ESC Series, 105ºC

Overview

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

Applications

Typical applications include high frequency switch mode circuits.

Benefits

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

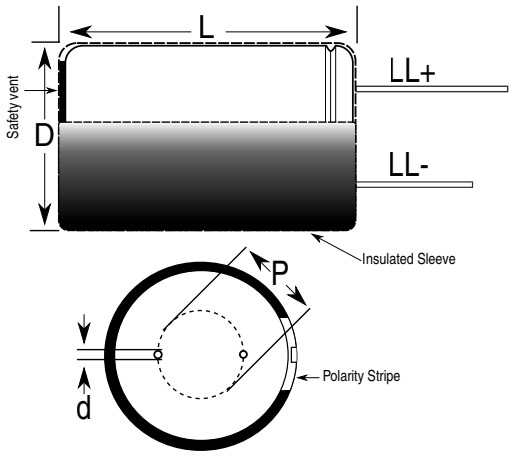
Part Number System

ESC	157	M	6R3	A	C3	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)	Electrical Parameters	Size Code	Packaging
Radial Leaded Aluminum Electrolytic	Digits 4 – 5 represent the first two digits of the capacitance value. The final digit indicates the number of zeros to be added.	M = ±20%	6R3 = 6.3 010 = 10 016 = 16 025 = 25 035 = 35 050 = 50 063 = 63 100 = 100	A = Standard	See Dimension Table	See Ordering Options Table

Ordering Options Table

Diameter	Packaging Type	Lead Type	Lead Length (mm)	Lead and Packaging Code
Standard Bulk Packaging Options				
4 – 22	Bulk (bag)	Straight	20/15 Minimum	AA
Standard Auto-Insertion Packaging Options				
4 – 5	Tape & Reel	Formed to 2.5 mm	H_0 = 16.5 ±0.75	LA
6.3	Tape & Reel	2.5 mm Lead Spacing	H_0 = 18.5 ±0.75	KA
8	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
10 – 13	Ammo	5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
16	Ammo	7.5 mm Lead Spacing	H_0 = 18.5 ±0.75	EA
Other Packaging Options				
4 – 8	Ammo	Formed to 5 mm	H_0 = 16.5 ±0.75	DA
10	Ammo	5 mm Lead Spacing	H_0 = 16.5 ±0.75	DA
4 – 8	Ammo	Straight	H_0 = 18.5 ±0.75	EA
4 – 5	Ammo	Formed to 2.5 mm	H_0 = 16.5 ±0.75	FA
4 – 6.3	Tape & Reel	Formed to 5 mm	H_0 = 16.5 ±0.75	JA
4 – 5, 8 – 16	Tape & Reel	Straight	H_0 = 18.5 ±0.75	KA
Contact KEMET for other Lead and Packaging options				

Dimensions – Millimeters



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

Performance Characteristics

Item	Performance Characteristics
Capacitance Range	1.0 – 15,000 µF
Capacitance Tolerance	±20% at 120 Hz / 20°C
Rated Voltage	6.3 – 100 VDC
Life Test	2,000 – 3,000 hours (see conditions in Test Method & Performance)
Operating Temperature	-40°C to +105°C
Leakage Current	I ≤ 0.01 CV or 3 mA, whichever is greater
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

Impedance Z Characteristics at 120 Hz

Rated Voltage (VDC)	6.3	10	16	25	35	50	63	100
Z (-40°C) / Z (20°C)	10	8	5	4	4	4	4	4

Compensation Factor of Ripple Current (RC) vs. Frequency

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

Compensation Factor of Ripple Current (RC) vs. Temperature

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

Test Method & Performance

Conditions	Load Life Test		Shelf Life Test
Temperature	105°C		105°C
Test Duration	D x L ≤ 10 x 12 mm	2,000 hours	1,000 hours
	D x L ≤ 10 x 15 mm	3,000 hours	
Ripple Current	Maximum ripple current specified at 100 KHz 105°C		No ripple current applied
Voltage	The sum of DC voltage and the peak AC voltage must not exceed the rated voltage of the capacitor		No voltage applied
Performance	**The following specifications will be satisfied when the capacitor is restored to 20°C:**		
Capacitance Change	Within ±20% of the initial value		
Dissipation Factor	Does not exceed 200% of the specified value		
Leakage Current	Does not exceed specified value		

