

Overview

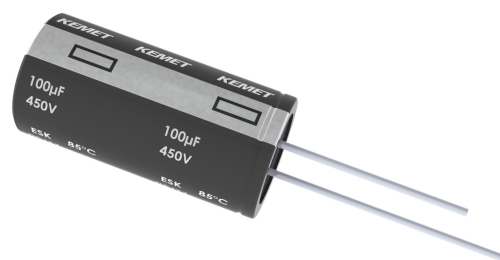
KEMET's ESK Series of single-ended aluminum electrolytic capacitors are designed for high-density printed circuit boards requiring a miniature solution.

Applications

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

Benefits

- Operating temperature of up to 85°C
- 2,000 hour operating life
- Case with $\varnothing D \geq 5$ 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
Single-Ended Aluminum Electrolytic	First two digits represent significant figures for capacitance values. Last digit specifies the number of zeros to be added.	M = $\pm 20\%$	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	$H_0 = 16 \pm 0.75$	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	$H_0 = 16 \pm 0.75$	JA
10 – 13	Ammo	5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
16 – 18	Ammo	7.5 mm Lead Spacing	$H_0 = 18.5 \pm 0.75$	EA
Other Packaging Options				
4 – 8	Ammo	Formed to 5 mm	$H_0 = 16 \pm 0.75$	DA
4 – 8	Ammo	Straight	$H_0 = 18.5 \pm 0.75$	EA
4 – 5	Ammo	Formed to 2.5 mm	$H_0 = 16 \pm 0.75$	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	$H_0 = 16 \pm 0.75$	JA
4 – 5, 8 – 18	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.

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
G4	8	±0.5	15	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
H9	10	±0.5	12.5	+1.5/-0	5	±0.5	0.6	Nominal	20/15	Minimum
H2	10	±0.5	15	+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
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
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
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
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	1 – 22,000 μ F	1 – 470 μ F
Capacitance Tolerance	$\pm 20\%$ at 120 Hz / 20°C	
Rated Voltage	6.3 – 100 VDC	160 – 500 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	$I \leq 0.01 CV$ or 3 μ A, whichever is greater	$I = 0.03 CV + 10 (\mu A)$
	C = rated capacitance (μ F), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.	

Impedance Z Characteristics at 120 Hz

Rated Voltage (VDC)	6	10	16	25	35 – 100	160 – 250	315 – 350	400 – 500
Z (-25°C)/Z (20°C)	8	6	5	3	3	7	10	15
Z (-40°C)/Z (20°C)	10	8	6	4	3	–	–	–

Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	Capacitance Range (μ F)	120 Hz	300 Hz	1 kHz	10 kHz
6.3 – 100	1 – 68	1.00	1.20	1.30	1.50
6.3 – 100	100 – 680	1.00	1.10	1.15	1.20
6.3 – 100	1000 – 22000	1.00	1.05	1.10	1.15
160 – 450	1 – 220	1.00	1.25	1.40	1.40
160 – 450	220 – 22000	1.00	1.10	1.13	1.13
500		1.00	1.05	1.10	1.10

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 $\pm 20\%$ of the initial value	
Dissipation Factor	Does not exceed 200% of the specified value	
Leakage Current	Does not exceed specified value	

Shelf Life

The capacitance, ESR and impedance of a capacitor will not change significantly after extended storage periods, however the leakage current will very slowly increase.

KEMET's E-series aluminum electrolytic capacitors should not be stored in high temperatures or where there is a high level of humidity.

The suitable storage condition for KEMET's E-series aluminum electrolytic capacitors is +5 to +35°C and less than 75% in relative humidity.

KEMET's E-series aluminum electrolytic capacitors should not be stored in damp conditions such as water, saltwater spray or oil spray.

KEMET's E-series aluminum electrolytic capacitors should not be stored in an environment full of hazardous gas (hydrogen sulphide, sulphurous acid gas, nitrous acid, chlorine gas, ammonium, etc.)

KEMET's E-series aluminum electrolytic capacitors should not be stored under exposure to ozone, ultraviolet rays or radiation.

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

Re-age (Reforming) Procedure

Apply the rated voltage to the capacitor at room temperature for a period of one hour, or until the leakage current has fallen to a steady value below the specified limit. During re-aging a maximum charging current of twice the specified leakage current or 5 mA (whichever is greater) is suggested.

