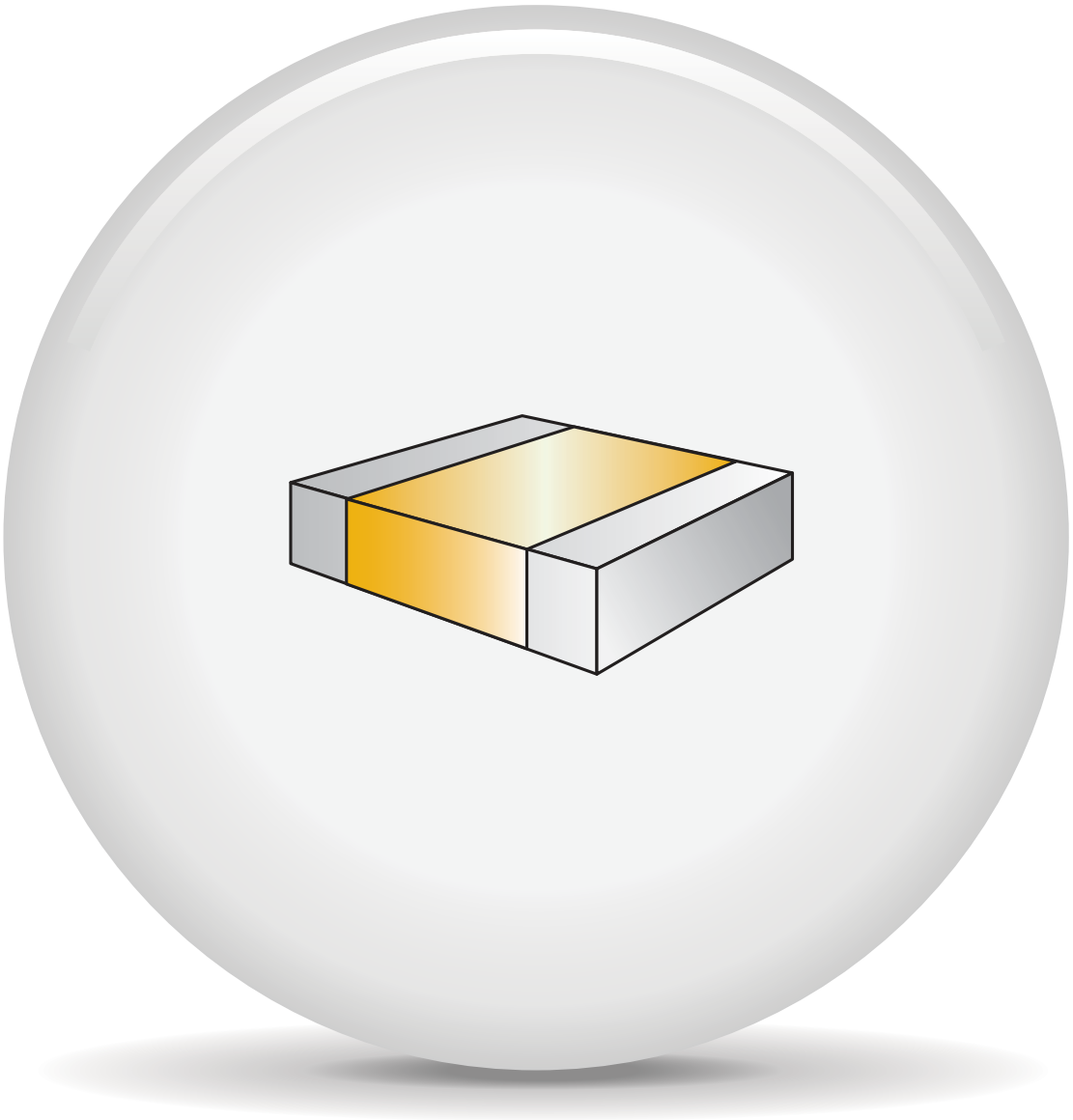
# Surface Mount Multilayer Ceramic Capacitors

