KEMET

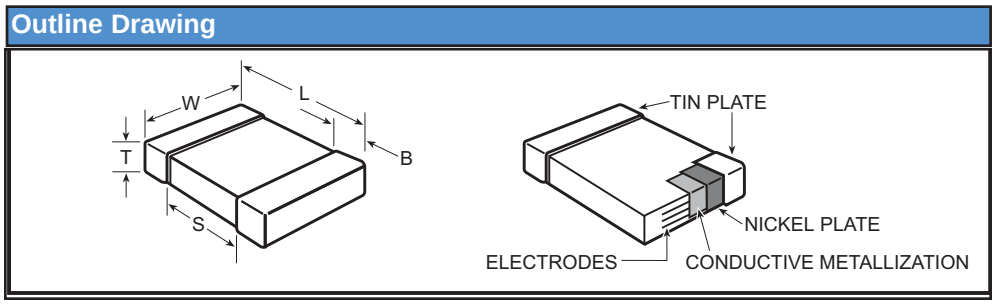
CHARGED.™

FlexDesign
SAMPLE KIT

Product-ID: FD-Kemet

Fail-Safe Floating Electrode MLCC / *FE-CAP* / X7R Dielectric

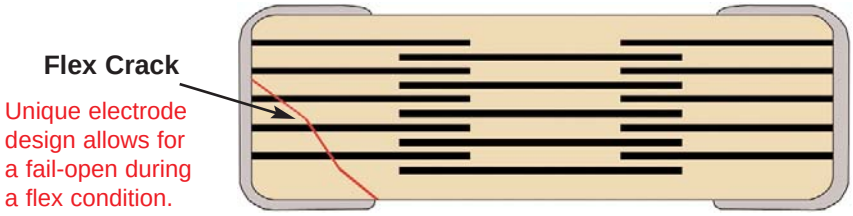
Outline Drawing



Product Description

The FE-CAP is a SMD MLCC which utilizes a floating internal electrode design, wherein the electrodes are configured to form multiple capacitors in series within a single MLCC package. This not only yields improved voltage and ESD performance over standard designs, but also mitigates the risk of low-IR or short-circuit failures that can occur due to board flex. Combined with the stability of an X7R dielectric, the FE-CAP complements KEMET's Open Mode Devices by providing a fail-safe design optimized for low- to mid-range capacitance values.

FE-CAP Internal Design



Dimensions – Millimeters (Inches)

EIA Size Code	Metric Size Code	L Length	W Width	B Bandwidth	S Separation
0402	1005	1.0 (.04) ± 0.05 (.002)	0.5 (.02) ± 0.05 (.002)	0.20 (.008) -0.40 (.016)	0.30 (.012)
0603	1608	1.6 (.063) ± 0.15 (.006)	0.8 (.032) ± 0.15 (.006)	0.35 (.014) ± 0.15 (.006)	0.70 (.028)
0805	2012	2.0 (.079) ± 0.20 (.008)	1.25 (.049) ± 0.20 (.008)	0.05 (.02) ± 0.25 (.010)	0.75 (.030)
1206	3216	3.2 (.126) ± 0.20 (.008)	1.6 (.063) ± 0.20 (.008)	0.50 (.02) ± .25 (.010)	N/A
1210	3225	3.2 (.126) ± 0.20 (.008)	2.5 (.098) ± 0.20 (.008)	0.50 (.02) ± .25 (.010)	N/A
1812	4532	4.5 (.177) ± 0.30 (.012)	3.2 (.126) ± 0.30 (.012)	0.60 (.024) ± .35 (.014)	N/A

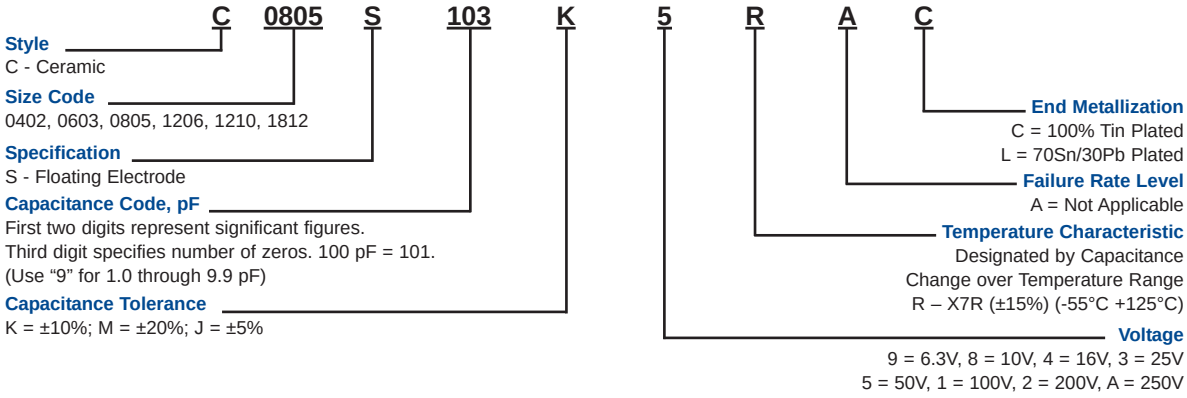
Refer to standard thickness dimensions and table located in the F3102 SMT catalog on pages 73, 74, and 77.

RoHS Compliant

X7R Capacitance Range

CAP (pF)	CAP (nF)	CAP CODE	0402					0603							0805								1206								1210								1812				
			6.3	10	16	25	50	6.3	10	16	25	50	100	200	6.3	10	16	25	50	100	200	250	6.3	10	16	25	50	100	200	250	6.3	10	16	25	50	100	200	250	25	50	100	200	250
150	0.15	151	■	■	■	■	■																																				
180	0.18	181	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
220	0.22	221	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
270	0.27	271	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
330	0.33	331	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
390	0.39	391	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
470	0.47	471	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
560	0.56	561	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
680	0.68	681	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
820	0.82	821	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																					
1000	1.00	102	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
1200	1.2	122						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
1500	1.5	152						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
1800	1.8	182						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
2200	2.2	222						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
2700	2.7	272						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3300	3.3	332						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3900	3.9	392						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
4700	4.7	472						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
5600	5.6	562						■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
6800	6.8	682						■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8200	8.2	822						■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10000	10	103						■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
12000	12	123						■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
15000	15	153						■	■	■	■	■			■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
18000	18	183						■	■	■	■	■			■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
22000	22	223						■	■	■	■	■			■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
27000	27	273													■	■	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
33000	33	333													■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■
39000	39	393													■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■
47000	47	473													■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■
56000	56	563													■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■
68000	68	683																					■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■
82000	82	823																					■	■	■	■	■				■	■	■	■	■	■			■	■	■	■	■	■
100000	100	104																					■	■	■	■	■				■	■	■	■	■	■			■	■	■			
120000	120	124																					■	■	■	■	■				■	■	■	■	■				■	■	■			
150000	150	154																													■	■	■	■	■				■	■	■			
180000	180	184																													■	■	■	■	■				■	■				
220000	220	224																													■	■	■	■	■				■	■				

Ordering Information



Electrical Parameters

As detailed in the KEMET Surface Mount Catalog F3102 for X7R, with following specific requirements based on room temperature (25°C) parameters:

- Operating Range: -55°C to +125°C, with no-bias capacitance shift limited to ± 15% over that range.
- Insulation Resistance (IR) measured after 2 minutes at rated voltage @ 25°C: Limit is 1,000 megohm microfarads or 100 gigohm, whichever is less.
- Capacitance and Dissipation Factor (DF) measured at 1kHz and 1 Vrms.
  DF Limits are:

50 - 250 Volts	2.5%
16 - 25 Volts	3.5%
6.3 - 10 Volts	5.0%

Soldering Process

These components are suitable for reflow and wave soldering. All parts incorporate the standard KEMET barrier layer of pure nickel, with an overplate of pure tin to provide excellent solderability as well as resistance to leaching.

Marking

These chips will be supplied unmarked. If required, they can be laser-marked as an extra option. Details on the marking format are included in KEMET Surface Mount catalog F3102.

Qualification/Certification

AEC-Q200 Rev. C - Automotive
RoHS 6 - 100% tin termination

In general, the information in the KEMET Surface Mount catalog F3102 applies to these capacitors. The information in this bulletin supplements that in the catalog.

RoHS Compliant KEMET CHARGED.

FEATURES

KEMET's Open Mode Ceramic Surface Mount Capacitor is designed to significantly minimize the probability of a low IR or Short Circuit Condition when forced to failure in a board flex situation. This reduces the potential for causing catastrophic failures. This product is RoHS Compliant.

Applications:
- Input side filtering (power plane/bus)
- High current applications (battery line)
- Circuits that cannot be fused to open when short circuits occur due to flex cracks

Markets:
- *Automotive*
  - All applications connected directly to the battery
  - Conversion to 42V power system
- *Power Conversion*
  - Raw power input side filtering

OUTLINE DRAWING

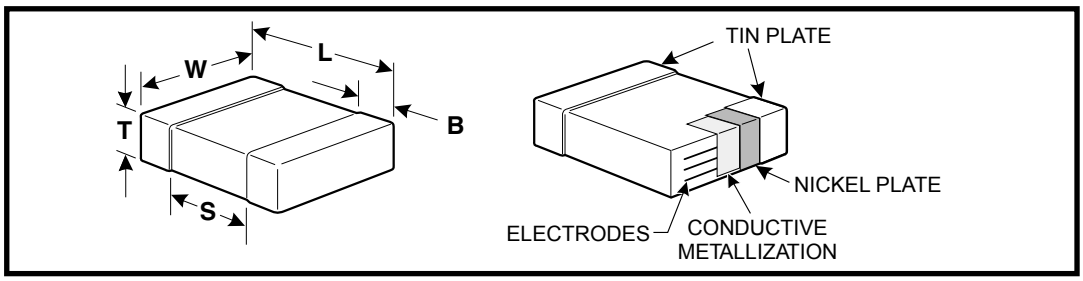


TABLE 1 - DIMENSIONS - MILLIMETERS (INCHES)

Metric Size Code	EIA Size Code	L - Length	W - Width	B - Bandwidth	Separation
2012	0805	2.0 (.079) ± .20 (.008)	1.25 (.049) ± 0.2 (.008)	0.50 (.02) ± .25 (.010)	0.75 (.030)
3216	1206	3.2 (.126) ± .20 (.008)	1.6 (.063) ± 0.2 (.008)	0.50 (.02) ± .25 (.010)	N/A
3225	1210	3.2 (.126) ± .20 (.008)	2.5 (.098) ± 0.2 (.008)	0.50 (.02) ± .25 (.010)	N/A
4532	1812	4.5 (.177) ± 0.3 (.012)	3.2 (.126) ± 0.3 (.012)	0.60 (.024) ± .35 (.014)	N/A

Note: For thickness dimensions, see Table 2.

