

## Overview

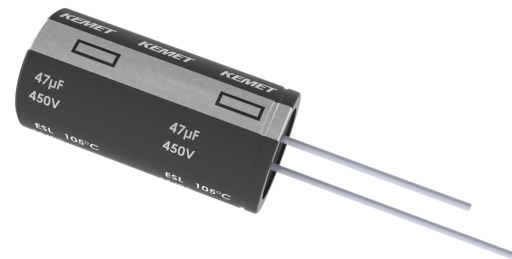
KEMET's ESL Series of aluminum electrolytic single-ended capacitors are designed for high reliability and long life (up to 10,000 hours) applications.

## Applications

Typical applications include LED drive source.

## Benefits

- Long life, up to 10,000 hours
- Operating temperature of up to +105°C
- Safety vent on the capacitor base



## Part Number System

ESL	106	M	016		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%	016 = 16 025 = 25 035 = 35 050 = 50 063 = 63 100 = 100	160 = 160 200 = 200 250 = 250 350 = 350 400 = 400 450 = 450	A = Standard	See Dimension Table	See Ordering Options Table

## Ordering Options Table

Diameter	Packaging Type	Lead Type	Lead Length (mm)	Lead and Packaging Code
Standard Bulk Packaging Options				
4 – 22	Bulk (bag)	Straight	20/15 Minimum	AA
Standard Auto-Insertion Packaging Options				
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
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	2.0	±0.5	0.5	Nominal	20/15	Minimum
GM	8	±0.5	11.5	+2.0/-0	3.5	±0.5	0.6	Nominal	20/15	Minimum
G9	8	±0.5	12	+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
GG	8	±0.5	50	+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
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
HB	10	±0.5	40	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
HE	10	±0.5	50	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K7	12.5	±0.5	15	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K5	12.5	±0.5	20	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K1	12.5	±0.5	25	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K2	12.5	±0.5	30	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K3	12.5	±0.5	35	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
K4	12.5	±0.5	40	+2.0/-0	5	±0.5	0.6	Nominal	20/15	Minimum
KB	12.5	±0.5	50	+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
M9	16	±0.5	30	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
MP	16	±0.5	35	+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
N8	18	±0.5	30	+2.0/-0	7.5	±0.5	0.8	Nominal	20/15	Minimum
NA	18	±0.5	35	+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 – 6,800 $\mu$ F	
Capacitance Tolerance	$\pm$ 20% at 120 Hz/20°C	
Rated Voltage	16 – 100 VDC	160 – 450 VDC
Life Test	8,000 – 10,000 hours (see conditions in Test Methods & Performance)	
Operating Temperature	-40°C to +105°C	
Leakage Current	$I \leq 0.01 CV$ or 3 $\mu$ A, whichever is greater	$I \leq 0.02 CV + 10 \mu$ A
	C = rated capacitance ( $\mu$ F), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.	

## Impedance Z Characteristics at 120 Hz

Rated Voltage (VDC)	16	25	35	50	63	100	160	200	250	350	400	450
Z (-40°C)/Z (20°C)	8	6	6	6	4	4	6	6	6	7	7	9

## Compensation Factor of Ripple Current (RC) vs. Frequency

Rated Voltage (VDC)	50 Hz	120 Hz	1 kHz	10 kHz	100 kHz
Coefficient	0.40	0.50	0.80	0.90	1.00