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
6.3	8	22	5 x 11	24	35	3.0	ESK226M6R3AC3(1)
6.3	8	33	5 x 11	24	55	3.0	ESK336M6R3AC3(1)
6.3	8	47	5 x 11	24	75	3.0	ESK476M6R3AC3(1)
6.3	8	100	5 x 11	24	130	6.3	ESK107M6R3AC3(1)
6.3	8	220	5 x 11	24	200	13.9	ESK227M6R3AC3(1)
6.3	8	220	6.3 x 11	24	240	13.9	ESK227M6R3AE3(1)
6.3	8	330	6.3 x 11	24	260	20.8	ESK337M6R3AE3(1)
6.3	8	470	6.3 x 11	24	330	29.6	ESK477M6R3AE3(1)
6.3	8	680	8 x 11	24	410	42.8	ESK687M6R3AG3(1)
6.3	8	1000	8 x 11	24	460	63.0	ESK108M6R3AG3(1)
6.3	8	1000	10 x 12.5	24	580	63.0	ESK108M6R3AH9(1)
6.3	8	2200	10 x 20	24	840	138.6	ESK228M6R3AH4(1)
6.3	8	3300	10 x 20	24	1000	207.9	ESK338M6R3AH4(1)
6.3	8	4700	13 x 20	24	1300	296.1	ESK478M6R3AL3(1)
6.3	8	6800	13 x 25	24	1550	428.4	ESK688M6R3AL4(1)
6.3	8	10000	16 x 25	24	1900	630.0	ESK109M6R3AM7(1)
6.3	8	15000	16 x 36	24	2500	945.0	ESK159M6R3AM3(1)
6.3	8	22000	18 x 40	24	3650	1386.0	ESK229M6R3AN3(1)
10	13	4.7	5 x 11	20	20	3.0	ESK475M010AC3(1)
10	13	10	5 x 11	20	35	3.0	ESK106M010AC3(1)
10	13	22	5 x 11	20	55	3.0	ESK226M010AC3(1)
10	13	33	5 x 11	20	80	3.3	ESK336M010AC3(1)
10	13	47	5 x 11	20	95	4.7	ESK476M010AC3(1)
10	13	100	5 x 11	20	180	10.0	ESK107M010AC3(1)
10	13	220	6.3 x 11	20	250	22.0	ESK227M010AE3(1)
10	13	330	6.3 x 11	20	265	33.0	ESK337M010AE3(1)
10	13	470	6.3 x 11	20	320	47.0	ESK477M010AE3(1)
10	13	680	8 x 11	20	410	68.0	ESK687M010AG3(1)
10	13	1000	10 x 12.5	20	580	100.0	ESK108M010AH9(1)
10	13	2200	10 x 20	20	880	220.0	ESK228M010AH4(1)
10	13	3300	13 x 20	20	1250	330.0	ESK338M010AL3(1)
10	13	4700	13 x 25	20	1500	470.0	ESK478M010AL4(1)
10	13	6800	16 x 25	20	1900	680.0	ESK688M010AM7(1)
10	13	10000	16 x 36	20	2225	1000.0	ESK109M010AM3(1)
10	13	10000	18 x 32	20	2225	1000.0	ESK109M010AN1(1)
10	13	15000	18 x 36	20	2950	1500.0	ESK159M010AN2(1)
10	13	22000	22 x 40	20	3700	2200.0	ESK229M010AQ4(1)
16	20	4.7	5 x 11	16	25	3.0	ESK475M016AC3(1)
16	20	10	5 x 11	16	40	3.0	ESK106M016AC3(1)
16	20	22	5 x 11	16	75	3.5	ESK226M016AC3(1)
16	20	33	5 x 11	16	110	5.3	ESK336M016AC3(1)
16	20	47	5 x 11	16	130	7.5	ESK476M016AC3(1)
16	20	68	5 x 11	16	150	10.9	ESK686M016AC3(1)
16	20	100	5 x 11	16	165	16.0	ESK107M016AC3(1)
16	20	150	6.3 x 11	16	205	24.0	ESK157M016AE3(1)
16	20	220	6.3 x 11	16	260	35.2	ESK227M016AE3(1)
16	20	330	6.3 x 11	16	290	52.8	ESK337M016AE3(1)
16	20	330	8 x 11	16	360	52.8	ESK337M016AG3(1)
16	20	470	8 x 11	16	400	75.2	ESK477M016AG3(1)
16	20	680	10 x 12.5	16	510	108.8	ESK687M016AH9(1)
16	20	1000	10 x 15	16	630	160.0	ESK108M016AH2(1)
16	20	2200	13 x 20	16	1100	352.0	ESK228M016AL3(1)
16	20	3300	13 x 25	16	1400	528.0	ESK338M016AL4(1)
16	20	4700	16 x 25	16	1800	752.0	ESK478M016AM7(1)
16	20	6800	16 x 32	16	1980	1088.0	ESK688M016AM2(1)
16	20	10000	18 x 36	16	2700	1600.0	ESK109M016AN2(1)
16	20	15000	22 x 40	16	3150	2400.0	ESK159M016AQ4(1)
16	20	22000	22 x 40	16	3800	3520.0	ESK229M016AQ4(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 120 Hz 85°C (mA)	LC 20°C 2 minutes (μA)	Part Number
25	32	4.7	5 x 11	14	30	3.0	ESK475M025AC3(1)
25	32	10	5 x 11	14	50	3.0	ESK106M025AC3(1)
25	32	22	5 x 11	14	90	5.5	ESK226M025AC3(1)
25	32	33	5 x 11	14	115	8.3	ESK336M025AC3(1)
25	32	47	5 x 11	14	135	11.8	ESK476M025AC3(1)
25	32	68	5 x 11	14	145	17.0	ESK686M025AC3(1)
25	32	100	6.3 x 11	14	160	25.0	ESK107M025AE3(1)
25	32	220	8 x 11	14	290	55.0	ESK227M025AG3(1)
25	32	330	8 x 11	14	315	82.5	ESK337M025AG3(1)
25	32	470	8 x 15	14	420	117.5	ESK477M025AG4(1)
25	32	470	10 x 12.5	14	460	117.5	ESK477M025AH9(1)
25	32	680	10 x 15	14	550	170.0	ESK687M025AH2(1)
25	32	1000	10 x 20	14	760	250.0	ESK108M025AH4(1)
25	32	1000	13 x 16	14	760	250.0	ESK108M025AL2(1)
25	32	2200	13 x 25	14	1300	550.0	ESK228M025AL4(1)
25	32	3300	16 x 25	14	1660	825.0	ESK338M025AM7(1)
25	32	4700	16 x 32	14	1950	1175.0	ESK478M025AM2(1)
25	32	6800	18 x 36	14	2550	1700.0	ESK688M025AN2(1)
25	32	10000	22 x 40	14	2800	2500.0	ESK109M025AQ4(1)
25	32	15000	22 x 40	14	3200	3750.0	ESK159M025AQ4(1)
35	44	4.7	5 x 11	12	35	3.0	ESK475M035AC3(1)
35	44	10	5 x 11	12	60	3.5	ESK106M035AC3(1)
35	44	22	5 x 11	12	95	7.7	ESK226M035AC3(1)
35	44	33	5 x 11	12	120	11.6	ESK336M035AC3(1)
35	44	47	5 x 11	12	120	16.5	ESK476M035AC3(1)
35	44	100	6.3 x 11	12	185	35.0	ESK107M035AE3(1)
35	44	220	8 x 11	12	290	77.0	ESK227M035AG3(1)
35	44	330	10 x 12.5	12	420	115.5	ESK337M035AH9(1)
35	44	470	10 x 15	12	430	164.5	ESK477M035AH2(1)
35	44	680	10 x 20	12	550	238.0	ESK687M035AH4(1)
35	44	1000	13 x 20	12	950	350.0	ESK108M035AL3(1)
35	44	2200	16 x 25	12	1600	770.0	ESK228M035AM7(1)
35	44	3300	16 x 36	12	1970	1155.0	ESK338M035AM3(1)
35	44	3300	18 x 32	12	2050	1155.0	ESK338M035AN1(1)
35	44	4700	18 x 36	12	2400	1645.0	ESK478M035AN2(1)
35	44	6800	22 x 40	12	2600	2380.0	ESK688M035AQ4(1)
50	63	1.0	5 x 11	10	10	3.0	ESK105M050AC3(1)
50	63	2.2	5 x 11	10	23	3.0	ESK225M050AC3(1)
50	63	3.3	5 x 11	10	35	3.0	ESK335M050AC3(1)
50	63	4.7	5 x 11	10	40	3.0	ESK475M050AC3(1)
50	63	6.8	5 x 11	10	50	3.4	ESK685M050AC3(1)
50	63	10	5 x 11	10	65	5.0	ESK106M050AC3(1)
50	63	22	5 x 11	10	100	11.0	ESK226M050AC3(1)
50	63	33	5 x 11	10	105	16.5	ESK336M050AC3(1)
50	63	47	6.3 x 11	10	140	23.5	ESK476M050AE3(1)
50	63	100	8 x 11	10	230	50.0	ESK107M050AG3(1)
50	63	220	10 x 12.5	10	380	110.0	ESK227M050AH9(1)
50	63	330	10 x 15	10	490	165.0	ESK337M050AH2(1)
50	63	470	10 x 20	10	610	235.0	ESK477M050AH4(1)
50	63	1000	13 x 25	10	1100	500.0	ESK108M050AL4(1)
50	63	2200	16 x 36	10	1850	1100.0	ESK228M050AM3(1)
50	63	2200	18 x 32	10	1850	1100.0	ESK228M050AN1(1)
50	63	3300	18 x 36	10	2170	1650.0	ESK338M050AN2(1)
50	63	4700	22 x 40	10	2500	2350.0	ESK478M050AQ4(1)
63	79	1.0	5 x 11	10	10	3.0	ESK105M063AC3(1)
63	79	2.2	5 x 11	10	29	3.0	ESK225M063AC3(1)
63	79	3.3	5 x 11	10	40	3.0	ESK335M063AC3(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 120 Hz 85°C (mA)	LC 20°C 2 minutes (μA)	Part Number
63	79	4.7	5 x 11	10	45	3.0	ESK475M063AC3(1)
63	79	10	5 x 11	10	70	6.3	ESK106M063AC3(1)
63	79	22	5 x 11	10	95	13.9	ESK226M063AC3(1)
63	79	22	6.3 x 11	10	115	13.9	ESK226M063AE3(1)
63	79	33	6.3 x 11	10	130	20.8	ESK336M063AE3(1)
63	79	47	6.3 x 11	10	190	29.6	ESK476M063AE3(1)
63	79	100	10 x 12.5	10	300	63.0	ESK107M063AH9(1)
63	79	220	10 x 15	10	410	138.6	ESK227M063AH2(1)
63	79	220	10 x 20	10	490	138.6	ESK227M063AH4(1)
63	79	330	10 x 20	10	540	207.9	ESK337M063AH4(1)