## Commercial Grade



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## Table of Contents

Page

**Why Choose KEMET** ..... 4

**Surface Mount Devices** ..... 6

### Standard Products

C0G Dielectric, 10 – 250 VDC (Commercial Grade) ..... 6
X7R Dielectric, 6.3 – 250 VDC (Commercial Grade) ..... 19
X5R Dielectric, 4 – 50 VDC (Commercial Grade) ..... 34
Z5U Dielectric, 50 – 100 VDC (Commercial Grade) ..... 46
Y5V Dielectric, 6.3 – 50 VDC (Commercial Grade) ..... 55
Capacitor Array, C0G Dielectric, 10 – 200 VDC (Commercial & Automotive Grade) ..... 65
Capacitor Array, X7R Dielectric, 10 – 200 VDC (Commercial & Automotive Grade) ..... 76
Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, C0G Dielectric, 10 – 250 VDC ..... 87
Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, X7R Dielectric, 6.3 – 250 VDC ..... 99
Telecom “Tip and Ring” X7R Dielectric, 250 VDC (Commercial Grade) ..... 112

### Flex Mitigation Solutions

Open Mode Design (FO-CAP), X7R Dielectric, 16 – 200 VDC (Commercial & Automotive Grade) ..... 124
Floating Electrode Design (FE-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade) ..... 138
Flexible Termination System (FT-CAP), C0G Dielectric, 10 – 250 VDC (Commercial & Automotive Grade) ..... 151
Flexible Termination System (FT-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial Grade) ..... 164
Floating Electrode Design with Flexible Termination System (FF-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade) ..... 178
Flexible Termination System (FT-CAP), Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade) ..... 190
High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade) ..... 202
High Voltage with Flexible Termination System (HV FT-CAP), C0G Dielectric, 500 – 3,000 VDC (Commercial & Automotive Grade) ..... 215
High Voltage with Flexible Termination System (HV FT-CAP), X7R Dielectric, 500 – 3,000 VDC (Commercial Grade) ..... 229
ArcShield™ Technology, High Voltage, X7R Dielectric, 500 – 1,000 VDC (Commercial & Automotive Grade) ..... 242
KPS Series, X7R Dielectric, 10 – 250 VDC (Commercial Grade) ..... 256
KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade) ..... 267
KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade) ..... 275

### SnPb End Metallization

Commercial “L” Series, SnPb Termination, C0G Dielectric, 10 – 250 VDC (Commercial Grade) ..... 283
Commercial “L” Series, SnPb Termination, X7R Dielectric, 6.3 – 250 VDC (Commercial Grade) ..... 296
Commercial “L” Series, SnPb Termination, X5R Dielectric, 4 – 50 VDC (Commercial Grade) ..... 309
Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, C0G Dielectric, 10 – 250 VDC ..... 320
Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, X7R Dielectric, 6.3 – 250 VDC ..... 332
High Temperature 150°C, Ultra Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade) ..... 345
High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade) ..... 357
Telecom “Tip and Ring,” X7R Dielectric, 250 VDC (Commercial Grade) ..... 370
Open Mode Design (FO-CAP), X7R Dielectric, 16 – 200 VDC (Commercial & Automotive Grade) ..... 382
Floating Electrode Design (FE-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade) ..... 396


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### SnPb End Metallization (cont.)

Flexible Termination System (FT-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial Grade) ....409
Floating Electrode Design with Flexible Termination System (FF-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade) ....423
HV-HT Series, High Voltage, High Temperature 200°C, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade) ....435

### Bulk Capacitance Solutions (Stacked Capacitors)

KPS Series, X7R Dielectric, 10 – 250 VDC (Commercial Grade) ....451
KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade) ....462
KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 VDC – 50 VDC (Commercial & Automotive Grade) ....470
KPS MIL Series, SMPS Stacked Capacitors, MIL–PRF–49470, DSCC 87106, 25 – 1,000 VDC (Commercial, Military, & Space Grades) ....478

### High Temperature

High Temperature 150ºC, Ultra Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade) ....501
High Temperature 150ºC, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade) ....513
High Temperature 175ºC, X7R Dielectric, 16 – 200 VDC (Industrial Grade) ....526
High Temperature 200ºC, C0G Dielectric, 10 – 200 VDC (Industrial Grade) ....538
HV-HT Series, High Voltage, High Temperature 200ºC, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade) ....551
Flexible Termination System (FT-CAP), Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade) ....567
KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade) ....580
Pulse Discharge, High Voltage, High Temperature 200ºC, C0G Dielectric, 1,000 – 3,500 VDC (Industrial Grade) ....588

