EST Series, +105°C

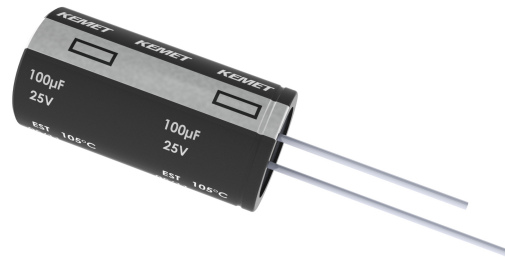**Electronic Components**
KEMET
CHARGED.

Overview

KEMET's EST Series of single-ended aluminum electrolytic capacitors are designed for low impedance and long life (up to 10,000 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 ≥ 5 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
Single-Ended Aluminum Electrolytic	First two digits represent significant figures for capacitance values. Last digit specifies 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

One world. One KEMET

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

SIDE VIEW

TERMINAL END VIEW

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
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
H8	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	35	+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
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	2.2 – 15,000 µF
Capacitance Tolerance	±20% at 120 Hz/20°C
Rated Voltage	6.3 – 100 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.

Impedance Z Characteristics at 120 Hz

Rated Voltage (VDC)	6	10	16	25	35	50	63	100
Z (−25°C)/Z (20°C)	4	3	2	2	2	2	2	2
Z (−40°C)/Z (20°C)	8	6	4	3	3	3	3	3

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	
	Can Ø = 8, 10 mm	V ≤ 10 VDC	6,000 hours	
	Can Ø = 8, 10 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			

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.