63	79	470	13 x 20	10	755	296.1	ESK477M063AL3(1)
63	79	680	13 x 25	10	965	428.4	ESK687M063AL4(1)
63	79	1000	16 x 25	10	1310	630.0	ESK108M063AM7(1)
63	79	2200	18 x 36	10	2200	1386.0	ESK228M063AN2(1)
63	79	3300	22 x 40	10	2500	2079.0	ESK338M063AQ4(1)
100	125	1.0	5 x 11	10	21	3.0	ESK105M100AC3(1)
100	125	2.2	5 x 11	10	30	3.0	ESK225M100AC3(1)
100	125	3.3	5 x 11	10	45	3.3	ESK335M100AC3(1)
100	125	4.7	5 x 11	10	50	4.7	ESK475M100AC3(1)
100	125	6.8	5 x 11	10	55	6.8	ESK685M100AC3(1)
100	125	10	5 x 11	10	65	10.0	ESK106M100AC3(1)
100	125	10	6.3 x 11	10	75	10.0	ESK106M100AE3(1)
100	125	22	6.3 x 11	10	105	22.0	ESK226M100AE3(1)
100	125	22	8 x 11	10	130	22.0	ESK226M100AG3(1)
100	125	33	8 x 11	10	140	33.0	ESK336M100AG3(1)
100	125	47	10 x 12.5	10	190	47.0	ESK476M100AH9(1)
100	125	68	10 x 15	10	280	68.0	ESK686M100AH2(1)
100	125	100	10 x 20	10	400	100.0	ESK107M100AH4(1)
100	125	150	13 x 20	10	500	150.0	ESK157M100AL3(1)
100	125	220	13 x 25	10	710	220.0	ESK227M100AL4(1)
100	125	330	13 x 25	10	720	330.0	ESK337M100AL4(1)
100	125	470	16 x 25	10	1100	470.0	ESK477M100AM7(1)
100	125	680	16 x 36	10	1260	680.0	ESK687M100AM3(1)
100	125	1000	18 x 40	10	1350	1000.0	ESK108M100AN3(1)
160	200	1.0	5 x 11	20	17	14.8	ESK105M160AC3(1)
160	200	1.0	6.3 x 11	20	17	14.8	ESK105M160AE3(1)
160	200	2.2	6.3 x 11	20	26	20.6	ESK225M160AE3(1)
160	200	3.3	6.3 x 11	20	30	25.8	ESK335M160AE3(1)
160	200	4.7	6.3 x 11	20	32	32.6	ESK475M160AE3(1)
160	200	10	8 x 11	20	50	58.0	ESK106M160AG3(1)
160	200	22	10 x 15	20	110	115.6	ESK226M160AH2(1)
160	200	33	10 x 15	20	135	168.4	ESK336M160AH2(1)
160	200	33	10 x 20	20	150	168.4	ESK336M160AH4(1)
160	200	47	10 x 20	20	160	235.6	ESK476M160AH4(1)
160	200	68	13 x 20	20	200	336.4	ESK686M160AL3(1)
160	200	100	13 x 25	20	250	490.0	ESK107M160AL4(1)
160	200	150	16 x 25	20	330	730.0	ESK157M160AM7(1)
160	200	220	16 x 32	20	450	1066.0	ESK227M160AM2(1)
160	200	330	18 x 36	20	540	1594.0	ESK337M160AN2(1)
160	200	470	18 x 40	20	750	2266.0	ESK477M160AN3(1)
200	250	1.0	5 x 11	20	19	16.0	ESK105M200AC3(1)
200	250	2.2	6.3 x 11	20	22	23.2	ESK225M200AE3(1)
200	250	3.3	6.3 x 11	20	30	29.8	ESK335M200AE3(1)
200	250	4.7	6.3 x 11	20	35	38.2	ESK475M200AE3(1)
200	250	6.8	8 x 11	20	40	50.8	ESK685M200AG3(1)
200	250	10	8 x 11	20	45	70.0	ESK106M200AG3(1)
200	250	22	10 x 15	20	120	142.0	ESK226M200AH2(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 120 Hz 85°C (mA)	LC 20°C 2 minutes (μA)	Part Number
200	250	33	10 x 20	20	160	208.0	ESK336M200AH4(1)
200	250	47	10 x 20	20	170	292.0	ESK476M200AH4(1)
200	250	47	13 x 20	20	200	292.0	ESK476M200AL3(1)
200	250	100	16 x 25	20	330	610.0	ESK107M200AM7(1)
200	250	220	16 x 32	20	505	1330.0	ESK227M200AM2(1)
200	250	220	18 x 25	20	485	1330.0	ESK227M200AN5(1)
200	250	330	16 x 40	20	710	1990.0	ESK337M200AM4(1)
200	250	330	18 x 32	20	685	1990.0	ESK337M200AN1(1)
200	250	470	18 x 40	20	750	2830.0	ESK477M200AN3(1)
250	300	1.0	5 x 11	20	17	17.5	ESK105M250AC3(1)
250	300	1.0	6.3 x 11	20	19	17.5	ESK105M250AE3(1)
250	300	2.2	6.3 x 11	20	24	26.5	ESK225M250AE3(1)
250	300	2.2	8 x 11	20	30	26.5	ESK225M250AG3(1)
250	300	3.3	8 x 11	20	30	34.8	ESK335M250AG3(1)
250	300	4.7	8 x 11	20	36	45.3	ESK475M250AG3(1)
250	300	6.8	8 x 11	20	40	61.0	ESK685M250AG3(1)
250	300	10	10 x 12.5	20	65	85.0	ESK106M250AH9(1)
250	300	22	10 x 20	20	130	175.0	ESK226M250AH4(1)
250	300	33	13 x 20	20	140	257.5	ESK336M250AL3(1)
250	300	47	13 x 25	20	210	362.5	ESK476M250AL4(1)
250	300	100	16 x 25	20	250	760.0	ESK107M250AM7(1)
250	300	150	16 x 32	20	330	1135.0	ESK157M250AM2(1)
250	300	220	18 x 40	20	540	1660.0	ESK227M250AN3(1)
350	400	1.0	6.3 x 11	24	19	20.5	ESK105M350AE3(1)
350	400	2.2	8 x 11	24	33	33.1	ESK225M350AG3(1)
350	400	3.3	8 x 11	24	33	44.7	ESK335M350AG3(1)
350	400	4.7	10 x 12.5	24	39	59.4	ESK475M350AH9(1)
350	400	10	10 x 15	24	70	115.0	ESK106M350AH2(1)
350	400	22	13 x 20	24	130	241.0	ESK226M350AL3(1)
350	400	33	13 x 25	24	170	356.5	ESK336M350AL4(1)
350	400	47	16 x 25	24	220	503.5	ESK476M350AM7(1)
350	400	100	16 x 36	24	620	1060.0	ESK107M350AM3(1)
350	400	100	18 x 32	24	300	1060.0	ESK107M350AN1(1)
400	450	1.0	6.3 x 11	24	16	22.0	ESK105M400AE3(1)
400	450	1.0	8 x 11	24	19	22.0	ESK105M400AG3(1)
400	450	2.2	6.3 x 11	24	20	36.4	ESK225M400AE3(1)
400	450	2.2	8 x 11	24	26	36.4	ESK225M400AG3(1)
400	450	3.3	8 x 11	24	35	49.6	ESK335M400AG3(1)
400	450	4.7	8 x 11	24	38	66.4	ESK475M400AG3(1)
400	450	4.7	10 x 12.5	24	42	66.4	ESK475M400AH9(1)
400	450	6.8	8 x 15	24	42	91.6	ESK685M400AG4(1)
400	450	6.8	10 x 12.5	24	45	91.6	ESK685M400AH9(1)
400	450	10	10 x 15	24	50	130.0	ESK106M400AH2(1)
400	450	22	13 x 20	24	100	274.0	ESK226M400AL3(1)
400	450	33	13 x 25	24	140	406.0	ESK336M400AL4(1)
400	450	47	16 x 25	24	180	574.0	ESK476M400AM7(1)
400	450	68	16 x 32	24	250	826.0	ESK686M400AM2(1)
400	450	68	18 x 25	24	220	826.0	ESK686M400AN5(1)
400	450	100	18 x 32	24	320	1210.0	ESK107M400AN1(1)
400	450	150	18 x 40	24	420	1810.0	ESK157M400AN3(1)
450	500	1.0	8 x 11	24	19	23.5	ESK105M450AG3(1)
450	500	2.2	10 x 12.5	24	33	39.7	ESK225M450AH9(1)
450	500	3.3	10 x 12.5	24	40	54.6	ESK335M450AH9(1)
450	500	4.7	10 x 12.5	24	45	73.5	ESK475M450AH9(1)
450	500	6.8	10 x 15	24	50	101.8	ESK685M450AH2(1)
450	500	10	10 x 20	24	58	145.0	ESK106M450AH4(1)
450	500	10	13 x 20	24	60	145.0	ESK106M450AL3(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 120 Hz 85°C (mA)	LC 20°C 2 minutes (μA)	Part Number
450	500	22	13 x 25	24	98	307.0	ESK226M450AL4(1)
450	500	33	16 x 25	24	145	455.5	ESK336M450AM7(1)
450	500	47	16 x 32	24	165	644.5	ESK476M450AM2(1)
450	500	47	18 x 25	24	160	644.5	ESK476M450AN5(1)
450	500	68	18 x 25	24	265	928.0	ESK686M450AN5(1)
450	500	100	18 x 40	24	330	1360.0	ESK107M450AN3(1)
450	500	150	22 x 35	24	420	2035.0	ESK157M450AQ3(1)
500	550	2.2	10 x 12.5	24	33	43.0	ESK225M500AH9(1)
500	550	3.3	10 x 15	24	43	59.5	ESK335M500AH2(1)
500	550	6.8	10 x 20	24	70	112.0	ESK685M500AH4(1)
500	550	10	13 x 20	24	93	160.0	ESK106M500AL3(1)
500	550	22	16 x 25	24	105	340.0	ESK226M500AM7(1)
500	550	33	16 x 25	24	200	505.0	ESK336M500AM7(1)
500	550	47	18 x 32	24	185	715.0	ESK476M500AN1(1)
500	550	68	18 x 36	24	370	1030.0	ESK686M500AN2(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 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 $V_R \leq 160$ 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)



