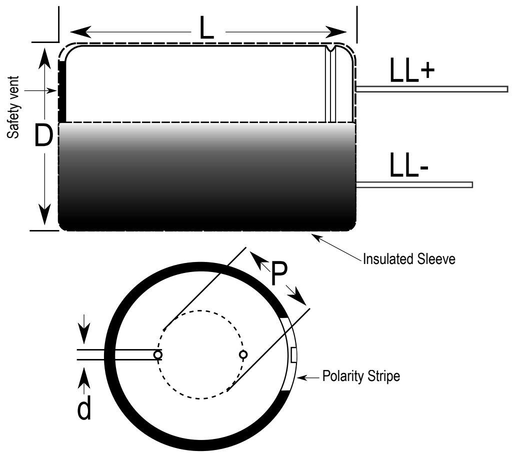
As an environmentally conscious company, KEMET is working continuously with improvements concerning the environmental effects of both our capacitors and their production. In Europe (RoHS Directive) and in some other geographical areas like China, legislation has been put in place to prevent the use of some hazardous materials, such as lead (Pb), in electronic equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
Q4	22	±0.5	40	+2.0/-0	10.0	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics	
Capacitance Range	0.47 – 15,000 µF	0.47 – 470 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C	
Rated Voltage	6.3 – 100 VDC	160 – 450 VDC
Life Test	2,000 hours (see conditions in Test Methods & Performance)	
Operating Temperature	-40°C to +105°C	-25°C to +85°C
Leakage Current	I ≤ 0.01 CV (µA) or 3 µA, whichever is greater	I = 0.03 CV (µA) + 10µA
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.	

Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	Capacitance Range (µF)	50 Hz	120 Hz	300 Hz	1 kHz	10 to 100 kHz
6.3 – 100	0.47 – 68 µF	0.75	1.00	1.30	1.57	2.00
6.3 – 100	100 – 470 µF	0.75	1.00	1.23	1.34	1.50
6.3 – 100	680 – 15,000 µF	0.75	1.00	1.10	1.13	1.15
160 – 450	0.47 – 470 µF	0.80	1.00	1.25	1.40	1.60

Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	65°C	85°C	105°C
Coefficient	1.70	1.40	1.00

Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	105°C	105°C
Test Duration	2,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 105°C	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	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
6.3	8	100	5 x 11	26	100	ESH107M6R3AC3(1)
6.3	8	150	5 x 11	26	120	ESH157M6R3AC3(1)
6.3	8	220	6 x 11	26	165	ESH227M6R3AE3(1)
6.3	8	330	6 x 11	26	200	ESH337M6R3AE3(1)
6.3	8	330	8 x 11	26	200	ESH337M6R3AG3(1)
6.3	8	470	8 x 11	26	280	ESH477M6R3AG3(1)
6.3	8	680	10 x 12	26	320	ESH687M6R3AH1(1)
6.3	8	1000	10 x 12	26	470	ESH108M6R3AH1(1)
6.3	8	1500	10 x 16	26	600	ESH158M6R3AH2(1)
6.3	8	2200	13 x 20	26	930	ESH228M6R3AL3(1)
6.3	8	3300	13 x 20	26	1100	ESH338M6R3AL3(1)
6.3	8	4700	16 x 25	26	1320	ESH478M6R3AM7(1)
6.3	8	6800	16 x 25	26	1490	ESH688M6R3AM7(1)
6.3	8	10000	16 x 32	26	1830	ESH109M6R3AM2(1)
6.3	8	15000	16 x 36	26	2280	ESH159M6R3AM3(1)
10	13	47	5 x 11	22	75	ESH476M010AC3(1)
10	13	68	5 x 11	22	80	ESH686M010AC3(1)
10	13	100	5 x 11	22	110	ESH107M010AC3(1)
10	13	150	6 x 11	22	130	ESH157M010AE3(1)
10	13	220	6 x 11	22	180	ESH227M010AE3(1)
10	13	330	8 x 11	22	255	ESH337M010AG3(1)
10	13	470	8 x 11	22	305	ESH477M010AG3(1)
10	13	680	10 x 12	22	420	ESH687M010AH1(1)
10	13	1000	10 x 16	22	570	ESH108M010AH2(1)
10	13	1500	10 x 20	22	750	ESH158M010AH4(1)
10	13	2200	13 x 20	22	1010	ESH228M010AL3(1)
10	13	3300	13 x 25	22	1220	ESH338M010AL4(1)
10	13	4700	16 x 25	22	1410	ESH478M010AM7(1)
10	13	6800	16 x 32	22	1610	ESH688M010AM2(1)
10	13	10000	18 x 36	22	1980	ESH109M010AN2(1)
16	20	33	5 x 11	18	70	ESH336M016AC3(1)
16	20	47	5 x 11	18	85	ESH476M016AC3(1)
16	20	68	5 x 11	18	100	ESH686M016AC3(1)
16	20	100	6 x 11	18	135	ESH107M016AE3(1)
16	20	150	8 x 11	18	180	ESH157M016AG3(1)
16	20	220	8 x 11	18	235	ESH227M016AG3(1)
16	20	330	10 x 12	18	285	ESH337M016AH1(1)
16	20	470	10 x 12	18	395	ESH477M016AH1(1)
16	20	680	10 x 16	18	530	ESH687M016AH2(1)
16	20	1000	10 x 20	18	700	ESH108M016AH4(1)
16	20	1500	13 x 20	18	860	ESH158M016AL3(1)
16	20	2200	13 x 25	18	1150	ESH228M016AL4(1)
16	20	3300	16 x 25	18	1350	ESH338M016AM7(1)
16	20	4700	16 x 32	18	1560	ESH478M016AM2(1)
16	20	6800	18 x 36	18	1790	ESH688M016AN2(1)
25	32	22	5 x 11	16	60	ESH226M025AC3(1)
25	32	33	5 x 11	16	75	ESH336M025AC3(1)
25	32	47	5 x 11	16	90	ESH476M025AC3(1)
25	32	68	6 x 11	16	125	ESH686M025AE3(1)
25	32	100	6 x 11	16	145	ESH107M025AE3(1)
25	32	150	8 x 11	16	200	ESH157M025AG3(1)
25	32	220	8 x 11	16	250	ESH227M025AG3(1)
25	32	220	10 x 12	16	250	ESH227M025AH1(1)
25	32	330	10 x 12	16	355	ESH337M025AH1(1)
25	32	470	10 x 12	16	405	ESH477M025AH1(1)
25	32	470	10 x 16	16	470	ESH477M025AH2(1)
25	32	680	10 x 20	16	650	ESH687M025AH4(1)
25	32	1000	13 x 20	16	855	ESH108M025AL3(1)
25	32	1500	13 x 25	16	1020	ESH158M025AL4(1)
25	32	2200	16 x 25	16	1230	ESH228M025AM7(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
25	32	3300	16 x 32	16	1450	ESH338M025AM2(1)
25	32	4700	18 x 36	16	1690	ESH478M025AN2(1)
35	44	10	5 x 11	14	44	ESH106M035AC3(1)
35	44	15	5 x 11	14	50	ESH156M035AC3(1)
35	44	22	5 x 11	14	65	ESH226M035AC3(1)
35	44	33	5 x 11	14	85	ESH336M035AC3(1)
35	44	47	6 x 11	14	115	ESH476M035AE3(1)
35	44	68	8 x 11	14	130	ESH686M035AG3(1)
35	44	100	8 x 11	14	190	ESH107M035AG3(1)
35	44	150	10 x 12	14	240	ESH157M035AH1(1)
35	44	220	10 x 12	14	315	ESH227M035AH1(1)
35	44	330	10 x 16	14	440	ESH337M035AH2(1)
35	44	470	10 x 20	14	580	ESH477M035AH4(1)
35	44	470	13 x 20	14	580	ESH477M035AL3(1)
35	44	680	13 x 20	14	730	ESH687M035AL3(1)
35	44	1000	13 x 25	14	995	ESH108M035AL4(1)
35	44	1500	16 x 25	14	1110	ESH158M035AM7(1)
35	44	2200	16 x 32	14	1450	ESH228M035AM2(1)
35	44	3300	18 x 36	14	1660	ESH338M035AN2(1)
50	63	0.47	5 x 11	12	7	ESH474M050AC3(1)
50	63	1.0	5 x 11	12	12	ESH105M050AC3(1)
50	63	2.2	5 x 11	12	18	ESH225M050AC3(1)
50	63	3.3	5 x 11	12	25	ESH335M050AC3(1)
50	63	4.7	5 x 11	12	30	ESH475M050AC3(1)
50	63	6.8	5 x 11	12	30	ESH685M050AC3(1)
50	63	10	5 x 11	12	50	ESH106M050AC3(1)
50	63	15	5 x 11	12	50	ESH156M050AC3(1)
50	63	22	5 x 11	12	75	ESH226M050AC3(1)
50	63	33	6 x 11	12	105	ESH336M050AE3(1)
50	63	47	8 x 11	12	125	ESH476M050AG3(1)
50	63	68	8 x 11	12	159	ESH686M050AG3(1)
50	63	100	10 x 12	12	210	ESH107M050AH1(1)
50	63	150	10 x 12	12	289	ESH157M050AH1(1)
50	63	220	10 x 16	12	400	ESH227M050AH2(1)
50	63	330	10 x 20	12	535	ESH337M050AH4(1)
50	63	470	13 x 20	12	730	ESH477M050AL3(1)
50	63	680	13 x 25	12	860	ESH687M050AL4(1)
50	63	1000	16 x 25	12	1110	ESH108M050AM7(1)
50	63	1500	16 x 32	12	1350	ESH158M050AM2(1)
50	63	2200	18 x 36	12	1530	ESH228M050AN2(1)
63	79	0.47	5 x 11	10	8	ESH474M063AC3(1)
63	79	1.0	5 x 11	10	12	ESH105M063AC3(1)
63	79	2.2	5 x 11	10	20	ESH225M063AC3(1)
63	79	3.3	5 x 11	10	27	ESH335M063AC3(1)
63	79	4.7	5 x 11	10	34	ESH475M063AC3(1)
63	79	6.8	5 x 11	10	37	ESH685M063AC3(1)
63	79	10	5 x 11	10	55	ESH106M063AC3(1)
63	79	15	5 x 11	10	65	ESH156M063AC3(1)
63	79	22	6 x 11	10	90	ESH226M063AE3(1)
63	79	33	8 x 11	10	110	ESH336M063AG3(1)
63	79	47	8 x 11	10	155	ESH476M063AG3(1)
63	79	68	10 x 12	10	198	ESH686M063AH1(1)
63	79	100	10 x 12	10	260	ESH107M063AH1(1)
63	79	150	10 x 16	10	330	ESH157M063AH2(1)
63	79	220	10 x 20	10	465	ESH227M063AH4(1)
63	79	330	13 x 20	10	650	ESH337M063AL3(1)
63	79	470	13 x 25	10	800	ESH477M063AL4(1)
63	79	680	16 x 25	10	1000	ESH687M063AM7(1)
63	79	1000	16 x 32	10	1200	ESH108M063AM2(1)
63	79	1500	16 x 36	10	1450	ESH158M063AM3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
100	125	0.47	5 x 11	10	10	ESH474M100AC3(1)
100	125	1.0	5 x 11	10	15	ESH105M100AC3(1)
100	125	2.2	5 x 11	10	22	ESH225M100AC3(1)
100	125	3.3	5 x 11	10	29	ESH335M100AC3(1)
100	125	4.7	5 x 11	10	37	ESH475M100AC3(1)
100	125	6.8	5 x 11	10	46	ESH685M100AC3(1)
100	125	10	6 x 11	10	65	ESH106M100AE3(1)
100	125	15	8 x 11	10	82	ESH156M100AG3(1)
100	125	22	8 x 11	10	115	ESH226M100AG3(1)
100	125	33	10 x 12	10	160	ESH336M100AH1(1)
100	125	47	10 x 16	10	210	ESH476M100AH2(1)
100	125	68	10 x 20	10	241	ESH686M100AH4(1)
100	125	100	13 x 20	10	385	ESH107M100AL3(1)
100	125	150	13 x 25	10	414	ESH157M100AL4(1)
100	125	220	16 x 25	10	590	ESH227M100AM7(1)
100	125	330	16 x 25	10	720	ESH337M100AM7(1)
100	125	470	16 x 32	10	875	ESH477M100AM2(1)
100	125	680	16 x 36	10	1200	ESH687M100AM3(1)
160	200	0.47	5 x 11	15	12	ESH474M160AC3(1)
160	200	1.0	5 x 11	15	17	ESH105M160AC3(1)
160	200	2.2	6 x 11	15	25	ESH225M160AE3(1)
160	200	3.3	8 x 11	15	36	ESH335M160AG3(1)
160	200	4.7	8 x 11	15	43	ESH475M160AG3(1)
160	200	6.8	10 x 12	15	54	ESH685M160AH1(1)
160	200	10	10 x 12	15	70	ESH106M160AH1(1)
160	200	15	10 x 16	15	90	ESH156M160AH2(1)
160	200	22	10 x 20	15	130	ESH226M160AH4(1)
160	200	33	13 x 20	15	180	ESH336M160AL3(1)
160	200	47	13 x 25	15	250	ESH476M160AL4(1)
160	200	68	13 x 25	15	270	ESH686M160AL4(1)
160	200	100	16 x 25	15	390	ESH107M160AM7(1)
160	200	150	16 x 32	15	435	ESH157M160AM2(1)
160	200	220	16 x 36	15	700	ESH227M160AM3(1)
160	200	330	18 x 40	15	850	ESH337M160AN3(1)
160	200	470	22 x 40	15	980	ESH477M160AQ4(1)
200	250	0.47	5 x 11	15	12	ESH474M200AC3(1)
200	250	1.0	6 x 11	15	17	ESH105M200AE3(1)
200	250	2.2	6 x 11	15	25	ESH225M200AE3(1)
200	250	3.3	8 x 11	15	36	ESH335M200AG3(1)
200	250	4.7	10 x 12	15	50	ESH475M200AH1(1)
200	250	6.8	10 x 12	15	60	ESH685M200AH1(1)
200	250	10	10 x 16	15	80	ESH106M200AH2(1)
200	250	15	10 x 20	15	110	ESH156M200AH4(1)
200	250	22	10 x 20	15	140	ESH226M200AH4(1)
200	250	33	13 x 20	15	190	ESH336M200AL3(1)
200	250	33	13 x 25	15	190	ESH336M200AL4(1)
200	250	47	13 x 20	15	260	ESH476M200AL3(1)
200	250	47	13 x 25	15	260	ESH476M200AL4(1)
200	250	68	16 x 25	15	280	ESH686M200AM7(1)
200	250	100	16 x 32	15	400	ESH107M200AM2(1)
200	250	150	16 x 36	15	450	ESH157M200AM3(1)
200	250	220	18 x 36	15	750	ESH227M200AN2(1)
200	250	220	18 x 40	15	750	ESH227M200AN3(1)
200	250	330	18 x 40	15	920	ESH337M200AN3(1)
200	250	330	22 x 40	15	920	ESH337M200AQ4(1)
250	300	0.47	5 x 11	15	12	ESH474M250AC3(1)
250	300	1.0	6 x 11	15	17	ESH105M250AE3(1)
250	300	2.2	8 x 11	15	29	ESH225M250AG3(1)
250	300	3.3	10 x 12	15	42	ESH335M250AH1(1)
250	300	4.7	10 x 12	15	52	ESH475M250AH1(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	RC 120 Hz 105°C (mA)	Part Number
250	300	6.8	10 x 12	15	62	ESH685M250AH1(1)
250	300	10	10 x 16	15	75	ESH106M250AH2(1)
250	300	10	10 x 20	15	88	ESH106M250AH4(1)
250	300	15	13 x 20	15	120	ESH156M250AL3(1)
250	300	22	13 x 20	15	155	ESH226M250AL3(1)
250	300	22	13 x 25	15	155	ESH226M250AL4(1)
250	300	33	13 x 25	15	200	ESH336M250AL4(1)
250	300	47	16 x 25	15	270	ESH476M250AM7(1)
250	300	68	16 x 32	15	300	ESH686M250AM2(1)
250	300	100	18 x 36	15	440	ESH107M250AN2(1)
250	300	150	18 x 40	15	600	ESH157M250AN3(1)
250	300	220	22 x 40	15	800	ESH227M250AQ4(1)
350	400	0.47	6 x 11	20	14	ESH474M350AE3(1)
350	400	1.0	8 x 11	20	20	ESH105M350AG3(1)
350	400	2.2	10 x 12	20	35	ESH225M350AH1(1)
350	400	3.3	10 x 16	20	47	ESH335M350AH2(1)
350	400	4.7	10 x 16	20	55	ESH475M350AH2(1)
350	400	6.8	10 x 20	20	65	ESH685M350AH4(1)
350	400	10	13 x 20	20	95	ESH106M350AL3(1)
350	400	15	13 x 20	20	140	ESH156M350AL3(1)
350	400	22	16 x 25	20	165	ESH226M350AM7(1)
350	400	33	16 x 32	20	195	ESH336M350AM2(1)
350	400	47	16 x 36	20	210	ESH476M350AM3(1)
350	400	47	18 x 36	20	240	ESH476M350AN2(1)
350	400	68	18 x 36	20	320	ESH686M350AN2(1)
350	400	100	18 x 40	20	300	ESH107M350AN3(1)
350	400	100	22 x 40	20	360	ESH107M350AQ4(1)
350	400	150	22 x 40	20	480	ESH157M350AQ4(1)
400	450	0.47	6 x 11	20	14	ESH474M400AE3(1)
400	450	1.0	8 x 11	20	20	ESH105M400AG3(1)
400	450	2.2	10 x 12	20	35	ESH225M400AH1(1)
400	450	3.3	10 x 12	20	42	ESH335M400AH1(1)
400	450	3.3	10 x 16	20	49	ESH335M400AH2(1)
400	450	4.7	10 x 16	20	57	ESH475M400AH2(1)
400	450	6.8	10 x 20	20	67	ESH685M400AH4(1)
400	450	10	10 x 20	20	75	ESH106M400AH4(1)
400	450	10	13 x 20	20	97	ESH106M400AL3(1)
400	450	15	13 x 25	20	145	ESH156M400AL4(1)
400	450	22	13 x 25	20	140	ESH226M400AL4(1)
400	450	22	16 x 25	20	170	ESH226M400AM7(1)
400	450	33	16 x 25	20	190	ESH336M400AM7(1)
400	450	33	16 x 32	20	230	ESH336M400AM2(1)
400	450	47	16 x 32	20	250	ESH476M400AM2(1)
400	450	47	18 x 36	20	300	ESH476M400AN2(1)
400	450	68	18 x 36	20	325	ESH686M400AN2(1)
400	450	100	18 x 36	20	290	ESH107M400AN2(1)
400	450	100	22 x 40	20	365	ESH107M400AQ4(1)
400	450	150	22 x 40	20	465	ESH157M400AQ4(1)
450	500	0.47	6 x 11	20	16	ESH474M450AE3(1)
450	500	1.0	8 x 11	20	22	ESH105M450AG3(1)
450	500	2.2	10 x 12	20	37	ESH225M450AH1(1)
450	500	3.3	10 x 16	20	51	ESH335M450AH2(1)
450	500	4.7	10 x 16	20	59	ESH475M450AH2(1)
450	500	6.8	13 x 20	20	69	ESH685M450AL3(1)
450	500	10	13 x 25	20	99	ESH106M450AL4(1)
450	500	15	16 x 25	20	150	ESH156M450AM7(1)
450	500	22	16 x 25	20	145	ESH226M450AM7(1)
450	500	22	16 x 32	20	175	ESH226M450AM2(1)
450	500	33	18 x 36	20	250	ESH336M450AN2(1)
450	500	47	18 x 40	20	350	ESH476M450AN3(1)
450	500	68	22 x 40	20	380	ESH686M450AQ4(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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.
- 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

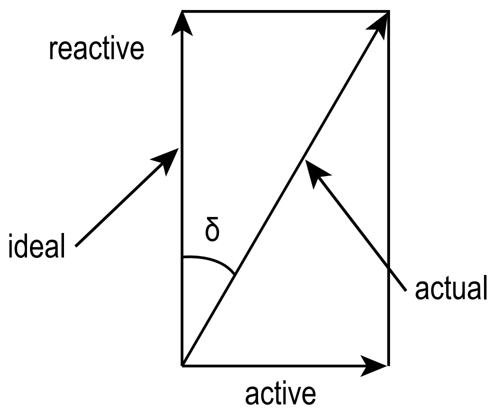
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.