Electronic Components
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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 25°C (Ω)	LC 20°C 2 Minutes (µA)	Part Number
6.3	8	150	5 x 11	22	210	0.72	9.5	EST157M6R3AC3(1)
6.3	8	330	6.3 x 11	22	340	0.38	20.8	EST337M6R3AE3(1)
6.3	8	680	8 x 11	22	640	0.2	42.8	EST687M6R3AG3(1)
6.3	8	820	8 x 15	22	840	0.16	51.7	EST827M6R3AG4(1)
6.3	8	1000	10 x 12.5	22	865	0.12	63.0	EST108M6R3AH9(1)
6.3	8	1500	8 x 20	22	1050	0.11	94.5	EST158M6R3AG6(1)
6.3	8	1500	10 x 15	22	1210	0.084	94.5	EST158M6R3AH2(1)
6.3	8	2200	10 x 20	22	1400	0.062	138.6	EST228M6R3AH4(1)
6.3	8	2700	10 x 25	22	1650	0.052	170.1	EST278M6R3AH5(1)
6.3	8	3300	13 x 20	22	1900	0.046	207.9	EST338M6R3AL3(1)
6.3	8	3900	13 x 25	22	2230	0.034	245.7	EST398M6R3AL4(1)
6.3	8	4700	13 x 30	22	2650	0.03	296.1	EST478M6R3AL8(1)
6.3	8	5600	13 x 35	22	2880	0.027	352.8	EST568M6R3AL6(1)
6.3	8	6800	13 x 40	22	3350	0.024	428.4	EST688M6R3AL7(1)
6.3	8	6800	16 x 25	22	2930	0.028	428.4	EST688M6R3AM7(1)
6.3	8	8200	16 x 32	22	3450	0.025	516.6	EST828M6R3AM2(1)
6.3	8	10000	16 x 36	22	3610	0.018	630.0	EST109M6R3AM3(1)
6.3	8	12000	18 x 32	22	4170	0.015	756.0	EST129M6R3AN1(1)
6.3	8	15000	18 x 36	22	4220	0.014	945.0	EST159M6R3AN2(1)
10	13	100	5 x 11	19	210	0.72	10.0	EST107M010AC3(1)
10	13	220	6.3 x 11	19	340	0.38	22.0	EST227M010AE3(1)
10	13	470	8 x 11	19	640	0.2	47.0	EST477M010AG3(1)
10	13	680	8 x 15	19	840	0.16	68.0	EST687M010AG4(1)
10	13	1000	10 x 15	19	1210	0.084	100.0	EST108M010AH2(1)
10	13	1500	10 x 20	19	1400	0.062	150.0	EST158M010AH4(1)
10	13	2200	10 x 25	19	1650	0.052	220.0	EST228M010AH5(1)
10	13	2700	13 x 20	19	1900	0.046	270.0	EST278M010AL3(1)
10	13	3300	13 x 25	19	2230	0.034	330.0	EST338M010AL4(1)
10	13	3900	13 x 30	19	2650	0.03	390.0	EST398M010AL8(1)
10	13	4700	13 x 35	19	2880	0.027	470.0	EST478M010AL6(1)
10	13	5600	13 x 40	19	3350	0.024	560.0	EST568M010AL7(1)
10	13	5600	16 x 25	19	2930	0.028	560.0	EST568M010AM7(1)
10	13	6800	16 x 32	19	3450	0.025	680.0	EST688M010AM2(1)
10	13	8200	16 x 36	19	3610	0.018	820.0	EST828M010AM3(1)
10	13	1000	18 x 36	19	4220	0.014	100.0	EST108M010AN2(1)
16	20	56	5 x 11	16	210	0.72	9.0	EST566M016AC3(1)
16	20	100	6.3 x 11	16	340	0.38	16.0	EST107M016AE3(1)
16	20	220	8 x 11	16	640	0.2	35.2	EST227M016AG3(1)
16	20	330	8 x 15	16	701	0.16	52.8	EST337M016AG4(1)
16	20	470	8 x 15	16	840	0.16	75.2	EST477M016AG4(1)
16	20	680	10 x 15	16	1210	0.084	108.8	EST687M016AH2(1)
16	20	1000	10 x 20	16	1400	0.062	160.0	EST108M016AH4(1)
16	20	1500	10 x 25	16	1650	0.052	240.0	EST158M016AH5(1)
16	20	2200	13 x 25	16	2230	0.034	352.0	EST228M016AL4(1)
16	20	2700	13 x 30	16	2650	0.03	432.0	EST278M016AL8(1)
16	20	3300	13 x 35	16	2880	0.027	528.0	EST338M016AL6(1)
16	20	3900	13 x 40	16	3350	0.024	624.0	EST398M016AL7(1)
16	20	4700	16 x 32	16	3450	0.028	752.0	EST478M016AM2(1)
16	20	5600	16 x 36	16	3610	0.018	896.0	EST568M016AM3(1)
16	20	5600	18 x 32	16	4170	0.015	896.0	EST568M016AN1(1)
16	20	6800	18 x 36	16	4220	0.014	1088.0	EST688M016AN2(1)
25	32	47	5 x 11	14	210	0.72	11.8	EST476M025AC3(1)
25	32	100	6.3 x 11	14	340	0.38	25.0	EST107M025AE3(1)
25	32	150	8 x 11	14	640	0.2	37.5	EST157M025AG3(1)
25	32	220	8 x 11	14	640	0.2	55.0	EST227M025AG3(1)
25	32	330	8 x 15	14	840	0.16	82.5	EST337M025AG4(1)
25	32	470	10 x 15	14	1210	0.084	117.5	EST477M025AH2(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**ESR**	**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 25°C (Ω)	LC 20°C 2 Minutes (µA)	Part Number
25	32	680	10 x 20	14	1400	0.062	170.0	EST687M025AH4(1)
25	32	820	10 x 25	14	1650	0.052	205.0	EST827M025AH5(1)
25	32	1000	13 x 20	14	1900	0.046	250.0	EST108M025AL3(1)
25	32	1500	13 x 25	14	2230	0.034	375.0	EST158M025AL4(1)
25	32	2200	13 x 35	14	2880	0.027	550.0	EST228M025AL6(1)
25	32	2700	16 x 25	14	2930	0.028	675.0	EST278M025AM7(1)
25	32	3300	16 x 32	14	3450	0.025	825.0	EST338M025AM2(1)
25	32	3900	18 x 32	14	4170	0.015	975.0	EST398M025AN1(1)
25	32	4700	18 x 36	14	4280	0.014	1175.0	EST478M025AN2(1)
35	44	33	5 x 11	12	210	0.72	11.6	EST336M035AC3(1)
35	44	47	6.3 x 11	12	340	0.38	16.5	EST476M035AE3(1)
35	44	150	8 x 11	12	640	0.2	52.5	EST157M035AG3(1)