Environmental Compliance

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

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

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

RoHS Compliant

Table 1 – Ratings & Part Number Reference

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

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

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

Table 1 – Ratings & Part Number Reference cont'd

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

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

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

Table 1 – Ratings & Part Number Reference cont'd

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

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

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

Mounting Positions (Safety Vent)

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

Installing

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

Case Diameter	Space Around Safety Vent
≤ 16 mm	> 2 mm
> 16 mm to ≤ 40 mm	> 3 mm
> 40 mm	> 5 mm

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

- If the capacitors are stored for a long time, the leakage current must be verified. If the leakage current is superior to the value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with V_R ≤ 160 V (5 W resistor).
- In the case of capacitors connected in series, a suitable voltage sharing must be used.
  In the case of balancing resistors, the approximate resistance value can be calculated as: R = 60/C

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

Application and Operation Guidelines

Electrical Ratings:
Capacitance (ESC)

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

Temperature Dependence of the Capacitance

Capacitance of an electrolytic capacitor depends upon temperature: with decreasing temperature the viscosity of the electrolyte increases, thereby reducing its conductivity.

Capacitance will decrease if temperature decreases. Furthermore, temperature drifts cause armature dilatation and, therefore, capacitance changes (up to 20% depending on the series considered, from 0 to 80°C). This phenomenon is more evident for electrolytic capacitors than for other types.

Frequency Dependence of the Capacitance

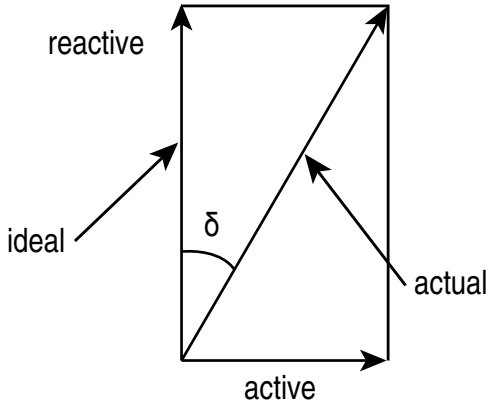
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

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

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

Dissipation Factor tan δ (DF)

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

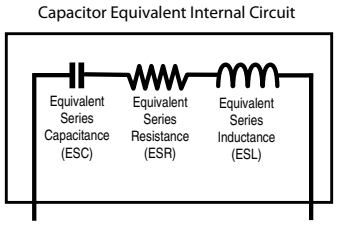


Tan δ is measured with the same set-up used for the series capacitance ESC.
tan δ = ω x ESC x ESR where:

ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Equivalent Series Inductance (ESL)

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



Equivalent Series Resistance (ESR)

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

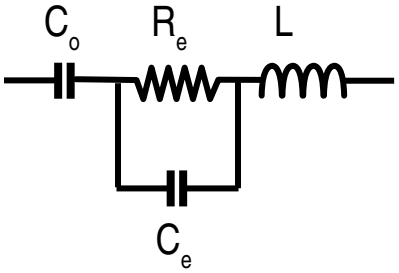
$$ESR = \frac{\tan \delta}{2\pi f\, ESC}$$