CAPACITOR ORDERING INFORMATION

C 1812 F 105 K 1 R A C

Style
C - Ceramic

Size Code
0805, 1206, 1210, 1812

Specification
F - Open-Mode

Capacitance Code, pF
First two digits represent significant figures.
Third digit specifies number of zeros. 100 pF = 101.
(Use "9" for 1.0 through 9.9 pF)
(Use "8" for 0.1 through .99 pF)

Capacitance Tolerance
K = ±10% M = ±20%

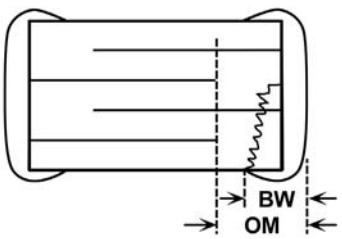
End Metallization
C = 100% Tin Plated
L = 70Sn/30Pb Plated

Failure Rate Level
A = Not Applicable

Temperature Characteristic
Designated by Capacitance Change over Temperature Range
R – X7R (±15%) (-55°C +125°C)

Voltage
2 = 200V 5 = 50V
1 = 100V 3 = 25V
4 = 16V

OPEN-MODE INTERNAL DESIGN



The open-mode dimension (OM) exceeds the termination bandwidth dimensions: OM >BW

CERAMIC OPEN MODE CAPACITORS

TABLE 2
X7R DIELECTRIC CAPACITANCE RANGE AND THICKNESS TARGETS (mm)

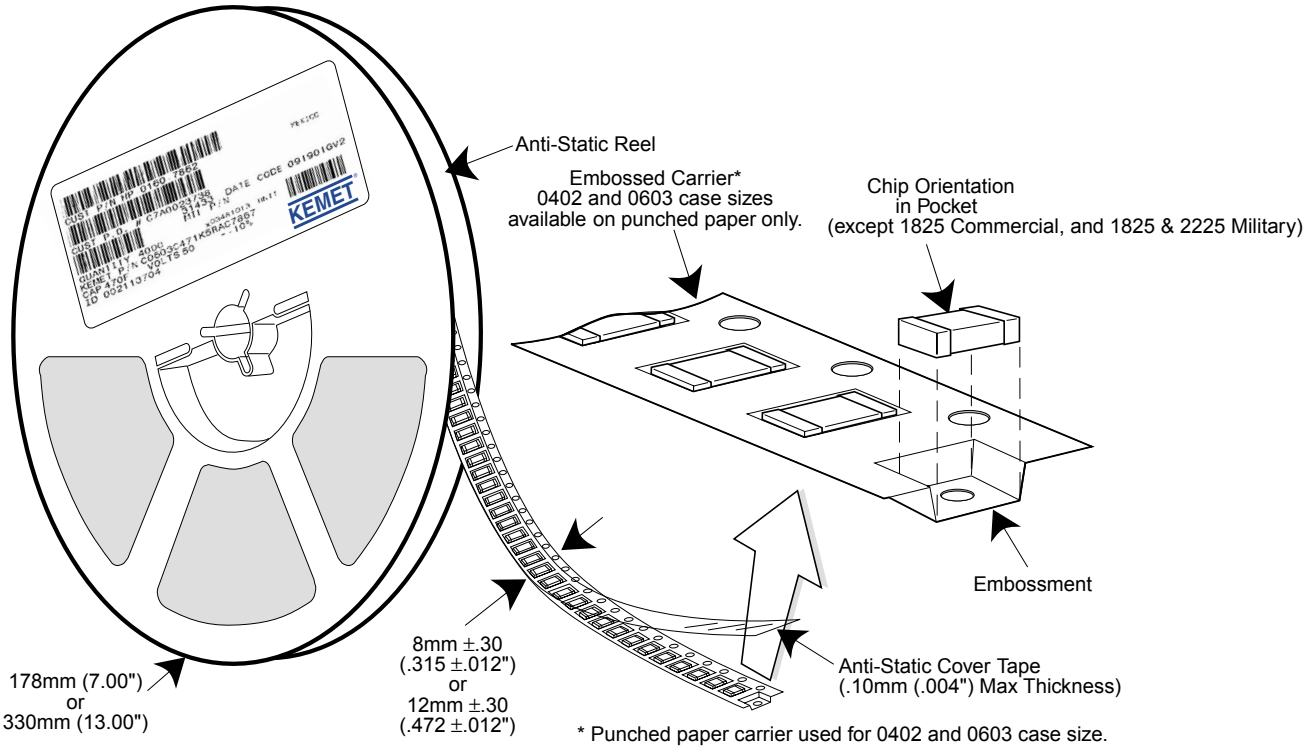
Cap Code	0805					1206					1210					1812			
	16V	25V	50V	100V	200V	16V	25V	50V	100V	200V	16V	25V	50V	100V	200V	25V	50V	100V	200V
102	DD	DD	DD	DD	DD														
122	DD	DD	DD	DD	DD														
152	DD	DD	DD	DD	DD														
182	DD	DD	DD	DD	DD														
222	DD	DD	DD	DD	DD														
272	DD	DD	DD	DD	DD														
332	DD	DD	DD	DD	DD														
392	DD	DD	DD	DD	DD														
472	DD	DD	DD	DD	DD														
562	DD	DD	DD	DD	DD														
682	DD	DD	DD	DD	DD														
822	DD	DD	DD	DD	DD														
103	DD	DD	DD	DD	DD														
123	DD	DD	DD	DD	DG														
153	DD	DD	DD	DD	DG														
183	DD	DD	DD	DD						EC									
223	DD	DD	DD	DG						EC									
273	DD	DD	DD	DG						EC									
333	DD	DD	DD	DG						EC									
393	DD	DD	DD	DG						EC									
473	DD	DD	DD	DE		EC	EC	EC	EC	EG									GB
563	DD	DD	DD			EC	EC	EC	EC	EG									GB
683	DD	DD	DG	DG		EC	EC	EC	EC	EG					FD				GB
823	DD	DD	DG			EC	EC	EC	EC	EG					FD				GB
104	DG	DG	DG			EC	EC	EC	EC	EG	FD	FD	FD	FD	FG	GB	GB	GB	GB
124	DG	DG				EC	EC	EC	EC		FD	FD	FD	FD	FG	GB	GB	GB	GB
154	DG	DG				EC	EC	EC	EG		FD	FD	FD	FD	FH	GB	GB	GB	GB
184	DG	DG				EC	EC	EC	EG		FD	FD	FD	FD	FH	GB	GB	GB	GB
224	DG	DD	DG			EC	EC	EC	ED		FD	FD	FD	FG	FJ	GB	GB	GB	GC
274	DD	DD				EC	EC	EC			FD	FD	FD	FG		GB	GB	GB	GF
334	DG	DG				EG	EG	EG	EG		FD	FD	FD	FH		GB	GB	GB	GK
394	DG	DG				EG	EG				FD	FD	FG	FH		GB	GB	GB	GL
474	DE	DG				EG	EG	EC			FD	FD	FG	FJ		GB	GB	GC	
564						EG					FD	FD	FG	FR		GB	GB	GD	
684	DG					EG					FD	FG	FH	FR		GD	GD	GF	
824						EG					FD	FG	FJ			GD	GD	GK	
105						EG	EC	EH			FD	FH	FJ	FQ		GN	GN	GM	
125											FG								
155											FH								
185											FH								
225						EC	EH				FJ		FM						
475						EH					FG	FM							
685												FQ							

THICKNESS AND PACKAGING INFORMATION

Thickness Code	Series	Dimension	7" Reel Qty.	13" Reel Qty.
DD	0805	.90 ± .10	4000	10000
DE	0805	1.00 ± .10	2500	10000
DG	0805	1.25 ± .15	2500	10000
EC	1206	.90 ± .10	4000	10000
ED	1206	1.00 ± .10	2500	10000
EG	1206	1.60 ± .15	2000	8000
EH	1206	1.60 ± .20	2000	8000
FD	1210	.95 ± .10	4000	10000
FG	1210	1.25 ± .15	2500	10000
FH	1210	1.55 ± .15	2000	8000
FJ	1210	1.85 ± .20	2000	8000
FM	1210	1.70 ± .20	2000	8000
FR	1210	2.25 ± .20	2000	8000
FQ	1210	2.5 ± .20	1500	8000
GB	1812	1.0 ± .10	1000	4000
GC	1812	1.1 ± .10	1000	4000
GD	1812	1.25 ± .15	1000	4000
GF	1812	1.50 ± .15	1000	4000
GK	1812	1.60 ± .20	1000	4000
GL	1812	1.90 ± .20	1000	4000
GM	1812	2.00 ± .20	1000	4000
GN	1812	1.70 ± .20	1000	4000

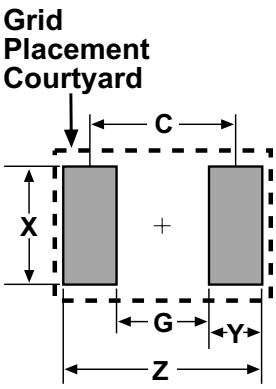
Tape & Reel Packaging

KEMET offers Multilayer Ceramic Chip Capacitors packaged in 8mm and 12mm plastic tape on 7" and 13" reels in accordance with EIA standard 481-1: Taping of surface mount components for automatic handling. This packaging system is compatible with all tape fed automatic pick and place systems. See page 78 for details on reeling quantities for commercial chips and page 87 for MIL-PRF-55681 chips.



Case Sizes ≤ 1210 are 8 mm tape with 4 mm pitch.
Case Sizes > 1210 are 12 mm tape with 8 mm pitch
Note: TU suffix represents tape and reel packaging of marked components.
TM suffix represents tape and reel packaging of marked components.