35	44	220	8 x 15	12	840	0.16	77.0	EST227M035AG4(1)
35	44	330	10 x 20	12	1400	0.062	115.5	EST337M035AH4(1)
35	44	470	10 x 25	12	1650	0.052	164.5	EST477M035AH5(1)
35	44	680	10 x 30	12	1910	0.044	238.0	EST687M035AH6(1)
35	44	680	13 x 20	12	1900	0.046	238.0	EST687M035AL3(1)
35	44	820	13 x 25	12	2230	0.045	287.0	EST827M035AL4(1)
35	44	1000	13 x 25	12	2230	0.045	350.0	EST108M035AL4(1)
35	44	1200	13 x 30	12	2650	0.03	420.0	EST128M035AL8(1)
35	44	1500	13 x 35	12	2880	0.027	525.0	EST158M035AL6(1)
35	44	1800	13 x 40	12	3350	0.024	630.0	EST188M035AL7(1)
35	44	2200	16 x 32	12	3450	0.025	770.0	EST228M035AM2(1)
35	44	2700	16 x 36	12	3610	0.022	945.0	EST278M035AM3(1)
35	44	3300	18 x 36	12	4220	0.02	1155.0	EST338M035AN2(1)
50	63	10	5 x 11	14	120	3.5	5.0	EST106M050AC3(1)
50	63	22	5 x 11	14	210	2.3	11.0	EST226M050AC3(1)
50	63	33	6.3 x 11	14	340	1.2	16.5	EST336M050AE3(1)
50	63	47	6.3 x 11	14	340	1.2	23.5	EST476M050AE3(1)
50	63	100	8 x 11	14	555	0.63	50.0	EST107M050AG3(1)
50	63	120	8 x 15	14	730	0.45	60.0	EST127M050AG4(1)
50	63	150	8 x 20	14	910	0.33	75.0	EST157M050AG6(1)
50	63	220	10 x 16	14	1050	0.31	110.0	EST227M050AH8(1)
50	63	330	10 x 20	14	1400	0.21	165.0	EST337M050AH4(1)
50	63	470	10 x 30	14	1690	0.15	235.0	EST477M050AH6(1)
50	63	470	13 x 20	14	1660	0.16	235.0	EST477M050AL3(1)
50	63	560	13 x 25	14	1950	0.12	280.0	EST567M050AL4(1)
50	63	680	13 x 30	14	2310	0.1	340.0	EST687M050AL8(1)
50	63	820	13 x 35	14	2510	0.083	410.0	EST827M050AL6(1)
50	63	1000	16 x 25	14	2555	0.073	500.0	EST108M050AM7(1)
50	63	1200	16 x 32	14	3010	0.054	600.0	EST128M050AM2(1)
50	63	1500	16 x 36	14	3150	0.045	750.0	EST158M050AM3(1)
50	63	1800	18 x 32	14	3635	0.047	900.0	EST188M050AN1(1)
50	63	2200	18 x 36	14	3680	0.04	1100.0	EST228M050AN2(1)
50	63	2700	18 x 40	14	3800	0.036	1350.0	EST278M050AN3(1)
63	79	10	5 x 11	14	55	2.3	6.3	EST106M063AC3(1)
63	79	33	6.3 x 11	14	115	1.2	20.8	EST336M063AE3(1)
63	79	56	8 x 11	14	232	0.63	35.3	EST566M063AG3(1)
63	79	120	10 x 16	14	357	0.31	75.6	EST127M063AH8(1)
63	79	180	10 x 20	14	466	0.21	113.4	EST187M063AH4(1)
63	79	220	10 x 25	14	531	0.2	138.6	EST227M063AH5(1)
63	79	270	10 x 30	14	663	0.15	170.1	EST277M063AH6(1)
63	79	270	13 x 20	14	690	0.16	170.1	EST277M063AL3(1)
63	79	330	13 x 25	14	784	0.12	207.9	EST337M063AL4(1)
63	79	470	13 x 30	14	905	0.1	296.1	EST477M063AL8(1)
63	79	560	13 x 35	14	1050	0.083	352.8	EST567M063AL6(1)
63	79	680	13 x 40	14	1180	0.071	428.4	EST687M063AL7(1)
VDC	**VDC Surge**	**Rated Capacitance**	**Case Size**	**DF**	**RC**	**ESR**	**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 25°C (Ω)	LC 20°C 2 Minutes (µA)	Part Number
63	79	820	16 x 32	14	1570	0.054	516.6	EST827M063AM2(1)
63	79	1000	16 x 36	14	1790	0.045	630.0	EST108M063AM3(1)
63	79	1200	16 x 40	14	2020	0.04	756.0	EST128M063AM4(1)
100	125	2.2	5 x 11	14	20	10	3.0	EST225M100AC3(1)
100	125	3.3	5 x 11	14	27	8.5	3.3	EST335M100AC3(1)
100	125	4.7	5 x 11	14	30	8	4.7	EST475M100AC3(1)
100	125	6.8	5 x 11	14	45	7.5	6.8	EST685M100AC3(1)
100	125	10	6.3 x 11	14	55	5	10.0	EST106M100AE3(1)
100	125	15	6.3 x 11	14	70	5	15.0	EST156M100AE3(1)
100	125	22	8 x 11	14	85	2.7	22.0	EST226M100AG3(1)
100	125	33	8 x 11	14	95	2.5	33.0	EST336M100AG3(1)
100	125	47	8 x 15	14	150	1.8	47.0	EST476M100AG4(1)
100	125	56	8 x 20	14	200	1.5	56.0	EST566M100AG6(1)
100	125	68	10 x 15	14	230	1.3	68.0	EST686M100AH2(1)
100	125	82	10 x 20	14	250	1.2	82.0	EST826M100AH4(1)
100	125	100	10 x 20	14	330	0.95	100.0	EST107M100AH4(1)
100	125	120	10 x 25	14	400	0.8	120.0	EST127M100AH5(1)
100	125	150	13 x 20	14	460	0.9	150.0	EST157M100AL3(1)
100	125	220	13 x 25	14	640	0.6	220.0	EST227M100AL4(1)
100	125	330	16 x 25	14	720	0.57	330.0	EST337M100AM7(1)
100	125	470	16 x 32	14	770	0.55	470.0	EST477M100AM2(1)
100	125	470	18 x 25	14	840	0.5	470.0	EST477M100AN5(1)
100	125	680	18 x 36	14	1400	0.18	680.0	EST687M100AN2(1)
100	125	820	18 x 40	14	1850	0.13	820.0	EST827M100AN3(1)
100	125	1000	18 x 40	14	1850	0.13	1000.0	EST108M100AN3(1)
VDC	VDC Surge	Rated Capacitance	Case Size	DF	RC	ESR	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 ≤ 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.