## Test Method & Performance

Conditions	Load Life Test		Shelf Life Test
Temperature	105°C		105°C
Test Duration	16 – 100 VDC	Can $\varnothing$ = 5 – 6 mm	1,000 hours
		Can $\varnothing$ $\geq$ 8 mm	
	160 – 450 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
<b>Performance</b>	<b>The following specifications will be satisfied when the capacitor is restored to 20°C:</b>		
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 100 kHz 105°C (mA)	LC 20°C 2 Minutes (µA)	Part Number
16	20	10	5x11	16	150	3	ESL106M016AC3(1)
16	20	15	5x11	16	155	3	ESL156M016AC3(1)
16	20	22	5x11	16	170	3.52	ESL226M016AC3(1)
16	20	33	5x11	16	185	5.28	ESL336M016AC3(1)
16	20	39	5x11	16	225	6.24	ESL396M016AC3(1)
16	20	47	5x11	16	245	7.52	ESL476M016AC3(1)
16	20	56	5x11	16	280	8.96	ESL566M016AC3(1)
16	20	68	5x11	16	305	10.88	ESL686M016AC3(1)
16	20	100	5x11	16	345	16	ESL107M016AC3(1)
16	20	120	6.3x11	16	485	19.2	ESL127M016AE3(1)
16	20	150	6.3x11	16	510	24	ESL157M016AE3(1)
16	20	180	6.3x11	16	525	28.8	ESL187M016AE3(1)
16	20	220	6.3x11	16	555	35.2	ESL227M016AE3(1)
16	20	270	8x11.5	16	870	43.2	ESL277M016AGM(1)
16	20	330	8x11.5	16	920	52.8	ESL337M016AGM(1)
16	20	390	8x11.5	16	940	62.4	ESL397M016AGM(1)
16	20	470	8x11.5	16	960	75.2	ESL477M016AGM(1)
16	20	560	8x16	16	1230	89.6	ESL567M016AG8(1)
16	20	560	10x12.5	16	1340	89.6	ESL567M016AH9(1)
16	20	680	8x16	16	1280	108.8	ESL687M016AG8(1)
16	20	680	10x12.5	16	1340	108.8	ESL687M016AH9(1)
16	20	820	8x20	16	1540	131.2	ESL827M016AG6(1)
16	20	820	10x16	16	1770	131.2	ESL827M016AH8(1)
16	20	1000	8x20	16	1540	160	ESL108M016AG6(1)
16	20	1000	10x16	16	1770	160	ESL108M016AH8(1)
16	20	1200	10x20	16	1970	192	ESL128M016AH4(1)
16	20	1200	12.5x15	16	2340	192	ESL128M016AK7(1)
16	20	1500	10x20	16	1970	240	ESL158M016AH4(1)
16	20	1500	12.5x15	16	2340	240	ESL158M016AK7(1)
16	20	1800	10x25	16	2260	288	ESL188M016AH5(1)
16	20	1800	12.5x20	16	2490	288	ESL188M016AK5(1)
16	20	2200	12.5x20	18	2490	352	ESL228M016AK5(1)
16	20	2700	12.5x25	18	2710	432	ESL278M016AK1(1)
16	20	3300	12.5x30	20	2960	528	ESL338M016AK2(1)
16	20	3300	16x20	20	2960	528	ESL338M016AM5(1)
16	20	3900	12.5x30	20	3060	624	ESL398M016AK2(1)
16	20	3900	16x20	20	3060	624	ESL398M016AM5(1)
16	20	4700	12.5x35	22	3280	752	ESL478M016AK3(1)
16	20	4700	16x25	22	3240	752	ESL478M016AM7(1)
16	20	5600	16x30	24	3700	896	ESL568M016AM9(1)
16	20	5600	18x25	24	3660	896	ESL568M016AN5(1)
16	20	6800	16x30	26	3900	1088	ESL688M016AM9(1)
16	20	6800	18x25	26	3860	1088	ESL688M016AN5(1)
25	32	10	5x11	14	160	3	ESL106M025AC3(1)
25	32	15	5x11	14	170	3.75	ESL156M025AC3(1)
25	32	22	5x11	14	185	5.5	ESL226M025AC3(1)
25	32	33	5x11	14	200	8.25	ESL336M025AC3(1)
25	32	39	5x11	14	225	9.75	ESL396M025AC3(1)
25	32	47	5x11	14	315	11.75	ESL476M025AC3(1)
25	32	56	5x11	14	335	14	ESL566M025AC3(1)
25	32	68	5x11	14	355	17	ESL686M025AC3(1)
25	32	100	6.3x11	14	485	25	ESL107M025AE3(1)
25	32	120	6.3x11	14	525	30	ESL127M025AE3(1)
25	32	150	6.3x11	14	555	37.5	ESL157M025AE3(1)
25	32	180	8x11.5	14	875	45	ESL187M025AGM(1)
25	32	220	8x11.5	14	905	55	ESL227M025AGM(1)
25	32	270	8x11.5	14	965	67.5	ESL277M025AGM(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)	LC 20°C 2 Minutes (µA)	Part Number
25	32	330	8x11.5	14	965	82.5	ESL337M025AGM(1)
25	32	390	8x16	14	1280	97.5	ESL397M025AG8(1)
25	32	390	10x12.5	14	1340	97.5	ESL397M025AH9(1)
25	32	470	10x12.5	14	1325	117.5	ESL477M025AH9(1)
25	32	560	8x20	14	1540	140	ESL567M025AG6(1)
25	32	560	10x16	14	1770	140	ESL567M025AH8(1)
25	32	680	10x16	14	1770	170	ESL687M025AH8(1)
25	32	820	10x20	14	2010	205	ESL827M025AH4(1)
25	32	820	12.5x15	14	2010	205	ESL827M025AK7(1)
25	32	1000	10x25	14	2260	250	ESL108M025AH5(1)
25	32	1000	12.5x20	14	2260	250	ESL108M025AK5(1)
25	32	1200	12.5x20	14	2370	300	ESL128M025AK5(1)
25	32	1500	12.5x20	14	2490	375	ESL158M025AK5(1)
25	32	1800	12.5x25	14	2910	450	ESL188M025AK1(1)
25	32	2200	12.5x30	16	3460	550	ESL228M025AK2(1)
25	32	2200	16x20	16	3260	550	ESL228M025AM5(1)
25	32	2700	12.5x35	16	3580	675	ESL278M025AK3(1)
25	32	2700	16x25	16	3640	675	ESL278M025AM7(1)
25	32	3300	12.5x40	18	3900	825	ESL338M025AK4(1)
25	32	3300	16x25	18	3640	825	ESL338M025AM7(1)
25	32	3900	16x30	18	3900	975	ESL398M025AM9(1)
25	32	3900	18x25	18	3660	975	ESL398M025AN5(1)
25	32	4700	16x35	20	3840	1175	ESL478M025AMP(1)
25	32	4700	18x30	20	4020	1175	ESL478M025AN8(1)
25	32	5600	18x35	22	4090	1400	ESL568M025ANA(1)
25	32	6800	18x40	24	4160	1700	ESL688M025AN3(1)
35	44	10	5x11	12	165	3.5	ESL106M035AC3(1)
35	44	15	5x11	12	175	5.25	ESL156M035AC3(1)
35	44	22	5x11	12	195	7.7	ESL226M035AC3(1)
35	44	33	5x11	12	205	11.55	ESL336M035AC3(1)
35	44	39	5x11	12	245	13.65	ESL396M035AC3(1)
35	44	47	5x11	12	345	16.45	ESL476M035AC3(1)
35	44	56	6.3x11	12	480	19.6	ESL566M035AE3(1)
35	44	68	6.3x11	12	520	23.8	ESL686M035AE3(1)
35	44	100	6.3x11	12	545	35	ESL107M035AE3(1)
35	44	120	8x11.5	12	780	42	ESL127M035AGM(1)
35	44	150	8x11.5	12	840	52.5	ESL157M035AGM(1)
35	44	180	8x11.5	12	965	63	ESL187M035AGM(1)
35	44	220	8x16	12	1020	77	ESL227M035AG8(1)
35	44	220	10x12.5	12	1180	77	ESL227M035AH9(1)
35	44	270	8x16	12	1050	94.5	ESL277M035AG8(1)
35	44	270	10x12.5	12	1210	94.5	ESL277M035AH9(1)
35	44	330	10x12.5	12	1340	115.5	ESL337M035AH9(1)
35	44	390	8x20	12	1520	136.5	ESL397M035AG6(1)
35	44	390	10x16	12	1650	136.5	ESL397M035AH8(1)
35	44	470	10x16	12	1755	164.5	ESL477M035AH8(1)
35	44	560	10x20	12	1970	196	ESL567M035AH4(1)
35	44	560	12.5x15	12	2340	196	ESL567M035AK7(1)
35	44	680	10x25	12	2260	238	ESL687M035AH5(1)
35	44	680	12.5x20	12	2360	238	ESL687M035AK5(1)
35	44	820	12.5x20	12	2490	287	ESL827M035AK5(1)
35	44	1000	12.5x20	12	2490	350	ESL108M035AK5(1)
35	44	1200	12.5x25	12	2910	420	ESL128M035AK1(1)
35	44	1500	12.5x30	12	3460	525	ESL158M035AK2(1)
35	44	1500	16x20	12	3260	525	ESL158M035AM5(1)
35	44	1800	12.5x35	12	3470	630	ESL188M035AK3(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)	LC 20°C 2 Minutes (µA)	Part Number
35	44	1800	16x25	12	3580	630	ESL188M035AM7(1)
35	44	2200	16x25	14	3640	770	ESL228M035AM7(1)
35	44	2700	16x30	14	3540	945	ESL278M035AM9(1)
35	44	2700	18x25	14	3650	945	ESL278M035AN5(1)
35	44	3300	18x35	16	4090	1155	ESL338M035ANA(1)
35	44	3900	18x40	16	4160	1365	ESL398M035AN3(1)
50	63	10	5x11	10	185	5	ESL106M050AC3(1)
50	63	15	5x11	10	195	7.5	ESL156M050AC3(1)
50	63	22	5x11	10	240	11	ESL226M050AC3(1)
50	63	33	6.3x11	10	400	16.5	ESL336M050AE3(1)
50	63	39	6.3x11	10	400	19.5	ESL396M050AE3(1)
50	63	47	6.3x11	10	420	23.5	ESL476M050AE3(1)
50	63	56	6.3x11	10	385	28	ESL566M050AE3(1)
50	63	68	8x11.5	10	640	34	ESL686M050AGM(1)
50	63	100	8x11.5	10	725	50	ESL107M050AGM(1)
50	63	120	8x16	10	975	60	ESL127M050AG8(1)
50	63	150	8x16	10	975	75	ESL157M050AG8(1)
50	63	180	10x16	10	1380	90	ESL187M050AH8(1)
50	63	220	8x20	10	1320	110	ESL227M050AG6(1)
50	63	220	10x16	10	1380	110	ESL227M050AH8(1)
50	63	270	12.5x15	10	1762	135	ESL277M050AK7(1)
50	63	270	10x20	10	1590	135	ESL277M050AH4(1)
50	63	330	10x25	10	1650	165	ESL337M050AH5(1)