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

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

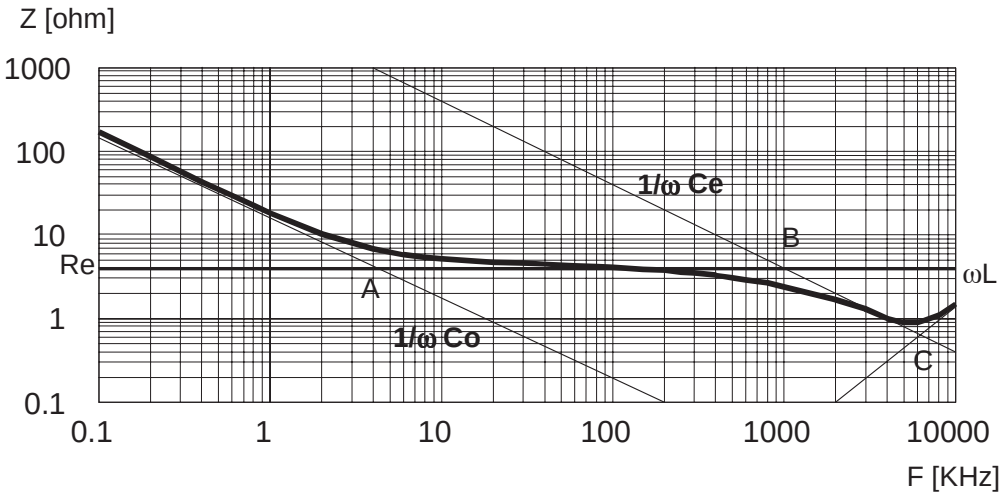
Impedance (Z)

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



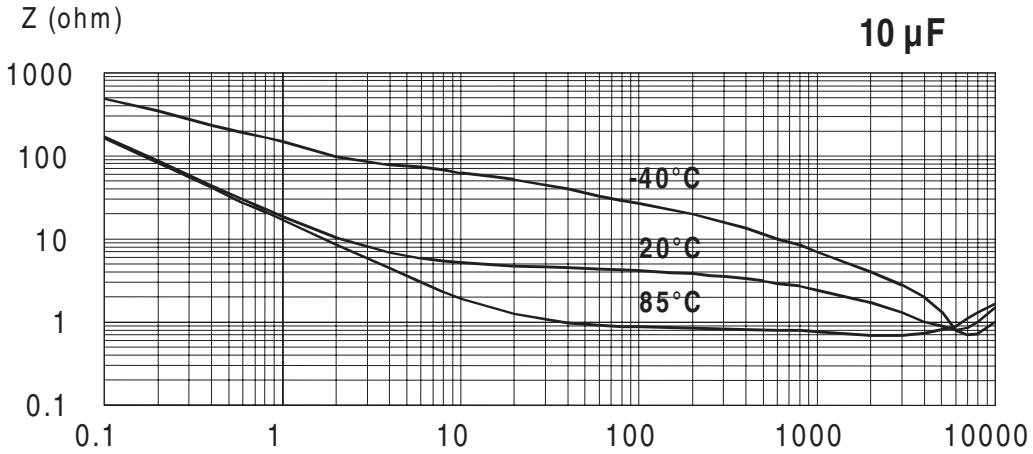
C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, etc.)
C_e = Electrolyte soaked paper capacitance
L = Inductive reactance of the capacitor winding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

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



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

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



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

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

Leakage Current (LC)

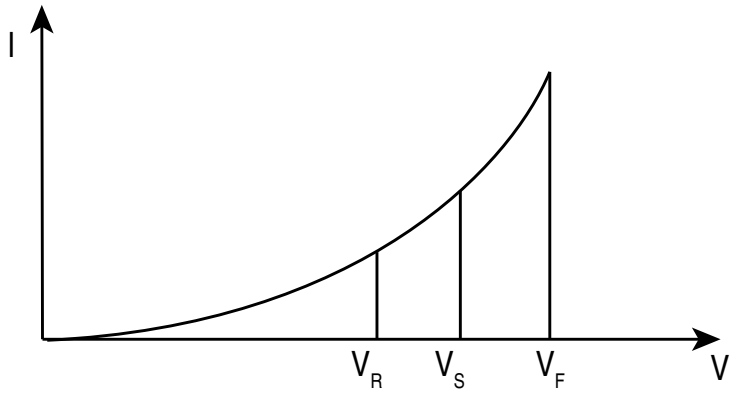
Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.

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

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

As the oxide layer is regenerated in use, the leakage current will gradually decrease to its normal level.

The relationship between the leakage current and voltage applied at constant temperature can be shown schematically as follows:



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

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

Ripple Current (RC)

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

tan δ or ESR
- Frequency

The capacitor's life depends on the thermal stress.

Frequency Dependence of the Ripple Current

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

Temperature Dependence of the Ripple Current

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

Expected Life Calculation

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

Where:

L: Expected life

Lo: Load life at maximum permissible operating temperature

T: Actual operating temperature

To: Maximum permissible operating temperature

This formula is applicable between 40°C and To.