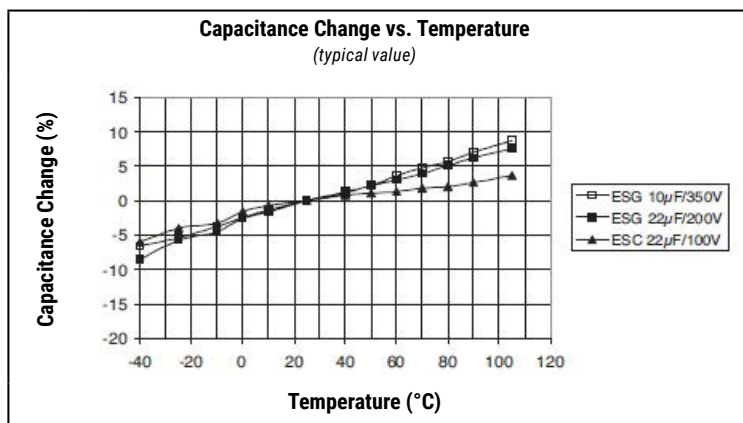
Simplified equivalent circuit diagram of an electrolytic capacitor

The capacitive component of the equivalent series circuit (Equivalent Series Capacitance ESC) is determined by applying an alternate voltage of ≤ 0.5 V at a frequency of 120 or 100 Hz and 20°C (IEC 384-1, 384-4).