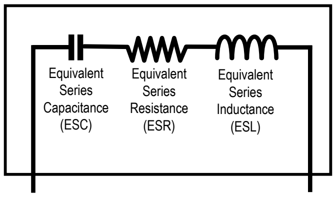


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:
ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

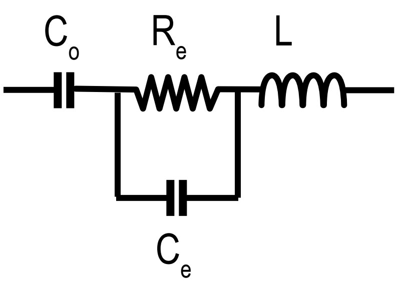
$$ESR = \frac{\tan \delta}{2\pi f \, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

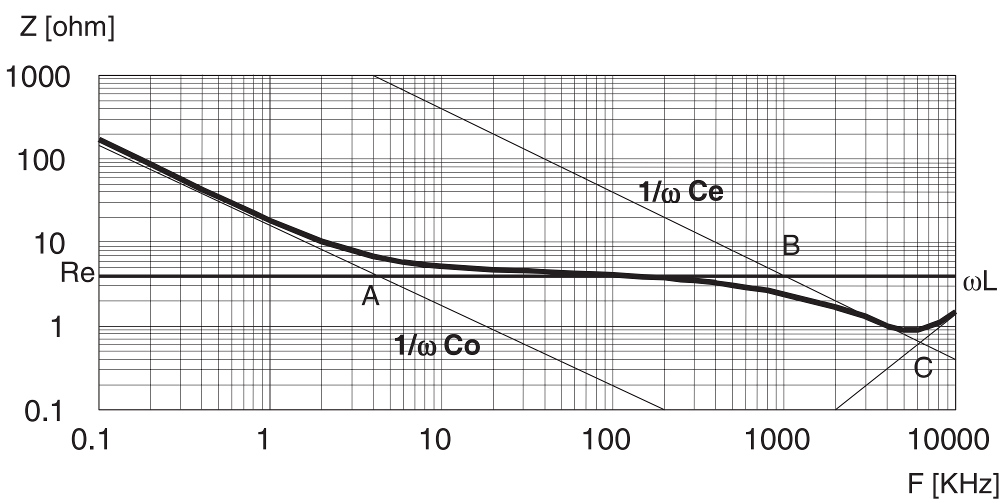
Impedance (Z)

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



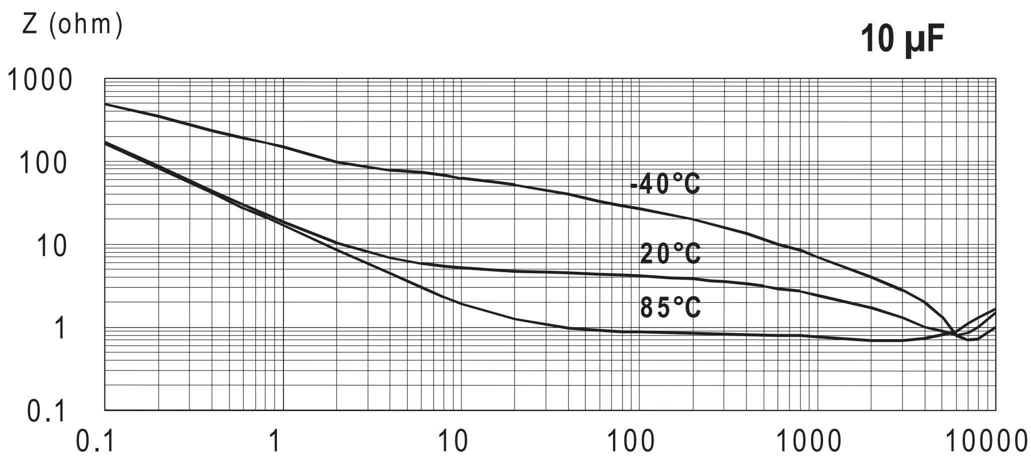
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals ($XL = Z = \omega L$) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

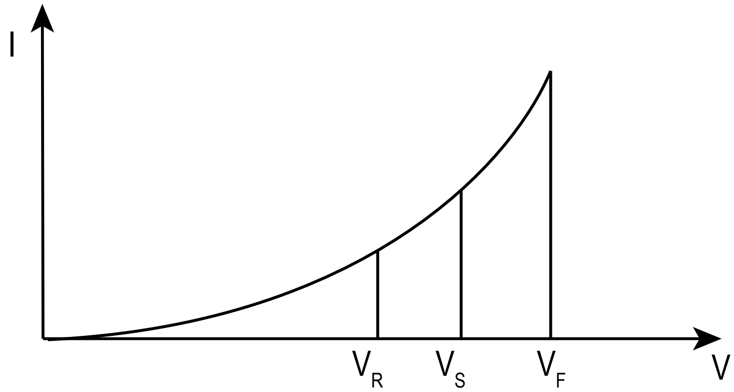
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
N2	18	36	500	500		
N3	18	40	500	500		
Q4	22	40	300	400		

Standard Marking for Radial Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: white line
- Date code

ESC Series, +105ºC

Overview

KEMET's ESC Series of aluminum electrolytic radial capacitors are designed for high frequency applications.

Applications

Typical applications include high frequency switch mode circuits.

Benefits

- Low impedance
- Operating temperature of up to +105°C
- 2,000 – 3,000 hour operating life
- Case with Ø D ≥ 6.3 mm
- Safety vent on the capacitor base

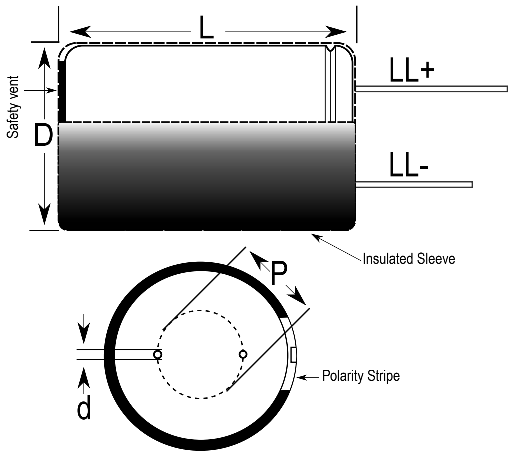
Part Number System

ESC	157	M	6R3	A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63 100 = 100	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.5	Nominal	20/15	Minimum
G4	8	±0.5	15	+2.0/-0	3.5	±0.5	0.5	Nominal	20/15	Minimum
G6	8	±0.5	20	+2.0/-0	3.5	±0.5	0.5	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	1.0 – 15,000 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 100 VDC
Life Test	2,000 – 3,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA, whichever is greater
	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)	6.3	10	16	25	35	50	63	100
Z (-40°C) / Z (20°C)	10	8	5	4	4	4	4	4

Compensation Factor of Ripple Current (RC) vs. Frequency

Capacitance Range (µF)	50 Hz	120 Hz	300 Hz	1 kHz	10 kHz	100 kHz
1.0 – 4.7	0.30	0.40	0.50	0.70	0.80	1.00
5.6 – 33	0.40	0.50	0.60	0.80	0.90	1.00
47 – 330	0.60	0.70	0.80	0.90	0.95	1.00
470 – 1,000	0.65	0.80	0.90	0.98	1.00	1.00
1,200 – 15,000	0.85	0.90	0.95	0.98	1.00	1.00

Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	65°C	85°C	105°C
Coefficient	1.90	1.60	1.00

Test Method & Performance

Conditions	Load Life Test		Shelf Life Test
Temperature	105°C		105°C
Test Duration	D x L ≤ 10 x 12 mm	2,000 hours	1,000 hours
	D x L ≤ 10 x 15 mm	3,000 hours	
Ripple Current	Maximum ripple current specified at 100 KHz 105°C		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	Does not exceed 200% of the specified value		
Leakage Current	Does not exceed specified value		

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
6.3	8	150	5 x 11	15	0.420	200	9	ESC157M6R3AC3(1)
6.3	8	220	6 x 11	15	0.320	250	14	ESC227M6R3AE3(1)
6.3	8	330	8 x 11	15	0.180	400	21	ESC337M6R3AG3(1)
6.3	8	470	8 x 11	15	0.140	550	30	ESC477M6R3AG3(1)
6.3	8	680	8 x 15	15	0.100	700	43	ESC687M6R3AG4(1)
6.3	8	820	8 x 20	15	0.085	750	52	ESC827M6R3AG6(1)
6.3	8	1000	8 x 20	15	0.069	800	63	ESC108M6R3AG6(1)
6.3	8	1200	10 x 16	15	0.064	1000	76	ESC128M6R3AH2(1)
6.3	8	1500	10 x 20	15	0.044	1250	94	ESC158M6R3AH4(1)
6.3	8	2200	13 x 20	15	0.043	1450	139	ESC228M6R3AL3(1)
6.3	8	3300	13 x 25	15	0.035	1700	208	ESC338M6R3AL4(1)
6.3	8	4700	16 x 25	15	0.028	1800	296	ESC478M6R3AM7(1)
6.3	8	6800	16 x 32	15	0.024	2000	428	ESC688M6R3AM2(1)
6.3	8	8200	16 x 32	15	0.019	2350	517	ESC828M6R3AM2(1)
6.3	8	10000	16 x 36	15	0.019	2550	630	ESC109M6R3AM3(1)
6.3	8	15000	18 x 36	15	0.019	3000	945	ESC159M6R3AN2(1)
10	13	100	5 x 11	14	0.420	150	10	ESC107M010AC3(1)
10	13	120	5 x 11	14	0.370	200	12	ESC127M010AC3(1)
10	13	150	6 x 11	14	0.320	250	15	ESC157M010AE3(1)
10	13	220	6 x 11	14	0.220	300	22	ESC227M010AE3(1)
10	13	330	8 x 11	14	0.140	550	33	ESC337M010AG3(1)
10	13	470	8 x 15	14	0.100	750	47	ESC477M010AG4(1)
10	13	470	10 x 12	14	0.120	630	47	ESC477M010AH1(1)
10	13	680	10 x 12	14	0.085	800	68	ESC687M010AH1(1)
10	13	820	10 x 16	14	0.064	1050	82	ESC827M010AH2(1)
10	13	1000	8 x 20	14	0.065	1080	100	ESC108M010AG6(1)
10	13	1200	10 x 20	14	0.044	1250	120	ESC128M010AH4(1)
10	13	1500	10 x 20	14	0.039	1450	150	ESC158M010AH4(1)
10	13	2200	13 x 20	14	0.038	1600	220	ESC228M010AL3(1)
10	13	3300	13 x 25	14	0.028	2000	330	ESC338M010AL4(1)
10	13	4700	16 x 25	14	0.024	2200	470	ESC478M010AM7(1)
10	13	6800	16 x 36	14	0.019	2550	680	ESC688M010AM3(1)
10	13	8200	18 x 36	14	0.019	2800	820	ESC828M010AN2(1)
16	20	68	5 x 11	12	0.420	150	11	ESC686M016AC3(1)
16	20	100	5 x 11	12	0.370	200	16	ESC107M016AC3(1)
16	20	120	6 x 11	12	0.320	250	19	ESC127M016AE3(1)
16	20	150	6 x 11	12	0.220	300	24	ESC157M016AE3(1)
16	20	220	8 x 11	12	0.140	550	35	ESC227M016AG3(1)
16	20	330	8 x 15	12	0.100	750	53	ESC337M016AG4(1)
16	20	470	10 x 12	12	0.085	800	75	ESC477M016AH1(1)
16	20	680	10 x 16	12	0.064	1050	109	ESC687M016AH2(1)
16	20	820	10 x 20	12	0.044	1100	131	ESC827M016AH4(1)
16	20	1000	10 x 20	12	0.039	1250	160	ESC108M016AH4(1)
16	20	1200	13 x 20	12	0.038	1450	192	ESC128M016AL3(1)
16	20	1500	13 x 20	12	0.034	1600	240	ESC158M016AL3(1)
16	20	2200	13 x 25	12	0.028	2000	352	ESC228M016AL4(1)
16	20	3300	16 x 25	12	0.024	2200	528	ESC338M016AM7(1)
16	20	4700	16 x 36	12	0.019	2550	752	ESC478M016AM3(1)
16	20	6800	18 x 36	12	0.019	2800	1088	ESC688M016AN2(1)
25	32	47	5 x 11	10	0.420	150	12	ESC476M025AC3(1)
25	32	68	6 x 11	10	0.370	200	17	ESC686M025AE3(1)
25	32	100	6 x 11	10	0.220	250	25	ESC107M025AE3(1)
25	32	120	8 x 11	10	0.200	300	30	ESC127M025AG3(1)
25	32	150	8 x 11	10	0.140	550	37	ESC157M025AG3(1)
25	32	220	8 x 15	10	0.100	750	55	ESC227M025AG4(1)
25	32	330	8 x 20	10	0.069	800	82	ESC337M025AG6(1)
25	32	470	10 x 16	10	0.064	1050	117	ESC477M025AH2(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	Z	RC	LC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
25	32	680	10 x 20	10	0.039	1100	170	ESC687M025AH4(1)
25	32	820	10 x 20	10	0.039	1250	205	ESC827M025AH4(1)
25	32	1000	13 x 20	10	0.038	1450	250	ESC108M025AL3(1)
25	32	1200	13 x 25	10	0.029	1600	300	ESC128M025AL4(1)
25	32	1500	16 x 25	10	0.028	2000	375	ESC158M025AM7(1)
25	32	2200	16 x 32	10	0.024	2200	550	ESC228M025AM2(1)
25	32	3300	16 x 36	10	0.019	2550	825	ESC338M025AM3(1)
25	32	4700	18 x 36	10	0.019	2800	1175	ESC478M025AN2(1)
35	44	4.7	5 x 11	10	1.200	115	3	ESC475M035AC3(1)
35	44	6.8	5 x 11	10	1.000	120	3	ESC685M035AC3(1)
35	44	10	5 x 11	10	0.900	140	3	ESC106M035AC3(1)
35	44	15	5 x 11	10	0.690	170	5	ESC156M035AC3(1)
35	44	22	5 x 11	10	0.420	190	8	ESC226M035AC3(1)
35	44	33	5 x 11	10	0.420	200	11	ESC336M035AC3(1)
35	44	47	6 x 11	10	0.370	250	16	ESC476M035AE3(1)
35	44	68	6 x 11	10	0.220	300	24	ESC686M035AE3(1)
35	44	100	8 x 11	10	0.140	450	35	ESC107M035AG3(1)
35	44	120	8 x 11	10	0.130	550	42	ESC127M035AG3(1)
35	44	150	8 x 15	10	0.100	650	52	ESC157M035AG4(1)
35	44	220	8 x 20	10	0.085	780	77	ESC227M035AG6(1)
35	44	220	10 x 12	10	0.069	800	77	ESC227M035AH1(1)
35	44	330	10 x 20	10	0.044	1050	115	ESC337M035AH4(1)
35	44	470	10 x 20	10	0.039	1300	164	ESC477M035AH4(1)
35	44	680	13 x 20	10	0.038	1400	238	ESC687M035AL3(1)
35	44	820	13 x 20	10	0.034	1550	287	ESC827M035AL3(1)
35	44	1000	13 x 25	10	0.029	1700	350	ESC108M035AL4(1)
35	44	1200	16 x 25	10	0.028	1900	420	ESC128M035AM7(1)
35	44	1500	16 x 25	10	0.024	2100	525	ESC158M035AM7(1)
35	44	2200	16 x 32	10	0.021	2500	770	ESC228M035AM2(1)
35	44	2200	16 x 36	10	0.019	2550	770	ESC228M035AM3(1)
35	44	3300	18 x 36	10	0.019	2800	1155	ESC338M035AN2(1)
50	63	1	5 x 11	8	2.400	40	3	ESC105M050AC3(1)
50	63	4.7	5 x 11	8	2.000	115	3	ESC475M050AC3(1)
50	63	6.8	5 x 11	8	1.850	120	3	ESC685M050AC3(1)
50	63	10	5 x 11	8	1.700	140	5	ESC106M050AC3(1)
50	63	15	5 x 11	8	1.200	180	7	ESC156M050AC3(1)
50	63	22	5 x 11	8	0.700	200	11	ESC226M050AC3(1)
50	63	33	6 x 11	8	0.600	250	16	ESC336M050AE3(1)
50	63	47	6 x 11	8	0.520	300	23	ESC476M050AE3(1)
50	63	68	8 x 11	8	0.350	450	34	ESC686M050AG3(1)
50	63	100	8 x 15	8	0.250	550	50	ESC107M050AG4(1)
50	63	120	8 x 20	8	0.210	650	60	ESC127M050AG6(1)
50	63	150	10 x 12	8	0.160	800	75	ESC157M050AH1(1)
50	63	220	10 x 16	8	0.100	1050	110	ESC227M050AH2(1)
50	63	330	10 x 20	8	0.072	1300	165	ESC337M050AH4(1)
50	63	470	13 x 20	8	0.060	1400	235	ESC477M050AL3(1)
50	63	680	13 x 25	8	0.050	1550	340	ESC687M050AL4(1)
50	63	820	16 x 25	8	0.040	1700	410	ESC827M050AM7(1)
50	63	1000	16 x 25	8	0.039	1900	500	ESC108M050AM7(1)
50	63	1200	16 x 32	8	0.025	2100	600	ESC128M050AM2(1)
50	63	1500	16 x 36	8	0.025	2550	750	ESC158M050AM3(1)
50	63	2200	18 x 40	8	0.025	2800	1100	ESC228M050AN3(1)
63	79	4.7	5 x 11	8	2.200	115	3	ESC475M063AC3(1)
63	79	6.8	5 x 11	8	2.000	120	4	ESC685M063AC3(1)
63	79	10	5 x 11	8	1.850	140	6	ESC106M063AC3(1)
63	79	15	5 x 11	8	1.700	200	9	ESC156M063AC3(1)
63	79	22	6 x 11	8	1.200	250	14	ESC226M063AE3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
63	79	33	6 x 11	8	0.900	300	21	ESC336M063AE3(1)
63	79	47	8 x 11	8	0.700	450	30	ESC476M063AG3(1)
63	79	68	8 x 11	8	0.520	550	43	ESC686M063AG3(1)
63	79	100	8 x 20	8	0.350	650	63	ESC107M063AG6(1)
63	79	120	10 x 16	8	0.300	800	76	ESC127M063AH2(1)
63	79	150	10 x 16	8	0.200	1050	94	ESC157M063AH2(1)
63	79	220	10 x 20	8	0.150	1300	139	ESC227M063AH4(1)
63	79	330	13 x 20	8	0.100	1400	208	ESC337M063AL3(1)
63	79	470	13 x 25	8	0.064	1550	296	ESC477M063AL4(1)
63	79	680	16 x 25	8	0.052	1700	428	ESC687M063AM7(1)
63	79	820	16 x 32	8	0.048	1900	517	ESC827M063AM2(1)
63	79	1000	16 x 32	8	0.042	2100	630	ESC108M063AM2(1)
63	79	1200	16 x 36	8	0.036	2550	756	ESC128M063AM3(1)
63	79	1500	18 x 36	8	0.033	2800	945	ESC158M063AN2(1)
100	125	4.7	5 x 11	7	2.000	120	5	ESC475M100AC3(1)
100	125	6.8	5 x 11	7	1.850	140	7	ESC685M100AC3(1)
100	125	10	6 x 11	7	1.500	200	10	ESC106M100AE3(1)
100	125	15	6 x 11	7	1.200	250	15	ESC156M100AE3(1)
100	125	22	8 x 11	7	0.790	300	22	ESC226M100AG3(1)
100	125	33	8 x 15	7	0.590	450	33	ESC336M100AG4(1)
100	125	47	10 x 16	7	0.350	550	47	ESC476M100AH2(1)
100	125	68	10 x 20	7	0.240	650	68	ESC686M100AH4(1)
100	125	100	13 x 20	7	0.180	800	100	ESC107M100AL3(1)
100	125	120	13 x 25	7	0.150	1050	120	ESC127M100AL4(1)
100	125	150	13 x 25	7	0.110	1300	150	ESC157M100AL4(1)
100	125	220	16 x 25	7	0.071	1400	220	ESC227M100AM7(1)
100	125	330	16 x 32	7	0.049	1550	330	ESC337M100AM2(1)
100	125	470	18 x 36	7	0.038	1700	470	ESC477M100AN2(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	Z	RC	LC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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.
- 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor).
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