Packaging Quantities

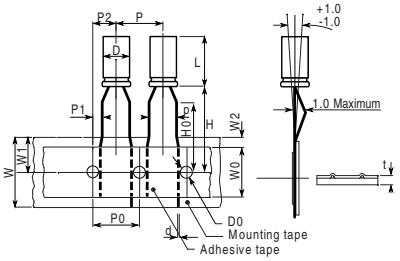
Size Code	Diameter (mm)	Length (mm)	Bulk Standard Leads	Auto-insertion		
				Cut Leads	Ammo	Tape & Reel
C3	5	11	10000	15000	2000	1300
E3	6.3	11	10000	15000	2000	1100
G3	8	11	6000	8000	1000	750
G4	8	15	5000	5000	1000	750
G6	8	20	4000	4000	1000	750
H1	10	12	4000	4000	700	600
H2	10	16	3000	4000	700	600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

Standard Marking for Radial Types

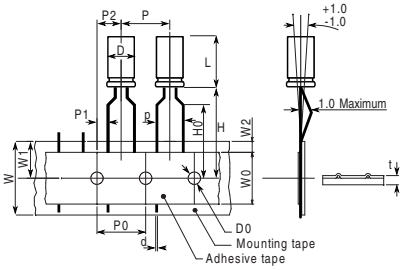
- KEMET logo
- Series
- Operating temperature (°C)
- Rated capacitance (µF)
- Rated voltage (VDC)
- Negative polarity: gold line
- Date code

Taping for Automatic Insertion Machines

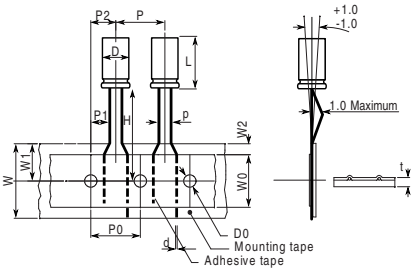
Formed to 2.5 mm
(Lead and packaging code LA and FA)



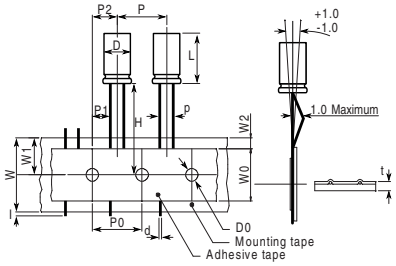
Formed to 5 mm
(Lead and packaging code JA and DA)



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



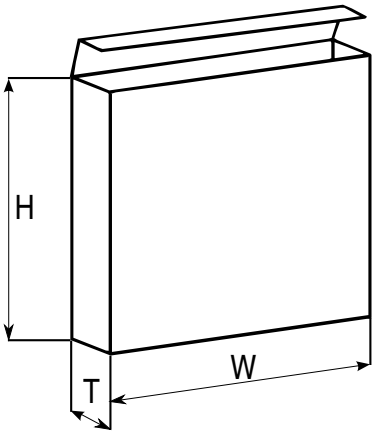
Straight Leads (Diameter > 8)
Lead and packaging code EA and KA



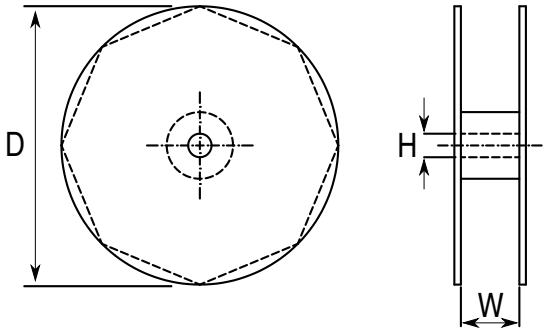
Dimensions (mm)	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H0	H1	I	D0	t
Tolerance	+0.5		+0.8/-0.2	±0.05	±1 .0	±0 .3	±0 .7	±1 .3	+1/-0.5	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	≤7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5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