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Application and Operation Guidelines

Electrical Ratings:
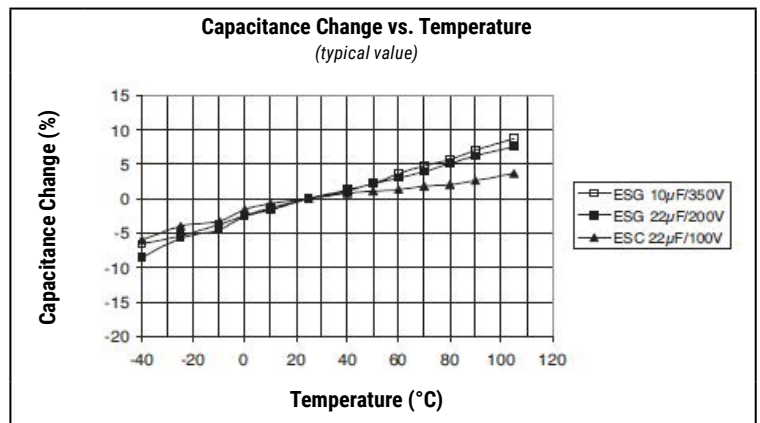**Capacitance (ESC)**

ESC   ESR   ESL

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.

Capacitance Change vs. Temperature
(typical value)

Capacitance Change (%) vs. Temperature (°C)

ESG 10μF/350V
ESG 22μF/200V
ESC 22μF/100V

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)

Capacitance Change vs. Frequency
(typical value)

Capacitance Change (%) vs. Frequency (kHz)

ESG 10μF/350V
ESG 22μF/200V
ESC 22μF/100V
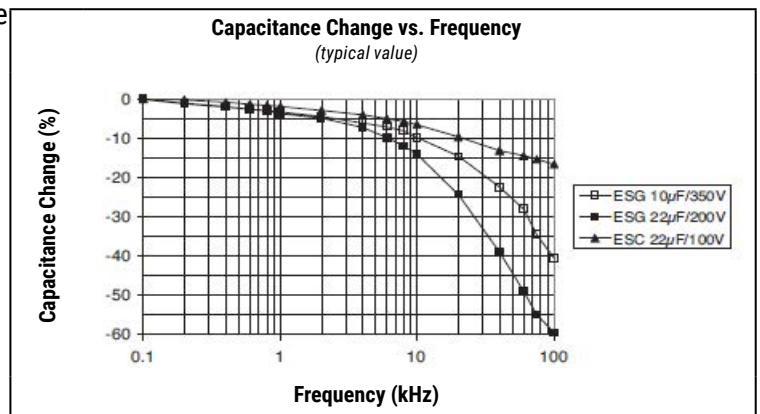
Dissipation Factor tan δ (DF)

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.
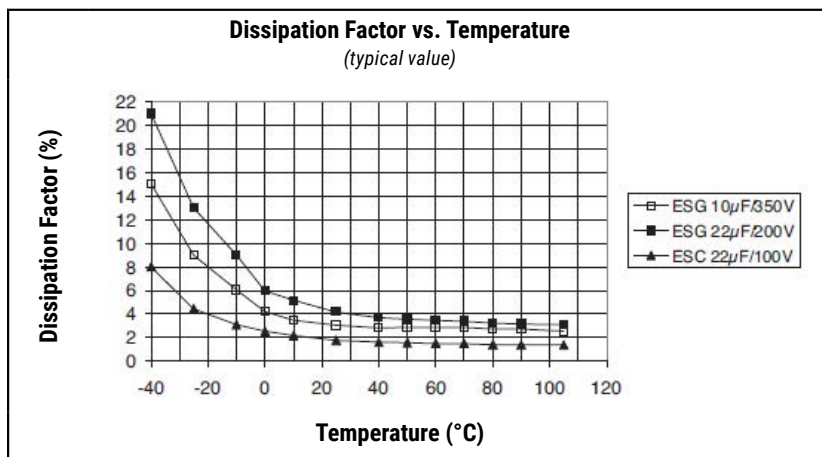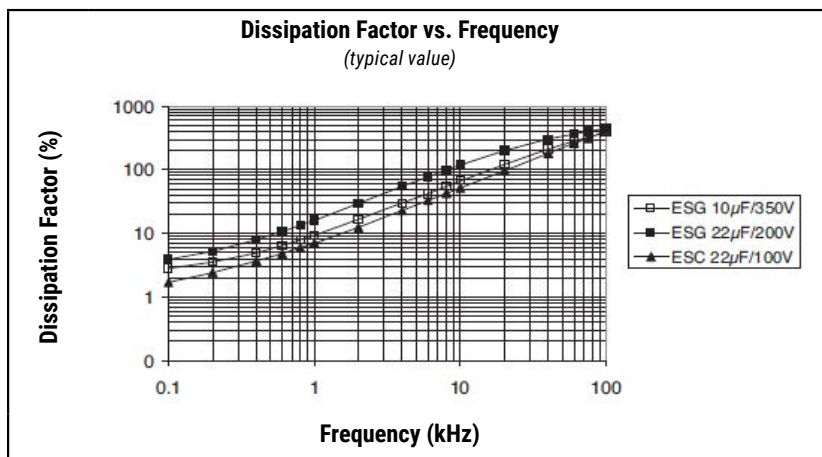
reactive

ideal

δ

actual

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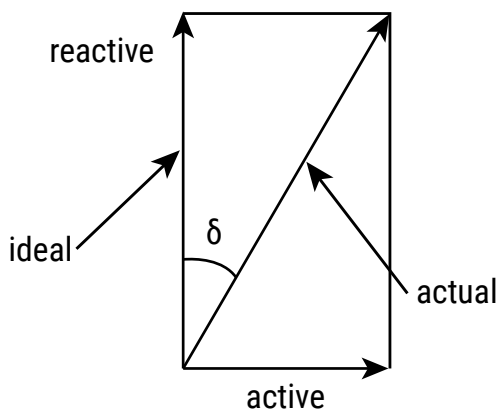
Tan δ is measured with the same set-up used for the series capacitance ESC.

tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance

ESR = Equivalent Series Resistance

Dissipation Factor vs. Frequency
(typical value)

Dissipation Factor (%)

Frequency (kHz)

- ESG 10µF/350V
- ESG 22µF/200V
- ESC 22µF/100V

Dissipation Factor vs. Temperature
(typical value)

Dissipation Factor (%)

Temperature (°C)

- ESG 10µF/350V
- ESG 22µF/200V
- ESC 22µF/100V

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 Capacitance (ESC)   Equivalent Series Resistance (ESR)   Equivalent Series Inductance (ESL)
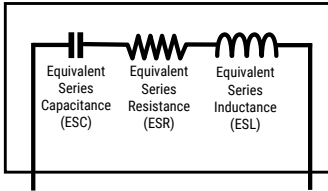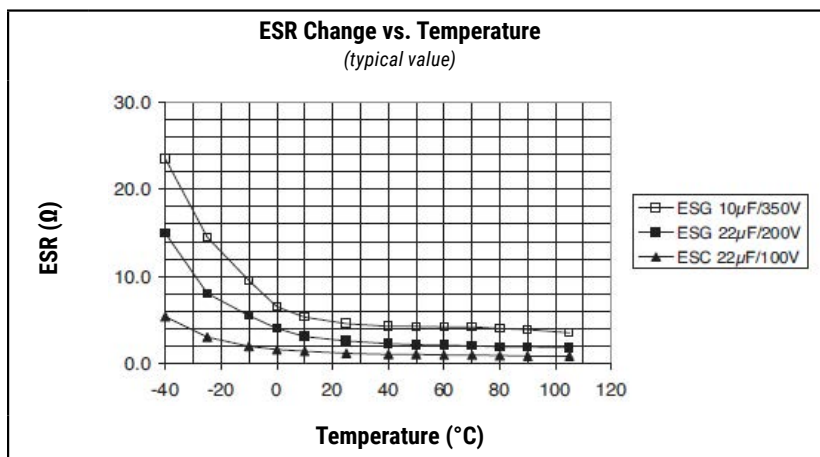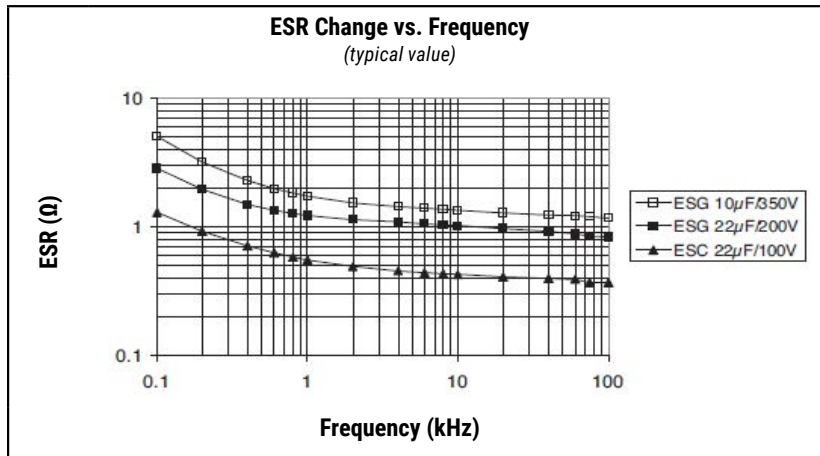
Equivalent Series Resistance (ESR)

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

ESR Change vs. Frequency
(typical value)

ESG 10μF/350V
ESG 22μF/200V
ESC 22μF/100V

ESR (Ω)

Frequency (kHz)

ESR Change vs. Temperature
(typical value)

ESG 10μF/350V
ESG 22μF/200V
ESC 22μF/100V

ESR (Ω)

Temperature (°C)

Impedance (Z)

Impedance of an electrolytic capacitor results from a circuit formed by the following individual equivalent series components:
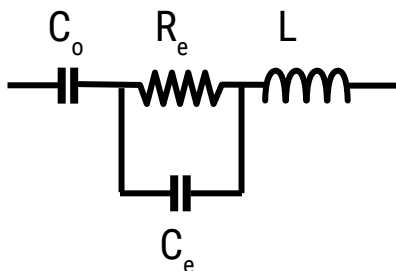
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)

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:
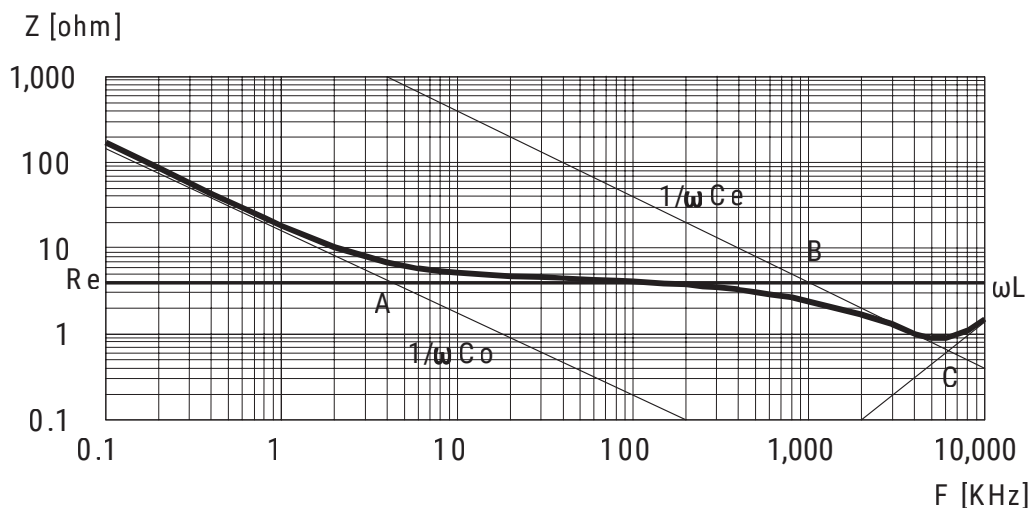