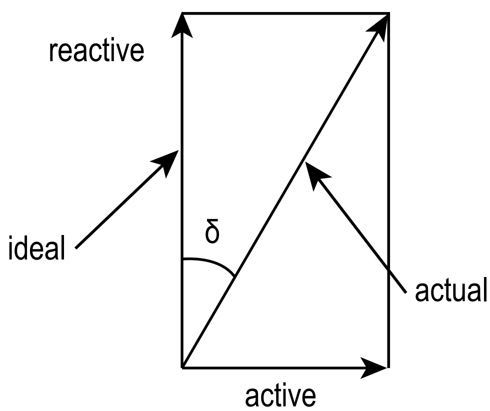
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



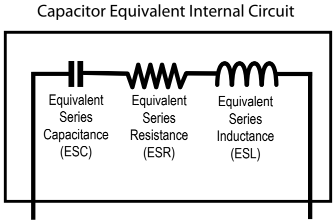
Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

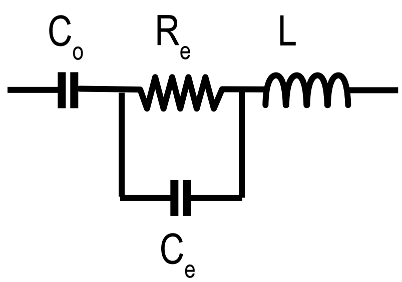
$$ESR = \frac{\tan\delta}{2\pi f\, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

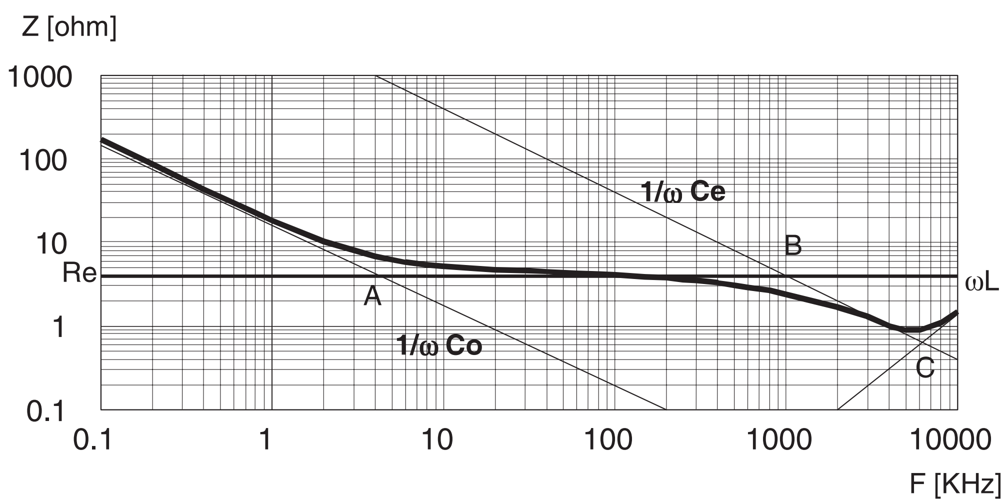
Impedance (Z)

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



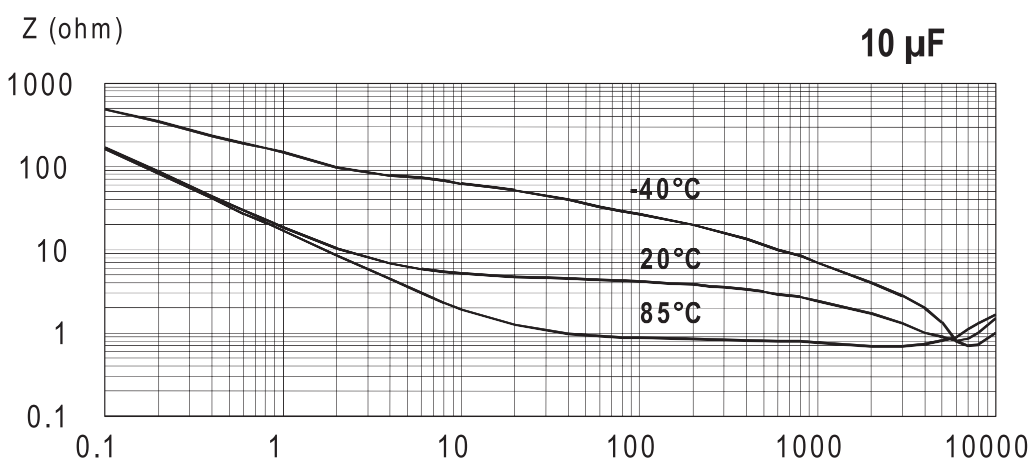
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

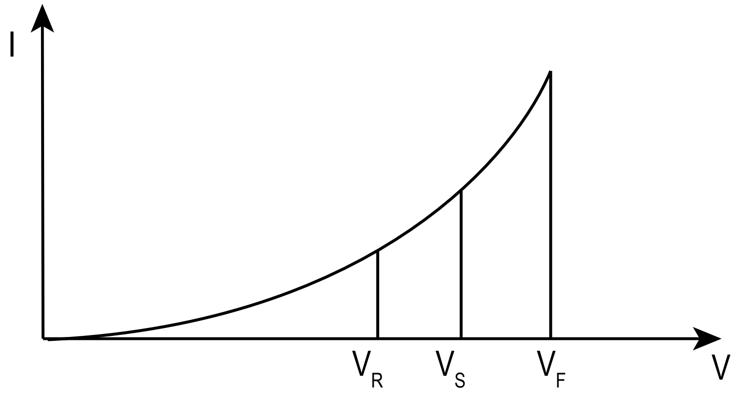
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
G6	8	20	4000	4000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
N2	18	36	500	500		
N3	18	40	500	500		

Standard Marking for Radial Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: gold line
- Date code

ESY Series, +105ºC

Overview

KEMET's ESY Series of aluminum electrolytic radial capacitors are designed for very low impedance and high ripple current applications.

Applications

Typical applications include high frequency switch mode circuits.

Benefits

- Very low impedance
- High ripple current
- Operating temperature of up to +105°C
- 1,000 – 5,000 hour operating life
- Case with Ø D ≥ 6.3 mm
- Safety vent on the capacitor base

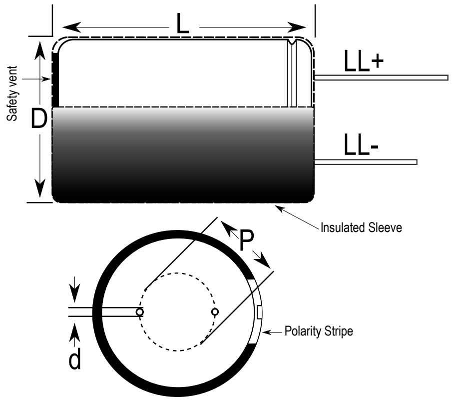
Part Number System

ESY	396	M	6R3	A	B2	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63 100 = 100	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
B2	4	±0.5	7	+1.5/-0	1.5	±0.5	0.45	Nominal	20/15	Minimum
C2	5	±0.5	7	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E2	6.3	±0.5	7	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
G1	8	±0.5	7	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G2	8	±0.5	9	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G7	8	±0.5	14	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G8	8	±0.5	16	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G6	8	±0.5	20	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H5	10	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L2	13	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L8	13	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L6	13	±0.5	36	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L7	13	±0.5	40	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M5	16	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M4	16	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N4	18	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N5	18	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	5.6 – 6800 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 100 VDC
Life Test	1,000 – 5,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA, whichever is greater
	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)	6.3	10	16	25	35	50	63	100
Z (-25°C) / Z (20°C)	3	3	3	3	3	3	3	3
Z (-40°C) / Z (20°C)	2	2	2	2	2	2	2	2

Compensation Factor of Ripple Current (RC) vs. Frequency

Capacitance Range (µF)	50 Hz	120 Hz	1 kHz	10 kHz	100 kHz
5.6 – 390	0.60	0.70	0.85	0.95	1.00
470 – 1,000	0.65	0.75	0.90	0.98	1.00
1,200 – 6,800	0.75	0.80	0.95	1.00	1.00

Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	65°C	85°C	105°C
Coefficient	2.00	1.50	1.00

Test Method & Performance

Conditions	Load Life Test			Shelf Life Test
Temperature	105°C			105°C
Test Duration	Can Ø ≤ 8.0 mm	L = 7	1,000 hours	1,000 hours
	Can Ø ≤ 6.3 mm	L ≥ 11	2,000 hours	
	Can Ø = 8.0 mm	L ≥ 11	3,000 hours	
	Can Ø = 10.0 mm	L ≥ 11	4,000 hours	
	Can Ø ≥ 13.0 mm	L ≥ 11	5,000 hours	
Ripple Current	Maximum ripple current specified at 100 kHz 105°C			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 ±25% of the initial value			
Dissipation Factor	Does not exceed 200% of the specified value			
Leakage Current	Does not exceed specified value			

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 20°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
6.3	8	39	4 x 7	22	0.85	130	3	ESY396M6R3AB2(1)
6.3	8	47	5 x 7	22	0.7	175	3	ESY476M6R3AC2(1)
6.3	8	56	5 x 7	22	0.56	190	3	ESY566M6R3AC2(1)
6.3	8	68	5 x 7	22	0.43	210	4	ESY686M6R3AC2(1)
6.3	8	100	5 x 11	22	0.43	200	6	ESY107M6R3AC3(1)
6.3	8	100	6 x 7	22	0.35	240	6	ESY107M6R3AE2(1)
6.3	8	120	5 x 11	22	0.38	220	7	ESY127M6R3AC3(1)
6.3	8	120	6 x 7	22	0.29	270	7	ESY127M6R3AE2(1)
6.3	8	150	5 x 11	22	0.3	250	9	ESY157M6R3AC3(1)
6.3	8	150	6 x 7	22	0.23	300	9	ESY157M6R3AE2(1)
6.3	8	180	8 x 7	22	0.18	340	11	ESY187M6R3AG1(1)
6.3	8	220	8 x 7	22	0.15	380	14	ESY227M6R3AG1(1)
6.3	8	270	6 x 11	22	0.16	370	17	ESY277M6R3AE3(1)
6.3	8	330	6 x 11	22	0.13	410	21	ESY337M6R3AE3(1)
6.3	8	470	8 x 11	22	0.086	680	30	ESY477M6R3AG3(1)
6.3	8	560	8 x 11	22	0.072	760	35	ESY567M6R3AG3(1)
6.3	8	680	8 x 14	22	0.062	900	43	ESY687M6R3AG7(1)
6.3	8	820	8 x 16	22	0.056	1000	52	ESY827M6R3AG8(1)
6.3	8	1000	10 x 12	22	0.053	1030	63	ESY108M6R3AH1(1)
6.3	8	1200	8 x 20	22	0.041	1250	76	ESY128M6R3AG6(1)
6.3	8	1200	10 x 16	22	0.038	1430	76	ESY128M6R3AH2(1)
6.3	8	1500	10 x 20	22	0.026	1820	94	ESY158M6R3AH4(1)
6.3	8	1800	10 x 25	22	0.025	1940	113	ESY188M6R3AH5(1)
6.3	8	2200	10 x 25	22	0.023	2150	139	ESY228M6R3AH5(1)
6.3	8	2700	13 x 20	22	0.022	2230	170	ESY278M6R3AL3(1)
6.3	8	3300	13 x 20	22	0.021	2360	208	ESY338M6R3AL3(1)
6.3	8	3900	13 x 25	22	0.018	2770	246	ESY398M6R3AL4(1)
6.3	8	4700	13 x 30	22	0.016	3290	296	ESY478M6R3AL8(1)
6.3	8	5600	13 x 36	22	0.015	3400	353	ESY568M6R3AL6(1)
6.3	8	5600	16 x 20	22	0.018	3140	353	ESY568M6R3AM5(1)
6.3	8	6800	16 x 25	22	0.016	3460	428	ESY688M6R3AM7(1)
10	13	27	4 x 7	19	0.89	130	3	ESY276M010AB2(1)
10	13	33	5 x 7	19	0.75	160	3	ESY336M010AC2(1)
10	13	39	5 x 7	19	0.64	175	4	ESY396M010AC2(1)
10	13	47	5 x 7	19	0.53	190	5	ESY476M010AC2(1)
10	13	56	5 x 7	19	0.44	210	6	ESY566M010AC2(1)
10	13	68	5 x 11	19	0.44	210	7	ESY686M010AC3(1)
10	13	100	5 x 11	19	0.3	250	10	ESY107M010AC3(1)
10	13	120	6 x 7	19	0.23	300	12	ESY127M010AE2(1)
10	13	150	8 x 9	19	0.18	345	15	ESY157M010AG2(1)
10	13	180	8 x 9	19	0.15	380	18	ESY187M010AG2(1)
10	13	220	6 x 11	19	0.13	410	22	ESY227M010AE3(1)
10	13	270	8 x 11	19	0.12	580	27	ESY277M010AG3(1)
10	13	330	8 x 11	19	0.1	640	33	ESY337M010AG3(1)
10	13	470	8 x 11	19	0.072	760	47	ESY477M010AG3(1)
10	13	560	8 x 16	19	0.068	910	56	ESY567M010AG8(1)
10	13	560	10 x 12	19	0.064	940	56	ESY567M010AH1(1)
10	13	680	8 x 16	19	0.056	1000	68	ESY687M010AG8(1)
10	13	680	10 x 12	19	0.053	1030	68	ESY687M010AH1(1)
10	13	820	8 x 20	19	0.05	1130	82	ESY827M010AG6(1)
10	13	820	10 x 16	19	0.046	1300	82	ESY827M010AH2(1)
10	13	1000	8 x 20	19	0.041	1250	100	ESY108M010AG6(1)
10	13	1000	10 x 16	19	0.038	1430	100	ESY108M010AH2(1)
10	13	1200	10 x 20	19	0.026	1820	120	ESY128M010AH4(1)
10	13	1500	10 x 25	19	0.023	2150	150	ESY158M010AH5(1)
10	13	1800	13 x 20	19	0.022	2230	180	ESY188M010AL3(1)
10	13	2200	13 x 20	19	0.021	2360	220	ESY228M010AL3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 20°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
10	13	2700	13 x 25	19	0.02	2510	270	ESY278M010AL4(1)
10	13	3300	13 x 25	19	0.018	2770	330	ESY338M010AL4(1)
10	13	3900	13 x 30	19	0.016	3290	390	ESY398M010AL8(1)
10	13	3900	16 x 20	19	0.018	3140	390	ESY398M010AM5(1)
10	13	4700	13 x 36	19	0.015	3400	470	ESY478M010AL6(1)
10	13	5600	16 x 25	19	0.016	3460	560	ESY568M010AM7(1)
16	20	18	4 x 7	16	0.92	130	3	ESY186M016AB2(1)
16	20	27	5 x 7	16	0.61	190	4	ESY276M016AC2(1)
16	20	33	5 x 7	16	0.45	210	5	ESY336M016AC2(1)
16	20	39	5 x 11	16	0.43	205	6	ESY396M016AC3(1)
16	20	47	5 x 11	16	0.36	230	7	ESY476M016AC3(1)
16	20	56	5 x 11	16	0.34	250	9	ESY566M016AC3(1)
16	20	68	6 x 7	16	0.24	300	11	ESY686M016AE2(1)
16	20	100	6 x 11	16	0.16	370	16	ESY107M016AE3(1)
16	20	100	8 x 7	16	0.18	350	16	ESY107M016AG1(1)
16	20	120	6 x 11	16	0.13	410	19	ESY127M016AE3(1)
16	20	120	8 x 7	16	0.15	380	19	ESY127M016AG1(1)
16	20	150	8 x 11	16	0.12	510	24	ESY157M016AG3(1)
16	20	180	8 x 11	16	0.11	560	29	ESY187M016AG3(1)
16	20	220	8 x 11	16	0.1	620	35	ESY227M016AG3(1)
16	20	270	8 x 11	16	0.088	690	43	ESY277M016AG3(1)
16	20	330	8 x 11	16	0.072	760	53	ESY337M016AG3(1)
16	20	470	8 x 16	16	0.056	1000	75	ESY477M016AG8(1)
16	20	470	10 x 12	16	0.053	1030	75	ESY477M016AH1(1)
16	20	560	8 x 20	16	0.049	1140	90	ESY567M016AG6(1)
16	20	560	10 x 16	16	0.046	1300	90	ESY567M016AH2(1)
16	20	680	8 x 20	16	0.041	1250	109	ESY687M016AG6(1)
16	20	680	10 x 16	16	0.038	1430	109	ESY687M016AH2(1)
16	20	820	10 x 20	16	0.032	1650	131	ESY827M016AH4(1)
16	20	1000	10 x 20	16	0.026	1820	160	ESY108M016AH4(1)
16	20	1200	10 x 25	16	0.023	2150	192	ESY128M016AH5(1)
16	20	1500	13 x 20	16	0.021	2360	240	ESY158M016AL3(1)
16	20	1800	13 x 25	16	0.02	2510	288	ESY188M016AL4(1)
16	20	2200	13 x 25	16	0.018	2770	352	ESY228M016AL4(1)
16	20	2700	13 x 30	16	0.016	3290	432	ESY278M016AL8(1)
16	20	2700	16 x 20	16	0.018	3140	432	ESY278M016AM5(1)
16	20	3300	13 x 36	16	0.015	3400	528	ESY338M016AL6(1)
16	20	3900	16 x 25	16	0.016	3460	624	ESY398M016AM7(1)
25	32	15	4 x 7	14	0.94	130	4	ESY156M025AB2(1)
25	32	18	5 x 7	14	0.69	170	4	ESY186M025AC2(1)
25	32	27	5 x 7	14	0.46	210	7	ESY276M025AC2(1)
25	32	33	5 x 11	14	0.42	220	8	ESY336M025AC3(1)
25	32	39	5 x 11	14	0.36	230	10	ESY396M025AC3(1)
25	32	47	5 x 11	14	0.3	250	12	ESY476M025AC3(1)
25	32	56	6 x 7	14	0.24	300	14	ESY566M025AE2(1)
25	32	68	6 x 11	14	0.19	340	17	ESY686M025AE3(1)
25	32	68	8 x 7	14	0.22	310	17	ESY686M025AG1(1)
25	32	100	6 x 11	14	0.13	410	25	ESY107M025AE3(1)
25	32	100	8 x 7	14	0.15	380	25	ESY107M025AG1(1)
25	32	120	8 x 11	14	0.12	560	30	ESY127M025AG3(1)
25	32	150	8 x 11	14	0.105	630	37	ESY157M025AG3(1)
25	32	180	8 x 11	14	0.088	690	45	ESY187M025AG3(1)
25	32	220	8 x 11	14	0.072	760	55	ESY227M025AG3(1)
25	32	270	8 x 16	14	0.068	900	67	ESY277M025AG8(1)
25	32	270	10 x 12	14	0.065	930	67	ESY277M025AH1(1)
25	32	330	8 x 16	14	0.056	1000	82	ESY337M025AG8(1)
25	32	330	10 x 12	14	0.053	1030	82	ESY337M025AH1(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	Z	RC	LC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 20°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
25	32	470	8 x 20	14	0.041	1250	117	ESY477M025AG6(1)
25	32	470	10 x 16	14	0.038	1430	117	ESY477M025AH2(1)
25	32	560	10 x 20	14	0.032	1650	140	ESY567M025AH4(1)
25	32	680	10 x 20	14	0.026	1820	170	ESY687M025AH4(1)
25	32	820	10 x 25	14	0.023	2150	205	ESY827M025AH5(1)
25	32	1000	13 x 20	14	0.021	2360	250	ESY108M025AL3(1)
25	32	1200	13 x 25	14	0.02	2510	300	ESY128M025AL4(1)
25	32	1500	13 x 25	14	0.018	2770	375	ESY158M025AL4(1)
25	32	1800	13 x 30	14	0.016	3290	450	ESY188M025AL8(1)
25	32	1800	16 x 20	14	0.018	3140	450	ESY188M025AM5(1)
25	32	2200	13 x 36	14	0.015	3400	550	ESY228M025AL6(1)
25	32	2700	16 x 25	14	0.016	3460	675	ESY278M025AM7(1)
35	44	10	4 x 7	12	0.96	130	3	ESY106M035AB2(1)
35	44	15	5 x 7	12	0.57	190	5	ESY156M035AC2(1)
35	44	18	5 x 7	12	0.47	210	6	ESY186M035AC2(1)
35	44	27	5 x 11	12	0.37	230	9	ESY276M035AC3(1)
35	44	33	5 x 11	12	0.32	250	11	ESY336M035AC3(1)
35	44	39	6 x 7	12	0.25	300	14	ESY396M035AE2(1)
35	44	47	6 x 11	12	0.15	380	16	ESY476M035AE3(1)
35	44	47	8 x 7	12	0.19	350	16	ESY476M035AG1(1)
35	44	56	6 x 11	12	0.13	410	20	ESY566M035AE3(1)
35	44	56	8 x 7	12	0.16	380	20	ESY566M035AG1(1)
35	44	68	8 x 11	12	0.12	510	24	ESY686M035AG3(1)
35	44	100	8 x 11	12	0.105	620	35	ESY107M035AG3(1)
35	44	120	8 x 11	12	0.088	680	42	ESY127M035AG3(1)
35	44	150	8 x 11	12	0.072	760	52	ESY157M035AG3(1)
35	44	180	8 x 16	12	0.068	910	63	ESY187M035AG8(1)
35	44	180	10 x 12	12	0.065	930	63	ESY187M035AH1(1)
35	44	220	8 x 16	12	0.056	1000	77	ESY227M035AG8(1)
35	44	220	10 x 12	12	0.053	1030	77	ESY227M035AH1(1)
35	44	270	8 x 20	12	0.041	1250	94	ESY277M035AG6(1)
35	44	330	10 x 16	12	0.038	1430	115	ESY337M035AH2(1)
35	44	470	10 x 20	12	0.026	1820	164	ESY477M035AH4(1)
35	44	560	10 x 25	12	0.023	2150	196	ESY567M035AH5(1)
35	44	680	13 x 20	12	0.021	2360	238	ESY687M035AL3(1)
35	44	820	13 x 25	12	0.02	2510	287	ESY827M035AL4(1)
35	44	1000	13 x 25	12	0.018	2770	350	ESY108M035AL4(1)
35	44	1200	13 x 30	12	0.016	3290	420	ESY128M035AL8(1)
35	44	1200	16 x 20	12	0.018	3140	420	ESY128M035AM5(1)
35	44	1500	13 x 36	12	0.015	3400	525	ESY158M035AL6(1)
35	44	1800	16 x 25	12	0.016	3460	630	ESY188M035AM7(1)
50	63	5.6	4 x 7	10	1	130	3	ESY565M050AB2(1)
50	63	6.8	5 x 7	10	0.74	170	3	ESY685M050AC2(1)
50	63	10	5 x 7	10	0.5	210	5	ESY106M050AC2(1)
50	63	15	5 x 11	10	0.48	215	7	ESY156M050AC3(1)
50	63	15	6 x 7	10	0.38	220	7	ESY156M050AE2(1)
50	63	22	5 x 11	10	0.34	240	11	ESY226M050AC3(1)
50	63	22	6 x 7	10	0.26	300	11	ESY226M050AE2(1)
50	63	27	8 x 7	10	0.21	340	13	ESY276M050AG1(1)
50	63	33	8 x 7	10	0.17	380	16	ESY336M050AG1(1)
50	63	39	6 x 11	10	0.16	330	19	ESY396M050AE3(1)
50	63	47	6 x 11	10	0.15	360	23	ESY476M050AE3(1)
50	63	56	6 x 11	10	0.14	390	28	ESY566M050AE3(1)
50	63	68	8 x 11	10	0.11	600	34	ESY686M050AG3(1)
50	63	82	8 x 11	10	0.09	660	41	ESY826M050AG3(1)
50	63	100	8 x 11	10	0.074	730	50	ESY107M050AG3(1)
50	63	120	8 x 16	10	0.065	950	60	ESY127M050AG8(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	Z	RC	LC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 20°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
50	63	150	10 x 12	10	0.061	980	75	ESY157M050AH1(1)
50	63	180	8 x 20	10	0.046	1190	90	ESY187M050AG6(1)
50	63	220	10 x 16	10	0.042	1370	110	ESY227M050AH2(1)
50	63	270	10 x 20	10	0.03	1580	135	ESY277M050AH4(1)
50	63	330	10 x 25	10	0.028	1870	165	ESY337M050AH5(1)
50	63	390	13 x 20	10	0.028	1870	195	ESY397M050AL3(1)
50	63	470	13 x 20	10	0.027	2050	235	ESY477M050AL3(1)
50	63	560	13 x 25	10	0.023	2410	280	ESY567M050AL4(1)
50	63	680	13 x 30	10	0.021	2860	340	ESY687M050AL8(1)
50	63	820	13 x 36	10	0.019	2960	410	ESY827M050AL6(1)
50	63	820	16 x 20	10	0.023	2730	410	ESY827M050AM5(1)
50	63	1000	16 x 32	10	0.021	3350	500	ESY108M050AM2(1)
63	79	15	5 x 11	9	0.88	170	9	ESY156M063AC3(1)
63	79	22	6 x 11	9	0.65	220	14	ESY226M063AE3(1)
63	79	27	6 x 11	9	0.43	240	17	ESY276M063AE3(1)
63	79	33	6 x 11	9	0.35	270	21	ESY336M063AE3(1)
63	79	39	8 x 11	9	0.31	385	24	ESY396M063AG3(1)
63	79	47	8 x 11	9	0.26	420	30	ESY476M063AG3(1)
63	79	56	8 x 11	9	0.22	500	35	ESY566M063AG3(1)
63	79	68	8 x 16	9	0.19	610	43	ESY686M063AG8(1)
63	79	68	10 x 12	9	0.18	625	43	ESY686M063AH1(1)
63	79	82	8 x 16	9	0.16	670	52	ESY826M063AG8(1)
63	79	82	10 x 12	9	0.15	690	52	ESY826M063AH1(1)
63	79	100	10 x 16	9	0.12	800	63	ESY107M063AH2(1)
63	79	120	8 x 20	9	0.12	820	75	ESY127M063AG6(1)
63	79	120	10 x 16	9	0.11	950	75	ESY127M063AH2(1)
63	79	150	10 x 20	9	0.096	1010	94	ESY157M063AH4(1)
63	79	150	13 x 16	9	0.098	1040	94	ESY157M063AL2(1)
63	79	180	10 x 20	9	0.08	1100	113	ESY187M063AH4(1)
63	79	180	13 x 16	9	0.082	1140	113	ESY187M063AL2(1)
63	79	220	10 x 25	9	0.073	1300	139	ESY227M063AH5(1)
63	79	270	13 x 20	9	0.06	1500	170	ESY277M063AL3(1)
63	79	330	13 x 25	9	0.043	1850	208	ESY337M063AL4(1)
63	79	390	13 x 30	9	0.047	2050	245	ESY397M063AL8(1)
63	79	390	16 x 20	9	0.054	1810	245	ESY397M063AM5(1)
63	79	470	13 x 30	9	0.039	2250	296	ESY477M063AL8(1)
63	79	470	16 x 20	9	0.045	1990	296	ESY477M063AM5(1)
63	79	560	13 x 36	9	0.035	2450	353	ESY567M063AL6(1)
63	79	560	16 x 25	9	0.032	2550	353	ESY567M063AM7(1)
63	79	680	13 x 40	9	0.029	2780	428	ESY687M063AL7(1)
63	79	680	18 x 20	9	0.038	2450	428	ESY687M063AN4(1)
63	79	820	16 x 32	9	0.026	2810	517	ESY827M063AM2(1)
63	79	820	18 x 25	9	0.031	2780	517	ESY827M063AN5(1)
63	79	1000	16 x 36	9	0.021	2840	630	ESY108M063AM3(1)
63	79	1000	18 x 32	9	0.025	3270	630	ESY108M063AN1(1)
63	79	1200	16 x 40	9	0.019	3340	756	ESY128M063AM4(1)
63	79	1200	18 x 36	9	0.02	3310	756	ESY128M063AN2(1)
63	79	1500	18 x 40	9	0.018	3420	945	ESY158M063AN3(1)
100	125	6.8	5 x 11	8	1.4	125	7	ESY685M100AC3(1)
100	125	10	6 x 11	8	0.95	170	10	ESY106M100AE3(1)
100	125	15	6 x 11	8	0.57	210	15	ESY156M100AE3(1)
100	125	22	8 x 11	8	0.44	330	22	ESY226M100AG3(1)
100	125	27	8 x 11	8	0.36	360	27	ESY276M100AG3(1)
100	125	33	8 x 14	8	0.3	375	33	ESY336M100AG7(1)
100	125	39	8 x 16	8	0.25	450	39	ESY396M100AG8(1)
100	125	47	10 x 12	8	0.24	450	47	ESY476M100AH1(1)
100	125	56	8 x 20	8	0.19	570	56	ESY566M100AG6(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 20ºC (Ω)	RC 100 kHz 105°C (mA)	LC 20ºC 2 Minutes (µA)	Part Number
100	125	68	10 x 16	8	0.18	580	68	ESY686M100AH2(1)
100	125	82	10 x 20	8	0.13	750	82	ESY686M100AH4(1)
100	125	82	13 x 16	8	0.13	740	82	ESY826M100AL2(1)
100	125	100	10 x 25	8	0.12	880	100	ESY107M100AH5(1)
100	125	120	13 x 20	8	0.094	1050	120	ESY127M100AL3(1)
100	125	150	13 x 25	8	0.085	1100	150	ESY157M100AL4(1)
100	125	180	13 x 25	8	0.071	1200	180	ESY187M100AL4(1)
100	125	220	13 x 30	8	0.063	1410	220	ESY227M100AL8(1)
100	125	220	16 x 20	8	0.071	1300	220	ESY227M100AM5(1)
100	125	270	13 x 36	8	0.052	1560	270	ESY277M100AL6(1)
100	125	270	16 x 25	8	0.053	1600	270	ESY277M100AM7(1)
100	125	270	18 x 20	8	0.069	1470	270	ESY277M100AN4(1)
100	125	330	13 x 40	8	0.046	1700	330	ESY337M100AL7(1)
100	125	390	16 x 32	8	0.041	1750	390	ESY397M100AM2(1)
100	125	390	18 x 25	8	0.049	1620	390	ESY397M100AN5(1)
100	125	470	16 x 36	8	0.033	1890	470	ESY477M100AM3(1)
100	125	470	18 x 32	8	0.039	1780	470	ESY477M100AN1(1)
100	125	560	16 x 40	8	0.03	2080	560	ESY567M100AM4(1)
100	125	560	18 x 36	8	0.031	2060	560	ESY567M100AN2(1)
100	125	680	18 x 40	8	0.028	2570	680	ESY687M100AN3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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.
- 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