SURFACE MOUNT LAND DIMENSIONS - CERAMIC CHIP CAPACITORS - MM



	Reflow Solder					Wave Solder				
Dimension	Z	G	X	Y(ref)	C(ref)	Z	G	X	Y(ref)	Smin
0402	2.14	0.28	0.74	0.93	1.21	Not Recommended				
0603	2.78	0.68	1.08	1.05	1.73	3.18	0.68	0.80	1.25	1.93
0805	3.30	0.70	1.60	1.30	2.00	3.70	0.70	1.10	1.50	2.20
1206	4.50	1.50	2.00	1.50	3.00	4.90	1.50	1.40	1.70	3.20
1210	4.50	1.50	2.90	1.50	3.00	4.90	1.50	2.00	1.70	3.20
1812	5.90	2.30	3.70	1.80	4.10	Not Recommended				
1825	5.90	2.30	6.90	1.80	4.10					
2220	7.00	3.30	5.50	1.85	5.15					
2225	7.00	3.30	6.80	1.85	5.15					

Calculation Formula
Z = Lmin + 2Jt + Tt
G = Smax - 2Jh -Th
X = Wmin + 2Js + Ts
Tt, Th, Ts = Combined tolerances

Performance Notes

1. **Cover Tape Break Force:** 1.0 Kg Minimum.
2. **Cover Tape Peel Strength:** The total peel strength of the cover tape from the carrier tape shall be:

Tape Width	Peel Strength
8 mm	0.1 Newton to 1.0 Newton (10g to 100g)
12 mm	0.1 Newton to 1.3 Newton (10g to 130g)

   The direction of the pull shall be opposite the direction of the carrier tape travel. The pull angle of the carrier tape shall be 165° to 180° from the plane of the carrier tape. During peeling, the carrier and/or cover tape shall be pulled at a velocity of 300 ±10 mm/minute.
3. **Reel Sizes:** Molded tantalum capacitors are available on either 180 mm (7") reels (standard) or 330 mm (13") reels (with C-7280). Note that 13" reels are preferred.
4. **Labeling:** Bar code labeling (standard or custom) shall be on the side of the reel opposite the sprocket holes. Refer to EIA-556.

Embossed Carrier Tape Configuration: Figure 1

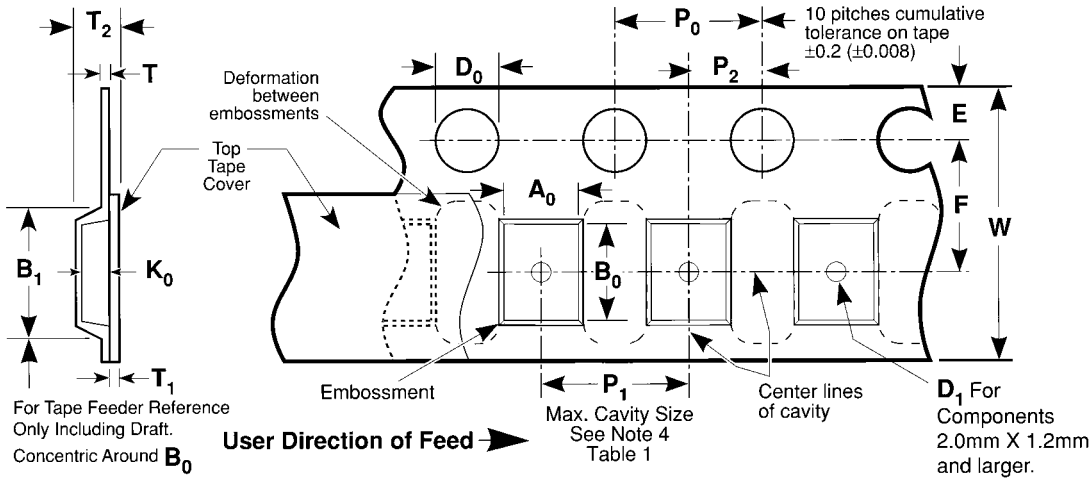


Table 1 — EMBOSSED TAPE DIMENSIONS (Metric will govern)

Constant Dimensions — Millimeters (Inches)							
Tape Size	**D_0**	**E**	**P_0**	**P_2**	**T Max**	**T_1 Max**	
8 mm and 12 mm	1.5 +0.10 -0.0 (0.059 +0.004, -0.0)	1.75 ±0.10 (0.069 ±0.004)	4.0 ±0.10 (0.157 ±0.004)	2.0 ±0.05 (0.079 ±0.002)	0.600 (0.024)	0.100 (0.004)	

Variable Dimensions — Millimeters (Inches)									
Tape Size	**Pitch**	**B_1 Max. Note 1**	**D_1 Min. Note 2**	**F**	**P_1**	**R Min. Note 3**	**T_2 Max**	**W**	**$A_0B_0K_0$ Note 4**
8 mm	Single (4 mm)	4.4 (0.173)	1.0 (0.039)	3.5 ±0.05 (0.138 ±0.002)	4.0 ±0.10 (0.157 ±0.004)	25.0 (0.984)	2.5 (0.098)	8.0 ±0.30 (.315 ±0.012)	
12 mm	Double (8 mm)	8.2 (0.323)	1.5 (0.059)	5.5 ±0.05 (0.217 ±0.002)	8.0 ±0.10 (0.315 ±0.004)	30.0 (1.181)	4.6 (0.181)	12.0 ±0.30 (0.472 ±0.012)	

NOTES

1. B1 dimension is a reference dimension for tape feeder clearance only.
2. The embossment hole location shall be measured from the sprocket hole controlling the location of the embossment. Dimensions of embossment location and hole location shall be applied independent of each other.
3. Tape with components shall pass around radius "R" without damage (see sketch A). The minimum trailer length (Fig. 2) may require additional length to provide R min. for 12 mm embossed tape for reels with hub diameters approaching N min. (Table 2)
4. The cavity defined by A_0, B_0, and K_0 shall be configured to surround the part with sufficient clearance such that the chip does not protrude beyond the sealing plane of the cover tape, the chip can be removed from the cavity in a vertical direction without mechanical restriction, rotation of the chip is limited to 20 degrees maximum in all 3 planes, and lateral movement of the chip is restricted to 0.5 mm maximum in the pocket (not applicable to vertical clearance.)

Embossed Carrier Tape Configuration (cont.)

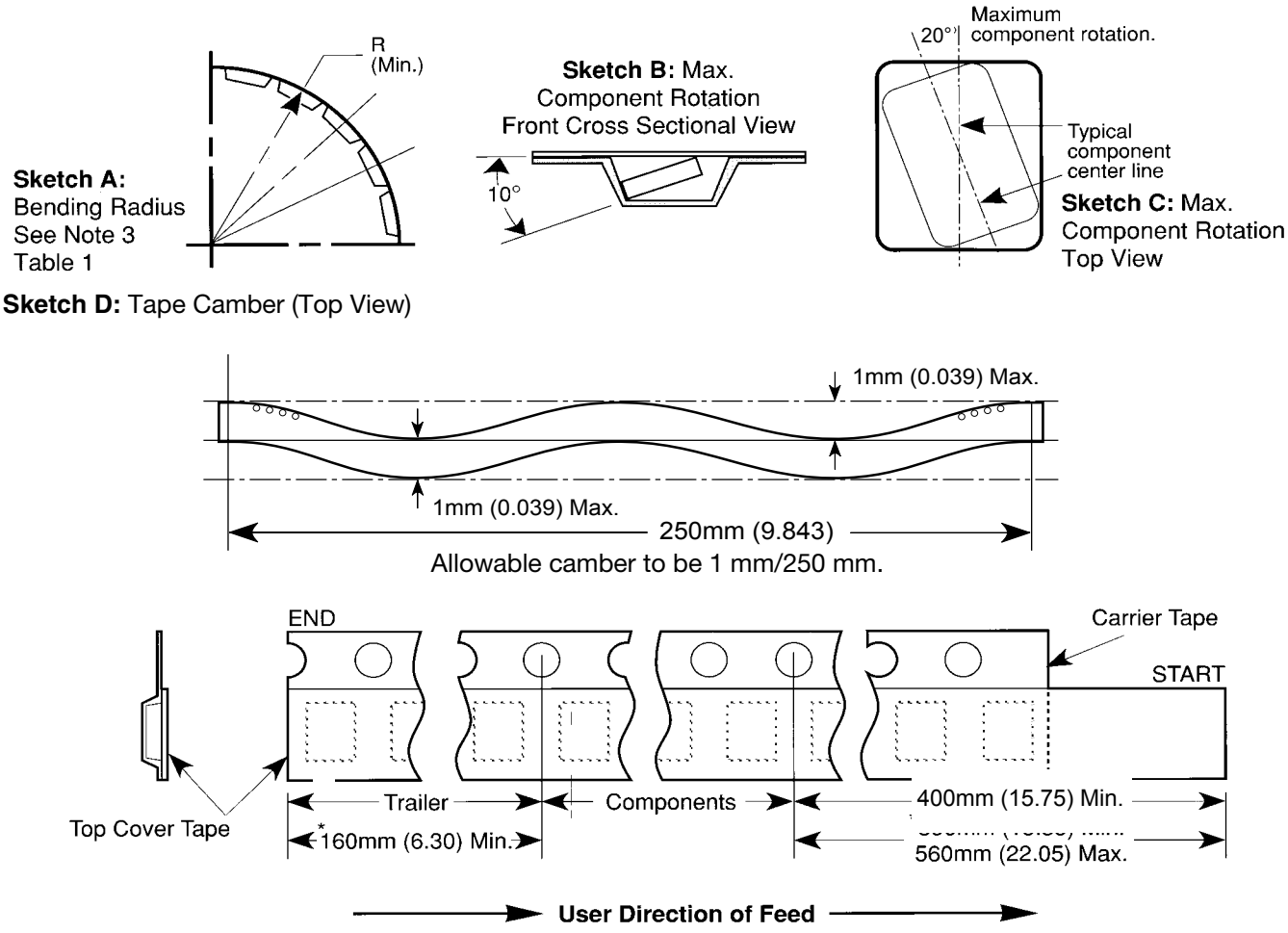


Figure 2: Tape Leader & Trailer Dimensions (Metric Dimensions Will Govern)