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.

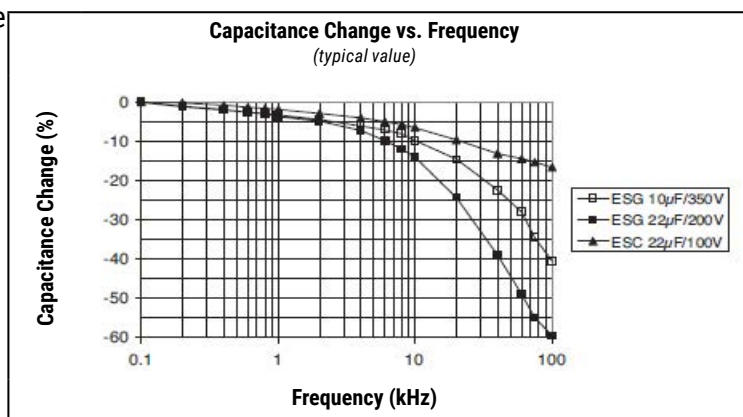


Frequency Dependence of the Capacitance

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

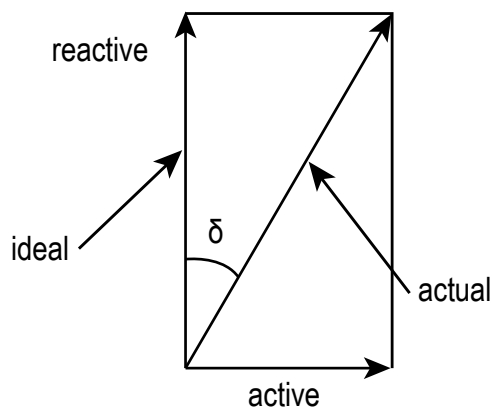
$$C = \frac{1}{2\pi fZ}$$

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



Dissipation Factor $\tan \delta$ (DF)

Dissipation Factor $\tan \delta$ 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.

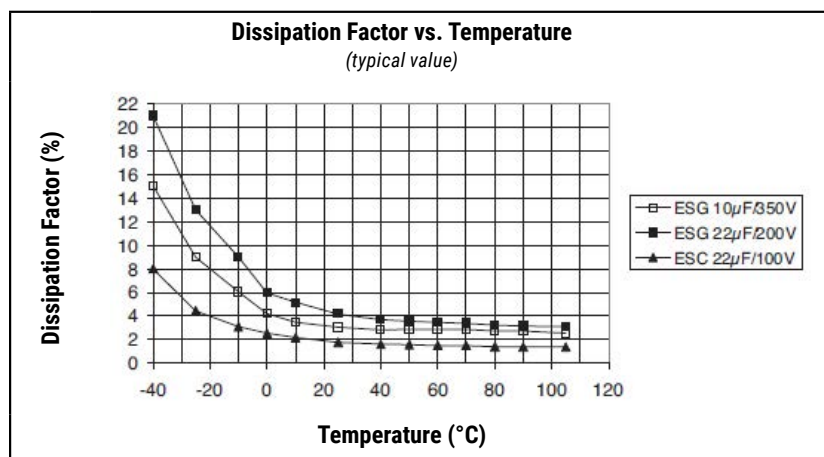
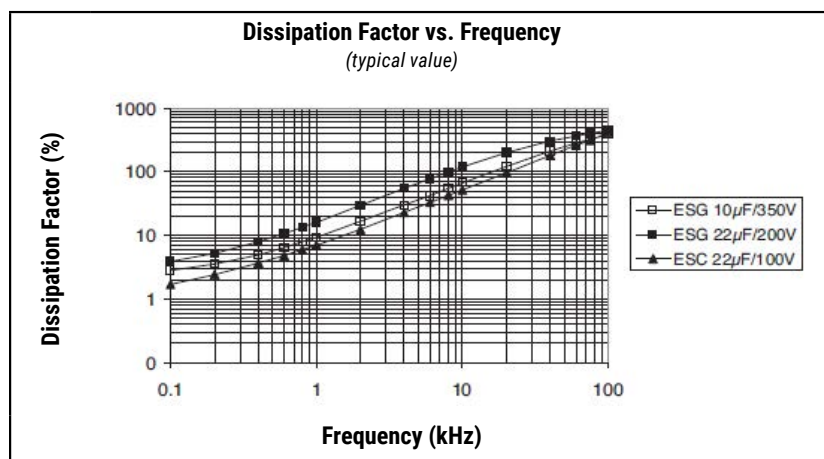


Tan δ is measured with the same set-up used for the series capacitance ESC.

$\tan \delta = \omega \times \text{ESC} \times \text{ESR}$ where:

ESC = Equivalent Series Capacitance

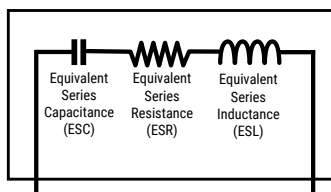
ESR = Equivalent Series Resistance



Equivalent Series Inductance (ESL)

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

Capacitor Equivalent Internal Circuit



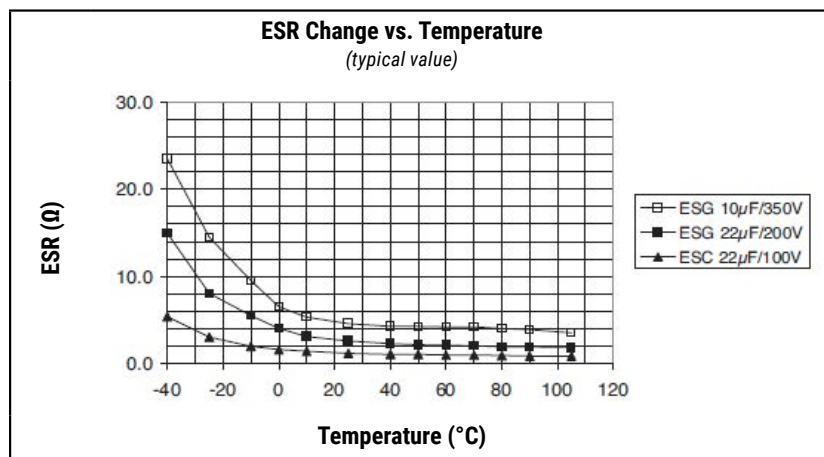
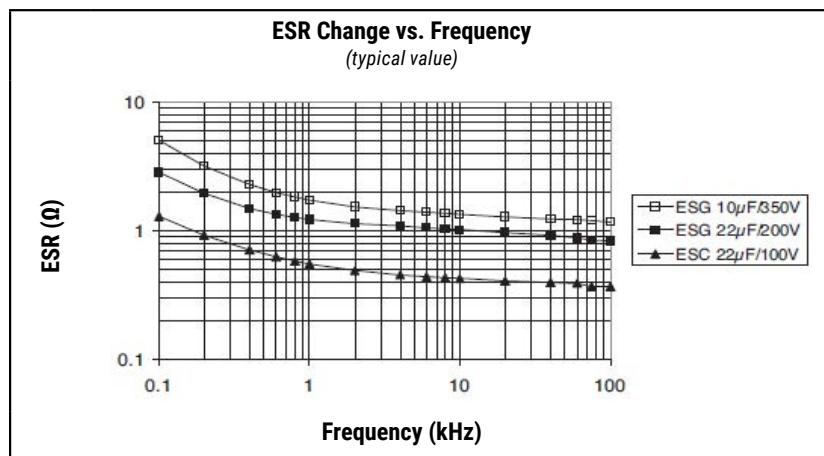
Equivalent Series Resistance (ESR)