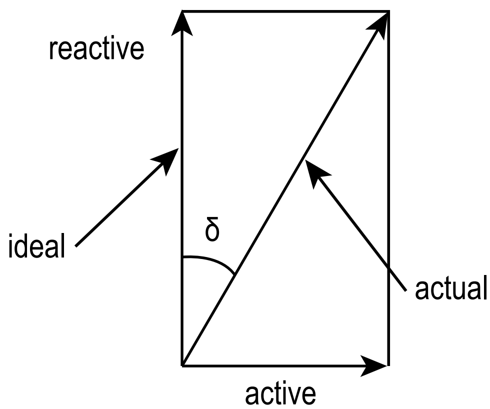
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.

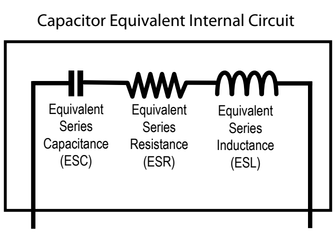


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

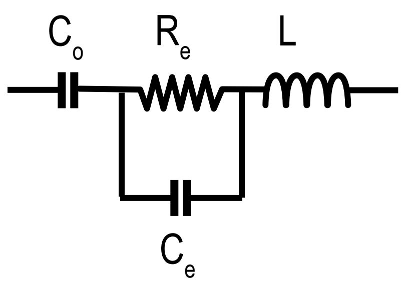
$$ESR = \frac{\tan \delta}{2\pi f \, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

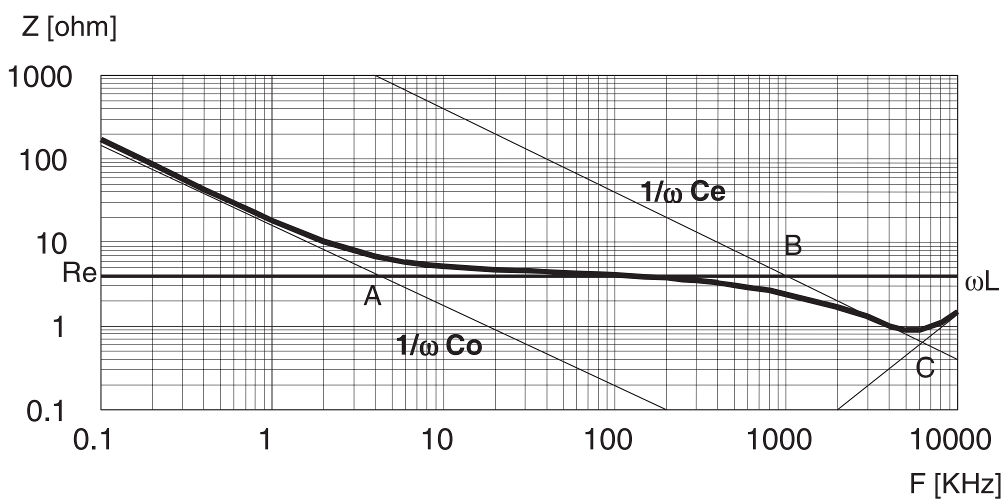
Impedance (Z)

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



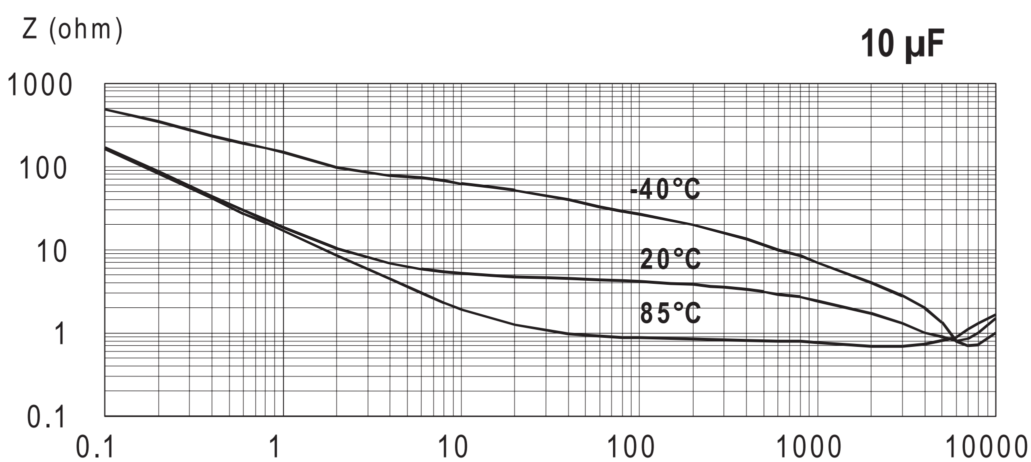
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

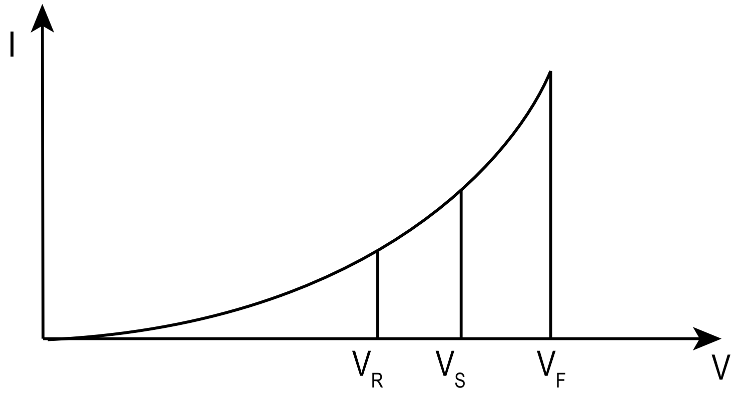
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor’s life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Cut Leads	Auto-insertion	
					Ammo	Tape & Reel
B2	4	7	10000	15000	2500	1500
C3	5	11	10000	15000	2000	1300
C2	5	7	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
E2	6.3	7	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G7	8	14	5000	5000	1000	750
G8	8	16	5000	5000	1000	750
G6	8	20	4000	4000	1000	750
G1	8	7	6000	8000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
H5	10	25	2400	2400	500	
L2	13	16	2400	2400	500	
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
L8	13	30	1200	2400		
L6	13	36	1000	1200	400	
L7	13	40	1000	500	500	
M5	16	20	1000	500	300	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
M4	16	40	600	500		
N4	18	20	800	1000		
N5	18	25	800	500		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		

Standard Marking for Radial Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: gold line
- Date code

ESG Series, +105ºC

Overview

KEMET's ESG Series of aluminum electrolytic radial capacitors are designed for long life (5,000 hours) and high reliability applications.

Applications

Typical applications include electronic ballast and long-life equipment.

Benefits

- Suited for long life, high reliability applications
- Operating temperature of up to +105°C
- 5,000 hour operating life
- Case with Ø D ≥ 6.3 mm
- Safety vent on the capacitor base

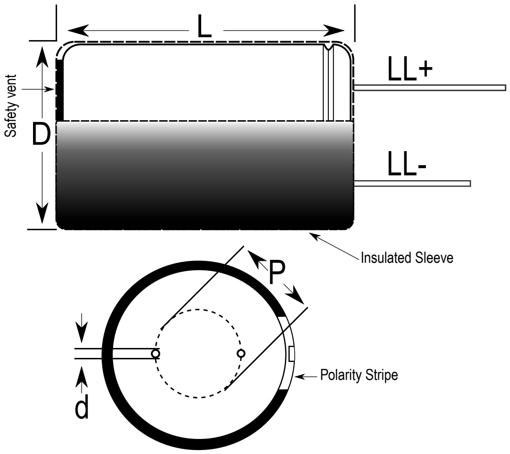
Part Number System

ESG	336	M	160	A	H4	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 405	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M5	16	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N4	18	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N5	18	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
Q4	22	±0.5	40	+2.0/-0	10.0	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics	
Capacitance Range	3.3 – 330 µF	
Capacitance Tolerance	±20% at 120 Hz / 20°C	
Rated Voltage	160 – 400 VDC	450 VDC
Life Test	5,000 hours (see conditions in Test Methods & Performance)	
Operating Temperature	-40°C to +105°C	-25°C to +85°C
Leakage Current	I = 0.06 CV (µA) + 10 µA	
	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
Z (-25°C) / Z (20°C)	3	3	3	5	5	6
Z (-40°C) / Z (20°C)	6	6	6	6	6	

Compensation Factor of Ripple Current (RC) vs. Frequency

Frequency	50 to 60 Hz	120 Hz	300 Hz	1 kHz	10 to 100 kHz
Coefficient	0.80	1.00	1.20	1.40	1.60