• Capacitive reactance predominates at low frequencies
• With increasing frequency, capacitive reactance $X_c = 1/\omega C_o$ decreases until it reaches the order of magnitude of electrolyte resistance R_e(A)
• At even higher frequencies, resistance of the electrolyte predominates: $Z = R_e$ (A - B)
• When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/\omega C_e = \omega L$, $\omega_0 = 1/SQR(LC_e)$
• 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):
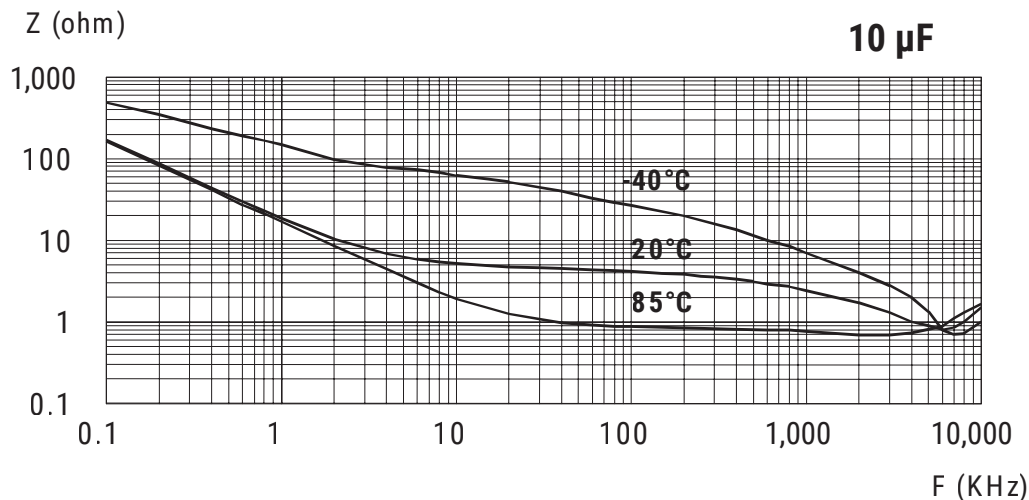
R_e is the most temperature-dependent component of an electrolytic capacitor equivalent circuit. Electrolyte resistivity will decrease if temperature rises.

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:
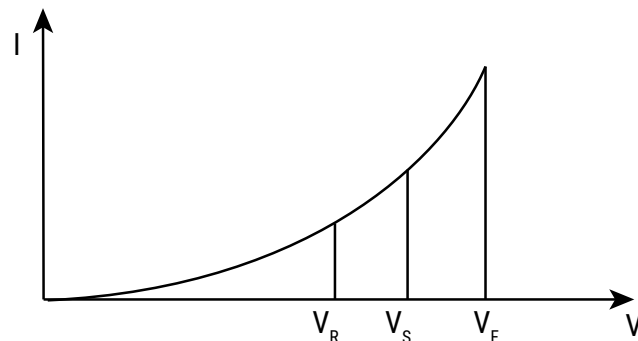
Where:

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: $L = Lo \times 2^{(To-T)/10}$
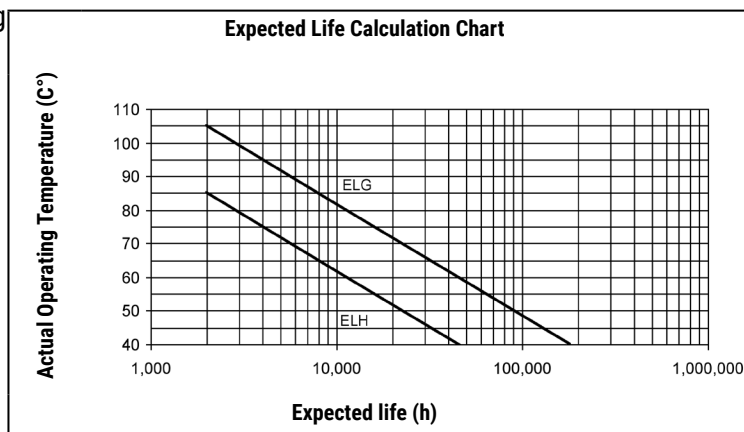
Where:

L: Expected life

Lo: Load life at maximum permissible operating temperature

T: Actual operating temperature
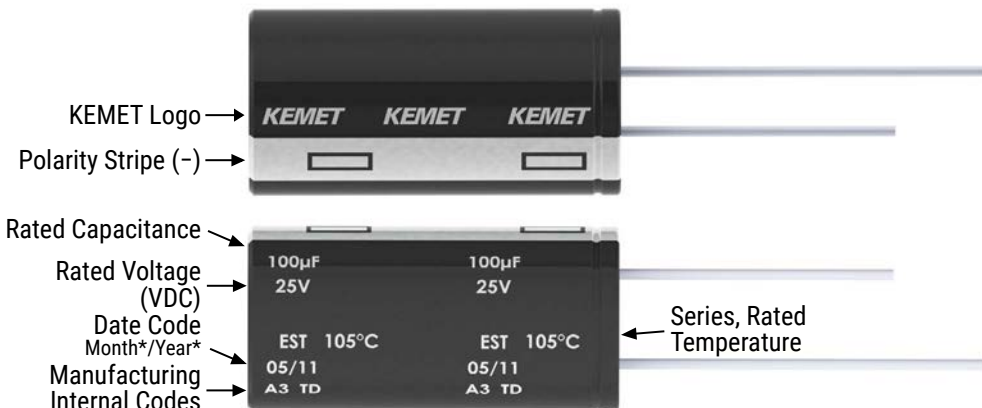
To: Maximum permissible operating temperature

This formula is applicable between 40°C and To.

Expected Life Calculation Chart

Packaging Quantities

Size Code	Diameter (mm)	Length (mm)	Bulk		Auto-insertion	
			Standard Leads	Cut Leads	Ammo	Tape & Reel
C3	5	11	10,000	15,000	2,000	2,600
E3	6.3	11	10,000	15,000	2,000	2,200
G3	8	11	6,000	8,000	1,000	1,500
G4	8	15	5,000	5,000	1,000	1,500
G6	8	20	4,000	4,000	1,000	1,500
H9	10	12.5	4,000	4,000	700	1,200
H2	10	15	3,000	4,000	700	1,200
H8	10	16	3,000	4,000	700	1,200
H4	10	20	2,400	3,000	700	1,200
H5	10	25	2,400	2,400	500	
H6	10	30	2,000	2,000	500	
L3	13	20	2,000	2,000	500	
L4	13	25	1,600	1,600	500	
L8	13	30	1,200	1,200	500	
L6	13	35	1,000	500	500	
L7	13	40	1,000	500	500	
M7	16	25	1,000	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		

Marking

KEMET Logo →

Polarity Stripe (−) →

Rated Capacitance

Rated Voltage (VDC)

Date Code
Month*/Year*

Manufacturing Internal Codes

100μF
25V

EST 105°C
05/11
A3 TD

100μF
25V

EST 105°C
05/11
A3 TD

Series, Rated Temperature

*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

Insulating End Disc

Insulating Sleeve

Aluminum Can with Safety Vent

Terminal Tabs

Polarity Stripe (−)

Paper Spacer Impregnated with Electrolyte (First Layer)

Anode Aluminum Foil, Etched, Covered with Aluminum Oxide (Second Layer)

Paper Spacer Impregnated with Electrolyte (Third Layer)

Cathode Aluminum Foil, Etched (Fourth Layer)

Rubber Seal

Lead (+)

Lead (−)

Detailed Cross Section

Lead

Rubber Seal

Terminal Tab

Margin

Aluminum Can

Insulating Sleeve

Taping for Automatic Insertion Machines

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

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

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

Straight Leads (Diameter > 8)
Lead and packaging code EA and KA
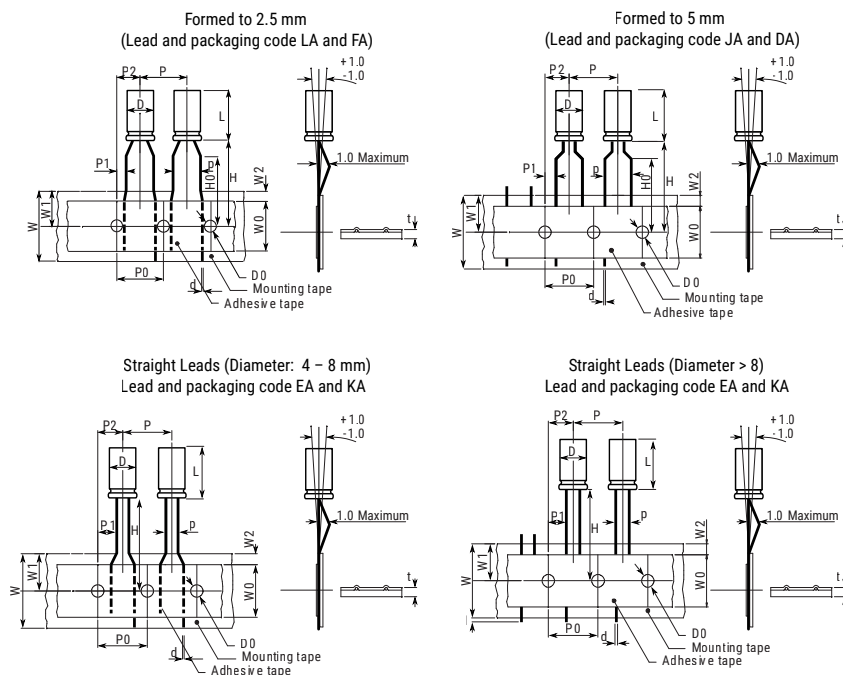
Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	I	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1.0	±0.3	±0.7	±1.3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5–7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	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
		15–25	5	0.6	15	15	3.85	7.5	18	12	11	3		18.5	1	4	1
	16		7.5	0.8	30	30	3.75	7.5	18	12	11	3		18.5	1	4	1
	18		7.5	0.8	30	30	3.75	7.5	18	12	11	3		18.5	1	4	1