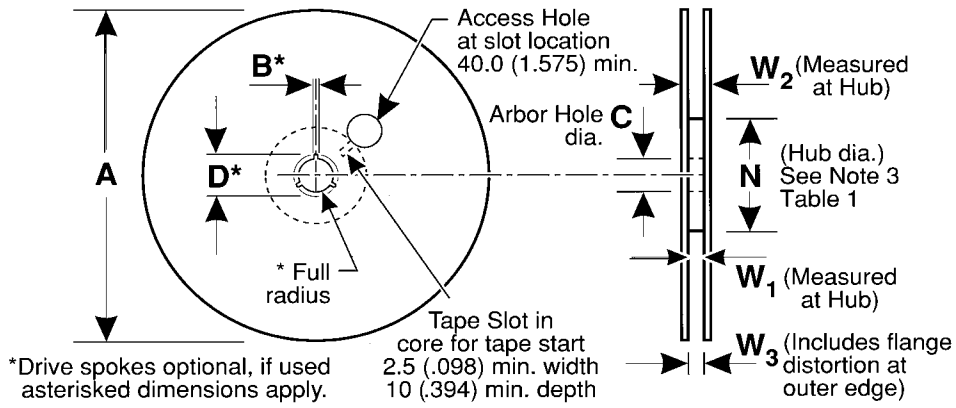


Figure 3: Reel Dimensions (Metric Dimensions will govern)

Table 2 – REEL DIMENSIONS (Metric will govern)

Tape Size	A Max	B* Min	C	D* Min	N Min	W_1	W_2 Max	W_3
8 mm	330.0 (12.992)	1.5 (0.059)	13.0 ± 0.20 (0.512 ± 0.008)	20.2 (0.795)	50.0 (1.969) See Note 3 Table 1	8.4 +1.5, -0.0 (0.331 +0.059, -0.0)	14.4 (0.567)	7.9 Min (0.311) 10.9 Max (0.429)
12 mm	330.0 (12.992)	1.5 (0.059)	13.0 ± 0.20 (0.512 ± 0.008)	20.2 (0.795)		12.4 +2.0, -0.0 (0.488 +0.078, -0.0)	18.4 (0.724)	11.9 Min (0.469) 15.4 Max (0.606)

Punched Carrier (Paper Tape) Configuration (Ceramic Chips Only):

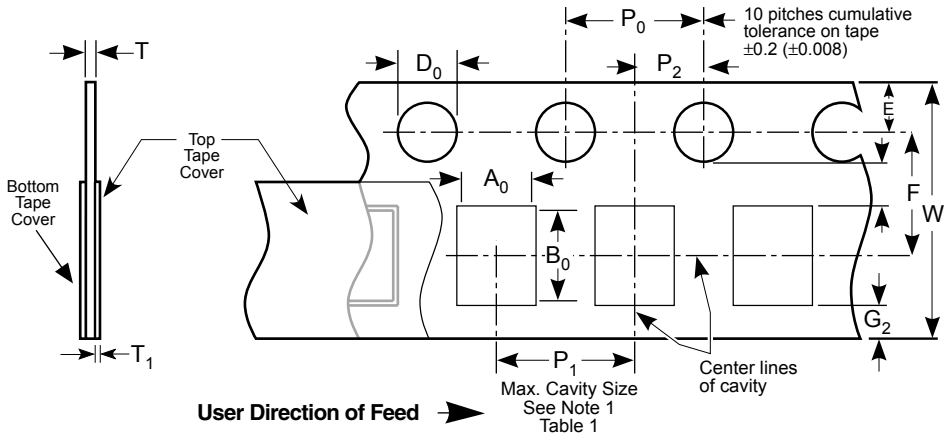


Table 1: 8 & 12mm Punched Tape
(Metric Dimensions Will Govern)

Constant Dimensions - Millimeters (Inches)

Tape Size	D_0	E	P_0	P_2	T_1	G_1	G_2	R Min.
8mm and 12mm	1.5 +0.10, -0.0 (.059 +0.004, -0.0)	1.75 ±0.10 (.069 ±0.004)	4.0 ± 0.10 (.157 ± 0.004)	2.0 ± 0.05 (.079 ± 0.002)	0.10 (.004) Max.	0.75 (.030) Min.	0.75 (.030) Min.	25 (.984) See Note 2 Table 1

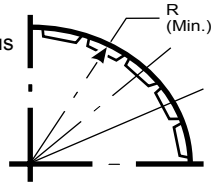
Table 1: 8 & 12mm Punched Tape
(Metric Dimensions Will Govern)

Variable Dimensions - Millimeters (Inches)

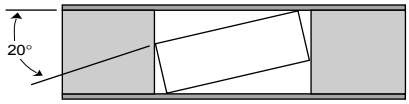
Tape Size	P_1	F	W	A_0B_0	T
8mm 1/2 Pitch	2.0 ± 0.10 (.079 ±.004) See Require-ments Section 3.3 (d)	3.5 ± 0.05 (.138 ± .002)	8.0 ± 0.3 (.315 ± 0.012)	See Note 1 Table 1	1.1mm (.043) Max. for Paper Base Tape and 1.6mm (.063) Max. for Non-Paper Base Compositions. See Note 3.
8mm	4.0 ± 0.10 (0.157 ± .004)				
12mm	4.0 ± 0.10 (0.157 ± .004)	5.5 ± 0.05 (.217 ± .002)	12.0 ± 0.3 (.472 ± .012)		
12mm Double Pitch	8.0 ± 0.10 (0.315 ± .004)				

Note:
1. A_0, B_0 and T determined by the maximum dimensions to the ends of the terminals extending from the body and/or the body dimensions of the component. The clearance between the ends of the terminals or body of the component to the sides and depth of the cavity (A_0, B_0 and T) must be within 0.05mm (.002) minimum and 0.50mm (.020) maximum. The clearance allowed must also prevent rotation of the component within the cavity of not more than 20 degrees (see sketches A and B).
2. Tape with components shall pass around radius "R" without damage.
3. KEMET nominal thicknesses are: 0402 = 0.6mm and all others 0.95mm minimum.

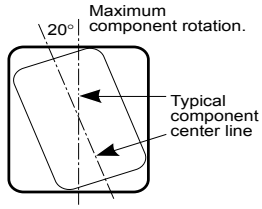
Sketch A:
Bending Radius
See Note 2
Table 1



Sketch B:
Max. Component Rotation - Front Cross Sectional View



Sketch C:
Component Rotation - Top View



Bulk Cassette Packaging (Ceramic Chips only)

(Meets Dimensional Requirements IEC-286-6 and EIAJ 7201)

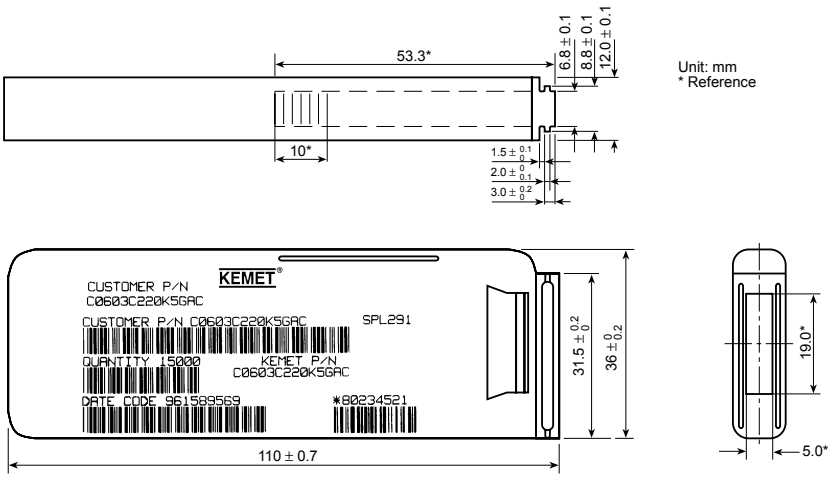


Table 2 – Capacitance Values Available In Bulk Cassette Packaging

Case Size	Dielectric	Voltage	Min. Cap Value	Max. Cap Value
0402	All	All	All	All
0603	All	All	All	All
0805	C0G	200 100 50	109 109 109	181 331 102
	X7R	200 100 50 25 16	221 221 221 221 221	392 103 273 104 104
	Y5V	25 16	104 104	224 224

Table 1 – Capacitor Dimensions for Bulk Cassette Packaging – Millimeters

Metric Size Code	EIA Size Code	Length L	Width W	Thickness T	Bandwidth B	Minimum Separation S	Number of Pcs/Cassette
1005	0402	1.0 ± 0.05	0.5 ± 0.05	0.5 ± .05	0.2 to 0.4	0.3	50,000
1608	0603	1.6 ± 0.07	0.8 ± 0.07	0.8 ± .07	0.2 to 0.5	0.7	15,000
2012	0805	2.0 ± 0.10	1.25 ± 0.10	0.6 ± .10	0.5 to 0.75	0.75	10,000

Terminations: KEMET nickel barrier layer with a tin overplate.

CAPACITOR MARKING TABLE (Marking Optional - Not Available for 0402 Size or Y5V Dielectric)