### High Voltage

High Voltage C0G Dielectric, 500 – 3,000 VDC (Commercial Grade) ....598
High Voltage X7R Dielectric, 500 – 3,000 VDC (Commercial Grade) ....613
High Voltage with Flexible Termination System (HV FT-CAP), X7R Dielectric, 500 – 3,000 VDC (Commercial Grade) ....626
High Voltage with Flexible Termination System (HV FT-CAP), C0G Dielectric, 500 – 3,000 VDC (Commercial Grade) ....639
ArcShield™ Technology, High Voltage, X7R Dielectric, 500 – 1,000 VDC (Commercial & Automotive Grade) ....653
KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade) ....667
KPS HV, Large Case, SM Series, C0G Dielectric, 500 – 10,000 VDC (Industrial Grade) ....675
KPS HV, Large Case, SM Series, X7R Dielectric, 500 – 10,000 VDC (Industrial Grade) ....685
HV-HT Series, High Voltage, High Temperature 200ºC, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade) ....696
Pulse Discharge, High Voltage, High Temperature 200ºC, C0G Dielectric, 1,000 – 3,500 VDC (Industrial Grade) ....712

**Marking Information (X7R) ....722**

*Marking Information for C0G, 200°C C0G, COTS (C0G), SnPb (C0G), HV C0G, FT-CAP (C0G), FT-CAP (X8R), Y5V, X8R, HV/HT PULSE Discharge (C0G), and Array C0G is included within the appropriate product sections.*

**Packaging Information ....724**

Surface Mount Devices ....724
KPS Devices ....730

**KEMET Corporation Sales Offices ....737**

**Disclaimer ....738**


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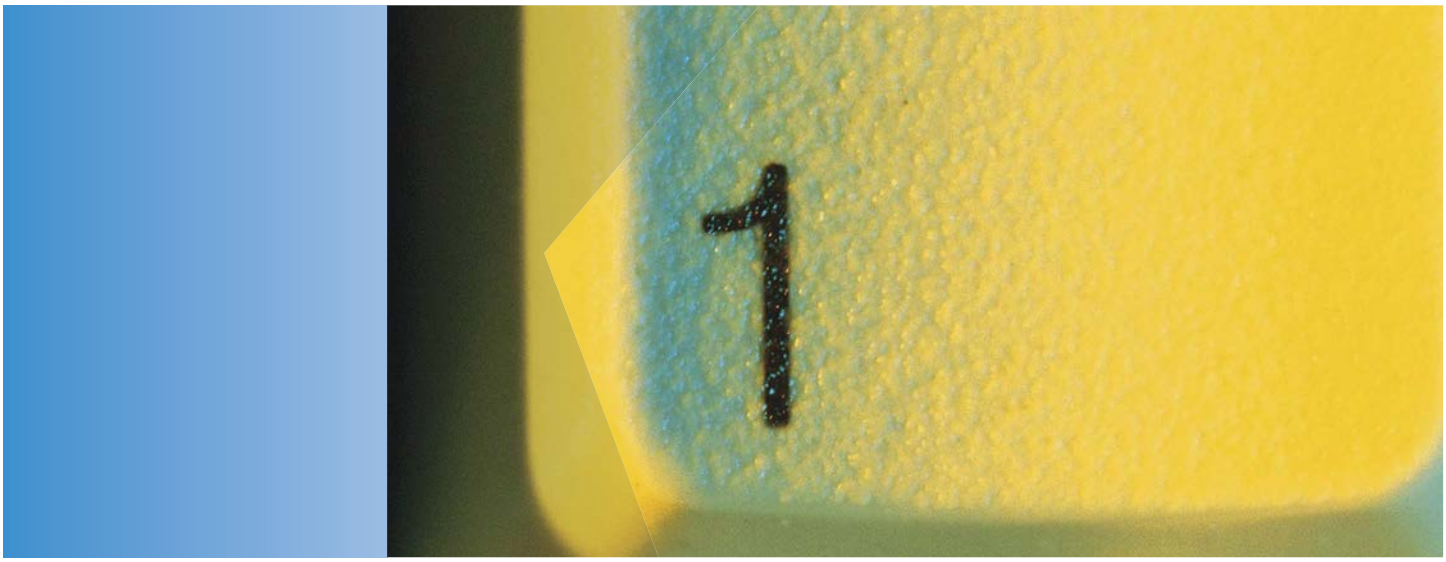

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## About KEMET.