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

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

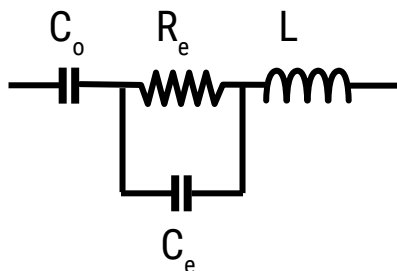
ESR = Equivalent Series Resistance (Ω)
 $\tan \delta$ = Dissipation Factor
 ESC = Equivalent Series Capacitance (F)
 f = Frequency (Hz)

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)

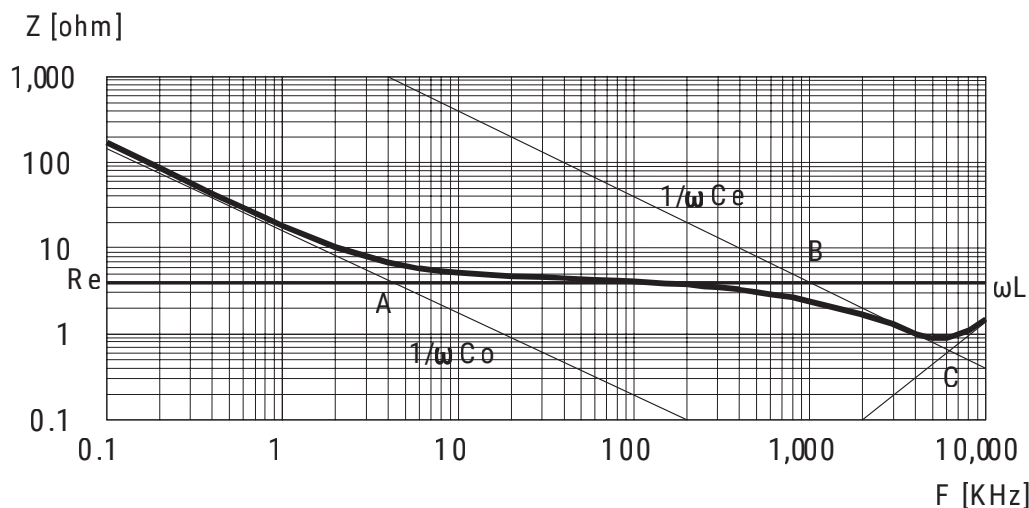
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)

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:

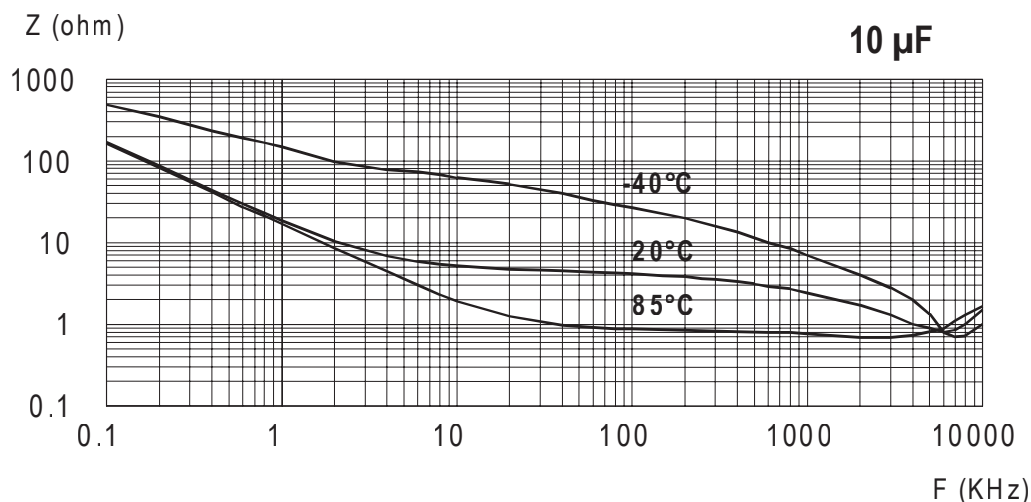


- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance $X_c = 1/\omega C_o$ decreases until it reaches the order of magnitude of electrolyte resistance R_e (A)
- At even higher frequencies, resistance of the electrolyte predominates: $Z = R_e$ (A - B)
- When the capacitor's resonance frequency is reached (ω_o), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_o = C\sqrt{1/LC_e}$
- Above this frequency, inductive reactance of the winding and its terminals ($X_L = Z = \omega L$) becomes effective and leads to an increase in impedance

Generally speaking, it can be estimated that $C_e \approx 0.01 C_o$.

Impedance (Z) cont'd

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.

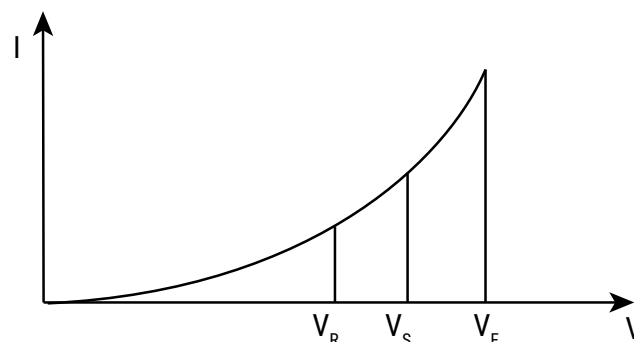
A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease and reach an almost constant value.

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.