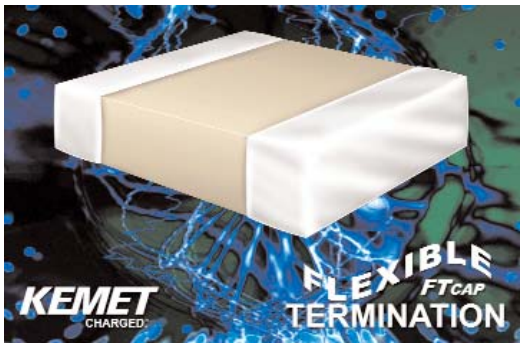
Numeral / Alpha Character	Capacitance (pF) For Various Numeral Identifiers								
	9	0	1	2	3	4	5	6	7
A	0.10	1.0	10	100	1000	10,000	100,000	1,000,000	10,000,000
B	0.11	1.1	11	110	1100	11,000	110,000	1,100,000	11,000,000
C	0.12	1.2	12	120	1200	12,000	120,000	1,200,000	12,000,000
D	0.13	1.3	13	130	1300	13,000	130,000	1,300,000	13,000,000
E	0.15	1.5	15	150	1500	15,000	150,000	1,500,000	15,000,000
F	0.16	1.6	16	160	1600	16,000	160,000	1,600,000	16,000,000
G	0.18	1.8	18	180	1800	18,000	180,000	1,800,000	18,000,000
H	0.20	2.0	20	200	2000	20,000	200,000	2,000,000	20,000,000
J	0.22	2.2	22	220	2200	22,000	220,000	2,200,000	22,000,000
K	0.24	2.4	24	240	2400	24,000	240,000	2,400,000	24,000,000
L	0.27	2.7	27	270	2700	27,000	270,000	2,700,000	27,000,000
M	0.30	3.0	30	300	3000	30,000	300,000	3,000,000	30,000,000
N	0.33	3.3	33	330	3300	33,000	330,000	3,300,000	33,000,000
P	0.36	3.6	36	360	3600	36,000	360,000	3,600,000	36,000,000
Q	0.39	3.9	39	390	3900	39,000	390,000	3,900,000	39,000,000
R	0.43	4.3	43	430	4300	43,000	430,000	4,300,000	43,000,000
S	0.47	4.7	47	470	4700	47,000	470,000	4,700,000	47,000,000
T	0.51	5.1	51	510	5100	51,000	510,000	5,100,000	51,000,000
U	0.56	5.6	56	560	5600	56,000	560,000	5,600,000	56,000,000
V	0.62	6.2	62	620	6200	62,000	620,000	6,200,000	62,000,000
W	0.68	6.8	68	680	6800	68,000	680,000	6,800,000	68,000,000
X	0.75	7.5	75	750	7500	75,000	750,000	7,500,000	75,000,000
Y	0.82	8.2	82	820	8200	82,000	820,000	8,200,000	82,000,000
Z	0.91	9.1	91	910	9100	91,000	910,000	9,100,000	91,000,000
a	0.25	2.5	25	250	2500	25,000	250,000	2,500,000	25,000,000
b	0.35	3.5	35	350	3500	35,000	350,000	3,500,000	35,000,000
d	0.40	4.0	40	400	4000	40,000	400,000	4,000,000	40,000,000
e	0.45	4.5	45	450	4500	45,000	450,000	4,500,000	45,000,000
f	0.50	5.0	50	500	5000	50,000	500,000	5,000,000	50,000,000
m	0.60	6.0	60	600	6000	60,000	600,000	6,000,000	60,000,000
n	0.70	7.0	70	700	7000	70,000	700,000	7,000,000	70,000,000
t	0.80	8.0	80	800	8000	80,000	800,000	8,000,000	80,000,000
y	0.90	9.0	90	900	9000	90,000	900,000	9,000,000	90,000,000

Laser marking is available as an extra-cost option for most KEMET ceramic chips. Such marking is two sided, and includes a $\overline{K}$ to identify KEMET, followed by two characters (per EIA-198 - see table below) to identify the capacitance value. Note that marking is not available for size 0402 nor for any Y5V chip. In addition, the 0603 marking option is limited to the $\overline{K}$ only.

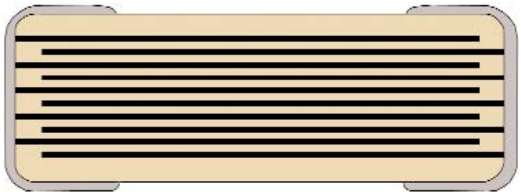
	$\overline{K}$A3	

Example shown is 1,000 pF capacitor.

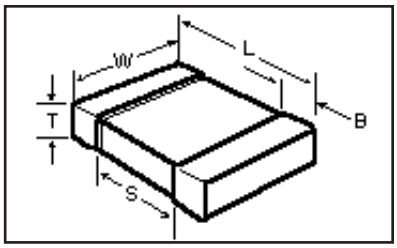
Surface Mount Ceramic Chip Capacitors / *FT-CAP* / Flexible Terminations

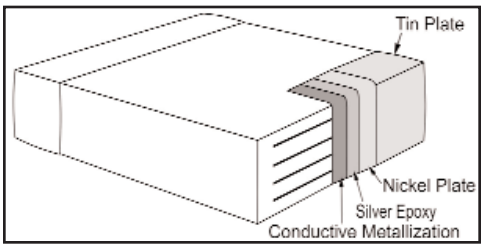


Standard Electrode Internal Design



Outline Drawing





The “Flexible Termination (FT-CAP)” capacitor is a surface mount multi-layer ceramic capacitor that incorporates a unique, flexible termination system that is integrated with standard termination materials. A conductive silver epoxy is utilized between the conductive metallization and nickel barrier finish in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed to address the primary failure mode of MLCC’s, flex cracks, which are typically the result of excessive shear stresses produced during board flexure. Flexible termination technology directs board flex stress away from the ceramic body and into the conductive epoxy area, therefore mitigating flex cracks which can result in low-IR or short-circuit failures. The FT-CAP offers up to 5mm of flex-bend capability, complementing our current "Open Mode","Floating Electrode (FE-CAP)"and “Floating Electrode with Flexible Termination (FF-CAP)” product lines by providing our customers with a complete portfolio of flex solutions.

Dimensions – Millimeters (Inches)

EIA Size Code	Metric Size Code	L Length	W Width	B Bandwidth	S Separation
0603	1608	1.6 (.063) ± 0.20 (.008)	0.8 (.031) ± 0.15 (.006)	0.35 (.014) ± 0.15 (.006)	0.70 (.028)
0805	2012	2.1 (.083) ± 0.30 (.012)	1.25 (.049) ± 0.20 (.008)	0.50 (.020) ± 0.25 (.010)	0.75 (.030)
1206	3216	3.3 (.130) ± 0.30 (.012)	1.6 (.063) ± 0.20 (.008)	0.50 (.020) ± 0.25 (.010)	-
1210	3225	3.4 (.134) ± 0.40 (.016)	2.5 (.098) ± 0.20 (.008)	0.50 (.020) ± 0.25 (.010)	-
1808	4520	4.7 (.185) ± 0.50 (.020)	2.0 (.079) ± 0.20 (.008)	0.60 (.024) ± 0.35 (.014)	-
1812	4532	4.6 (.181) ± 0.40 (.016)	3.2 (.126) ± 0.30 (.021)	0.60 (.024) ± 0.35 (.014)	-
1825	4564	4.6 (.181) ± 0.40 (.016)	6.4 (.250) ± 0.40 (.016)	0.60 (.024) ± 0.35 (.014)	-
2220	5650	5.9 (.232) ± 0.75 (.030)	5.0 (.197) ± 0.40 (.016)	0.60 (.024) ± 0.35 (.014)	-
2225	5664	5.9 (.232) ± 0.75 (.030)	6.4 (.250) ± 0.40 (.016)	0.60 (.024) ± 0.35 (.014)	-

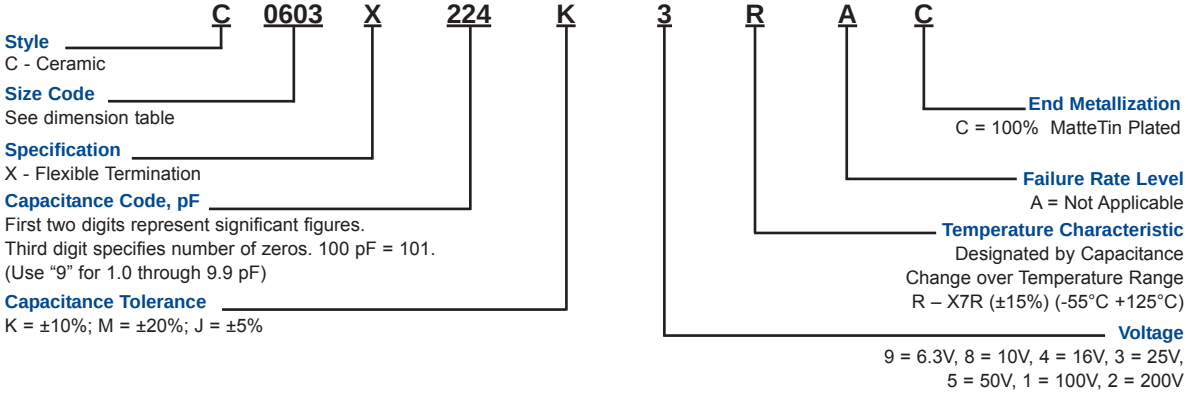
See “Capacitance Range” tables next page for capacitor chip thickness code specification. Capacitor chip thickness dimensions are detailed in the “Thickness Code Reference Chart” on page 5.

RoHS Compliant

Qualification/Certification

Automotive Grade Available: AEC-Q200 Rev. C
RoHS-PRC (6/6) - 100% matte tin termination

Ordering Information



Electrical Parameters

As detailed in the KEMET Surface Mount Catalog F3102 for X7R, with following specific requirements based on room temperature (25°C) parameters:

- Operating Range: -55°C to +125°C, with no-bias capacitance shift limited to ± 15% over that range.
- Insulation Resistance (IR) measured after 2 minutes at rated voltage @ 25°C: Limit is 1000 megohm microfarads or 100,000 MΩ, whichever of the two is smaller.
- Capacitance and Dissipation Factor (DF) measured under the following conditions:
  1kHz and 1 Vrms if capacitance ≤ 10µF
  120Hz and 0.5 Vrms if capacitance > 10µF

- DF Limits are:

50 - 200 Volts	2.5%
16 - 25 Volts	3.5%
6.3/10 Volts	5.0%

Soldering Process

All parts incorporate the standard KEMET barrier layer of pure nickel, with an overplate of pure tin to provide excellent solderability as well as resistance to leaching. The recommended techniques are as follows:

- 1210-2225 case sizes - Solder Reflow
- 0603/0805/1206 case sizes – Solder Wave/Solder Reflow

Marking

These chips will be supplied unmarked. If required, they can be laser-marked as an extra option. Details on the marking format are included in KEMET Surface Mount catalog F3102.

In general, the information in the KEMET Surface Mount catalog F3102 applies to these capacitors. The information in this bulletin supplements that in the catalog.

RoHS Compliant KEMET CHARGED.