50	63	390	10x25	10	1880	195	ESL397M050AH5(1)
50	63	390	12.5x20	10	2060	195	ESL397M050AK5(1)
50	63	470	12.5x20	10	2050	235	ESL477M050AK5(1)
50	63	560	12.5x25	10	2420	280	ESL567M050AK1(1)
50	63	680	12.5x30	10	2860	340	ESL687M050AK2(1)
50	63	820	12.5x30	10	2870	410	ESL827M050AK2(1)
50	63	1000	12.5x35	10	3050	500	ESL108M050AK3(1)
50	63	1000	16x25	10	3010	500	ESL108M050AM7(1)
50	63	1200	16x30	10	3290	600	ESL128M050AM9(1)
50	63	1200	18x25	10	3070	600	ESL128M050AN5(1)
50	63	1500	16x35	10	3050	750	ESL158M050AMP(1)
50	63	1500	18x25	10	3310	750	ESL158M050AN5(1)
50	63	1800	16x40	10	3440	900	ESL188M050AM4(1)
50	63	1800	18x35	10	3520	900	ESL188M050ANA(1)
50	63	2200	18x35	12	3580	1100	ESL228M050ANA(1)
63	79	0.47	5x11	9	80	3	ESL474M063AC3(1)
63	79	1	5x11	9	95	3	ESL105M063AC3(1)
63	79	1.8	5x11	9	95	3	ESL185M063AC3(1)
63	79	2.2	5x11	9	105	3	ESL225M063AC3(1)
63	79	2.7	5x11	9	105	3	ESL275M063AC3(1)
63	79	3.3	5x11	9	115	3	ESL335M063AC3(1)
63	79	3.9	5x11	9	115	3	ESL395M063AC3(1)
63	79	4.7	5x11	9	120	3	ESL475M063AC3(1)
63	79	5.6	5x11	9	135	3.528	ESL565M063AC3(1)
63	79	6.8	5x11	9	135	4.284	ESL685M063AC3(1)
63	79	8.2	5x11	9	145	5.166	ESL825M063AC3(1)
63	79	10	5x11	9	145	6.3	ESL106M063AC3(1)
63	79	12	5x11	9	155	7.56	ESL126M063AC3(1)
63	79	15	5x11	9	165	9.45	ESL156M063AC3(1)
63	79	18	6.3x11	9	265	11.34	ESL186M063AE3(1)
63	79	22	6.3x11	9	295	13.86	ESL226M063AE3(1)
63	79	27	6.3x11	9	305	17.01	ESL276M063AE3(1)
63	79	33	6.3x11	9	335	20.79	ESL336M063AE3(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)	LC 20°C 2 Minutes (µA)	Part Number
63	79	39	8x11.5	9	420	24.57	ESL396M063AGM(1)
63	79	47	8x11.5	9	435	29.61	ESL476M063AGM(1)
63	79	56	8x11.5	9	445	35.28	ESL566M063AGM(1)
63	79	68	8x11.5	9	460	42.84	ESL686M063AGM(1)
63	79	82	8x16	9	560	51.66	ESL826M063AG8(1)
63	79	100	8x16	9	580	63	ESL107M063AG8(1)
63	79	100	10x12.5	9	570	63	ESL107M063AH9(1)
63	79	120	10x12.5	9	580	75.6	ESL127M063AH9(1)
63	79	150	8x20	9	680	94.5	ESL157M063AG6(1)
63	79	150	10x16	9	705	94.5	ESL157M063AH8(1)
63	79	180	10x16	9	725	113.4	ESL187M063AH8(1)
63	79	220	10x20	9	1050	138.6	ESL227M063AH4(1)
63	79	220	12.5x15	9	1020	138.6	ESL227M063AK7(1)
63	79	270	10x20	9	1080	170.1	ESL277M063AH4(1)
63	79	270	12.5x15	9	1045	170.1	ESL277M063AK7(1)
63	79	330	10x25	9	1250	207.9	ESL337M063AH5(1)
63	79	330	12.5x20	9	1320	207.9	ESL337M063AK5(1)
63	79	390	12.5x20	9	1350	245.7	ESL397M063AK5(1)
63	79	470	12.5x25	9	1860	296.1	ESL477M063AK1(1)
63	79	560	12.5x30	9	2050	352.8	ESL567M063AK2(1)
63	79	560	16x20	9	1980	352.8	ESL567M063AM5(1)
63	79	680	12.5x35	9	2250	428.4	ESL687M063AK3(1)
63	79	680	16x25	9	2315	428.4	ESL687M063AM7(1)
63	79	820	12.5x40	9	2430	516.6	ESL827M063AK4(1)
63	79	820	16x25	9	2480	516.6	ESL827M063AM7(1)
63	79	1000	16x30	9	2620	630	ESL108M063AM9(1)
63	79	1200	16x30	9	2650	756	ESL128M063AM9(1)
63	79	1200	18x25	9	2610	756	ESL128M063AN5(1)
63	79	1500	16x35	9	2730	945	ESL158M063AMP(1)
63	79	1500	18x30	9	2780	945	ESL158M063AN8(1)
63	79	1800	16x40	9	3250	1134	ESL188M063AM4(1)
63	79	2200	18x40	11	3430	1386	ESL228M063AN3(1)
100	125	0.47	5x11	9	95	3	ESL474M100AC3(1)
100	125	1	5x11	9	105	3	ESL105M100AC3(1)
100	125	1.8	5x11	9	105	3	ESL185M100AC3(1)
100	125	2.2	5x11	9	115	3	ESL225M100AC3(1)
100	125	2.7	5x11	9	115	3	ESL275M100AC3(1)
100	125	3.3	5x11	9	125	3.3	ESL335M100AC3(1)
100	125	3.9	5x11	9	135	3.9	ESL395M100AC3(1)
100	125	4.7	5x11	9	145	4.7	ESL475M100AC3(1)
100	125	5.6	6.3x11	9	205	5.6	ESL565M100AE3(1)
100	125	6.8	6.3x11	9	235	6.8	ESL685M100AE3(1)
100	125	8.2	6.3x11	9	255	8.2	ESL825M100AE3(1)
100	125	10	6.3x11	9	280	10	ESL106M100AE3(1)
100	125	12	8x11.5	9	320	12	ESL126M100AGM(1)
100	125	15	8x11.5	9	320	15	ESL156M100AGM(1)
100	125	18	8x11.5	9	345	18	ESL186M100AGM(1)
100	125	22	8x11.5	9	365	22	ESL226M100AGM(1)
100	125	27	8x16	9	455	27	ESL276M100AG8(1)
100	125	27	10x12.5	9	460	27	ESL276M100AH9(1)
100	125	33	8x16	9	465	33	ESL336M100AG8(1)
100	125	33	10x12.5	9	475	33	ESL336M100AH9(1)
100	125	39	10x12.5	9	485	39	ESL396M100AH9(1)
100	125	47	10x12.5	9	510	47	ESL476M100AH9(1)
100	125	56	10x12.5	9	540	56	ESL566M100AH9(1)
100	125	68	8x20	9	675	68	ESL686M100AG6(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)	LC 20°C 2 Minutes (µA)	Part Number
100	125	82	10x16	9	785	82	ESL826M100AH8(1)
100	125	100	10x20	9	865	100	ESL107M100AH4(1)
100	125	100	12.5x15	9	845	100	ESL107M100AK7(1)
100	125	120	10x25	9	1050	120	ESL127M100AH5(1)
100	125	150	12.5x20	9	1440	150	ESL157M100AK5(1)
100	125	180	12.5x25	9	1460	180	ESL187M100AK1(1)
100	125	220	12.5x25	9	1630	220	ESL227M100AK1(1)
100	125	270	12.5x30	9	1620	270	ESL277M100AK2(1)
100	125	270	16x20	9	1650	270	ESL277M100AM5(1)
100	125	330	12.5x35	9	1950	330	ESL337M100AK3(1)
100	125	330	16x25	9	1920	330	ESL337M100AM7(1)
100	125	390	12.5x40	9	2050	390	ESL397M100AK4(1)
100	125	470	16x30	9	2010	470	ESL477M100AM9(1)
100	125	560	16x35	9	2430	560	ESL567M100AMP(1)
100	125	560	18x30	9	2480	560	ESL567M100AN8(1)
100	125	680	16x40	9	2680	680	ESL687M100AM4(1)
100	125	680	18x35	9	2870	680	ESL687M100ANA(1)
100	125	820	18x40	9	3250	820	ESL827M100AN3(1)
160	200	1.8	6.3x11	15	65	15.76	ESL185M160AE3(1)
160	200	2.2	6.3x11	15	70	17.04	ESL225M160AE3(1)
160	200	2.7	6.3x11	15	75	18.64	ESL275M160AE3(1)
160	200	3.3	6.3x11	15	80	20.56	ESL335M160AE3(1)
160	200	3.9	6.3x11	15	85	22.48	ESL395M160AE3(1)
160	200	4.7	8x11.5	15	85	25.04	ESL475M160AGM(1)
160	200	5.6	8x11.5	15	100	27.92	ESL565M160AGM(1)
160	200	6.8	8x11.5	15	105	31.76	ESL685M160AGM(1)
160	200	8.2	8x11.5	15	115	36.24	ESL825M160AGM(1)
160	200	10	8x16	15	135	42	ESL106M160AG8(1)
160	200	12	8x16	15	140	48.4	ESL126M160AG8(1)
160	200	15	8x16	15	285	58	ESL156M160AG8(1)
160	200	15	10x12.5	15	290	58	ESL156M160AH9(1)
160	200	18	8x16	15	310	67.6	ESL186M160AG8(1)
160	200	22	8x20	15	390	80.4	ESL226M160AG6(1)
160	200	22	10x16	15	390	80.4	ESL226M160AH8(1)
160	200	27	10x16	15	410	96.4	ESL276M160AH8(1)
160	200	33	10x20	15	530	115.6	ESL336M160AH4(1)
160	200	33	12.5x15	15	570	115.6	ESL336M160AK7(1)
160	200	39	10x25	15	590	134.8	ESL396M160AH5(1)
160	200	39	12.5x15	15	590	134.8	ESL396M160AK7(1)
160	200	47	10x25	15	610	160.4	ESL476M160AH5(1)
160	200	47	12.5x20	15	630	160.4	ESL476M160AK5(1)
160	200	56	12.5x20	15	740	189.2	ESL566M160AK5(1)
160	200	56	8x50	15	740	189.2	ESL566M160AGG(1)
160	200	68	12.5x20	15	800	227.6	ESL686M160AK5(1)
160	200	82	12.5x25	15	830	272.4	ESL826M160AK1(1)
160	200	100	16x20	15	1120	330	ESL107M160AM5(1)
160	200	100	10x50	15	1210	330	ESL107M160AHE(1)
160	200	120	16x25	15	1240	394	ESL127M160AM7(1)
160	200	150	16x30	15	1280	490	ESL157M160AM9(1)
160	200	150	12.5x50	15	1280	490	ESL157M160AKB(1)
160	200	180	16x30	15	1360	586	ESL187M160AM9(1)
160	200	220	18x30	15	1410	714	ESL227M160AN8(1)
160	200	270	18x35	15	1500	874	ESL277M160ANA(1)
160	200	330	18x40	15	1590	1066	ESL337M160AN3(1)
200	250	2.2	6.3x11	15	75	18.8	ESL225M200AE3(1)
200	250	2.7	6.3x11	15	80	20.8	ESL275M200AE3(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)	LC 20°C 2 Minutes (µA)	Part Number