Compensation Factor of Ripple Current (RC) vs. Temperature

Temperature	65°C	85°C	105°C
Coefficient	1.70	1.40	1.00

Test Method & Performance

Conditions	Load Life Test	Shelf Life Test
Temperature	105°C	105°C
Test Duration	5,000 hours	1,000 hours
Ripple Current	Maximum ripple current specified at 120 Hz 105°C	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	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 25ºC (Ω)	RC 100 kHz 105°C (mA)	LC 20ºC 2 Minutes (µA)	Part Number
160	200	33	10 x 20	15	1.3	210	327	ESG336M160AH4(1)
160	200	47	13 x 20	15	0.95	260	461	ESG476M160AL3(1)
160	200	68	13 x 25	15	0.6	360	663	ESG686M160AL4(1)
160	200	68	16 x 20	15	0.55	430	663	ESG686M160AM5(1)
160	200	100	16 x 25	15	0.3	475	970	ESG107M160AM7(1)
160	200	100	18 x 20	15	0.31	465	970	ESG107M160AN4(1)
160	200	150	16 x 32	15	0.22	650	1450	ESG157M160AM2(1)
160	200	150	18 x 25	15	0.24	625	1450	ESG157M160AN5(1)
160	200	220	16 x 32	15	0.22	750	2122	ESG227M160AM2(1)
160	200	220	18 x 25	15	0.24	725	2122	ESG227M160AN5(1)
160	200	330	18 x 32	15	0.22	960	3178	ESG337M160AN1(1)
200	250	10	10 x 12	15	6	60	130	ESG106M200AH1(1)
200	250	22	10 x 20	15	1.5	160	274	ESG226M200AH4(1)
200	250	33	13 x 20	15	0.95	210	406	ESG336M200AL3(1)
200	250	47	13 x 20	15	0.91	260	574	ESG476M200AL3(1)
200	250	68	13 x 25	15	0.6	360	826	ESG686M200AL4(1)
200	250	68	16 x 20	15	0.55	430	826	ESG686M200AM5(1)
200	250	100	16 x 25	15	0.3	475	1210	ESG107M200AM7(1)
200	250	100	18 x 20	15	0.31	465	1210	ESG107M200AN4(1)
200	250	150	18 x 25	15	0.27	650	1810	ESG157M200AN5(1)
200	250	220	18 x 32	15	0.22	780	2650	ESG227M200AN1(1)
250	300	10	10 x 20	15	3.5	100	160	ESG106M250AH4(1)
250	300	22	13 x 20	15	2.5	160	340	ESG226M250AL3(1)
250	300	33	13 x 20	15	1.9	210	505	ESG336M250AL3(1)
250	300	47	13 x 25	15	1.7	270	715	ESG476M250AL4(1)
250	300	47	16 x 20	15	1.5	275	715	ESG476M250AM5(1)
250	300	68	16 x 25	15	0.8	380	1030	ESG686M250AM7(1)
250	300	68	18 x 20	15	0.95	375	1030	ESG686M250AN4(1)
250	300	100	16 x 32	15	0.65	520	1510	ESG107M250AM2(1)
250	300	100	18 x 25	15	0.65	500	1510	ESG107M250AN5(1)
250	300	150	18 x 32	15	0.45	650	2260	ESG157M250AN1(1)
250	300	220	18 x 40	15	0.35	820	3310	ESG227M250AN3(1)
350	400	10	10 x 20	20	3	100	220	ESG106M350AH4(1)
350	400	22	13 x 20	20	2.1	160	472	ESG226M350AL3(1)
350	400	33	13 x 25	20	1	230	703	ESG336M350AL4(1)
350	400	33	16 x 20	20	0.91	250	703	ESG336M350AM5(1)
350	400	47	16 x 25	20	0.75	300	997	ESG476M350AM7(1)
350	400	47	18 x 20	20	0.8	315	997	ESG476M350AN4(1)
350	400	68	16 x 32	20	0.5	400	1438	ESG686M350AM2(1)
350	400	68	18 x 25	20	0.55	380	1438	ESG686M350AN5(1)
350	400	100	18 x 32	20	0.4	530	2110	ESG107M350AN1(1)
400	450	1.5	10 x 12	24	18	35	46	ESG155M400AH1(1)
400	450	2.2	10 x 12	24	12.5	40	63	ESG225M400AH1(1)
400	450	3.3	10 x 12	24	8	45	90	ESG335M400AH1(1)
400	450	4.7	10 x 16	24	3.5	50	123	ESG475M400AH2(1)
400	450	6.8	10 x 20	24	3.3	70	173	ESG685M400AH4(1)
400	450	10	10 x 20	24	2.9	100	250	ESG106M400AH4(1)
400	450	22	13 x 25	24	1.35	170	538	ESG226M400AL4(1)
400	450	22	16 x 20	24	1	200	538	ESG226M400AM5(1)
400	450	33	16 x 25	24	0.95	230	802	ESG336M400AM7(1)
400	450	33	18 x 20	24	0.91	250	802	ESG336M400AN4(1)
400	450	47	16 x 32	24	0.75	300	1138	ESG476M400AM2(1)
400	450	47	18 x 25	24	0.8	325	1138	ESG476M400AN5(1)
400	450	68	18 x 36	24	0.49	420	1642	ESG686M400AN2(1)
400	450	100	18 x 40	24	0.34	545	2410	ESG107M400AN3(1)
400	450	150	22 x 40	24	0.3	650	3610	ESG157M400AQ4(1)
450	500	3.3	10 x 20	24	6.5	60	99	ESG335M450AH4(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 20°C (tan δ %)*	Z 100 kHZ 25ºC (Ω)	RC 100 kHz 105°C (mA)	LC 20ºC 2 Minutes (µA)	Part Number
450	500	4.7	13 x 20	24	3.6	80	137	ESG475M450AL3(1)
450	500	6.8	10 x 20	24	3.4	90	194	ESG685M450AH4(1)
450	500	10	13 x 20	24	3	110	280	ESG106M450AL3(1)
450	500	22	16 x 25	24	1.8	190	604	ESG226M450AM7(1)
450	500	22	18 x 20	24	2.2	200	604	ESG226M450AN4(1)
450	500	33	16 x 32	24	1.3	275	901	ESG336M450AM2(1)
450	500	33	18 x 25	24	1.2	280	901	ESG336M450AN5(1)
450	500	47	18 x 32	24	1	340	1279	ESG476M450AN1(1)
450	500	68	18 x 40	24	0.8	460	1846	ESG686M450AN3(1)
450	500	100	22 x 40	24	0.6	580	2710	ESG107M450AQ4(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	Z	RC	LC	Part Number

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

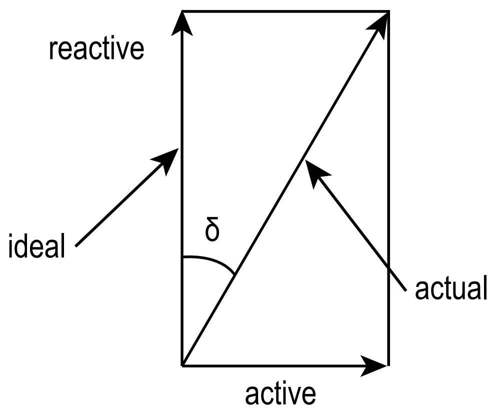
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.

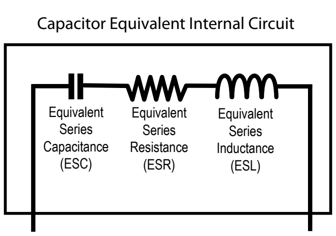


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

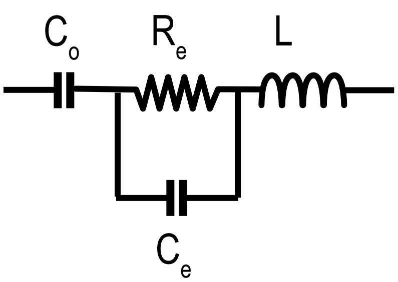
$$ESR = \frac{\tan \delta}{2\pi f \, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

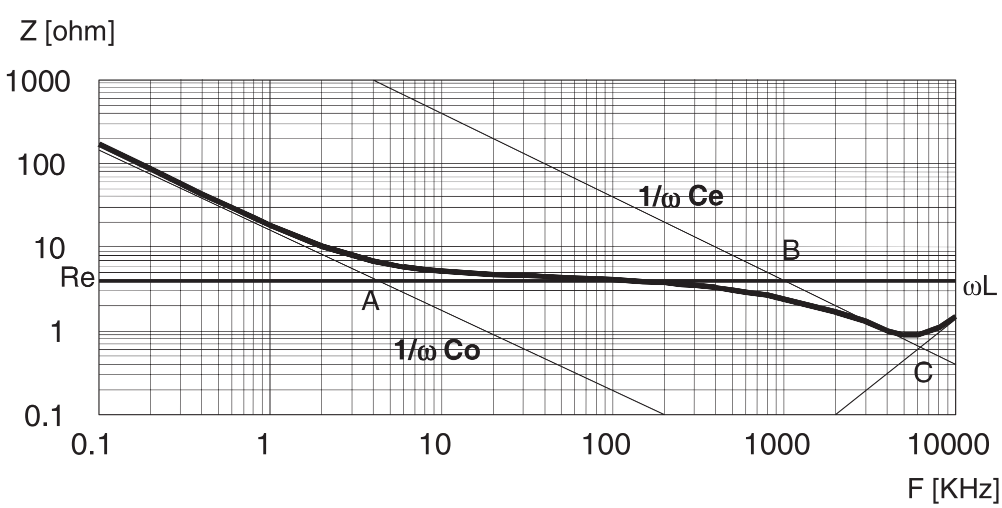
Impedance (Z)

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



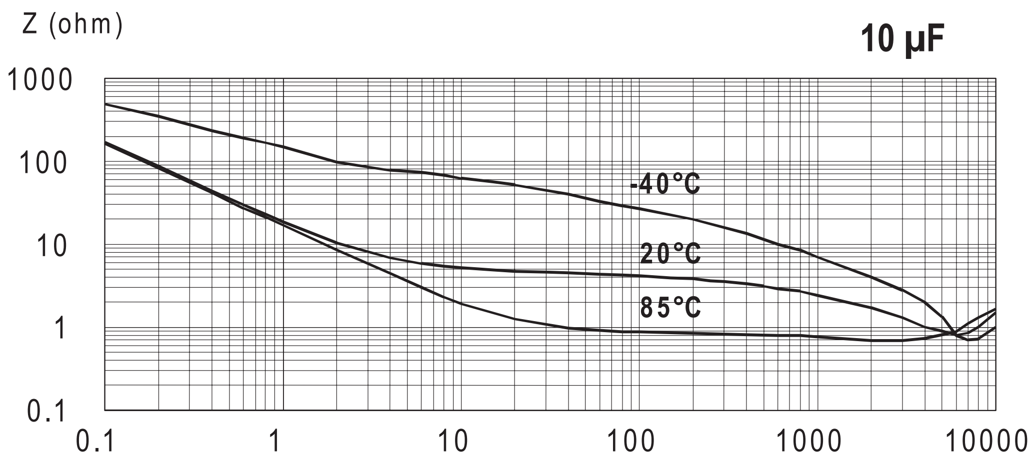
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

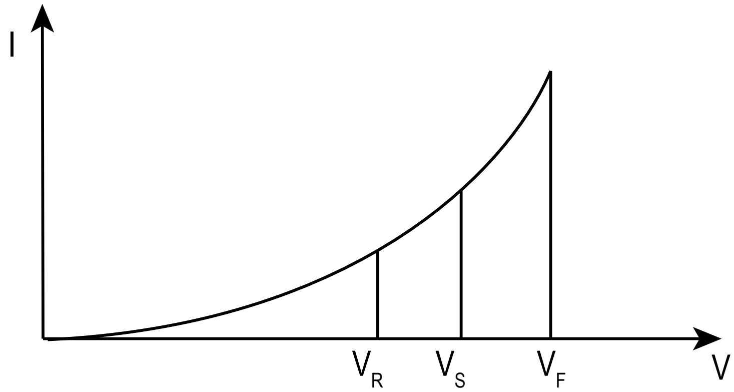
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
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		
N4	18	20	800	1000		
N5	18	25	800	500		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		
Q4	22	40	300	400		

Standard Marking for Surface Mount Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: white line
- Date code

ESW Series, +105ºC

Overview

KEMET's ESW Series of aluminum electrolytic radial capacitors are designed for long life (3,000 – 5,000 hours) and high reliability applications.

Applications

Typical applications include high frequency switch mode circuits.

Benefits

- Suited for long life, high reliability applications
- Operating temperature of up to +105°C
- 3,000 – 6,000 hour operating life
- Case with Ø D ≥ 6.3 mm
- Safety vent on the capacitor base

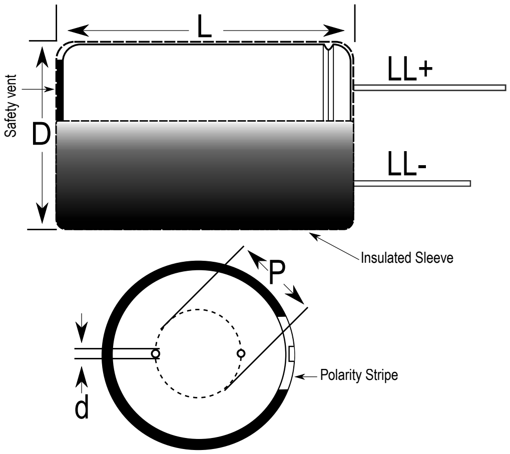
Part Number System

ESW	226	M	6R3	A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63 100 = 100	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
E4	6.3	±0.5	15	+2.0/-0	2.5	±0.5	0.5	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G4	8	±0.5	15	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G6	8	±0.5	20	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H5	10	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H6	10	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L2	13	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L8	13	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L6	13	±0.5	36	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M6	16	±0.5	15	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M5	16	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N6	18	±0.5	16	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N4	18	±0.5	20	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N5	18	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	0.47 – 15,000 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 100 VDC
Life Test	3,000 – 6,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA, whichever is greater
	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)	6.3	10	16	25	35	50	63	100
Z (-40°C) / Z (20°C)	3	3	3	3	3	3	3	3

Compensation Factor of Ripple Current (RC) vs. Frequency

Capacitance Range (µF)	120 Hz	1 kHz	10 kHz	100 kHz
0.47 – 33	0.42	0.70	0.90	1.00
39 – 270	0.50	0.73	0.92	1.00
330 – 680	0.55	0.77	0.94	1.00
820 – 1,800	0.60	0.80	0.96	1.00
2,200 – 15,000	0.70	0.85	0.98	1.00

Test Method & Performance

Conditions	Load Life Test		Shelf Life Test
Temperature	105°C		105°C
Test Duration	Can Ø ≤ 6.3 mm	3,000 hours	1,000 hours
	Can Ø = 8.0 mm	4,000 hours	
	Can Ø = 10.0 mm	5,000 hours	
	Can Ø ≥ 13.0 mm	6,000 hours	
Ripple Current	Maximum ripple current specified at 100 kHz 105°C		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 ±25% of the initial value		
Dissipation Factor	Does not exceed 200% of the specified value		
Leakage Current	Does not exceed specified value		