Leakage Current (LC) cont'd

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: $L = L_0 \times 2^{(T_0 - T)/10}$

Where:

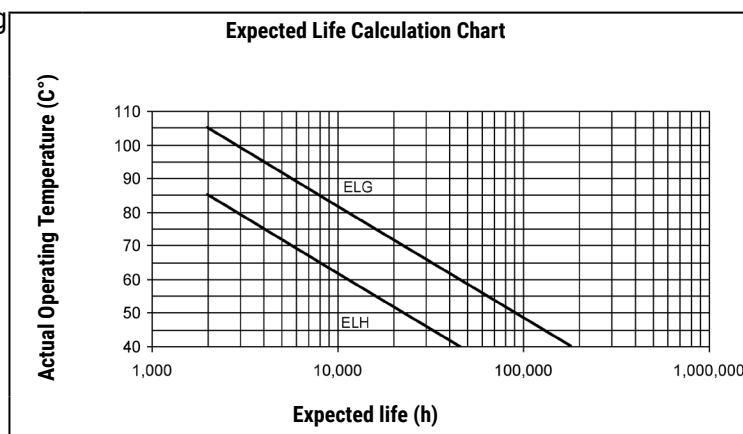
L : Expected life

L_0 : Load life at maximum permissible operating temperature

T : Actual operating temperature

T_0 : Maximum permissible operating temperature

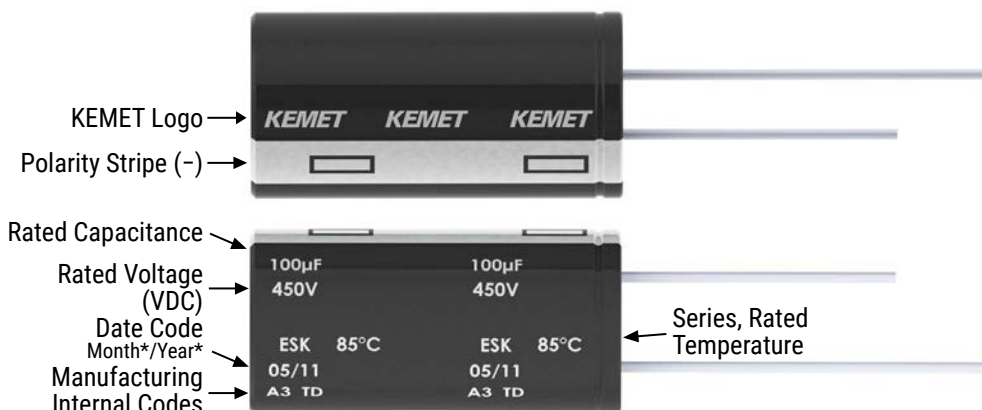
This formula is applicable between 40°C and T_0 .



Packaging Quantities

Size Code	Diameter (mm)	Length (mm)	Bulk		Auto-insertion	
			Standard Leads	Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	2600
E3	6.3	11	10000	15000	2000	2200
G3	8	11	6000	8000	1000	1500
G4	8	15	5000	5000	1000	1500
H9	10	12.5	4000	4000	700	1200
H2	10	15	3000	4000	700	1200
H4	10	20	2400	3000	700	1200
L2	13	16	2400	2400	500	
L3	13	20	2000	2000	500	
L4	13	25	1600	1600	500	
M7	16	25	1000	500	300	
M2	16	32	800	500	300	
M3	16	36	600	500	300	
M4	16	40	600	500	300	
N5	18	25	800	500	300	
N1	18	32	500	500		
N2	18	36	500	500		
N3	18	40	500	500		
Q3	22	35	400	400		
Q4	22	40	300	400		