200	250	3.3	6.3x11	15	95	23.2	ESL335M200AE3(1)
200	250	3.9	6.3x11	15	105	25.6	ESL395M200AE3(1)
200	250	4.7	8x11.5	15	130	28.8	ESL475M200AGM(1)
200	250	5.6	8x11.5	15	135	32.4	ESL565M200AGM(1)
200	250	6.8	8x11.5	15	145	37.2	ESL685M200AGM(1)
200	250	8.2	8x11.5	15	165	42.8	ESL825M200AGM(1)
200	250	10	8x12	15	175	50	ESL106M200AG9(1)
200	250	12	8x16	15	190	58	ESL126M200AG8(1)
200	250	15	8x16	15	360	70	ESL156M200AG8(1)
200	250	18	10x16	15	385	82	ESL186M200AH8(1)
200	250	22	10x16	15	390	98	ESL226M200AH8(1)
200	250	27	10x20	15	410	118	ESL276M200AH4(1)
200	250	33	10x25	15	530	142	ESL336M200AH5(1)
200	250	39	12.5x20	15	620	166	ESL396M200AK5(1)
200	250	47	12.5x20	15	630	198	ESL476M200AK5(1)
200	250	47	8x50	15	650	198	ESL476M200AGG(1)
200	250	56	12.5x25	15	670	234	ESL566M200AK1(1)
200	250	56	10x50	15	670	234	ESL566M200AHE(1)
200	250	68	12.5x30	15	850	282	ESL686M200AK2(1)
200	250	82	16x25	15	860	338	ESL826M200AM7(1)
200	250	100	16x25	15	930	410	ESL107M200AM7(1)
200	250	120	16x30	15	1090	490	ESL127M200AM9(1)
200	250	150	16x35	15	1125	610	ESL157M200AMP(1)
200	250	180	18x30	15	1340	730	ESL187M200AN8(1)
200	250	220	18x35	15	1420	890	ESL227M200ANA(1)
250	300	2.2	6.3x11	15	80	21	ESL225M250AE3(1)
250	300	2.7	6.3x11	15	90	23.5	ESL275M250AE3(1)
250	300	3.3	6.3x11	15	100	26.5	ESL335M250AE3(1)
250	300	3.9	8x11.5	15	110	29.5	ESL395M250AGM(1)
250	300	4.7	8x11.5	15	135	33.5	ESL475M250AGM(1)
250	300	5.6	8x11.5	15	150	38	ESL565M250AGM(1)
250	300	6.8	8x11.5	15	160	44	ESL685M250AGM(1)
250	300	8.2	8x12	15	170	51	ESL825M250AG9(1)
250	300	10	8x16	15	250	60	ESL106M250AG8(1)
250	300	10	10x12.5	15	250	60	ESL106M250AH9(1)
250	300	15	8x20	15	380	85	ESL156M250AG6(1)
250	300	15	10x16	15	390	85	ESL156M250AH8(1)
250	300	18	10x16	15	410	100	ESL186M250AH8(1)
250	300	22	10x20	15	475	120	ESL226M250AH4(1)
250	300	33	12.5x20	15	570	175	ESL336M250AK5(1)
250	300	33	8x50	15	570	175	ESL336M250AGG(1)
250	300	47	12.5x25	15	650	245	ESL476M250AK1(1)
250	300	56	12.5x30	15	750	290	ESL566M250AK2(1)
250	300	68	12.5x30	15	870	350	ESL686M250AK2(1)
250	300	68	10x50	15	870	350	ESL686M250AHE(1)
250	300	82	16x30	15	910	420	ESL826M250AM9(1)
250	300	100	16x30	15	960	510	ESL107M250AM9(1)
250	300	100	12.5x50	15	960	510	ESL107M250AKB(1)
250	300	120	18x30	15	1210	610	ESL127M250AN8(1)
250	300	150	18x30	15	1400	760	ESL157M250AN8(1)
250	300	180	18x35	15	1540	910	ESL187M250ANA(1)
250	300	220	18x40	15	1620	1110	ESL227M250AN3(1)
350	400	1	6.3x11	20	55	17	ESL105M350AE3(1)
350	400	1.2	6.3x11	20	55	18.4	ESL125M350AE3(1)
350	400	1.5	6.3x11	20	60	20.5	ESL155M350AE3(1)
350	400	1.8	6.3x11	20	65	22.6	ESL185M350AE3(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)	LC 20°C 2 Minutes (µA)	Part Number
350	400	2.2	6.3x11	20	70	25.4	ESL225M350AE3(1)
350	400	2.7	8x11.5	20	85	28.9	ESL275M350AGM(1)
350	400	3.3	8x11.5	20	95	33.1	ESL335M350AGM(1)
350	400	3.9	8x11.5	20	100	37.3	ESL395M350AGM(1)
350	400	4.7	8x11.5	20	130	42.9	ESL475M350AGM(1)
350	400	5.6	8x16	20	155	49.2	ESL565M350AG8(1)
350	400	5.6	10x12.5	20	155	49.2	ESL565M350AH9(1)
350	400	6.8	10x12.5	20	170	57.6	ESL685M350AH9(1)
350	400	8.2	8x20	20	240	67.4	ESL825M350AG6(1)
350	400	8.2	10x16	20	240	67.4	ESL825M350AH8(1)
350	400	10	10x16	20	250	80	ESL106M350AH8(1)
350	400	15	10x25	20	340	115	ESL156M350AH5(1)
350	400	15	12.5x15	20	340	115	ESL156M350AK7(1)
350	400	18	10x25	20	430	136	ESL186M350AH5(1)
350	400	18	12.5x20	20	430	136	ESL186M350AK5(1)
350	400	22	12.5x20	20	475	164	ESL226M350AK5(1)
350	400	22	8x50	20	475	164	ESL226M350AGG(1)
350	400	33	12.5x25	20	570	241	ESL336M350AK1(1)
350	400	33	10x50	20	570	241	ESL336M350AHE(1)
350	400	47	16x25	20	800	339	ESL476M350AM7(1)
350	400	56	16x30	20	840	402	ESL566M350AM9(1)
350	400	68	18x25	20	880	486	ESL686M350AN5(1)
350	400	68	12.5x50	20	880	486	ESL686M350AKB(1)
350	400	82	18x30	20	940	584	ESL826M350AN8(1)
350	400	100	18x35	20	1120	710	ESL107M350ANA(1)
350	400	120	18x35	20	1200	850	ESL127M350ANA(1)
400	450	1	6.3x11	20	65	18	ESL105M400AE3(1)
400	450	1.2	6.3x11	20	70	19.6	ESL125M400AE3(1)
400	450	1.5	6.3x11	20	75	22	ESL155M400AE3(1)
400	450	1.8	6.3x11	20	85	24.4	ESL185M400AE3(1)
400	450	2.2	8x11.5	20	90	27.6	ESL225M400AGM(1)
400	450	2.7	8x11.5	20	95	31.6	ESL275M400AGM(1)
400	450	3.3	8x11.5	20	100	36.4	ESL335M400AGM(1)
400	450	3.9	8x11.5	20	105	41.2	ESL395M400AGM(1)
400	450	4.7	8x11.5	20	110	47.6	ESL475M400AGM(1)
400	450	4.7	8x16	20	115	47.6	ESL475M400AG8(1)
400	450	5.6	8x16	20	160	54.8	ESL565M400AG8(1)
400	450	5.6	10x12.5	20	180	54.8	ESL565M400AH9(1)
400	450	6.8	8x20	20	180	64.4	ESL685M400AG6(1)
400	450	6.8	10x16	20	220	64.4	ESL685M400AH8(1)
400	450	8.2	10x16	20	252	75.6	ESL825M400AH8(1)
400	450	10	10x20	20	288	90	ESL106M400AH4(1)
400	450	15	12.5x20	20	400	130	ESL156M400AK5(1)
400	450	18	12.5x20	20	470	154	ESL186M400AK5(1)
400	450	22	12.5x25	20	475	186	ESL226M400AK1(1)
400	450	22	8x50	20	475	186	ESL226M400AGG(1)
400	450	33	16x25	20	610	274	ESL336M400AM7(1)
400	450	33	10x50	20	610	274	ESL336M400AHE(1)
400	450	47	18x25	20	795	386	ESL476M400AN5(1)
400	450	56	16x30	20	820	458	ESL566M400AM9(1)
400	450	56	12.5x50	20	820	458	ESL566M400AKB(1)
400	450	68	18x30	20	910	554	ESL686M400AN8(1)
400	450	82	16x40	20	980	666	ESL826M400AM4(1)
400	450	82	18x35	20	980	666	ESL826M400ANA(1)
400	450	100	18x40	20	1100	810	ESL107M400AN3(1)
450	500	1	6.3x11	20	50	19	ESL105M450AE3(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 ( $\mu$ F)	Case Size D x L (mm)	DF 120 Hz 20°C (tan $\delta$ %)*	RC 100 kHz 105°C (mA)	LC 20°C 2 Minutes ( $\mu$ A)	Part Number
450	500	1.2	6.3x11	20	55	20.8	ESL125M450AE3(1)
450	500	1.5	8x11.5	20	80	23.5	ESL155M450AGM(1)
450	500	1.8	8x11.5	20	85	26.2	ESL185M450AGM(1)
450	500	2.2	8x16	20	95	29.8	ESL225M450AG8(1)
450	500	2.7	8x16	20	100	34.3	ESL275M450AG8(1)
450	500	3.3	8x16	20	110	39.7	ESL335M450AG8(1)
450	500	3.9	8x16	20	120	45.1	ESL395M450AG8(1)
450	500	4.7	8x20	20	150	52.3	ESL475M450AG6(1)
450	500	4.7	10x16	20	150	52.3	ESL475M450AH8(1)
450	500	5.6	8x20	20	180	60.4	ESL565M450AG6(1)
450	500	5.6	10x16	20	180	60.4	ESL565M450AH8(1)
450	500	6.8	10x16	20	220	71.2	ESL685M450AH8(1)
450	500	8.2	10x20	20	265	83.8	ESL825M450AH4(1)
450	500	10	10x25	20	305	100	ESL106M450AH5(1)
450	500	10	12.5x20	20	305	100	ESL106M450AK5(1)
450	500	15	12.5x20	20	400	145	ESL156M450AK5(1)
450	500	15	8x50	20	400	145	ESL156M450AGG(1)
450	500	18	12.5x25	20	470	172	ESL186M450AK1(1)
450	500	22	16x20	20	550	208	ESL226M450AM5(1)
450	500	22	10x40	20	550	208	ESL226M450AHB(1)
450	500	33	16x25	20	665	307	ESL336M450AM7(1)
450	500	33	10x50	20	665	307	ESL336M450AHE(1)
450	500	47	16x35	20	730	433	ESL476M450AMP(1)
450	500	47	12.5x50	20	730	433	ESL476M450AKB(1)
450	500	56	16x35	20	750	514	ESL566M450AMP(1)
450	500	68	18x35	20	970	622	ESL686M450ANA(1)
450	500	82	18x40	20	1030	748	ESL826M450AN3(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  $\mu$ F, the DF value (%) is increased by 2% for every additional 1,000  $\mu$ F.