Product Availability - 0603 thru 1210 Case Sizes

FT-CAP / FLEXIBLE TERMINATION / X7R DIELECTRIC (0603 - 1210 Case Sizes)

Cap pF	Cap Code	Series	C0603X							C0805X							C1206X							C1210X						
		Voltage	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V
		Voltage Code	9	8	4	3	5	1	2	9	8	4	3	5	1	2	9	8	4	3	5	1	2	9	8	4	3	5	1	2
		Cap Tolerance	Product Availability and Chip Thickness Codes - See "ThicknessCodeReferenceChart"																											
180	181	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
220	221	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
270	271	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
330	331	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
390	391	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
470	471	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
560	561	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
680	681	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
820	821	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC														
1,000	102	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB							
1,200	122	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB							
1,500	152	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB							
1,800	182	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB							
2,200	222	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
2,700	272	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
3,300	332	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
3,900	392	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
4,700	472	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
5,600	562	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
6,800	682	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
8,200	822	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
10,000	103	J,K,M	CB	CB	CB	CB	CB	CB	CB	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
12,000	123	J,K,M	CB	CB	CB	CB	CB	CB	[illegible]	DC	DC	DC	DC	DC	DC	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
15,000	153	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DD	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
18,000	183	J,K,M	CB	CB	CB	CB	CB	CB	[illegible]	DC	DC	DC	DC	DC	DD	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
22,000	223	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DD	DC	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
27,000	273	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DD	DE	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
33,000	333	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DD	DE	EB	EB	EB	EB	EB	EB	EB	FB	FB	FB	FB	FB	FB	FB
39,000	393	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DD	DE	EB	EB	EB	EB	EB	EC	EB	FB	FB	FB	FB	FB	FB	FB
47,000	473	J,K,M	CB	CB	CB	CB	CB	CB		DC	DC	DC	DC	DC	DE	DG	EB	EB	EB	EB	EB	EC	ED	FB	FB	FB	FB	FB	FB	FC
56,000	563	J,K,M	CB	CB	CB	CB	CB	[illegible]	[illegible]	DD	DD	DD	DD	DD	DE	DG	EB	EB	EB	EB	EB	EB	ED	FB	FB	FB	FB	FB	FB	FC
68,000	683	J,K,M	CB	CB	CB	CB	CB			DD	DD	DD	DD	DD	DE		EB	EB	EB	EB	EB	EB	ED	FB	FB	FB	FB	FB	FB	FC
82,000	823	J,K,M	CB	CB	CB	CB	CB			DD	DD	DD	DD	DD	DE		EB	EB	EB	EB	EB	EB	ED	FB	FB	FB	FB	FB	FC	FF
100,000	104	J,K,M	CB	CB	CB	CB	CB			DD	DD	DD	DD	DD	DE		EB	EB	EB	EB	EB	EB	EM	FB	FB	FB	FB	FB	FD	FG
120,000	124	J,K,M	CB	CB	CB	CB	CB			DC	DC	DC	DC	DD	DG		EC	EC	EC	EC	EC	EC	EM	FB	FB	FB	FB	FB	FD	
150,000	154	J,K,M	CB	CB	CB	CD	CD			DC	DC	DC	DC	DD	DG		EC	EC	EC	EC	EC	EC	EG	FC	FC	FC	FC	FC	FD	
180,000	184	J,K,M	CB	CB	CB					DC	DC	DC	DC	DD	DG		EC	EC	EC	EC	EC	EC		FC	FC	FC	FC	FC	FD	
220,000	224	J,K,M	CB	CB	CB	CD				DC	DC	DC	DC	DD	DG		EC	EC	EC	EC	EC	EC		FC	FC	FC	FC	FC	FD	
270,000	274	J,K,M	CB	CB	CB					DD	DD	DD	DD	DD			EB	EB	EB	EB	EC	EM		FC	FC	FC	FC	FC	FD	
330,000	334	J,K,M	CB	CB	CB					DD	DD	DD	DD	DD			EB	EB	EB	EB	EC	EG		FD	FD	FD	FD	FD	FD	
390,000	394	J,K,M	CB	CB	CB					DG	DG	DG	DG	DE			EB	EB	EB	EB	EC	EG		FD	FD	FD	FD	FD	FD	
470,000	474	J,K,M	CB	CB	CB					DD	DD	DD	DD	DE			EC	EC	EC	EC	EC	EG		FD	FD	FD	FD	FD	FD	
560,000	564	J,K,M								DD	DD	DD	DG	DH			ED	ED	ED	ED	EC			FD	FD	FD	FD	FD	FF	
680,000	684	J,K,M								DD	DD	DD	DG	DH			EE	EE	EE	EE	ED			FD	FD	FD	FD	FD	FG	
820,000	824	J,K,M								DD	DD	DD	DG				EF	EF	EF	EF	ED			FF	FF	FF	FF	FF	FL	
1,000,000	105	J,K,M								DD	DD	DD	DG				EF	EF	EF	EG	ED			FH	FH	FH	FH	FH	FM	
1,200,000	125	J,K,M								DE	DE	DE					ED	ED	ED	EG	EH			FH	FH	FH	FH	FG		
1,500,000	155	J,K,M								DG	DG	DG					EF	EF	EF	EG	EH			FH	FH	FH	FH	FG		
1,800,000	185	J,K,M								DG	DG	DG					EF	EF	EF	EF	EH			FH	FH	FH	FH	FG		
2,200,000	225	J,K,M								DG	DG	DG					ED	ED	ED	EF	EH			FJ	FJ	FJ	FJ	FG		
2,700,000	275	J,K,M															EN	EN	EN	EH				FE	FE	FE	FG	FH		
3,300,000	335	J,K,M															ED	ED	ED	EH				FF	FF	FF	FM	FM		
3,900,000	395	J,K,M															EF	EF	EF	EH				FG	FG	FG	FG	FK		
4,700,000	475	J,K,M															EF	EF	EF	EH				FC	FC	FC	FG	FS		
5,600,000	565	J,K,M															EH	EH	EH					FF	FF	FF	FH			
6,800,000	685	J,K,M															EH	EH	EH					FG	FG	FG	FM			
8,200,000	825	J,K,M															EH	EH	EH					FH	FH	FH	FK			
10,000,000	106	J,K,M															EH	EH	EH					FH	FH	FH	FS			
12,000,000	126	J,K,M																												
15,000,000	156	J,K,M																												
18,000,000	186	J,K,M																												
22,000,000	226	J,K,M																						FS	FS					
Cap pF	Cap Code	Voltage Code	9	8	4	3	5	1	2	9	8	4	3	5	1	2	9	8	4	3	5	1	2	9	8	4	3	5	1	2
		Voltage	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V	6.3V	10V	16V	25V	50V	100V	200V
		Series	C0603X							C0805X							C1206X							C1210X						

Product Availablity - 1808 thru 2225 Case Sizes

FT-CAP / FLEXIBLE TERMINATION / X7R DIELECTRIC (1808 - 2225 Case Sizes)

Cap pF	Cap Code	Series	C1808X				C1812X				C1825X			C2220X				C2225X		
		Voltage	50V	100V	200V	250V	25V	50V	100V	200V	50V	100V	200V	25V	50V	100V	200V	50V	100V	200V
		Voltage Code	5	1	2	A	3	5	1	2	5	1	2	3	5	1	2	5	1	2
		Cap Tolerance	Product Availability and Chip Thickness Codes - See "ThicknessCodeReferenceChart"																	
2,200	222	J,K,M																		
2,700	272	J,K,M																		
3,300	332	J,K,M																		
2,900	392	J,K,M																		
4,700	472	J,K,M	LD	LD	LD															
5,600	562	J,K,M	LD	LD	LD															
6,800	682	J,K,M	LD	LD	LD		GB	GB	GB	GB										
8,200	822	J,K,M	LD	LD	LD		GB	GB	GB	GB										
10,000	103	J,K,M	LD	LD	LD		GB	GB	GB	GB										
12,000	123	J,K,M	LD	LD	LD		GB	GB	GB	GB										
15,000	153	J,K,M	LD	LD	LD		GB	GB	GB	GB										
18,000	183	J,K,M	LD	LD	LD		GB	GB	GB	GB										
22,000	223	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB							
27,000	273	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB							
33,000	333	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB							
39,000	393	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB							
47,000	473	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB					KC	KC	KC
56,000	563	J,K,M	LD	LD			GB	GB	GB	GB	HB	HB	HB					KC	KC	KC
68,000	683	J,K,M	LD				GB	GB	GB	GB	HB	HB	HB					KC	KC	KC
82,000	823	J,K,M	LD				GB	GB	GB	GB	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
100,000	104	J,K,M	LD				GB	GB	GB	GB	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
120,000	124	J,K,M	LD				GB	GB	GB	GB	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
150,000	154	J,K,M	LD				GB	GB	GB	GE	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
180,000	184	J,K,M	LD				GB	GB	GB	GF	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
220,000	224	J,K,M					GB	GB	GB	GG	HB	HB	HB	JC	JC	JC	JC	KC	KC	KC
270,000	274	J,K,M					GB	GB	GG	GG	HB	HB	HB	JC	JC	JC	JC	KB	KC	KC
330,000	334	J,K,M					GB	GB	GG	GG	HB	HB	HB	JC	JC	JC	JC	KB	KC	KC
390,000	394	J,K,M					GB	GB	GG	GG	HB	HB	HD	JC	JC	JC	JC	KB	KC	KC
470,000	474	J,K,M					GB	GB	GG	GJ	HB	HB	HD	JC	JC	JC	JC	KB	KC	KD
560,000	564	J,K,M					GC	GC	GG		HB	HD	HD	JC	JC	JC	JD	KB	KC	KD
680,000	684	J,K,M					GC	GC	GG		HB	HD	HD	JC	JC	JD	JD	KB	KC	KD
820,000	824	J,K,M					GE	GE	GG		HB	HF	HF	JC	JC	JF	JF	KB	KC	KE
1,000,000	105	J,K,M					GE	GE	GG		HB	HF	HF	JC	JC	JF	JF	KB	KD	KE
1,200,000	125	J,K,M									HB			JC	JC			KB	KE	KE
1,500,000	155	J,K,M									HC			JC	JC			KC		
1,800,000	185	J,K,M									HD			JD	JD			KD		
2,200,000	225	J,K,M									HF			JF	JF			KD		
2,700,000	275	J,K,M																		
3,300,000	335	J,K,M																		
3,900,000	395	J,K,M																		
4,700,000	475	J,K,M					GK	GK												
5,600,000	565	J,K,M																		
6,800,000	685	J,K,M																		
8,200,000	825	J,K,M																		
10,000,000	106	J,K,M					GK							JF	JO					
12,000,000	126	J,K,M																		
15,000,000	156	J,K,M												JO						
18,000,000	186	J,K,M																		
22,000,000	226	J,K,M												JO						
Cap pF	Cap Code	Voltage Code	5	1	2	A	3	5	1	2	5	1	2	3	5	1	2	5	1	2
		Voltage	50V	100V	200V	250V	25V	50V	100V	200V	50V	100V	200V	25V	50V	100V	200V	50V	100V	200V
		Series	C1808X				C1812X				C1825X			C2220X				C2225X		