Electronic Components

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Lead Taping & Packaging

Ammo Box
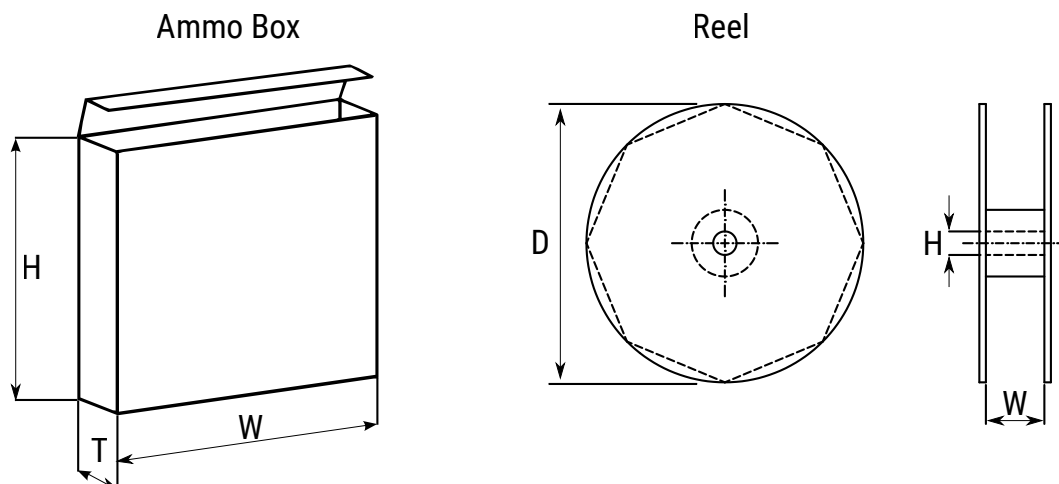
Reel

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			
6.3 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.
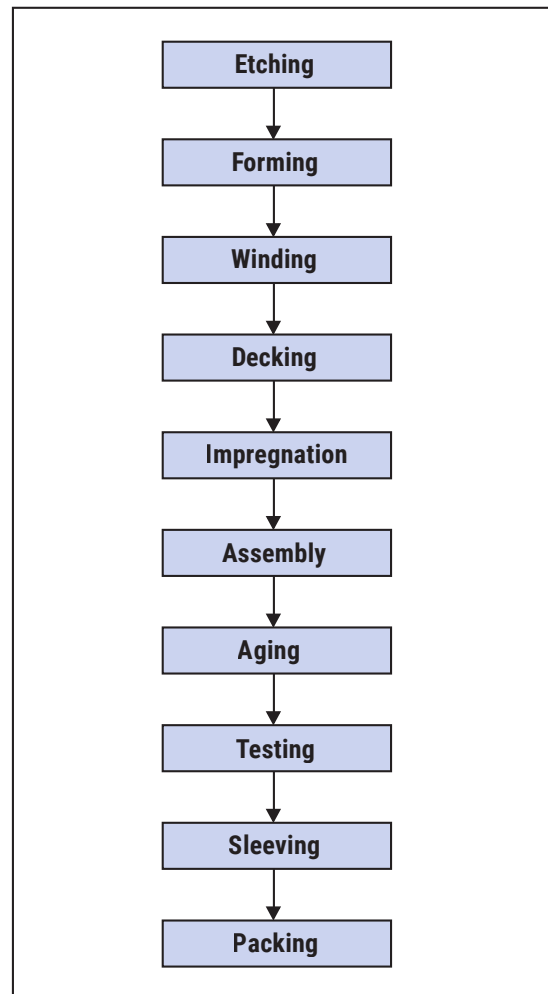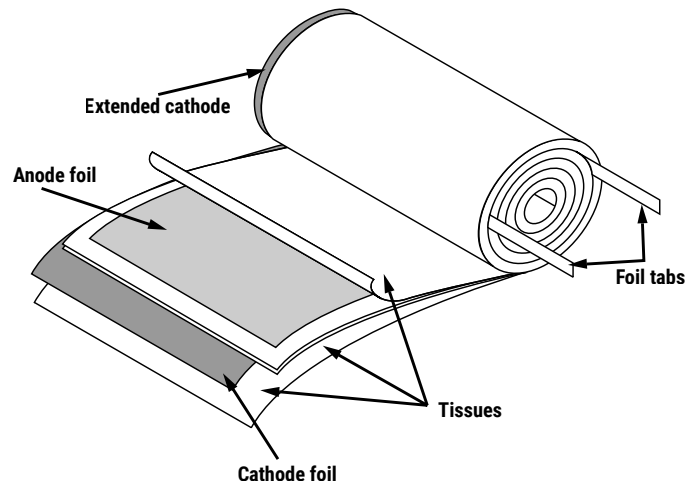
The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

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

Extended cathode

Anode foil

Foil tabs

Tissues

Cathode foil

Etching → Forming → Winding → Decking → Impregnation → Assembly → Aging → Testing → Sleeving → Packing

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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 indicted or that other measures may not be required.

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