KEMET Corporation is a leading global supplier of electronic components. We offer our customers the broadest selection of capacitor technologies in the industry across multiple dielectrics, along with an expanding range of electromechanical devices, and electromagnetic compatibility solutions. Our vision is to be the preferred supplier of electronic component solutions for customers demanding the highest standards of quality, delivery and service.


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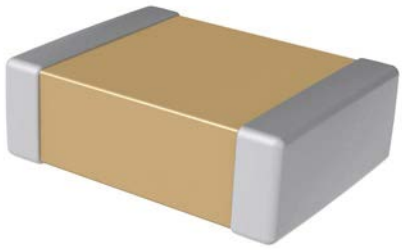
# C0G Dielectric, 10 – 250 VDC (Commercial Grade)

## Overview

KEMET's C0G dielectric features a 125°C maximum operating temperature and is considered "stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/ºC from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0201, 0402, 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 0.5 pF up to 0.47 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability



## Ordering Information

| C | 1206 | C | 104 | J | 3 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance[2] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[3] | Packaging/Grade (C-Spec) |
| | 0201<br>0402<br>0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | C = Standard | Two significant digits + number of zeros.<br>Use 9 for 1.0 – 9.9 pF<br>Use 8 for 0.5 – .99 pF<br>e.g., 2.2 pF = 229<br>e.g., 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | G = C0G | A = N/A | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Flexible termination option is available. Please see FT-CAP product bulletin C1062_C0G_FT-CAP_SMD*

*[2] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[3] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Benefits cont'd

- Preferred capacitance solution at line frequencies and into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, decoupling, bypass, filtering, transient voltage suppression, blocking and energy storage.

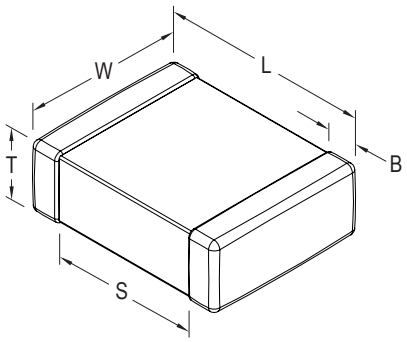
## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0201 | 0603 | 0.60 (.024) ± 0.03 (.001) | 0.30 (.012) ± 0.03 (.001) | See Table 2 for Thickness | 0.15 (.006) ± 0.05 (.002) | N/A | Solder Reflow Only |
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit at 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds at 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*

*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*

*[3] To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Capacitance and Dissipation Factor (DF) measured under the following conditions:*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0201 – 1206 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0201C | | | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.50 & 0.75 pF | 508 & 758 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | | | | | | |
| 0.75 pF | 758 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | | | | | | |
| 1.0 – 9.1 pF* | 109 – 919* | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.1 pF | 119 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.2 pF | 129 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.3 pF | 139 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.5 pF | 159 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.6 pF | 169 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1.8 pF | 189 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 2.0 pF | 209 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 2.2 pF | 229 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 2.4 pF | 249 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 2.7 pF | 279 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 3.0 pF | 309 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 3.3 pF | 339 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 3.6 pF | 369 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 3.9 pF | 399 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 4.3 pF | 439 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 4.7 pF | 479 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 5.1 pF | 519 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 5.6 pF | 569 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 6.2 pF | 629 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 6.8 pF | 689 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 7.5 pF | 759 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 8.2 pF | 829 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 9.1 pF | 919 | B C D | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 10 pF | 100 | F G J K M | AB[1] | AB[1] | AB[1] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 11 pF | 110 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 12 pF | 120 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 13 pF | 130 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 15 pF | 150 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 16 pF | 160 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 18 pF | 180 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 20 pF | 200 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 22 pF | 220 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DM | DM | DM | DM | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 24 pF | 240 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 27 pF | 270 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 30 pF | 300 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 33 pF | 330 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 36 pF | 360 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 39 pF | 390 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 43 pF | 430 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 47 pF | 470 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 51 pF | 510 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 56 pF | 560 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 62 pF | 620 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 68 pF | 680 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 75 pF | 750 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 82 pF | 820 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 91 pF | 910 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 100 pF | 101 | F G J K M | AB[2] | AB[2] | AB[2] | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | C0201C | | | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91).*