Revision 0 / 2009 .08/21

Thickness Code Reference Chart

Chip Size	Thickness Code	Chip Thickness Range (mm)	Qty per Reel 7" Plastic	Qty per Reel 13" Plastic	Qty per Reel 7" Paper	Qty per Reel 13" Paper	Qty per Bulk Cassette
0603	CB	0.80 ± 0.07	-	-	4,000	10,000	15,000
0603	CC	0.80 ± 0.10	-	-	4,000	10,000	-
0603	CD	0.80 ± 0.15	-	-	4,000	10,000	-
0805	DB	0.60 ± 0.10	-	-	4,000	10,000	10,000
0805	DC	0.78 ± 0.10	-	-	4,000	10,000	-
0805	DD	0.90 ± 0.10	-	-	4,000	10,000	-
0805	DE	1.00 ± 0.10	2,500	10,000	-	-	-
0805	DF	1.10 ± 0.10	2,500	10,000	-	-	-
0805	DG	1.25 ± 0.15	2,500	10,000	-	-	-
0805	DH	1.25 ± 0.20	2,500	10,000	-	-	-
0805	DL	0.95 ± 0.10	4,000	10,000	-	-	-
1206	EB	0.78 ± 0.10	4,000	10,000	4,000	10,000	-
1206	EC	0.90 ± 0.10	4,000	10,000	-	-	-
1206	ED	1.00 ± 0.10	2,500	10,000	-	-	-
1206	EE	1.10 ± 0.10	2,500	10,000	-	-	-
1206	EF	1.20 ± 0.15	2,500	10,000	-	-	-
1206	EG	1.60 ± 0.15	2,000	8,000	-	-	-
1206	EH	1.60 ± 0.20	2,000	8,000	-	-	-
1206	EJ	1.70 ± 0.20	2,000	8,000	-	-	-
1206	EK	0.80 ± 0.10	2,000	8,000	-	-	-
1206	EM	1.25 ± 0.15	2,500	10,000	-	-	-
1206	EN	0.95 ± 0.10	4,000	10,000	-	-	-
1210	FB	0.78 ± 0.10	4,000	10,000	-	-	-
1210	FC	0.90 ± 0.10	4,000	10,000	-	-	-
1210	FD	0.95 ± 0.10	4,000	10,000	-	-	-
1210	FE	1.00 ± 0.10	2,500	10,000	-	-	-
1210	FF	1.10 ± 0.10	2,500	10,000	-	-	-
1210	FG	1.25 ± 0.15	2,500	10,000	-	-	-
1210	FH	1.55 ± 0.15	2,000	8,000	-	-	-
1210	FJ	1.85 ± 0.20	2,000	8,000	-	-	-
1210	FK	2.10 ± 0.20	2,000	8,000	-	-	-
1210	FL	1.40 ± 0.15	2,000	8,000	-	-	-
1210	FM	1.70 ± 0.20	2,000	8,000	-	-	-
1210	FN	1.85 ± 0.20	2,000	8,000	-	-	-
1210	FO	1.50 ± 0.20	2,000	8,000	-	-	-
1210	FP	1.60 ± 0.20	2,000	8,000	-	-	-
1210	FR	2.25 ± 0.20	2,000	8,000	-	-	-
1210	FS	2.50 ± 0.20	1,000	4,000	-	-	-
1210	FT	1.90 ± 0.20	1,500	4,000	-	-	-
1632	MA	0.80 ± 0.10	4,000	10,000	-	-	-
1808	LD	0.90 ± 0.10	2,500	10,000	-	-	-
1808	LA	1.40 ± 0.15	1,000	4,000	-	-	-
1808	LB	1.60 ± 0.15	1,000	4,000	-	-	-
1808	LC	2.00 ± 0.15	1,000	4,000	-	-	-
1812	GB	1.00 ± 0.10	1,000	4,000	-	-	-
1812	GC	1.10 ± 0.10	1,000	4,000	-	-	-
1812	GD	1.25 ± 0.15	1,000	4,000	-	-	-
1812	GE	1.30 ± 0.10	1,000	4,000	-	-	-
1812	GF	1.50 ± 0.10	1,000	4,000	-	-	-
1812	GG	1.55 ± 0.10	1,000	4,000	-	-	-
1812	GH	1.40 ± 0.15	1,000	4,000	-	-	-
1812	GJ	1.70 ± 0.15	1,000	4,000	-	-	-
1812	GK	1.60 ± 0.20	1,000	4,000	-	-	-
1812	GL	1.90 ± 0.20	1,000	4,000	-	-	-
1812	GM	2.00 ± 0.20	1,000	4,000	-	-	-
1812	GN	1.70 ± 0.20	1,000	4,000	-	-	-
1812	GO	2.50 ± 0.20	500	-	-	-	-
1825	HB	1.10 ± 0.15	1,000	4,000	-	-	-
1825	HC	1.15 ± 0.15	1,000	4,000	-	-	-
1825	HD	1.30 ± 0.15	1,000	4,000	-	-	-
1825	HE	1.40 ± 0.15	1,000	4,000	-	-	-
1825	HF	1.50 ± 0.15	1,000	4,000	-	-	-
1825	HG	1.60 ± 0.20	1,000	4,000	-	-	-
2220	JB	1.00 ± 0.15	1,000	4,000	-	-	-
2220	JC	1.10 ± 0.15	1,000	4,000	-	-	-
2220	JD	1.30 ± 0.15	1,000	4,000	-	-	-
2220	JE	1.40 ± 0.15	1,000	4,000	-	-	-
2220	JF	1.50 ± 0.15	1,000	4,000	-	-	-
2220	JP	1.60 ± 0.20	1,000	4,000	-	-	-
2220	JG	1.70 ± 0.15	1,000	4,000	-	-	-
2220	JH	1.80 ± 0.15	1,000	4,000	-	-	-
2220	JO	2.40 ± 0.15	500	2,000	-	-	-
2225	KB	1.00 ± 0.15	1,000	4,000	-	-	-
2225	KC	1.10 ± 0.15	1,000	4,000	-	-	-
2225	KD	1.30 ± 0.15	1,000	4,000	-	-	-
2225	KE	1.40 ± 0.15	1,000	4,000	-	-	-
2225	KF	1.60 ± 0.20	1,000	4,000	-	-	-

Tech Topics
April 2008

Flex Crack Mitigation

by Bill Sloka, Ceramic Technical Consultant

As part of continuous process improvement at KEMET, most failure modes caused by the capacitor manufacturing process have been systematically eliminated. Today these capacitor manufacturing-related defects are now at a parts-per-billion (PPB) level. Pareto analysis of customer complaints indicates that the #1 failure mode is IR failure due to flex cracks.

Flex Cracks

Flex cracks have been known in PCB manufacturing for quite some time. Flex cracks are created in capacitors when board flex stress / bending stress is applied to a circuit board with ceramic components already affixed to the PCB. As the ceramic capacitor is inherently hard, non-elastic, and brittle (relative to the PCB), any bending of the board creates stress, and that stress can be transmitted through the solder joint, directly to the ceramic body. This stress must be relieved somehow – and this stress relief can result in the creation of a board flex crack (See Figure 1).

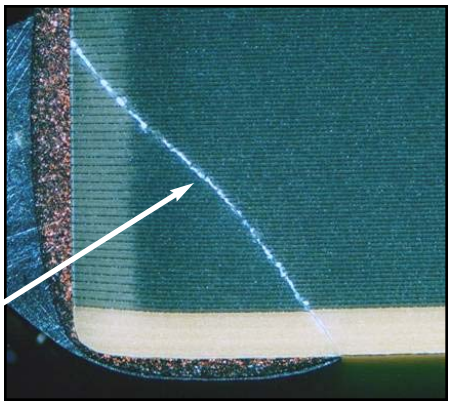


Figure 1. Typical Flex Crack

In PCB assembly, some of the sources of this stress include the following:

- *Connector Assembly/Connector Use* – MLCC's placed close to connectors are particularly susceptible to board flex stress (See Figure 2).

- *Depanelization* – where many small boards are assembled as one large panel that must then be separated, especially when MLCC's are located close to the edge of the PCB (See Figure 3).

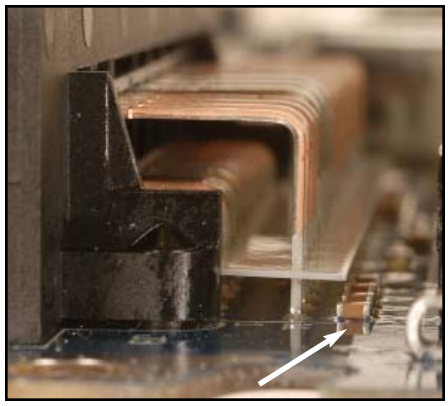


Figure 2. Filter capacitor very near to thru-hole connector.

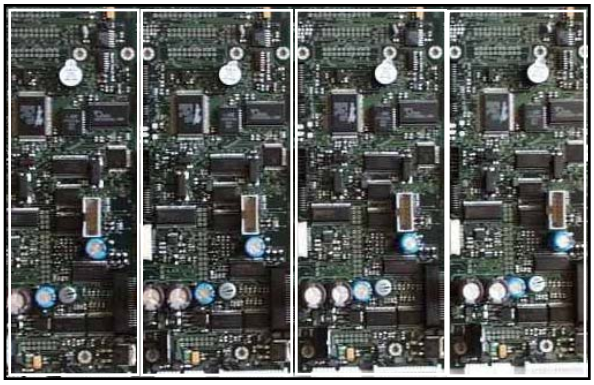


Figure 3. Board singulation can flex stress ceramic capacitors near board edge.

- *Box build* – assembly of a final product can involve stresses as boards are fitted together – particularly given the demands for today's thinner product offerings.

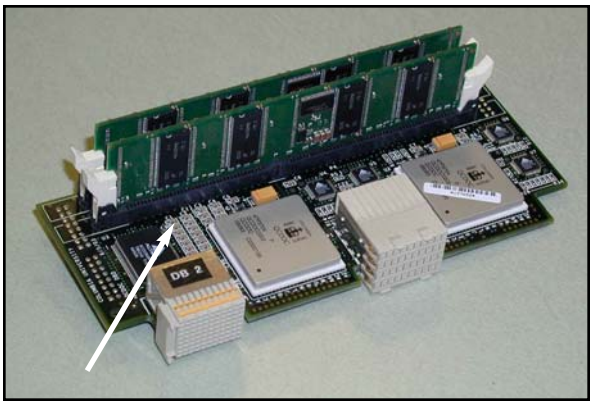


Figure 4. Parts located near connectors can be susceptible to board flex stress.