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 equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20ºC 2 Minutes (µA)	Part Number
6.3	8	22	5 x 11	22	0.600	180	3	ESW226M6R3AC3(1)
6.3	8	33	5 x 11	22	0.600	180	3	ESW336M6R3AC3(1)
6.3	8	47	5 x 11	22	0.600	180	3	ESW476M6R3AC3(1)
6.3	8	100	5 x 11	22	0.600	180	6	ESW107M6R3AC3(1)
6.3	8	150	6 x 11	22	0.250	290	9	ESW157M6R3AE3(1)
6.3	8	220	6 x 11	22	0.250	290	14	ESW227M6R3AE3(1)
6.3	8	330	6 x 11	22	0.250	290	21	ESW337M6R3AE3(1)
6.3	8	330	6 x 15	22	0.230	430	21	ESW337M6R3AE4(1)
6.3	8	470	8 x 11	22	0.117	555	30	ESW477M6R3AG3(1)
6.3	8	560	8 x 11	22	0.117	555	35	ESW567M6R3AG3(1)
6.3	8	680	10 x 12	22	0.090	755	43	ESW687M6R3AH1(1)
6.3	8	820	8 x 15	22	0.085	730	52	ESW827M6R3AG4(1)
6.3	8	820	10 x 12	22	0.090	755	52	ESW827M6R3AH1(1)
6.3	8	1000	10 x 12	22	0.090	755	63	ESW108M6R3AH1(1)
6.3	8	1200	8 x 20	22	0.065	955	76	ESW128M6R3AG6(1)
6.3	8	1200	10 x 16	22	0.068	1050	76	ESW128M6R3AH2(1)
6.3	8	1500	10 x 20	22	0.052	1220	94	ESW158M6R3AH4(1)
6.3	8	2200	10 x 25	22	0.045	1440	139	ESW228M6R3AH5(1)
6.3	8	2200	13 x 20	22	0.038	1815	139	ESW228M6R3AL3(1)
6.3	8	2700	10 x 30	22	0.035	1815	170	ESW278M6R3AH6(1)
6.3	8	3300	13 x 20	22	0.038	1655	208	ESW338M6R3AL3(1)
6.3	8	3900	13 x 25	22	0.030	1945	246	ESW398M6R3AL4(1)
6.3	8	4700	16 x 25	22	0.022	2555	296	ESW478M6R3AM7(1)
6.3	8	4700	13 x 30	22	0.025	2310	296	ESW478M6R3AL8(1)
6.3	8	5600	13 x 36	22	0.022	2510	353	ESW568M6R3AL6(1)
6.3	8	5600	16 x 20	22	0.029	2205	353	ESW568M6R3AM5(1)
6.3	8	6800	16 x 25	22	0.022	2555	428	ESW688M6R3AM7(1)
6.3	8	6800	18 x 20	22	0.028	2490	428	ESW688M6R3AN4(1)
6.3	8	8200	16 x 32	22	0.018	3010	517	ESW828M6R3AM2(1)
6.3	8	10000	16 x 32	22	0.016	3150	630	ESW109M6R3AM2(1)
6.3	8	10000	18 x 25	22	0.020	2740	630	ESW109M6R3AN5(1)
6.3	8	12000	18 x 32	22	0.016	3635	756	ESW129M6R3AN1(1)
6.3	8	15000	18 x 36	22	0.015	3680	945	ESW159M6R3AN2(1)
10	13	22	5 x 11	19	0.600	180	3	ESW226M010AC3(1)
10	13	33	5 x 11	19	0.600	180	3	ESW336M010AC3(1)
10	13	47	5 x 11	19	0.600	180	5	ESW476M010AC3(1)
10	13	82	5 x 11	19	0.600	180	8	ESW826M010AC3(1)
10	13	100	5 x 11	19	0.600	180	10	ESW107M010AC3(1)
10	13	150	6 x 11	19	0.250	290	15	ESW157M010AE3(1)
10	13	180	6 x 11	19	0.250	290	18	ESW187M010AE3(1)
10	13	220	6 x 11	19	0.250	290	22	ESW227M010AE3(1)
10	13	220	6 x 15	19	0.230	430	22	ESW227M010AE4(1)
10	13	330	8 x 11	19	0.117	555	33	ESW337M010AG3(1)
10	13	470	8 x 11	19	0.117	555	47	ESW477M010AG3(1)
10	13	680	8 x 15	19	0.085	730	68	ESW687M010AG4(1)
10	13	680	10 x 12	19	0.090	755	68	ESW687M010AH1(1)
10	13	1000	8 x 20	19	0.065	995	100	ESW108M010AG6(1)
10	13	1000	10 x 16	19	0.068	1050	100	ESW108M010AH2(1)
10	13	1200	10 x 20	19	0.052	1220	120	ESW128M010AH4(1)
10	13	1500	10 x 20	19	0.052	1220	150	ESW158M010AH4(1)
10	13	1500	10 x 25	19	0.045	1440	150	ESW158M010AH5(1)
10	13	2200	10 x 30	19	0.035	1815	220	ESW228M010AH6(1)
10	13	2200	13 x 20	19	0.038	1655	220	ESW228M010AL3(1)
10	13	2700	13 x 25	19	0.030	1945	270	ESW278M010AL4(1)
10	13	3300	13 x 25	19	0.030	1945	330	ESW338M010AL4(1)
10	13	3300	13 x 30	19	0.025	2310	330	ESW338M010AL8(1)
10	13	3900	13 x 36	19	0.022	2510	390	ESW398M010AL6(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25ºC (Ω)	RC 100 kHz 105°C (mA)	LC 20ºC 2 Minutes (µA)	Part Number
10	13	3900	16 x 20	19	0.029	2205	390	ESW398M010AM5(1)
10	13	4700	16 x 25	19	0.022	2555	470	ESW478M010AM7(1)
10	13	5600	16 x 25	19	0.022	2555	560	ESW568M010AM7(1)
10	13	5600	18 x 20	19	0.028	2490	560	ESW568M010AN4(1)
10	13	6800	16 x 32	19	0.018	3010	680	ESW688M010AM2(1)
10	13	6800	18 x 25	19	0.020	2740	680	ESW688M010AN5(1)
10	13	8200	16 x 36	19	0.016	3150	820	ESW828M010AM3(1)
10	13	8200	18 x 32	19	0.016	3635	820	ESW828M010AN1(1)
10	13	10000	18 x 36	19	0.015	3680	1000	ESW109M010AN2(1)
10	13	15000	18 x 40	19	0.014	3800	1500	ESW159M010AN3(1)
16	20	10	5 x 11	16	0.600	180	3	ESW106M016AC3(1)
16	20	22	5 x 11	16	0.600	180	4	ESW226M016AC3(1)
16	20	33	5 x 11	16	0.600	180	5	ESW336M016AC3(1)
16	20	47	5 x 11	16	0.600	180	8	ESW476M016AC3(1)
16	20	56	5 x 11	16	0.600	180	9	ESW566M016AC3(1)
16	20	100	6 x 11	16	0.250	290	16	ESW107M016AE3(1)
16	20	120	6 x 11	16	0.250	290	19	ESW127M016AE3(1)
16	20	150	6 x 11	16	0.250	290	24	ESW157M016AE3(1)
16	20	180	6 x 15	16	0.230	430	29	ESW187M016AE4(1)
16	20	220	8 x 11	16	0.117	555	35	ESW227M016AG3(1)
16	20	330	8 x 11	16	0.117	555	53	ESW337M016AG3(1)
16	20	470	8 x 15	16	0.085	730	75	ESW477M016AG4(1)
16	20	470	10 x 12	16	0.090	755	75	ESW477M016AH1(1)
16	20	680	8 x 20	16	0.065	995	109	ESW687M016AG6(1)
16	20	680	10 x 16	16	0.068	1050	109	ESW687M016AH2(1)
16	20	820	10 x 20	16	0.052	1220	131	ESW827M016AH4(1)
16	20	1000	10 x 20	16	0.052	1220	160	ESW108M016AH4(1)
16	20	1200	10 x 25	16	0.045	1440	192	ESW128M016AH5(1)
16	20	1500	10 x 30	16	0.035	1815	240	ESW158M016AH6(1)
16	20	1500	13 x 20	16	0.038	1655	240	ESW158M016AL3(1)
16	20	2200	13 x 25	16	0.030	1945	352	ESW228M016AL4(1)
16	20	2700	13 x 30	16	0.025	2310	432	ESW278M016AL8(1)
16	20	2700	16 x 20	16	0.029	2205	432	ESW278M016AM5(1)
16	20	3300	13 x 36	16	0.022	2510	528	ESW338M016AL6(1)
16	20	3300	16 x 25	16	0.022	2555	528	ESW338M016AM7(1)
16	20	3900	16 x 25	16	0.022	2555	624	ESW398M016AM7(1)
16	20	3900	18 x 20	16	0.028	2490	624	ESW398M016AN4(1)
16	20	4700	16 x 32	16	0.018	3010	752	ESW478M016AM2(1)
16	20	4700	18 x 25	16	0.020	2740	752	ESW478M016AN5(1)
16	20	5600	18 x 32	16	0.016	3150	896	ESW568M016AN1(1)
16	20	5600	18 x 36	16	0.016	3635	896	ESW568M016AN2(1)
16	20	6800	18 x 36	16	0.015	3680	1088	ESW688M016AN2(1)
16	20	8200	18 x 36	16	0.015	3680	1312	ESW828M016AN2(1)
16	20	10000	18 x 40	16	0.014	3800	1600	ESW109M016AN3(1)
25	32	4.7	5 x 11	14	0.600	180	3	ESW475M025AC3(1)
25	32	10	5 x 11	14	0.600	180	3	ESW106M025AC3(1)
25	32	22	5 x 11	14	0.600	180	5	ESW226M025AC3(1)
25	32	33	5 x 11	14	0.600	180	8	ESW336M025AC3(1)
25	32	39	5 x 11	14	0.600	180	10	ESW396M025AC3(1)
25	32	47	5 x 11	14	0.600	180	12	ESW476M025AC3(1)
25	32	82	6 x 11	14	0.250	290	20	ESW826M025AE3(1)
25	32	100	6 x 11	14	0.250	290	25	ESW107M025AE3(1)
25	32	120	6 x 15	14	0.230	430	30	ESW127M025AE4(1)
25	32	150	8 x 11	14	0.117	555	37	ESW157M025AG3(1)
25	32	220	8 x 11	14	0.117	555	55	ESW227M025AG3(1)
25	32	330	8 x 15	14	0.085	730	82	ESW337M025AG4(1)
25	32	330	10 x 12	14	0.090	755	82	ESW337M025AH1(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
25	32	470	8 x 20	14	0.065	995	117	ESW477M025AG6(1)
25	32	470	10 x 16	14	0.068	1050	117	ESW477M025AH2(1)
25	32	560	10 x 20	14	0.052	1220	140	ESW567M025AH4(1)
25	32	680	10 x 20	14	0.052	1220	170	ESW687M025AH4(1)
25	32	820	10 x 25	14	0.045	1440	205	ESW827M025AH5(1)
25	32	1000	10 x 30	14	0.035	1815	250	ESW108M025AH6(1)
25	32	1000	13 x 20	14	0.038	1655	250	ESW108M025AL3(1)
25	32	1500	13 x 25	14	0.030	1945	375	ESW158M025AL4(1)
25	32	1500	16 x 25	14	0.022	2555	375	ESW158M025AM7(1)
25	32	1800	13 x 30	14	0.025	2310	450	ESW188M025AL8(1)
25	32	1800	16 x 20	14	0.029	2205	450	ESW188M025AM5(1)
25	32	2200	13 x 36	14	0.022	2510	550	ESW228M025AL6(1)
25	32	2200	16 x 25	14	0.022	2555	550	ESW228M025AM7(1)
25	32	2200	18 x 20	14	0.028	2490	550	ESW228M025AN4(1)
25	32	2700	16 x 25	14	0.022	2555	675	ESW278M025AM7(1)
25	32	3300	16 x 32	14	0.018	3010	825	ESW338M025AM2(1)
25	32	3300	18 x 25	14	0.020	2740	825	ESW338M025AN5(1)
25	32	3900	16 x 36	14	0.016	3150	975	ESW398M025AM3(1)
25	32	3900	18 x 32	14	0.016	3635	975	ESW398M025AN1(1)
25	32	4700	18 x 36	14	0.015	3680	1175	ESW478M025AN2(1)
25	32	6800	18 x 40	14	0.014	3800	1700	ESW688M025AN3(1)
35	44	4.7	5 x 11	12	0.600	180	3	ESW475M035AC3(1)
35	44	10	5 x 11	12	0.600	180	3	ESW106M035AC3(1)
35	44	22	5 x 11	12	0.600	180	8	ESW226M035AC3(1)
35	44	27	5 x 11	12	0.600	180	9	ESW276M035AC3(1)
35	44	33	5 x 11	12	0.600	180	12	ESW336M035AC3(1)
35	44	47	6 x 11	12	0.250	290	16	ESW476M035AE3(1)
35	44	56	6 x 11	12	0.250	290	20	ESW566M035AE3(1)
35	44	82	6 x 15	12	0.230	430	29	ESW826M035AE4(1)
35	44	100	8 x 11	12	0.117	555	35	ESW107M035AG3(1)
35	44	150	8 x 11	12	0.117	555	52	ESW157M035AG3(1)
35	44	220	8 x 15	12	0.085	730	77	ESW227M035AG4(1)
35	44	220	10 x 12	12	0.090	755	77	ESW227M035AH1(1)
35	44	330	8 x 20	12	0.065	995	115	ESW337M035AG6(1)
35	44	330	10 x 16	12	0.068	1050	115	ESW337M035AH2(1)
35	44	390	10 x 20	12	0.052	1220	136	ESW397M035AH4(1)
35	44	470	10 x 20	12	0.052	1220	164	ESW477M035AH4(1)
35	44	560	10 x 25	12	0.045	1440	196	ESW567M035AH5(1)
35	44	680	10 x 30	12	0.035	1815	238	ESW687M035AH6(1)
35	44	680	13 x 20	12	0.038	1655	238	ESW687M035AL3(1)
35	44	1000	13 x 25	12	0.030	1945	350	ESW108M035AL4(1)
35	44	1200	13 x 30	12	0.025	2310	420	ESW128M035AL8(1)
35	44	1200	16 x 20	12	0.029	2205	420	ESW128M035AM5(1)
35	44	1500	13 x 36	12	0.022	2510	525	ESW158M035AL6(1)
35	44	1500	16 x 25	12	0.022	2555	525	ESW158M035AM7(1)
35	44	1800	16 x 25	12	0.022	2555	630	ESW188M035AM7(1)
35	44	1800	18 x 20	12	0.028	2490	630	ESW188M035AN4(1)
35	44	2200	16 x 32	12	0.018	3010	770	ESW228M035AM2(1)
35	44	2200	18 x 25	12	0.020	2740	770	ESW228M035AN5(1)
35	44	2700	16 x 36	12	0.016	3150	945	ESW278M035AM3(1)
35	44	2700	18 x 32	12	0.016	3635	945	ESW278M035AN1(1)
35	44	3300	18 x 36	12	0.015	3680	1155	ESW338M035AN2(1)
35	44	4700	18 x 40	12	0.014	3800	1645	ESW478M035AN3(1)
50	63	4.7	5 x 11	10	2.300	90	3	ESW475M050AC3(1)
50	63	10	5 x 11	10	1.400	120	5	ESW106M050AC3(1)
50	63	18	5 x 11	10	1.300	155	9	ESW186M050AC3(1)
50	63	22	5 x 11	10	1.200	170	11	ESW226M050AC3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
50	63	33	6 x 11	10	0.430	300	16	ESW336M050AE3(1)
50	63	47	6 x 11	10	0.430	300	23	ESW476M050AE3(1)
50	63	56	6 x 15	10	0.400	360	28	ESW566M050AE4(1)
50	63	82	8 x 11	10	0.234	485	41	ESW826M050AG3(1)
50	63	100	8 x 11	10	0.234	485	50	ESW107M050AG3(1)
50	63	120	8 x 15	10	0.155	635	60	ESW127M050AG4(1)
50	63	120	10 x 12	10	0.162	615	60	ESW127M050AH1(1)
50	63	150	10 x 12	10	0.162	615	75	ESW157M050AH1(1)
50	63	180	8 x 20	10	0.120	860	90	ESW187M050AG6(1)
50	63	180	10 x 16	10	0.119	850	90	ESW187M050AH2(1)
50	63	220	10 x 16	10	0.119	850	110	ESW227M050AH2(1)
50	63	220	10 x 20	10	0.090	1030	110	ESW227M050AH4(1)
50	63	270	10 x 25	10	0.082	1200	135	ESW277M050AH5(1)
50	63	330	10 x 20	10	0.090	1030	165	ESW337M050AH4(1)
50	63	330	10 x 30	10	0.060	1610	165	ESW337M050AH6(1)
50	63	390	13 x 20	10	0.063	1480	195	ESW397M050AL3(1)
50	63	470	13 x 20	10	0.060	1500	235	ESW477M050AL3(1)
50	63	560	13 x 25	10	0.050	1832	280	ESW567M050AL4(1)
50	63	680	13 x 25	10	0.050	1832	340	ESW687M050AL4(1)
50	63	680	16 x 20	10	0.048	1835	340	ESW687M050AM5(1)
50	63	820	13 x 36	10	0.034	2285	410	ESW827M050AL6(1)
50	63	820	18 x 20	10	0.042	2420	410	ESW827M050AN4(1)
50	63	1000	16 x 25	10	0.034	2235	500	ESW108M050AM7(1)
50	63	1200	16 x 32	10	0.028	2700	600	ESW128M050AM2(1)
50	63	1200	18 x 25	10	0.029	2610	600	ESW128M050AN5(1)
50	63	1500	16 x 32	10	0.028	2700	750	ESW158M050AM2(1)
50	63	1500	16 x 36	10	0.025	2790	750	ESW158M050AM3(1)
50	63	1800	18 x 32	10	0.025	3000	900	ESW188M050AN1(1)
50	63	2200	18 x 36	10	0.023	3100	1100	ESW228M050AN2(1)
63	79	4.7	5 x 11	9	4.700	68	3	ESW475M063AC3(1)
63	79	6.8	5 x 11	9	2.500	95	4	ESW685M063AC3(1)
63	79	10	5 x 11	9	2.100	110	6	ESW106M063AC3(1)
63	79	12	5 x 11	9	2.000	145	8	ESW126M063AC3(1)
63	79	15	6 x 11	9	1.200	160	9	ESW156M063AE3(1)
63	79	22	6 x 11	9	0.710	250	14	ESW226M063AE3(1)
63	79	33	6 x 11	9	0.710	250	21	ESW336M063AE3(1)
63	79	39	6 x 15	9	0.700	330	25	ESW396M063AE4(1)
63	79	47	8 x 11	9	0.342	405	30	ESW476M063AG3(1)
63	79	68	8 x 11	9	0.342	405	43	ESW686M063AG3(1)
63	79	100	8 x 15	9	0.230	535	63	ESW107M063AG4(1)
63	79	100	10 x 12	9	0.256	535	63	ESW107M063AH1(1)
63	79	120	10 x 16	9	0.194	600	76	ESW127M063AH2(1)
63	79	150	10 x 16	9	0.194	660	94	ESW157M063AH2(1)
63	79	180	10 x 20	9	0.147	885	113	ESW187M063AH4(1)
63	79	180	13 x 16	9	0.150	1020	113	ESW187M063AL2(1)
63	79	220	10 x 20	9	0.147	885	139	ESW227M063AH4(1)
63	79	220	10 x 25	9	0.130	1050	139	ESW227M063AH5(1)
63	79	270	16 x 15	9	0.090	1410	170	ESW277M063AM6(1)
63	79	330	13 x 20	9	0.085	1285	208	ESW337M063AL3(1)
63	79	390	13 x 25	9	0.070	1720	246	ESW397M063AL4(1)
63	79	390	18 x 16	9	0.086	1690	246	ESW397M063AN6(1)
63	79	470	13 x 25	9	0.070	1720	296	ESW477M063AL4(1)
63	79	470	13 x 30	9	0.055	2090	296	ESW477M063AL8(1)
63	79	470	16 x 20	9	0.059	1765	296	ESW477M063AM5(1)
63	79	560	16 x 25	9	0.050	2160	353	ESW567M063AM7(1)
63	79	680	13 x 36	9	0.047	2265	428	ESW687M063AL6(1)
63	79	680	18 x 20	9	0.055	2290	428	ESW687M063AN4(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	Rated Capacitance 120 Hz 20°C (µF)	Case Size D x L (mm)	DF 120 Hz 25°C (tan δ %)*	Z 100 kHZ 25°C (Ω)	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
63	79	820	16 x 32	9	0.043	2670	517	ESW827M063AM2(1)
63	79	820	18 x 25	9	0.043	2585	517	ESW827M063AN5(1)
63	79	1000	16 x 32	9	0.043	2670	630	ESW108M063AM2(1)
63	79	1000	16 x 36	9	0.036	2770	630	ESW108M063AM3(1)
63	79	1200	18 x 32	9	0.032	2950	756	ESW128M063AN1(1)
63	79	1500	18 x 36	9	0.030	3095	945	ESW158M063AN2(1)
63	79	2200	18 x 40	9	0.028	3200	1386	ESW228M063AN3(1)
100	125	0.47	5 x 11	8	43.000	20	3	ESW474M100AC3(1)
100	125	1.0	5 x 11	8	20.000	30	3	ESW105M100AC3(1)
100	125	2.2	5 x 11	8	9.800	44	3	ESW225M100AC3(1)
100	125	3.3	5 x 11	8	6.600	58	3	ESW335M100AC3(1)
100	125	4.7	5 x 11	8	4.600	74	5	ESW475M100AC3(1)
100	125	6.8	5 x 11	8	3.500	95	7	ESW685M100AC3(1)
100	125	10	6 x 11	8	1.800	130	10	ESW106M100AE3(1)
100	125	15	8 x 11	8	0.830	180	15	ESW156M100AG3(1)
100	125	18	6 x 15	8	0.800	200	18	ESW186M100AE4(1)
100	125	22	8 x 11	8	0.680	230	22	ESW226M100AG3(1)
100	125	33	8 x 15	8	0.450	360	33	ESW336M100AG4(1)
100	125	33	10 x 12	8	0.460	320	33	ESW336M100AH1(1)
100	125	47	8 x 20	8	0.370	420	47	ESW476M100AG6(1)
100	125	47	10 x 16	8	0.370	420	47	ESW476M100AH2(1)
100	125	68	10 x 20	8	0.300	490	68	ESW686M100AH4(1)
100	125	82	10 x 25	8	0.250	540	82	ESW826M100AH5(1)
100	125	100	13 x 20	8	0.180	580	100	ESW107M100AL3(1)
100	125	150	13 x 25	8	0.130	710	150	ESW157M100AL4(1)
100	125	180	13 x 30	8	0.120	790	180	ESW187M100AL8(1)
100	125	180	16 x 20	8	0.130	750	180	ESW187M100AM5(1)
100	125	220	16 x 25	8	0.100	890	220	ESW227M100AM7(1)
100	125	220	18 x 20	8	0.110	850	220	ESW227M100AN4(1)
100	125	330	16 x 25	8	0.090	1080	330	ESW337M100AM7(1)
100	125	390	18 x 25	8	0.083	1260	390	ESW397M100AN5(1)
100	125	470	16 x 32	8	0.076	1310	470	ESW477M100AM2(1)
100	125	560	18 x 32	8	0.068	1370	560	ESW567M100AN1(1)
100	125	560	18 x 36	8	0.064	1410	560	ESW567M100AN2(1)
100	125	820	18 x 40	8	0.047	1520	820	ESW827M100AN3(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**Z**	**RC**	**LC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

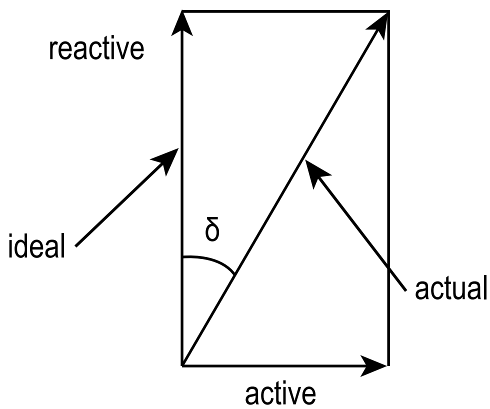
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.



Tan δ is measured with the same set-up used for the series capacitance ESC.

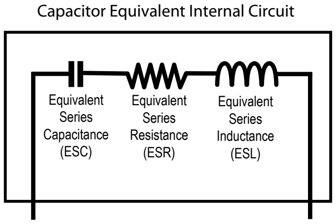
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.