## 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)



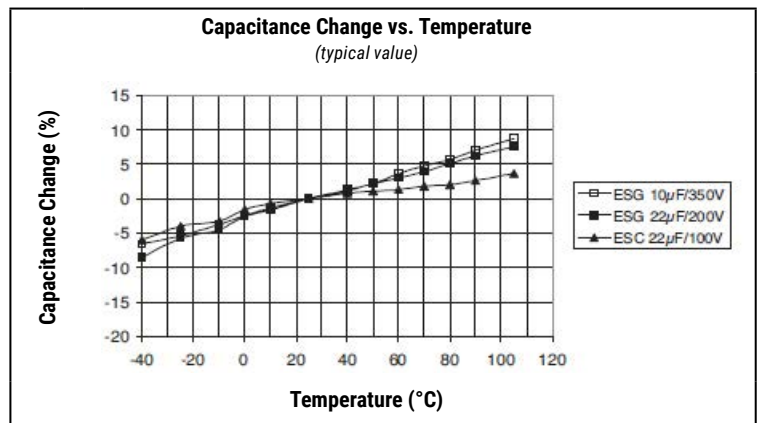
Simplified equivalent circuit diagram of an electrolytic capacitor

The capacitive component of the equivalent series circuit (Equivalent Series Capacitance ESC) is determined by applying an alternate voltage of  $\leq 0.5$  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.

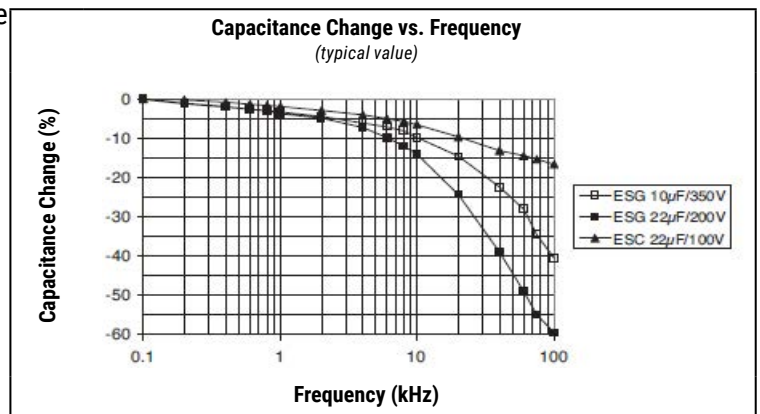


### Frequency Dependence of the Capacitance

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

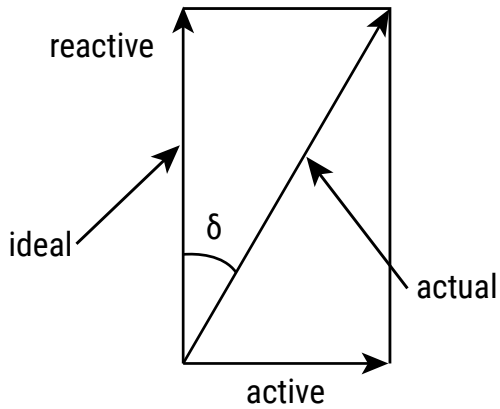
$$C = \frac{1}{2\pi fZ}$$

$C$  = Capacitance (F)  
 $f$  = Frequency (Hz)  
 $Z$  = Impedance ( $\Omega$ )