Marking



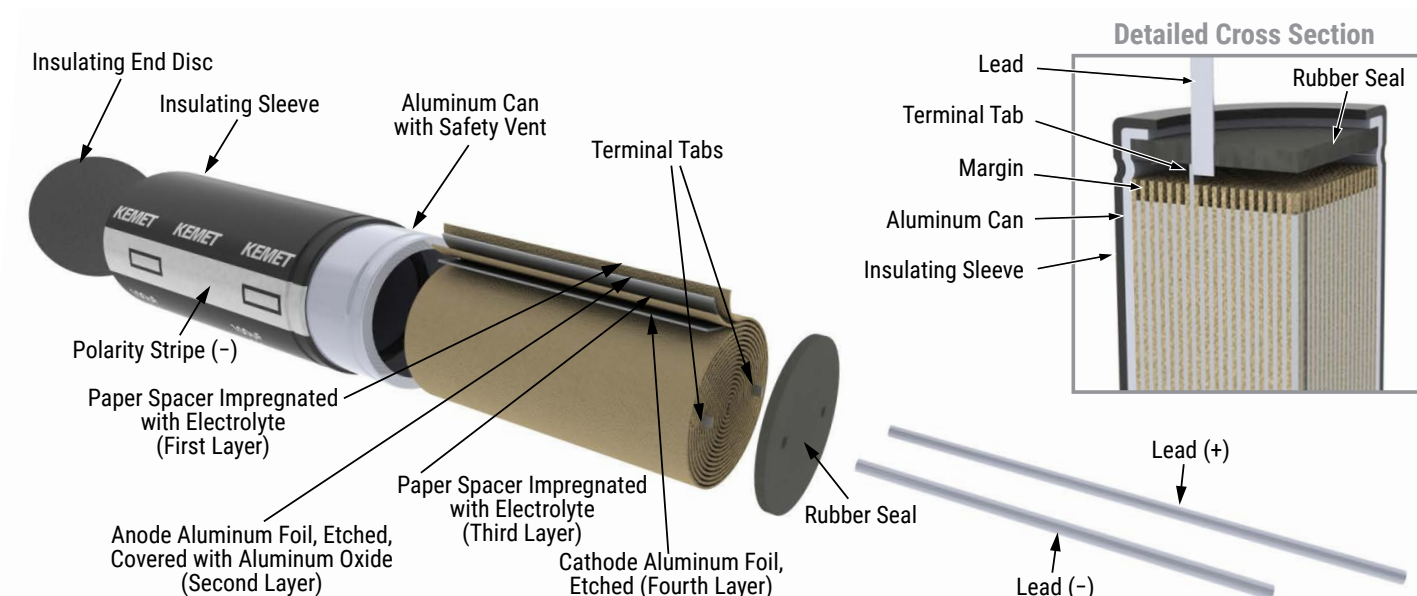
*Y = Year

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

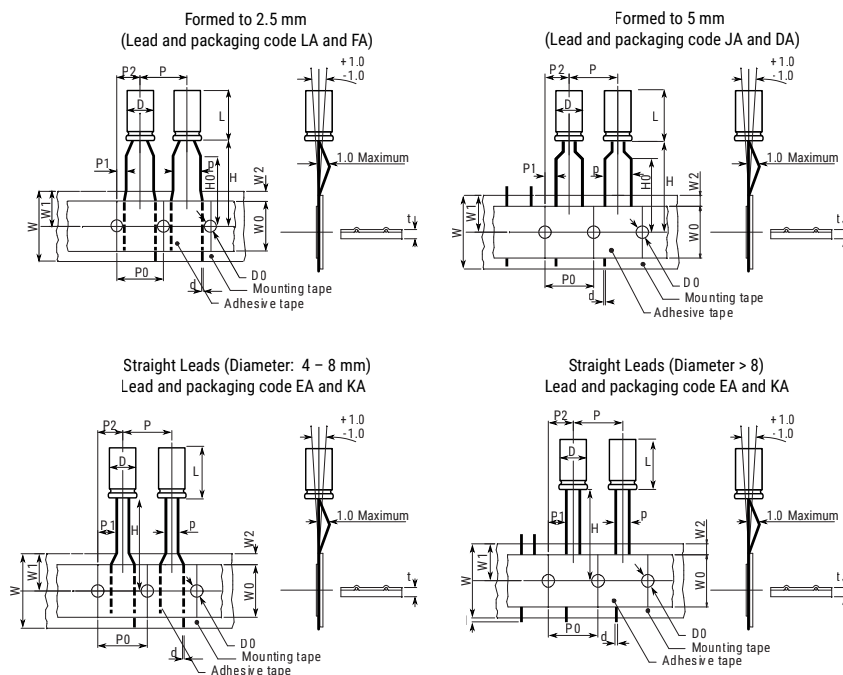
*M = Month

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

Construction

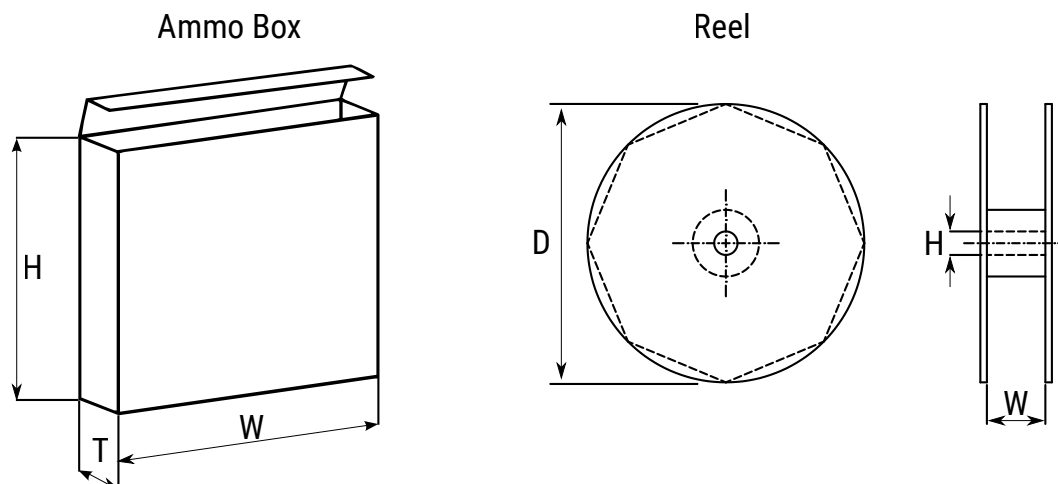


Taping for Automatic Insertion Machines



Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	I	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1.0	±0.3	±0.7	±1.3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤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
	10	12-25	5	0.6	12.7	12.7	3.85	6.35	18	12	11	3	18.5		1	4	1
	12		5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
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		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
	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

Lead Taping & Packaging



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			
6.3 x 5 – 7	275	340	42			
8 x 5 – 9	235	340	45			
5 x 11	230	340	48			
6.3 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 Data

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. This sample size is controlled by the use of recognized sampling tables defined in BS 6001.

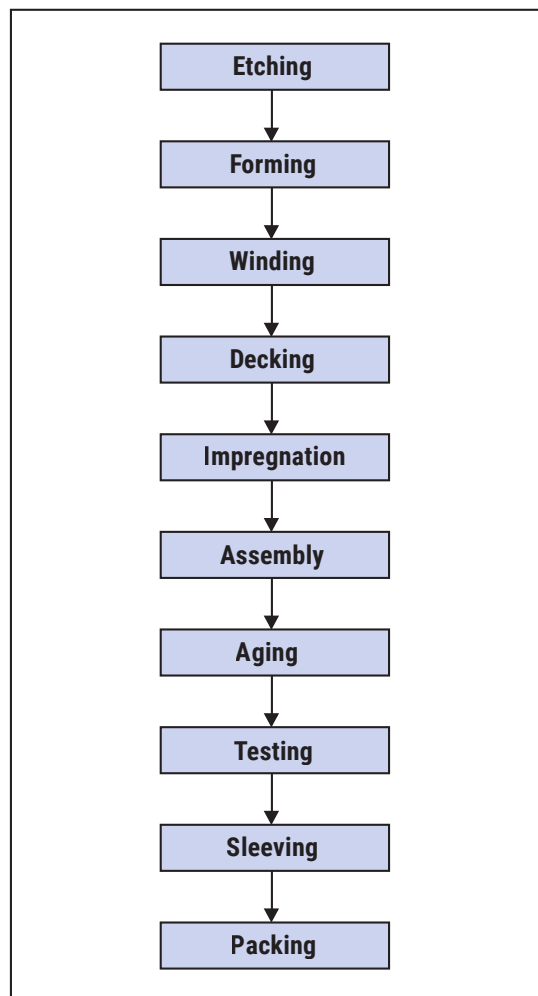
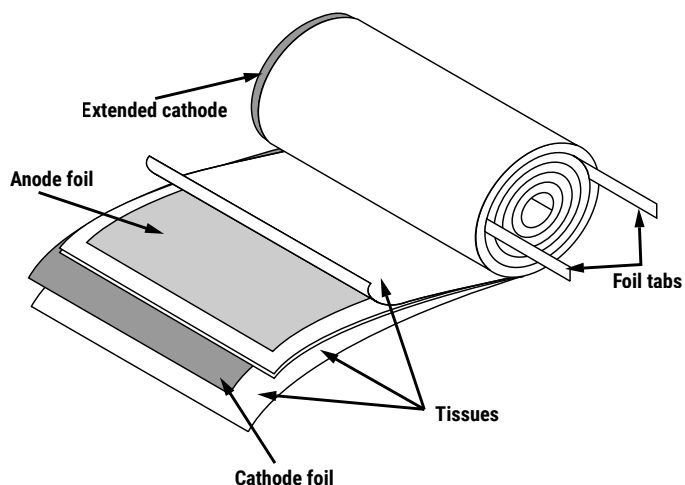
The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

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



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