Capacitor Equivalent Internal Circuit



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

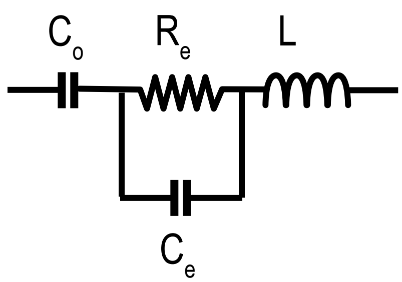
$$ESR = \frac{\tan \delta}{2\pi f \, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

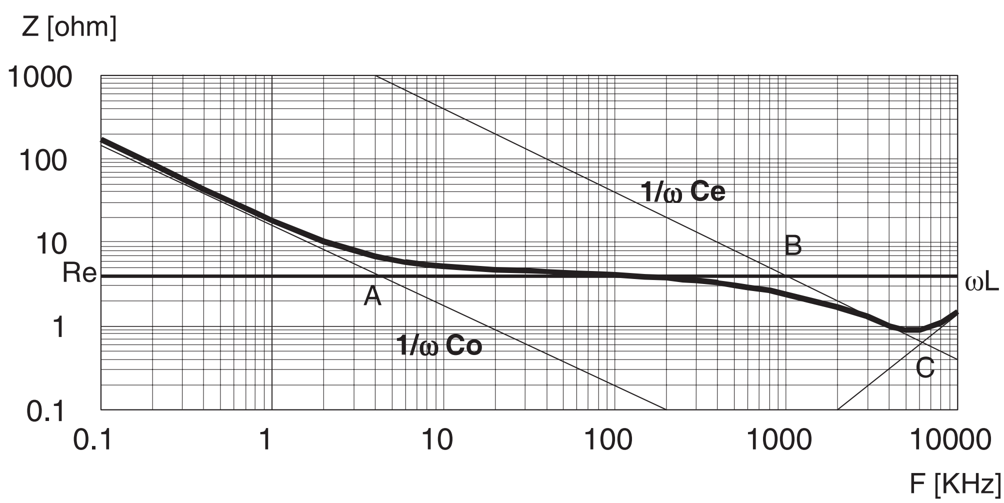
Impedance (Z)

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



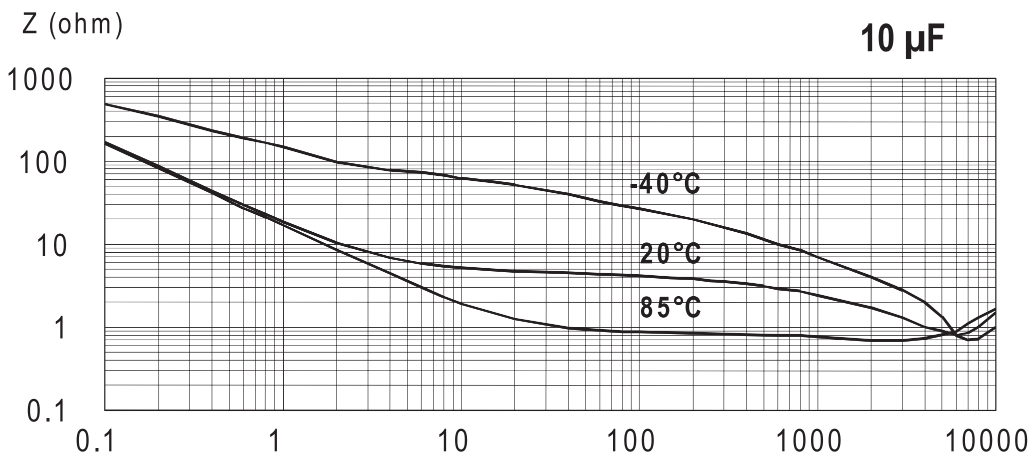
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

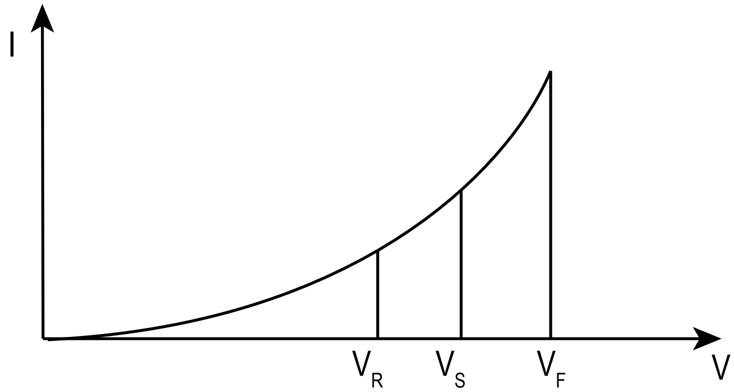
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 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 Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
E4	6.3	15	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
G6	8	20	4000	4000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
H5	10	25	2400	2400	500	
H6	10	30	2000	2000	500	
L2	13	16	2400	2400	500	
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
L8	13	30	1200	2400		
L6	13	36	1000	1200	400	
M6	16	15	1000	1000	300	
M5	16	20	1000	500	300	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
N6	18	16	800	1000	300	
N4	18	20	800	1000		
N5	18	25	800	500		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		

Standard Marking for Surface Mount Types

- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: white line
- Date code

EST Series, +105ºC

Overview

KEMET's EST Series of aluminum electrolytic radial capacitors are designed for low impedance and long life (up to 1,000 hours) applications.

Applications

Typical applications include SMPS, power supplies, adaptors, chargers, monitors and computers.

Benefits

- Long life, up to 10,000 hours
- Low impedance
- Operating temperature of up to +105°C
- Case with Ø D ≥ 6.3 mm
- Safety vent on the capacitor base

Part Number System

EST	157	M	6R3	A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63	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 & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	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 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Environmental Compliance

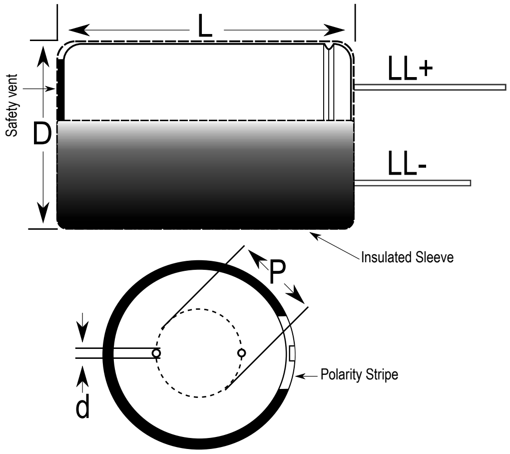
As an environmentally conscious company, KEMET is working continuously with improvements concerning the environmental effects of both our capacitors and their production. In Europe (RoHS Directive) and in some other geographical areas like China, legislation has been put in place to prevent the use of some hazardous materials, such as lead (Pb), in electronic equipment. All products in this catalog are produced to help our customers' obligations to guarantee their products and fulfill these legislative requirements. The only material of concern in our products has been lead (Pb), which has been removed from all designs to fulfill the requirement of containing less than 0.1% of lead in any homogeneous material. KEMET will closely follow any changes in legislation world wide and makes 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.

Because of customer requirements, there may appear additional markings such as LF = Lead Free or LFW = Lead Free Wires on the label.

RoHS Compliant

Dimensions – Millimeters



Size Code	D		L		p		d		LL+/LL-	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
C3	5	±0.5	11	+1.5/-0	2	±0.5	0.5	Nominal	20/15	Minimum
E3	6.3	±0.5	11	+1.5/-0	2.0	±0.5	0.5	Nominal	20/15	Minimum
G3	8	±0.5	11	+1.5/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G4	8	±0.5	15	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G6	8	±0.5	20	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
H1	10	±0.5	12	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	16	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H4	10	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H5	10	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H6	10	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L3	13	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L4	13	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L8	13	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L6	13	±0.5	36	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
L7	13	±0.5	40	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
M7	16	±0.5	25	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M2	16	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M3	16	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
M4	16	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N1	18	±0.5	32	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N2	18	±0.5	36	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
N3	18	±0.5	40	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	10 – 15,000 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 63 VDC
Life Test	4,000 – 10,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 µA, whichever is greater
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

Compensation Factor of Ripple Current (RC) vs. Frequency

Capacitance Range (µF)	120 Hz	1 kHz	10 kHz	100 kHz
6.8 – 180	0.40	0.75	0.90	1.00
220 – 560	0.50	0.85	0.94	1.00
680 – 1,800	0.60	0.87	0.95	1.00
2,200 – 3,900	0.75	0.90	0.95	1.00
≥ 4,700	0.85	0.95	0.98	1.00

Test Method & Performance

Conditions	Load Life Test			Shelf Life Test
Temperature	105°C			105°C
Test Duration	Can Ø ≤ 6.3 mm	V ≤ 10 VDC	4,000 hours	1,000 hours
	Can Ø ≤ 6.3 mm	V ≤ 16 VDC	5,000 hours	
	8.0 ≤ Can Ø ≥ 10.0 mm	V ≤ 10 VDC	6,000 hours	
	8.0 ≤ Can Ø ≥ 10.0 mm	V ≤ 16 VDC	7,000 hours	
	Can Ø ≥ 12.5 mm	V ≤ 10 VDC	8,000 hours	
	Can Ø ≥ 12.5 mm	V ≤ 16 VDC	10,000 hours	
Ripple Current	Maximum ripple current specified at 100 kHz 105°C			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 ±25% of the initial value			
Dissipation Factor	Does not exceed 200% of the specified value			
Leakage Current	Does not exceed specified value			

Table 1 – Ratings & Part Number Reference

VDC	VDC Surge Voltage	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)	ESR 100 kHz 20°C (Ω)	Part Number
6.3	8	150	5x11	22	210	0.72	EST157M6R3AC3(1)
6.3	8	330	6.3x11	22	340	0.38	EST337M6R3AE3(1)
6.3	8	680	8x11	22	640	0.2	EST687M6R3AG3(1)
6.3	8	820	8x15	22	840	0.16	EST827M6R3AG4(1)
6.3	8	1000	10x12	22	865	0.12	EST108M6R3AH1(1)
6.3	8	1500	8x20	22	1050	0.11	EST158M6R3AG6(1)
6.3	8	1500	10x16	22	1210	0.084	EST158M6R3AH2(1)
6.3	8	2200	10x20	22	1400	0.062	EST228M6R3AH4(1)
6.3	8	2700	10x25	22	1650	0.052	EST278M6R3AH5(1)
6.3	8	3300	13x20	22	1900	0.046	EST338M6R3AL3(1)
6.3	8	3900	13x25	22	2230	0.034	EST398M6R3AL4(1)
6.3	8	4700	13x30	22	2650	0.03	EST478M6R3AL8(1)
6.3	8	5600	13x36	22	2880	0.027	EST568M6R3AL6(1)
6.3	8	6800	13x40	22	3350	0.024	EST688M6R3AL7(1)
6.3	8	6800	16x25	22	2930	0.028	EST688M6R3AM7(1)
6.3	8	8200	16x32	22	3450	0.025	EST828M6R3AM2(1)
6.3	8	10000	16x36	22	3610	0.018	EST109M6R3AM3(1)
6.3	8	12000	18x32	22	4170	0.015	EST129M6R3AN1(1)
6.3	8	15000	18x36	22	4220	0.014	EST159M6R3AN2(1)
10	13	100	5x11	19	210	0.72	EST107M010AC3(1)
10	13	220	6.3x11	19	340	0.38	EST227M010AE3(1)
10	13	470	8x11	19	640	0.2	EST477M010AG3(1)
10	13	680	8x15	19	840	0.16	EST687M010AG4(1)
10	13	1000	10x16	19	1210	0.084	EST108M010AH2(1)
10	13	1500	10x20	19	1400	0.062	EST158M010AH4(1)
10	13	220	10x25	19	1650	0.052	EST227M010AH5(1)
10	13	270	13x20	19	1900	0.046	EST277M010AL3(1)
10	13	330	13x25	19	2230	0.034	EST337M010AL4(1)
10	13	390	13x30	19	2650	0.03	EST397M010AL8(1)
10	13	4700	13x36	19	2880	0.027	EST478M010AL6(1)
10	13	4700	13x40	19	3350	0.024	EST478M010AL7(1)
10	13	5600	16x25	19	2930	0.028	EST568M010AM7(1)
10	13	6800	16x32	19	3450	0.025	EST688M010AM2(1)
10	13	8200	16x36	19	3610	0.018	EST828M010AM3(1)
10	13	1000	18x36	19	4220	0.014	EST108M010AN2(1)
16	20	56	5x11	16	210	0.72	EST566M016AC3(1)
16	20	100	6.3x11	16	340	0.38	EST107M016AE3(1)
16	20	220	8x11	16	640	0.2	EST227M016AG3(1)
16	20	330	8x15	16	701	0.16	EST337M016AG4(1)
16	20	470	8x15	16	840	0.16	EST477M016AG4(1)
16	20	680	10x16	16	1210	0.084	EST687M016AH2(1)
16	20	1000	10x20	16	1400	0.062	EST108M016AH4(1)
16	20	4700	10x25	16	1650	0.052	EST478M016AM2(1)
16	20	2200	13x25	16	2230	0.034	EST228M016AL4(1)
16	20	2700	13x30	16	2650	0.03	EST278M016AL8(1)
16	20	3300	13x36	16	2880	0.027	EST338M016AL6(1)
16	20	3900	13x40	16	3350	0.024	EST398M016AL7(1)
16	20	4700	16x32	16	3450	0.028	EST478M016AM2(1)
16	20	5600	16x36	16	3610	0.018	EST568M016AM3(1)
16	20	5600	18x32	16	4170	0.015	EST568M016AN1(1)
16	20	6800	18x36	16	4220	0.014	EST688M016AN2(1)
25	32	47	5x11	14	210	0.72	EST476M025AC3(1)
25	32	100	6.3x11	14	340	0.38	EST107M025AE3(1)
25	32	150	8x11	14	640	0.2	EST157M025AG3(1)
25	32	220	8x11	14	640	0.2	EST227M025AG3(1)
25	32	330	8x15	14	840	0.16	EST337M025AG4(1)
25	32	470	10x16	14	1210	0.084	EST477M025AH2(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Roll Over for Order Info.

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	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)	ESR 100 kHz 20°C (Ω)	Part Number
25	32	680	10x20	14	1400	0.062	EST687M025AH4(1)
25	32	680	10x25	14	1650	0.052	EST687M025AH5(1)
25	32	1000	13x20	14	1900	0.046	EST108M025AL3(1)
25	32	150	13x25	14	2230	0.034	EST157M025AL4(1)
25	32	220	13x25	14	2880	0.027	EST227M025AL4(1)
25	32	2700	16x25	14	2930	0.028	EST278M025AM7(1)
25	32	3300	16x32	14	3450	0.025	EST338M025AM2(1)
25	32	3900	18x32	14	4170	0.015	EST398M025AN1(1)
25	32	4700	18x36	14	4280	0.014	EST478M025AN2(1)
35	44	33	5x11	12	210	0.72	EST336M035AC3(1)
35	44	47	6.3x11	12	340	0.38	EST476M035AE3(1)
35	44	150	8x11	12	640	0.2	EST157M035AG3(1)
35	44	220	8x15	12	840	0.16	EST227M035AG4(1)
35	44	330	10x20	12	1400	0.062	EST337M035AH4(1)
35	44	470	10x25	12	1650	0.052	EST477M035AH5(1)
35	44	680	10x30	12	1910	0.044	EST687M035AH6(1)
35	44	680	13x20	12	1900	0.046	EST687M035AL3(1)
35	44	820	13x25	12	2230	0.034	EST827M035AL4(1)
35	44	1000	13x25	12	2230	0.034	EST108M035AL4(1)
35	44	1200	13x30	12	2650	0.03	EST128M035AL8(1)
35	44	1500	13x36	12	2880	0.027	EST158M035AL6(1)
35	44	1800	13x40	12	3350	0.024	EST188M035AL7(1)
35	44	2200	16x32	12	3450	0.025	EST228M035AM2(1)
35	44	2700	16x36	12	3610	0.018	EST278M035AM3(1)
35	44	3300	18x36	12	4220	0.014	EST338M035AN2(1)
50	63	10	5x11	10	120	3.5	EST106M050AC3(1)
50	63	22	5x11	10	210	2.3	EST226M050AC3(1)
50	63	33	6.3x11	10	340	1.2	EST336M050AE3(1)
50	63	47	6.3x11	10	340	1.2	EST476M050AE3(1)
50	63	100	8x11	10	555	0.63	EST107M050AG3(1)
50	63	120	8x15	10	730	0.45	EST127M050AG4(1)
50	63	150	8x20	10	910	0.33	EST157M050AG6(1)
50	63	220	10x16	10	1050	0.31	EST227M050AH2(1)
50	63	330	10x20	10	1400	0.21	EST337M050AH4(1)
50	63	470	10x30	10	1690	0.15	EST477M050AH6(1)
50	63	470	13x20	10	1660	0.16	EST477M050AL3(1)
50	63	560	13x25	10	1950	0.12	EST567M050AL4(1)
50	63	680	13x30	10	2310	0.1	EST687M050AL8(1)
50	63	820	13x36	10	2510	0.083	EST827M050AL6(1)
50	63	1000	16x25	10	2555	0.073	EST108M050AM7(1)
50	63	1200	16x32	10	3010	0.054	EST128M050AM2(1)
50	63	1500	16x36	10	3150	0.045	EST158M050AM3(1)
50	63	1800	18x32	10	3635	0.047	EST188M050AN1(1)
50	63	2200	18x36	10	3680	0.04	EST228M050AN2(1)
50	63	2700	18x40	10	3800	0.036	EST278M050AN3(1)
63	79	10	5x11	9	55	2.3	EST106M063AC3(1)
63	79	33	6.3x11	9	115	1.2	EST336M063AE3(1)
63	79	56	8x11	9	232	0.63	EST566M063AG3(1)
63	79	270	10x16	9	357	0.31	EST277M063AH6(1)
63	79	180	10x20	9	466	0.21	EST187M063AH4(1)
63	79	220	10x25	9	531	0.2	EST227M063AH5(1)
63	79	270	10x30	9	663	0.15	EST277M063AH6(1)
63	79	270	13x20	9	690	0.16	EST277M063AL3(1)
63	79	330	13x25	9	784	0.12	EST337M063AL4(1)
63	79	470	13x30	9	905	0.1	EST477M063AL8(1)
63	79	560	13x36	9	1050	0.083	EST567M063AL6(1)
63	79	680	13x40	9	1180	0.071	EST687M063AL7(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**LC**	**Part Number**

(1) Insert packaging code. See Ordering Options Table for available options.
** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Table 1 – Ratings & Part Number Reference cont'd

VDC	VDC Surge Voltage	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)	ESR 100 kHz 20°C (Ω)	Part Number
63	79	820	16x32	9	1570	0.054	EST827M063AM2(1)
63	79	1000	16x36	9	1790	0.045	EST108M063AM3(1)
63	79	1200	16x40	9	2020	0.04	EST128M063AM4(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**LC**	**Part Number**

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

** When capacitance exceeds 1,000 µF, the DF value (%) is increased by 2% for every additional 1,000 µF.*

Mounting Positions (Safety Vent)

In operation, electrolytic capacitors will always conduct a leakage current which 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
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 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.

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor) and 10 kΩ for the other rated voltages.
- In the case of capacitors connected in 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)

Capacitance is measured by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C.

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

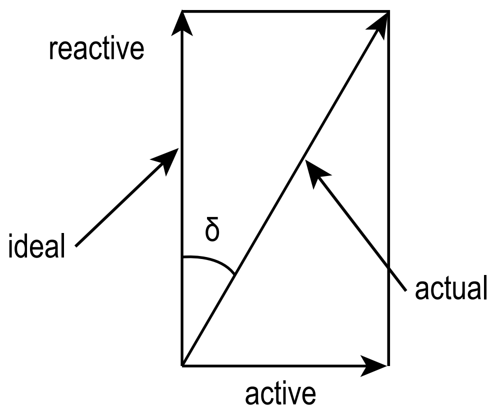
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi fZ}$$

C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Dissipation Factor tan δ (DF)

Dissipation Factor tan δ is the ratio between the active and reactive power for a sinusoidal waveform voltage. It can be thought of as a measurement of the gap between an actual and ideal capacitor.

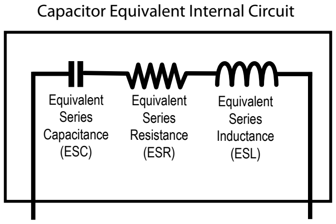


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

Self inductance or Equivalent Series Inductance results from the terminal configuration and internal design of the capacitor.



Equivalent Series Resistance (ESR)

Equivalent Series Resistance is the resistive component of the equivalent series circuit. ESR value depends on frequency and temperature and is related to the tan δ by the following equation:

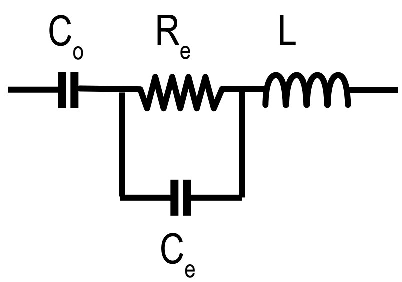
$$ESR = \frac{\tan\delta}{2\pi f\, ESC}$$

ESR = Equivalent Series Resistance (Ω)
tan δ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

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

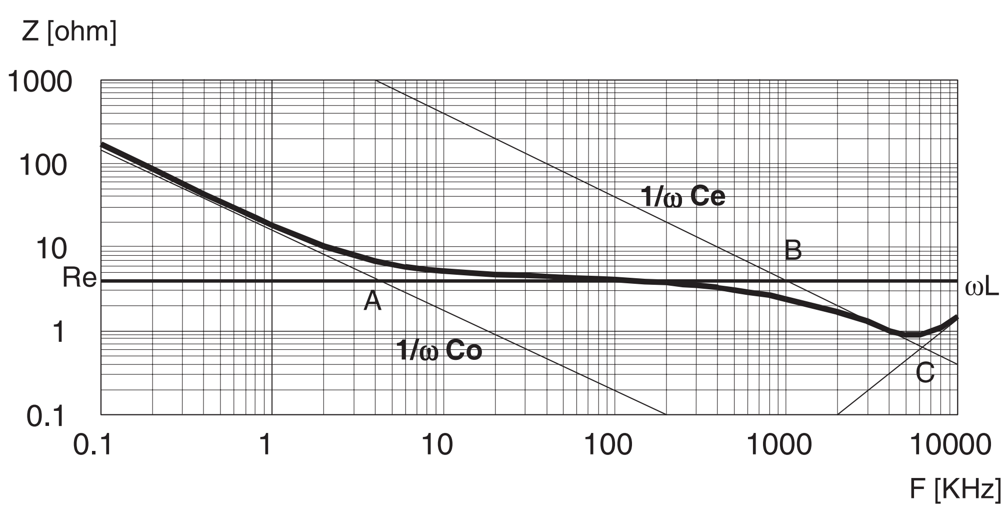
Impedance (Z)

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



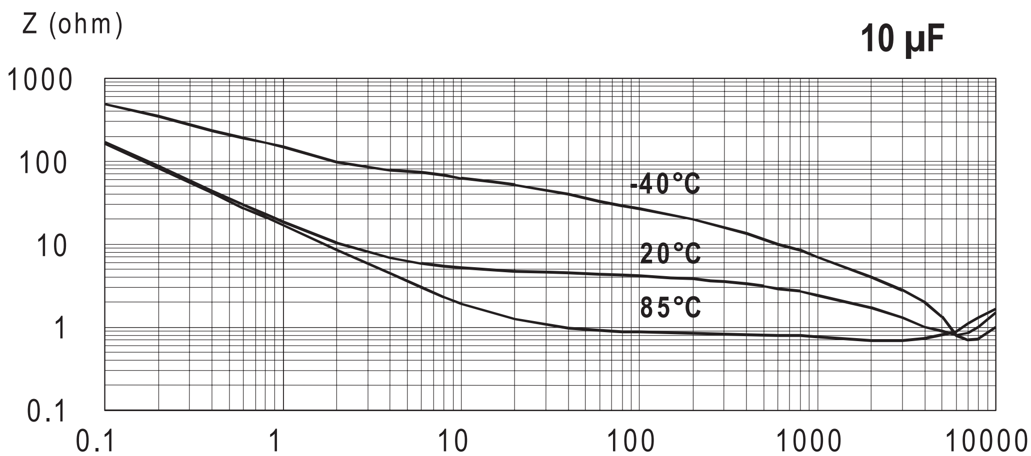
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding 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:



- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $Xc = 1/\omega C_o$ 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)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = C\sqrt{1/LCe}$
- Above this frequency, inductive reactance of the winding and its terminals (XL = Z = ωL) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01\ C_o$.
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

In order to obtain a low impedance value throughout the temperature range, R_e must be as little as possible. However, R_e values that are too low indicate a very aggressive electrolyte, resulting in a shorter life of the electrolytic capacitor at high temperatures. A compromise must be reached.