### 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.

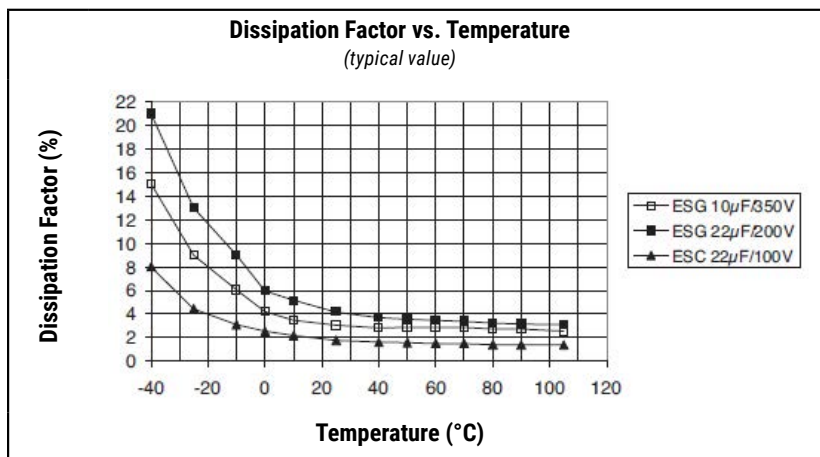
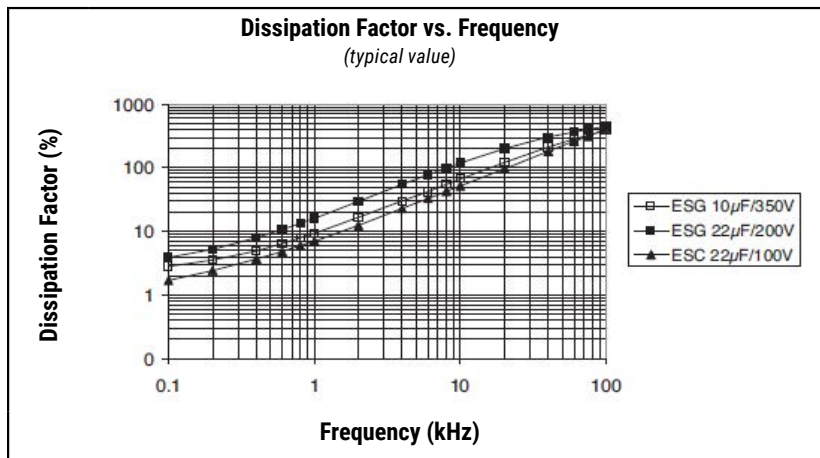


Tan  $\delta$  is measured with the same set-up used for the series capacitance ESC.

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

ESC = Equivalent Series Capacitance

ESR = Equivalent Series Resistance

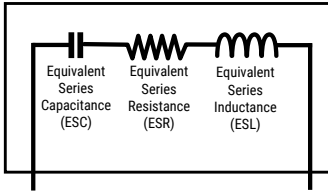




### Equivalent Series Inductance (ESL)

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

Capacitor Equivalent Internal Circuit



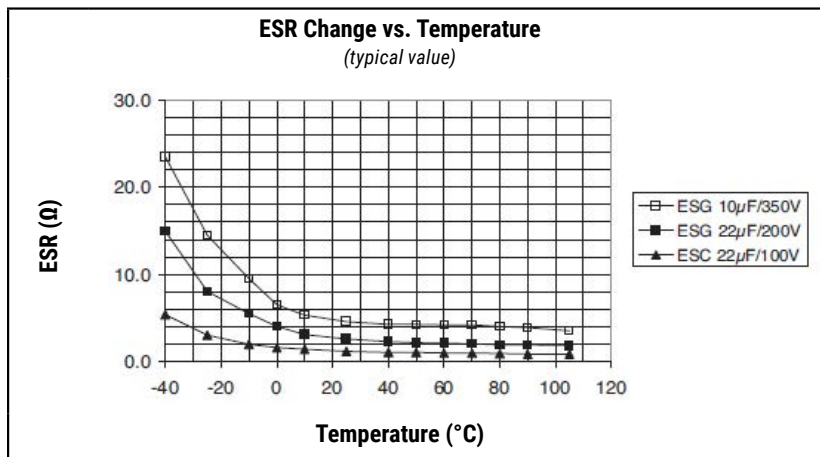
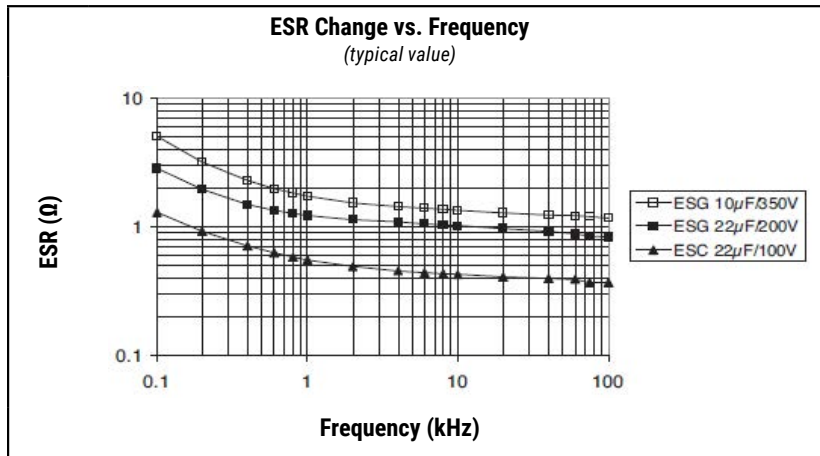
### Equivalent Series Resistance (ESR)

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:

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

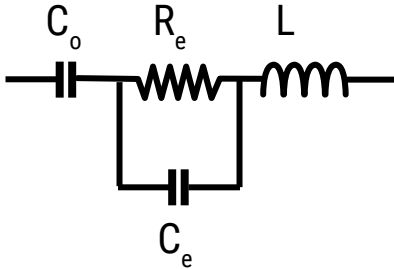
ESR = Equivalent Series Resistance ( $\Omega$ )  
 $\tan \delta$  = Dissipation Factor  
 ESC = Equivalent Series Capacitance (F)  
 f = Frequency (Hz)

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)

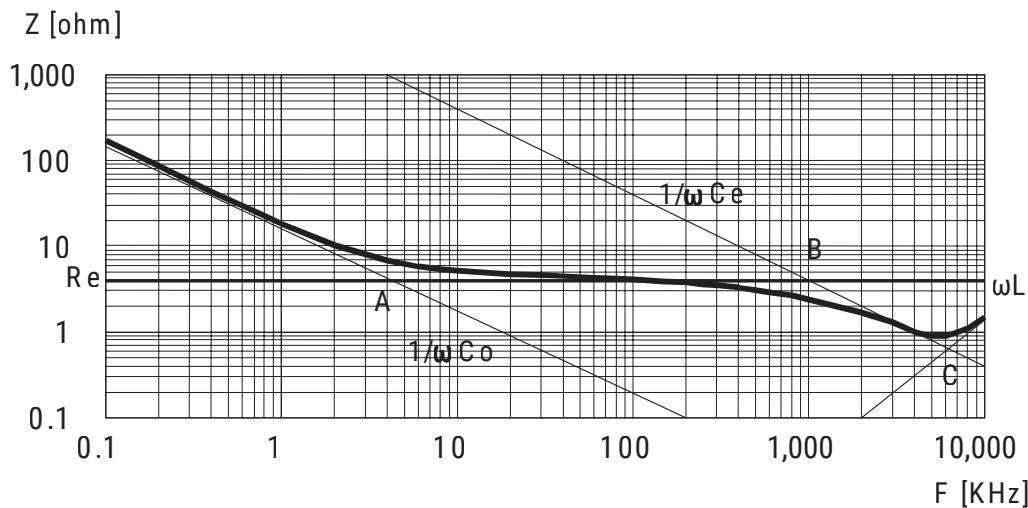
$R_e$  = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)

$C_e$  = 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:

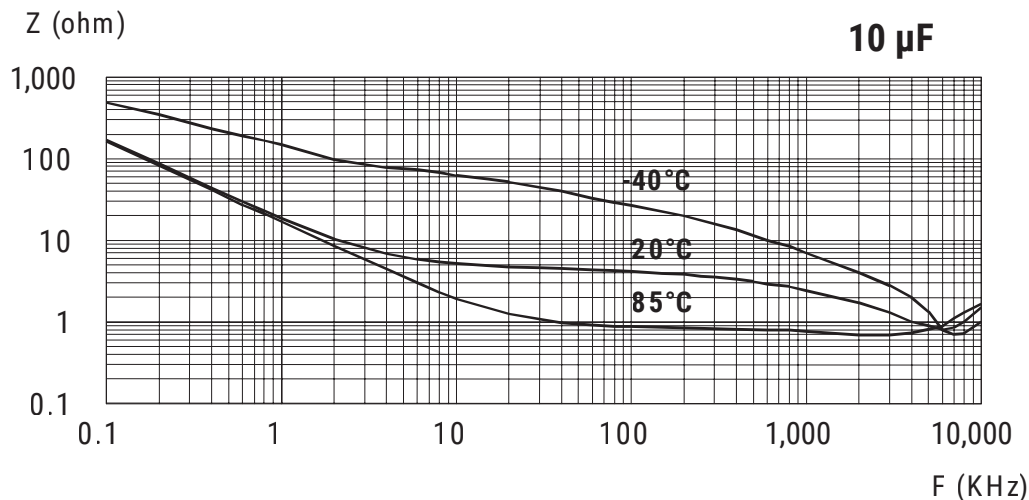


- Capacitive reactance predominates at low frequencies
- With increasing frequency, capacitive reactance  $X_c = 1/\omega C_o$  decreases until it reaches the order of magnitude of electrolyte resistance  $R_e$  (A)
- At even higher frequencies, resistance of the electrolyte predominates:  $Z = R_e$  (A - B)
- When the capacitor's resonance frequency is reached ( $\omega_o$ ), 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.

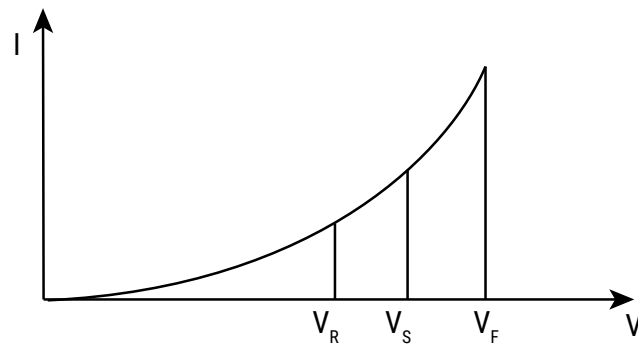
A high leakage current flows after applying voltage to the capacitor then decreases in a few minutes, e.g., after prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease and reach an almost constant value.

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  $\delta$  or ESR
- Frequency

The capacitor's life depends on the thermal stress.

### Frequency Dependence of the Ripple Current

ESR and, thus, the tan  $\delta$  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:  $L = L_o \times 2^{(T_o - T)/10}$

Where:

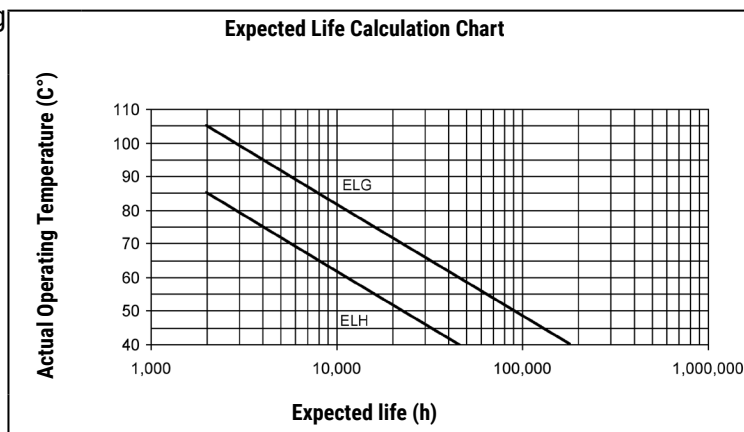
L: Expected life

$L_o$ : Load life at maximum permissible operating temperature

T: Actual operating temperature

$T_o$ : Maximum permissible operating temperature

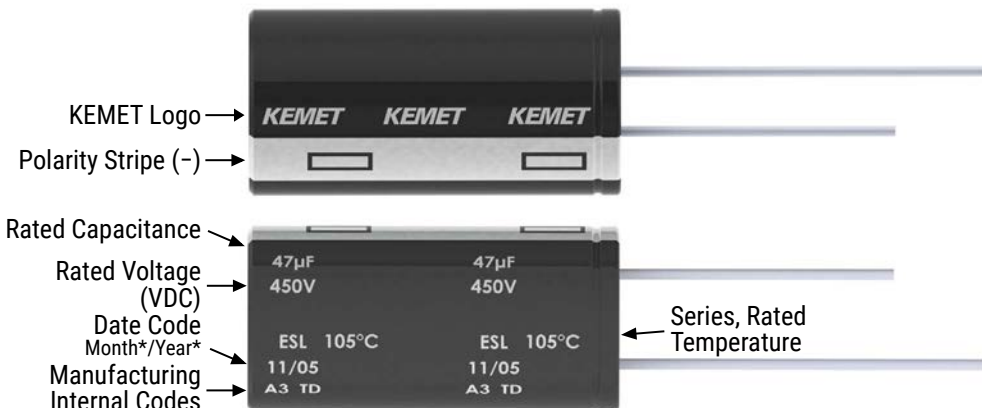
This formula is applicable between 40°C and  $T_o$ .



## 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	-
E3	6.3	11	10,000	15,000	2,000	-
GM	8	11.5	6,000	8,000	1,000	-
G9	8	12	6,000	8,000	1,000	-
G8	8	16	5,000	5,000	1,000	-
G6	8	20	4,000	4,000	1,000	-
GG	8	50	2,400	2,400	-	-
H9	10	12.5	4,000	4,000	700	-
H8	10	16	3,000	4,000	700	-
H4	10	20	2,400	3,000	700	-
H5	10	25	2,400	2,400	500	-
HB	10	40	2,100	2,100	-	-
HE	10	50	2,100	2,100	-	-
K7	12.5	15	2,000	2,000	500	-
K5	12.5	20	2,000	2,000	500	-
K1	12.5	25	2,000	2,000	500	-
K2	12.5	30	2,000	2,000	500	-
K3	12.5	35	2,000	2,000	500	-
K4	12.5	40	2,000	2,000	500	-
KB	12.5	50	1,200	1,200	-	-
M5	16	20	1,000	500	300	-
M7	16	25	1,000	500	300	-
M9	16	30	800	500	300	-
MP	16	35	600	500	300	-
M4	16	40	600	500	300	-
N5	18	25	800	500	300	-
N8	18	30	800	500	-	-
NA	18	35	500	500	-	-
N3	18	40	500	500	-	-