PCB assembly continues to evolve, and by carefully understanding and controlling the board assembly process, the occurrence of board flex stress can be reduced. However, these board flex stresses have not been eliminated – and in many cases the worst-case scenario is a resultant short circuit which leads to field failure. KEMET now offers a portfolio of engineered solutions to mitigate the effects of board flex stress. By creating solutions that lend themselves to open failure mode rather than short circuit failure mode, KEMET is offering a measure of protection for customers who know that short circuit failure is not an option.

FAQ's and Definitions

The following statements are based on extensive industry research, whitepapers, and presentations. All of these questions are answered assuming the customer is using a standard, 2-terminal MLCC.

1. *Does a flex crack always lead to failure?* Answer – no; as with all cracks in MLCC's, there needs to be some type of ionic penetration or humidity along the crack path which allows current to flow between electrode plates of opposite polarity, in order for the chip to fail. (See Figure 5).

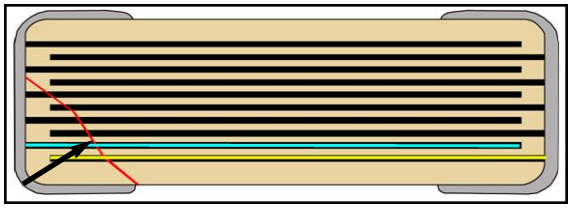


Figure 5. Yellow electrode represents (+); blue electrode represents (-); flex crack leads to short circuit.

2. *Does it matter which direction the board is flexed?* Answer – no; our studies have shown that a board bent "up" or "down" leads to the formation of a board flex crack that looks the same regardless of board bend direction, all other factors being equal.

3. *Does a Flex Crack always have the same crack signature?* Answer – yes. There is a distinctive crack signature for board flex cracks – it always starts near the edge of the termination margin, and usually extends upwards toward the termination face. The flex crack signature is distinctly different than other crack signatures in MLCC's. (See Figure 6)

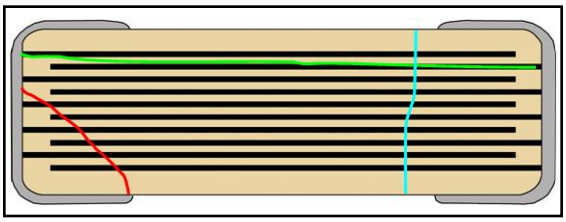


Figure 6. Red crack represents flex crack; green crack represents typical thermal shock crack; blue crack represents mechanical damage.

4. Are there PCB assembly process parameters that can be modified to reduce the risk of board flex cracks? Answer – yes. Studies have shown that by minimizing the amount of solder (size of solder fillet), and minimizing chip size (smaller chips are inherently more robust than larger chips), the chances of failure due to board flex cracking can be reduced.

5. Are there ways to place parts away from "problem areas" on the PCB? Answer – yes. By placing parts parallel to the edge of the PCB, as far away from the edge of the PCB as practical, and as far away from thru-hole connectors/screws/etc., manufacturers can reduce their risk of MLCC board flex cracks.

6. Does KEMET ever ship capacitors with flex cracks, while still in the tape & reel? Answer – no, flex cracks can only occur post solder attach.

Board Flex Crack Solutions at KEMET

If board flex stress cannot be eliminated, there are several options available that offer methods to mitigate the risk associated with board flex cracks. In order to offer a cost-effective solution, there are several options available, based on the capacitance value selected.

- For ***low*** capacitance values, KEMET offers the Floating Electrode (FE-CAP) design. This is also known in the industry as a Serial Cap design, as the Floating Electrode part contains two parts in series, within a singular capacitor body. In Automotive (Clamp 30) designs, sometimes 2 distinct capacitors will be used in series on the PCB – the FE-CAP gives a designer this "two parts in series" - within a singular capacitor. This solution works by eliminating the short-circuit path between electrodes of opposite polarity (See Figure 7). Due to the sacrifice of active area necessitated by the creation of two serial capacitors, the Floating Electrode solution can only be used for lower capacitance values. To order this device, simply place an S for "Serial Cap" in the 6th digit of the KEMET part number.
  - For customers desiring an additional mode of protection, KEMET now offers the FF-CAP (Floating Electrode + Flexible Termination – see Flexible Termination description later in this paper). To order this device, place a "Y" in the 6th digit of the KEMET part number.

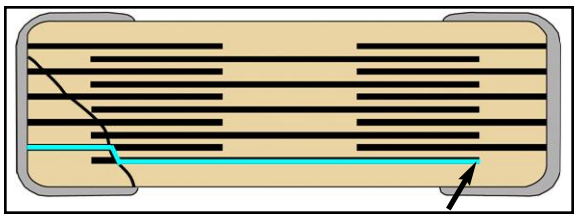


Figure 7. Flex crack does not complete circuit - no short circuit failure.

- For ***mid*** capacitance values, KEMET offers the Open Mode solution. The Open Mode device creates a safe zone on both ends of the capacitor (See Figure 8), so that only the innermost portion of the capacitor is active area. Any board flex crack that occurs (remember, this crack always starts within the end termination) can only cross electrodes of like polarity; thus eliminating the possibility of a short-circuit failure from a board flex crack. As with the FE-CAP, active area has been sacrificed in order to create the safe zones on both ends of the chip; thus, the Open Mode solution is only applicable for mid capacitance values. To order this device, place an "F" for "Fail Open" in the 6th digit of the KEMET part number. Open Mode can be ordered with Flexible Termination by changing the 6th digit of the KEMET Part Number to a "D".

Figure 8. Blue represents (-), Yellow represents (+), flex crack only crosses electrode of like polarity.

- Finally, for ***high*** capacitance values (also called HiCV in the industry), KEMET offers the Flexible Termination (FT-CAP). KEMET applies a special conductive silver epoxy on both end terminations, between the copper/electrode interface and the nickel/tin plating. This special epoxy layer is essentially a tear-away solution, providing a path of least resistance for board flex stress. This solution acts to steer the potential flex crack away from the ceramic body, into the more benign area of the termination (See Figure 9). Technically, Flexible Termination can be applied to any commercial SMD (Surface Mount) product, but due to additional manufacturing costs (primarily materials and labor), the Flexible Termination is more cost effective when used on HiCV devices. KEMET's Flexible Termination offers up to 5mm of board bend stress capability. To order this device, place an X for "Flexible Termination" in the 6th digit of the KEMET part number.

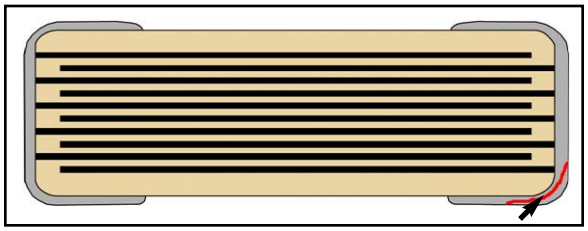


Figure 9. Flexible termination moves flex cracks to the end termination, away from the ceramic body.

Availability

All solutions mentioned above are available today from KEMET. As Automotive is a primary market focus for these Flex Crack solutions, KEMET has qualified all of the solutions per AEC-Q200 (documentation available upon request). For more specific information, including available capacitance values, sample requests, datasheets, etc., please visit our website:

http://www.kemet.com/flex

Conclusion

Board flex cracks have been around since the inception of SMT processing, and still represent a significant headache as measured by customer complaints, field failures, etc. By selecting an appropriate board flex mitigation product, designers now have an option when board flex stresses cannot be eliminated from the PCB manufacturing process.

References

"Capacitance Monitoring While Flex Testing", 1997, Jim Bergenthal and John D. Prymak, F-2110, KEMET Electronics Corporation

CE FLEXDESIGN

No.	Ordercode	Casesize	Cap.	Tol.	Volt	Technology	Dielec.
1	C0603S221J2RAC	0603	220pF	±5%	200V	Floating Electrode	X7R
2	C0603S222J2RAC	0603	2.2nF	±5%	200V	Floating Electrode	X7R
3	C0603S472J2RAC	0603	4.7nF	±5%	200V	Floating Electrode	X7R
4	C0805S223K1RAC	0805	22nF	±10%	100V	Floating Electrode	X7R
5	C0805F223K3RAC	0805	22nF	±10%	25V	Open Mode	X7R
6	C0805S473K5RAC	0805	47nF	±10%	50V	Floating Electrode	X7R
7	C0805F473K3RAC	0805	47nF	±10%	25V	Open-Mode	X7R
8	C0603X473K1RAC	0603	47nF	±10%	100V	Flexible Termination	X7R
9	C1210S563K5RAC	1210	56nF	±10%	50V	Floating Electrode	X7R
10	C0805S104K5RAC	0805	100nF	±10%	50V	Floating Electrode	X7R
11	C0805F104K3RAC	0805	100nF	±10%	25V	Open Mode	X7R
12	C1206X124K2RAC	1206	120nF	±10%	200V	Flexible Termination	X7R
13	C0805F224K3RAC	0805	220nF	±10%	25V	Open-Mode	X7R
14	C0805X224K1RAC	0805	220nF	±10%	100V	Flexible Termination	X7R
15	C0805F474K3RAC	0805	470nF	±10%	25V	Open Mode	X7R
16	C0603X474K4RAC	0603	470nF	±10%	16V	Flexible Termination	X7R
17	C0805X474K5RAC	0805	470nF	±10%	50V	Flexible Termination	X7R
18	C1206X474K1RAC	1206	470nF	±10%	100V	Flexible Termination	X7R
19	C0805X105K3RAC	0805	1uF	±10%	25V	Flexible Termination	X7R
20	C1210X105K1RAC	1210	1uF	±10%	100V	Flexible Termination	X7R
21	C1206F225K4RAC	1206	2.2uF	±10%	16V	Open Mode	X7R
22	C0805X225K4RAC	0805	2.2uF	±10%	16V	Flexible Termination	X7R
23	C1206X225K5RAC	1206	2.2uF	±10%	50V	Flexible Termination	X7R
24	C1206F475K4RAC	1206	4.7uF	±10%	16V	Open Mode	X7R
25	C1206X475K3RAC	1206	4.7uF	±10%	25V	Flexible Termination	X7R
26	C1210X475K5RAC	1210	4.7uF	±10%	50V	Flexible Termination	X7R
27	C1206X106K4RAC	1206	10uF	±10%	16V	Flexible Termination	X7R
28	C1210X106K3RAC	1210	10uF	±10%	25V	Flexible Termination	X7R