Ammo Box



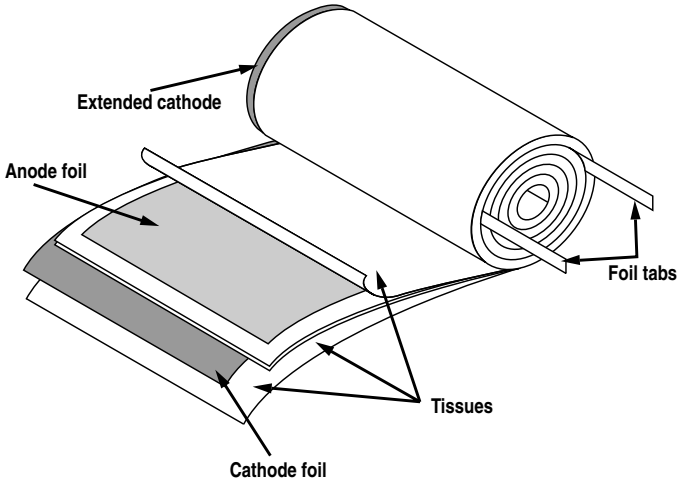
Reel



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

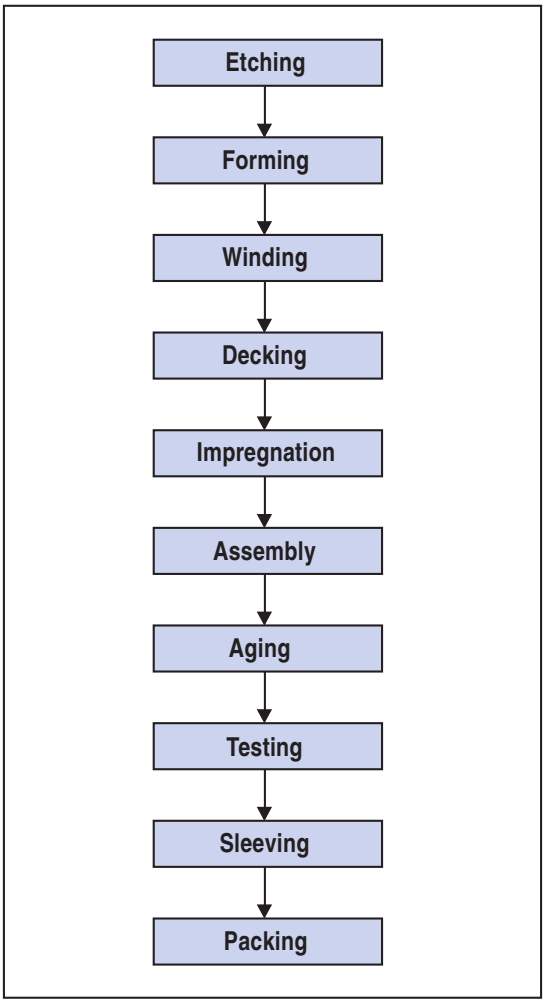
Construction

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



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

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



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

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

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

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

Electrical:

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

Mechanical/Visual:

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

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Northern Europe
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Espoo, Finland
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Northeast Asia
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Beijing, China
Tel: 86-10-5829-1711

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

Taipei, Taiwan
Tel: 886-2-27528585

Southeast Asia
Singapore
Tel: 65-6586-1900

Penang, Malaysia
Tel: 60-4-6430200

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

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Other KEMET Resources

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

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

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

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

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All Information given herein is believed to be accurate and reliable, but is presented without guarantee, warranty, or responsibility of any kind, expressed or implied.

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Although we design and manufacture our products to the most stringent quality and safety standards, given the current state of the art, isolated component failures may still occur. Accordingly, customer applications which require a high degree of reliability or safety should employ suitable designs or other safeguards (such as installation of protective circuitry or redundancies) in order to ensure that the failure of an electrical component does not result in a risk of personal injury or property damage.

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

Digitally signed by Jeannette Calvo
DN: c=US, st=FL, l=Fort Lauderdale, o=KEMET Corp., ou=Marketing Communications, cn=Jeannette Calvo, email=jeannettecalvo@kemet.com
Date: 2012.10.10 16:20:28 -04'00'