## Marking



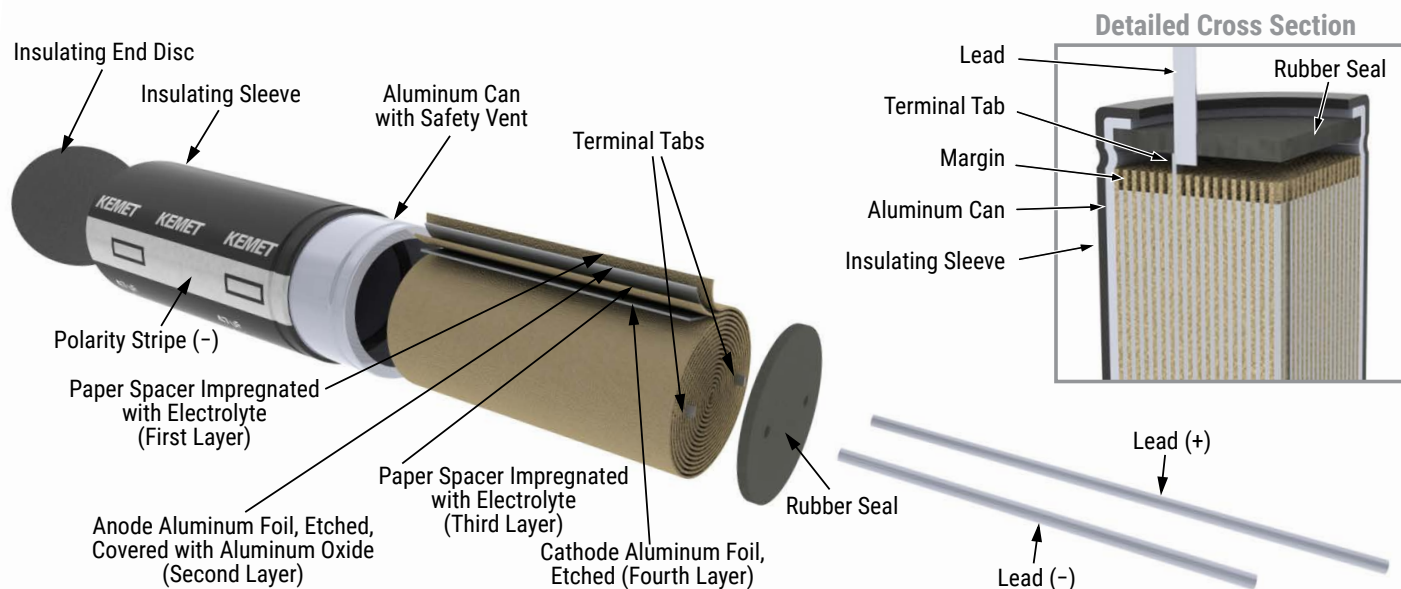
\*Y = Year

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

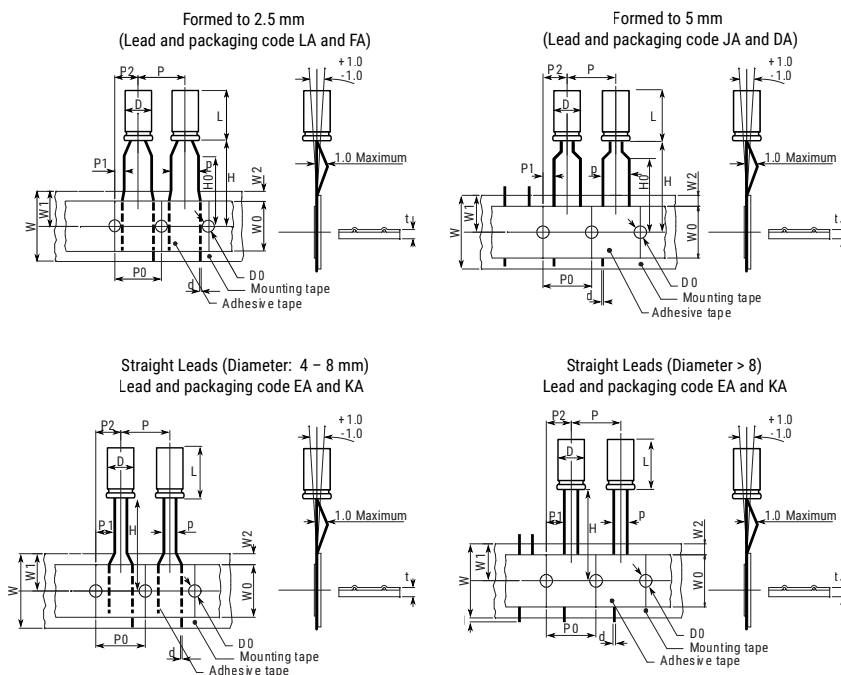
\*M = Month

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

## Construction

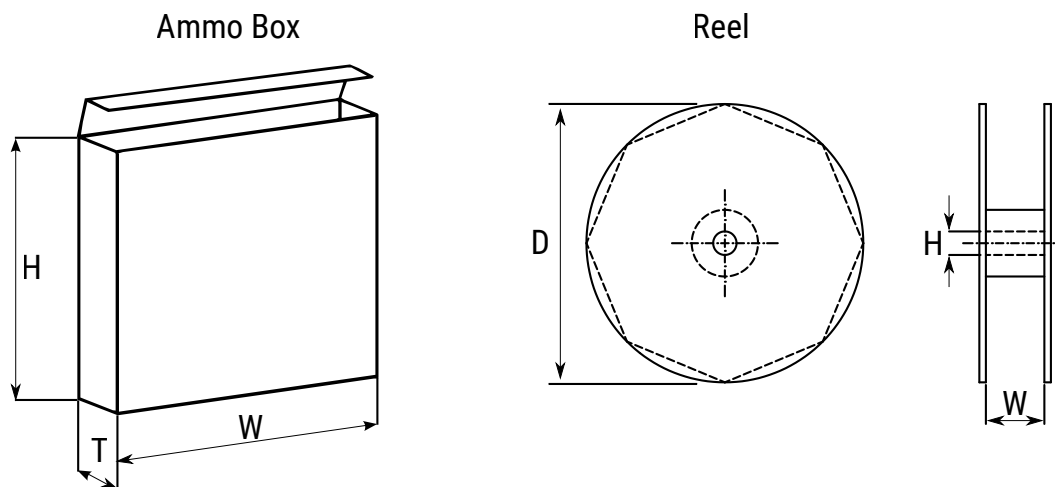


## Taping for Automatic Insertion Machines



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
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.

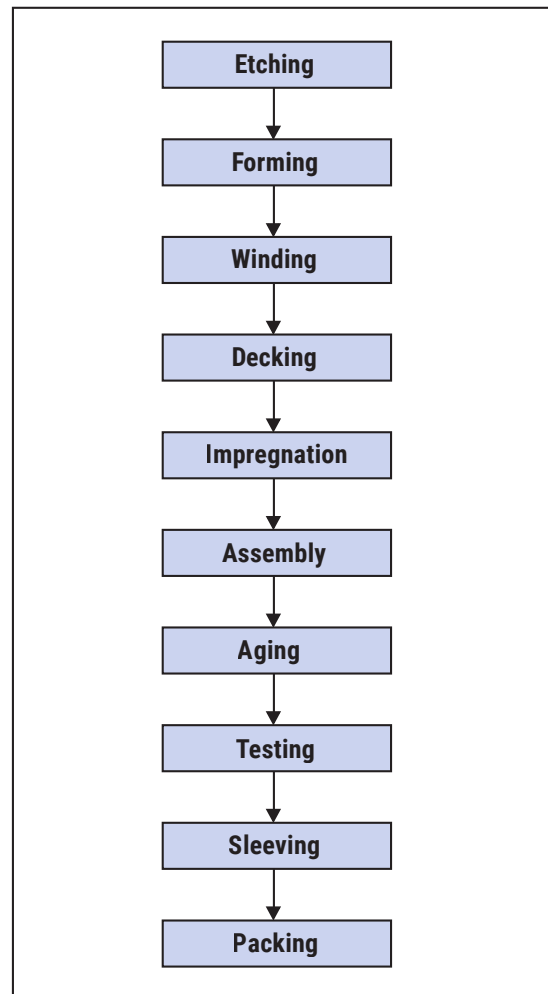
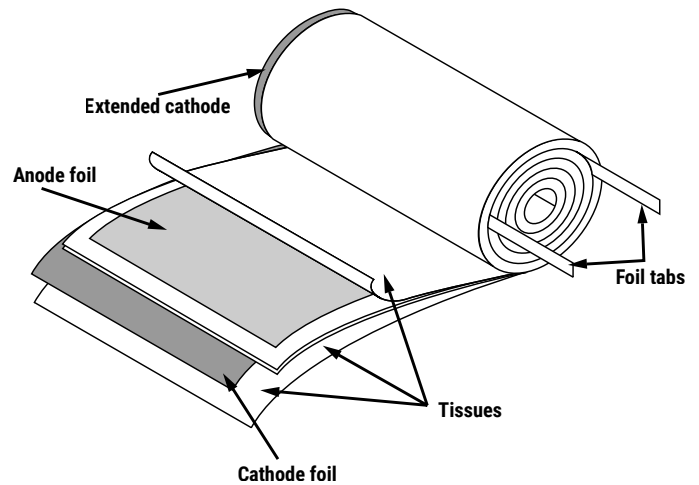
The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

### 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.