Leakage Current (LC)

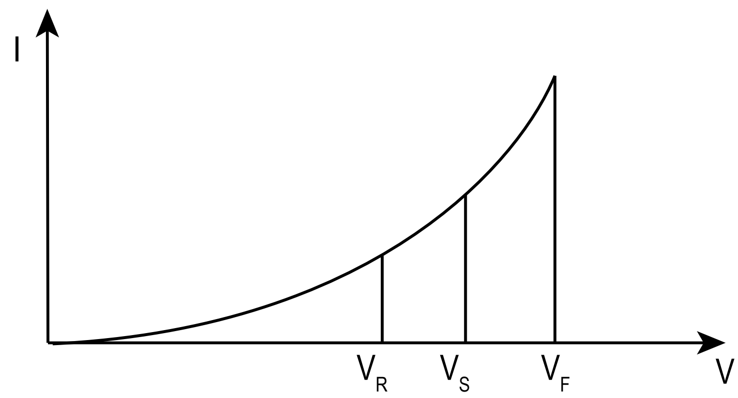
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after 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 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 leakage current will flow when voltage is applied after prolonged storage.

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)
  tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

ESR and, thus, the tan δ depend on the frequency of the applied voltage. This indicates that the allowed ripple current is also a function of the frequency.

Temperature Dependence of the Ripple Current

The data sheet specifies maximum ripple current at the upper category temperature for each capacitor.

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 maximum permissible operating temperature
T: Actual operating temperature
To: Maximum permissible operating temperature
This formula is applicable between 40°C and To.

Packaging Quantities

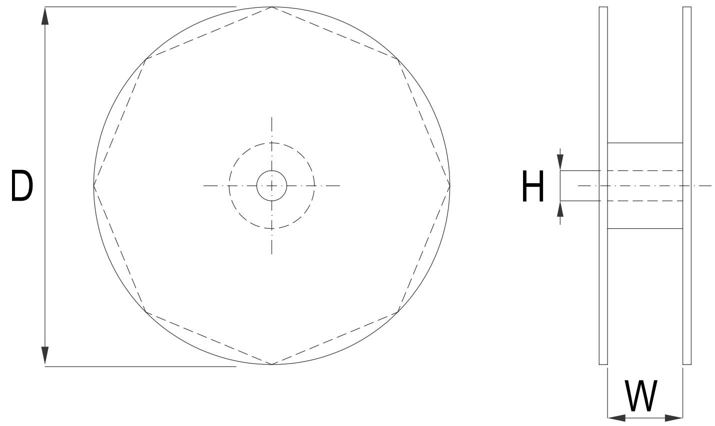
Size Code	Diameter (mm)	Length (mm)	Bulk Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
G6	8	20	4000	4000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600
H4	10	20	2400	3000	700	600
H5	10	25	2400	2400	500	
H6	10	30	2000	2000	500	
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
L8	13	30	1200	2400		
L6	13	36	1000	1200	400	
L7	13	40	1000	500	500	
M7	16	25	1000	500	300	
M2	16	32	800	500		
M3	16	36	600	500		
M4	16	40	600	500		
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		

Standard Marking for Surface Mount Types

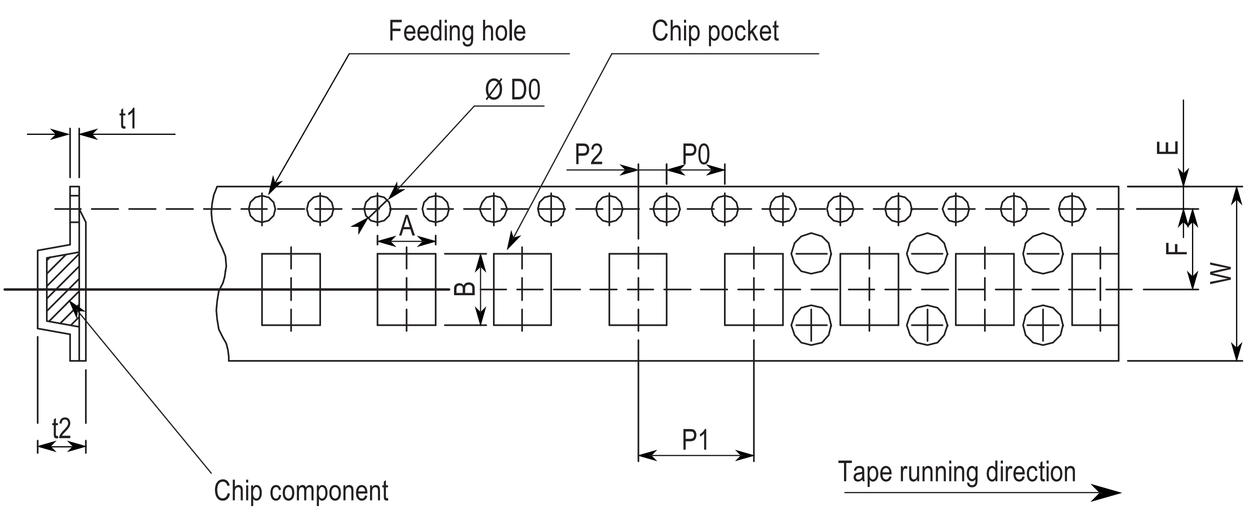
- KEMET logo
- Series
- Operating temperature (°C)
- Rated voltage (VDC)
- Rated capacitance (µF)
- Negative polarity
- Date code

Lead Taping & Packaging for EDK, EEV, & EXV

Case Size (mm)	Reel		
	D	H	W
	±0.2	±0.8	±1.0
4 x 5.4	380	21	14
5 x 5.4		21	14
6.3 x 5.4		21	18
6.3 x 7.7		21	18
8 x 6.2		21	18
8 x 10.2		21	26
10 x 10.2		21	26
12.5 x 13.5		23	34
12.5 x 16		23	34
16 x 16.5		23	46



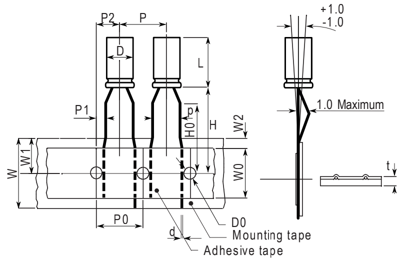
Taping for Automatic Insertion Machines



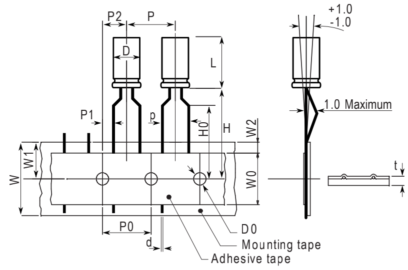
Dimensions (mm)	W	A	B	P0	P1	P2	F	D0	E	t1	t2
Tolerance	Nominal	Nominal	Nominal	±0.1	±0.1	±0.1	Nominal	±0.1	Nominal	Nominal	Nominal
4 x 5.4	12	4.7	4.7	4	8	2	5.5	1.5	1.75	0.4	5.8
5 x 5.4	12	5.7	5.7	4	12	2	5.5	1.5	1.75	0.4	5.8
6.3 x 5.4	16	7	7	4	12	2	7.5	1.5	1.75	0.4	5.8
6.3 x 7.7	16	7	7	4	12	2	7.5	1.5	1.75	0.4	5.8
8 x 6.2	16	8.7	8.7	4	12	2	7.5	1.5	1.75	0.4	6.8
8 x 10.2	24	8.7	8.7	4	16	2	11.5	1.5	1.75	0.4	11
10 x 10.2	24	10.7	10.7	4	16	2	11.5	1.5	1.75	0.4	11
12.5 x 13.5	32	13.4	13.4	4	24	2	14.2	1.5	1.75	0.5	14
12.5 x 16	32	13.4	13.4	4	24	2	14.2	1.5	1.75	0.5	17.5
16 x 16.5	44	17.5	17.5	4	28	2	20.2	1.5	1.75	0.5	17.5

Taping for Automatic Insertion Machines (ESK, ESH, ESC, ESY, ESG, ESW, and EST)

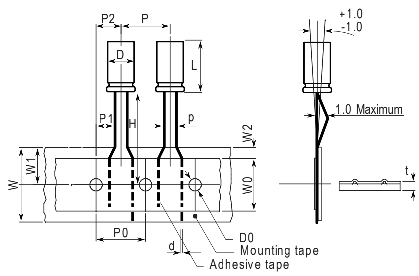
Formed to 2.5 mm
(Lead and packaging code LA and FA)



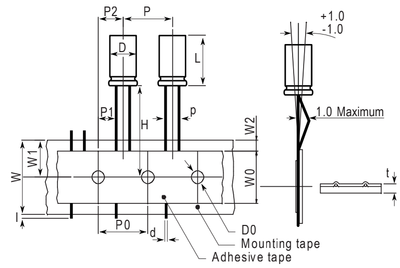
Formed to 5 mm
(Lead and packaging code JA and DA)



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



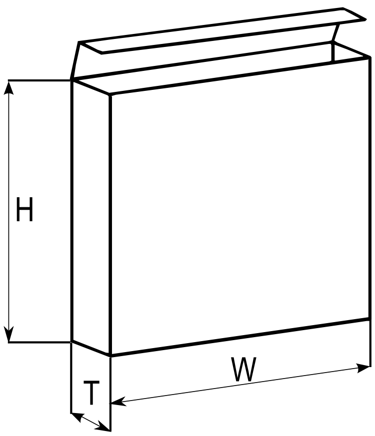
Straight Leads (Diameter > 8)
Lead and packaging code EA and KA



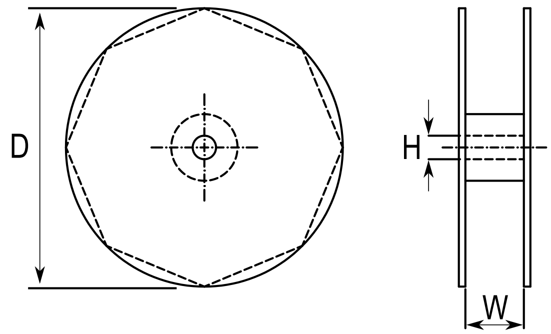
Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	l	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1 .0	±0 .3	±0 .7	±1 .3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		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	≤7	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	≤7	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	≤7	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	≤7	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	≤7	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	≤7	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	15-25	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
			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

Taping for Automatic Insertion Machines (ESK, ESH, ESC, ESY, ESG, ESW, and EST) cont'd

Ammo Box



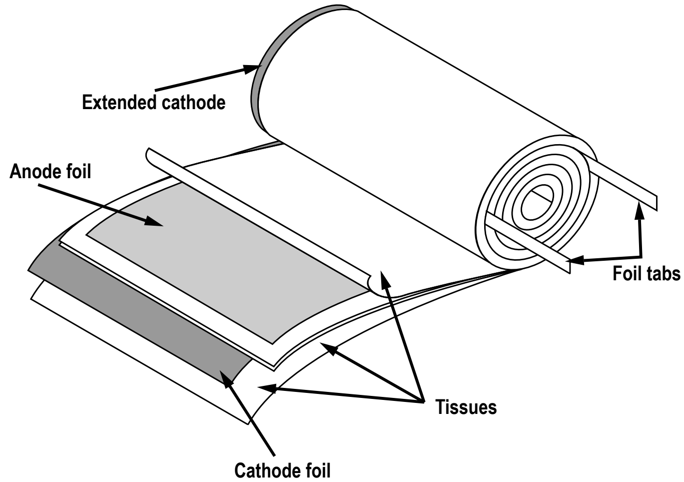
Reel



Case Size (mm)	Ammo			Reel		
	H	W	T	D	H	W
		Maximum	Maximum	±2	±0.5	+1/-0.1
4	230	340	42	350	30	50
5 x 5 – 7	230	340	42			
6 x 5 – 7	275	340	42			
8 x 5 – 9	235	340	45			
5 x 11	230	340	48			
6 x 11	270	340	48			
8 x 11	235	340	48			
8 x 14 – 20	240	340	57			
10 x 12	250	340	52			
10 x 15 – 19	256	340	57			
10 x 22 – 25	250	340	60			
12	270	340	57			
13	285	340	62			
16	265	340	62			

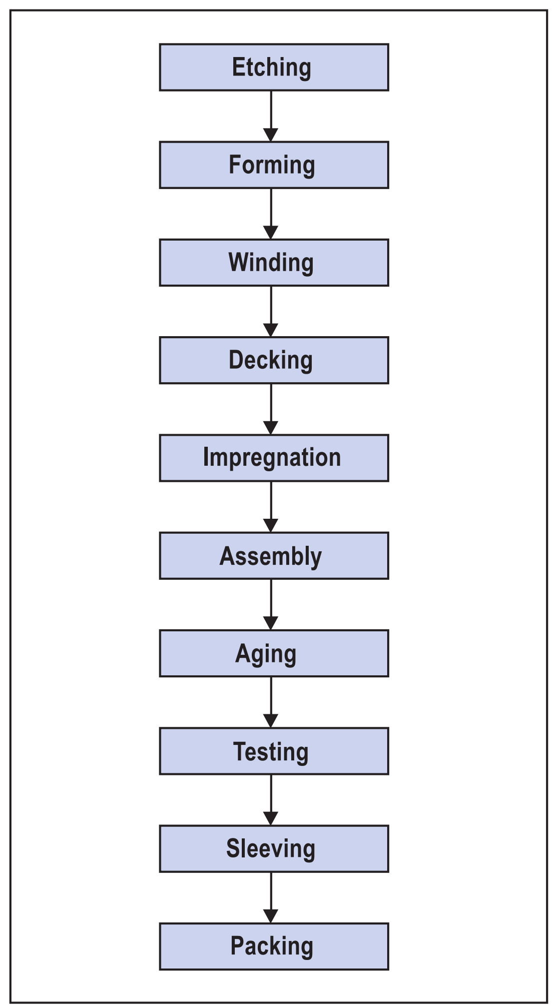
Construction

The manufacturing process begins with the anode foil being electrochemically etched to increase the surface area and then "formed" to produce the aluminum oxide layer. Both the anode and cathode foils are then interleaved with absorbent paper and wound into a cylinder. During the winding process, aluminum tabs are attached to each foil to provide the electrical contact.



The deck, complete with terminals, is attached to the tabs and then folded down to rest on top of the winding. The complete winding is impregnated with electrolyte before being housed in a suitable container, usually an aluminum can, and sealed. Throughout the process, all materials inside the housing must be maintained at the highest purity and be compatible with the electrolyte.

Each capacitor is aged and tested before being sleeved and packed. The purpose of aging is to repair any damage in the oxide layer and thus reduce the leakage current to a very low level. Aging is normally carried out at the rated temperature of the capacitor and is accomplished by applying voltage to the device while carefully controlling the supply current. The process may take several hours to complete.



Damage to the oxide layer can occur due to variety of reasons:

- Slitting of the anode foil after forming
- Attaching the tabs to the anode foil
- Minor mechanical damage caused during winding

A sample from each batch is taken by the quality department after completion of the production process.

The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

Electrical:

- Leakage current
- Capacitance
- ESR
- Impedance
- Tan Delta

Mechanical/Visual:

- Overall dimensions
- Torque test of mounting stud
- Print detail
- Box labels
- Packaging, including packed quantity

KEMET Corporation World Headquarters

2835 KEMET Way
Simpsonville, SC 29681

Mailing Address:
P.O. Box 5928
Greenville, SC 29606

www.kemet.com
Tel: 864-963-6300
Fax: 864-963-6521

Corporate Offices
Fort Lauderdale, FL
Tel: 954-766-2800

North America

Southeast
Lake Mary, FL
Tel: 407-855-8886

Northeast
Wilmington, MA
Tel: 978-658-1663

Central
Novi, MI
Tel: 248-994-1030

West
Milpitas, CA
Tel: 408-433-9950

Mexico
Guadalajara, Jalisco
Tel: 52-33-3123-2141

Europe

Southern Europe
Paris, France
Tel: 33-1-4646-1006

Sasso Marconi, Italy
Tel: 39-051-939111

Central Europe
Landsberg, Germany
Tel: 49-8191-3350800

Kamen, Germany
Tel: 49-2307-438110

Northern Europe
Bishop's Stortford, United Kingdom
Tel: 44-1279-460122

Espoo, Finland
Tel: 358-9-5406-5000

Asia

Northeast Asia
Hong Kong
Tel: 852-2305-1168

Shenzhen, China
Tel: 86-755-2518-1306

Beijing, China
Tel: 86-10-5829-1711

Shanghai, China
Tel: 86-21-6447-0707

Taipei, Taiwan
Tel: 886-2-27528585

Southeast Asia
Singapore
Tel: 65-6586-1900

Penang, Malaysia
Tel: 60-4-6430200

Bangalore, India
Tel: 91-806-53-76817

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Other KEMET Resources

Tools	
Resource	Location
Configure A Part: CapEdge	http://capacitoredge.kemet.com
SPICE & FIT Software	http://www.kemet.com/spice
Search Our FAQs: KnowledgeEdge	http://www.kemet.com/keask
Electrolytic LifeCalculator	http://www.kemet.com:8080/elc

Product Information	
Resource	Location
Products	http://www.kemet.com/products
Technical Resources (Including Soldering Techniques)	http://www.kemet.com/technicalpapers
RoHS Statement	http://www.kemet.com/rohs
Quality Documents	http://www.kemet.com/qualitydocuments

Product Request	
Resource	Location
Sample Request	http://www.kemet.com/sample
Engineering Kit Request	http://www.kemet.com/kits

Contact	
Resource	Location
Website	www.kemet.com
Contact Us	http://www.kemet.com/contact
Investor Relations	http://www.kemet.com/ir
Call Us	1-877-MyKEMET
Twitter	http://twitter.com/kemetcapacitors

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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.

Digitally signed by Jeannette Calvo
DN: c=US, st=FL, l=Fort Lauderdale, o=KEMET Corp., ou=Marketing Communications, cn=Jeannette Calvo, email=jeannettecalvo@kemet.com
Date: 2013.09.11 10:44:07 -04'00'

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Corporate Offices
KEMET Corporation
2835 KEMET Way
Simpsonville, SC 29681
USA
Tel: 864.963.6300
Fax: 864.963.6521

KEMET Electronics GmbH
Rudolf-Diesel-Straße 21
86899 Landsberg
Germany
Tel: +49 8191 3350 ext. 0
Fax: 49 8191 335063

KEMET Electronics Marketing (S) Pte Ltd.
73 Bukit Timah Road
#05-01 Rex House
Singapore 229832
Tel: 65.6586.1900
Fax: 65.6586.1901

www.kemet.com