*xx[1] Available only in D, J, K,M tolerance*

*xx[2] Available only in J, K, M tolerance.*

*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1A – Capacitance Range/Selection Waterfall (0201 – 1206 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0201C | | | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 110 – 180 pF* | 111 – 181* | F G J K M | | | | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 200 – 270 pF* | 201 – 271* | F G J K M | | | | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 300 pF | 301 | F G J K M | | | | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 330 pF | 331 | F G J K M | | | | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 360 pF | 361 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 390 pF | 391 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 430 pF | 431 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 470 pF | 471 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 510 pF | 511 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 560 pF | 561 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 620 pF | 621 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 680 pF | 681 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 750 pF | 751 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 820 pF | 821 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 910 pF | 911 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 1,000 pF | 102 | F G J K M | | | | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 1,100 pF | 112 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1,200 pF | 122 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1,300 pF | 132 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 1,500 pF | 152 | F G J K M | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | EC | EC |
| 1,600 pF | 162 | F G J K M | | | | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 1,800 pF | 182 | F G J K M | | | | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 2,000 pF | 202 | F G J K M | | | | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 2,200 pF | 222 | F G J K M | | | | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EE | EE | EE |
| 2,400 pF | 242 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 2,700 pF | 272 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 3,000 pF | 302 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN | EC | EC | EC | EC | EC | EB | EB |
| 3,300 pF | 332 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN | EC | EC | EC | EC | EE | EB | EB |
| 3,600 pF | 362 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DP | DP | EC | EC | EC | EC | EE | EB | EB |
| 3,900 pF | 392 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EF | EB | EB |
| 4,300 pF | 432 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EC | EB | EB |
| 4,700 pF | 472 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EC | EB | EB |
| 5,100 pF | 512 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | | | | DE | DE | DE | DE | DN | DP | DP | ED | ED | ED | ED | ED | EB | EB |
| 5,600 pF | 562 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DP | DP | ED | ED | ED | ED | ED | EB | EB |
| 6,200 pF | 622 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 6,800 pF | 682 | F G J K M | | | | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 7,500 pF | 752 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 8,200 pF | 822 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG | EC | EC | EC | EC | EB | EC | EC |
| 9,100 pF | 912 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | | | EC | EC | EC | EC | EB | EC | EC |
| 10,000 pF | 103 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DP | | | ED | ED | ED | ED | EB | EC | EC |
| 12,000 pF | 123 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | ED | ED |
| 15,000 pF | 153 | F G J K M | | | | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DP | DG | | | EB | EB | EB | EB | EB | EF | EF |
| 18,000 pF | 183 | F G J K M | | | | | | | | | | | | | | | | | | DN | DN | DN | DP | | | | EB | EB | EB | EB | EB | EH | EH |
| 22,000 pF | 223 | F G J K M | | | | | | | | | | | | | | | | | | DP | DP | DP | DF | | | | EB | EB | EB | EB | EC | EH | EH |
| 27,000 pF | 273 | F G J K M | | | | | | | | | | | | | | | | | | DF | DF | DF | | | | | EB | EB | EB | EB | EE | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | | | | | | | | | | | DG | DG | DG | | | | | EB | EB | EB | EB | EE | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | | | | DG | DG | DG | | | | | EC | EC | EC | EE | EH | | |
| 47,000 pF | 473 | F G J K M | | | | | | | | | | | | | | | | | | DG | DG | DG | | | | | EC | EC | EC | EE | EH | | |
| 56,000 pF | 563 | F G J K M | | | | | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EF | | | |
| 68,000 pF | 683 | F G J K M | | | | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | |
| 82,000 pF | 823 | F G J K M | | | | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | EH | | | |
| 0.10 µF | 104 | F G J K M | | | | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | C0201C | | | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91).*
*xx¹ Available only in D, J, K,M tolerance*
*xx² Available only in J, K, M tolerance.*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 – 9.1 pF* | 109 – 919* | B C D | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | F G J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | |
| 100 – 300 pF* | 101 – 301* | F G J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | |
| 330 – 430 pF* | 331 – 431* | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | | | | | | | | | | | | | | | | |
| 470 – 910 pF* | 471 – 911* | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,000 pF | 102 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,300 pF | 132 | F G J K M | FB | FB | FB | FB | FB | FC | FC | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,500 pF | 152 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,600 pF | 162 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,800 pF | 182 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,000 pF | 202 | F G J K M | FB | FB | FB | FB | FC | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,200 pF | 222 | F G J K M | FB | FB | FB | FB | FC | FG | FG | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,400 pF | 242 | F G J K M | FB | FB | FB | FB | FC | FC | FC | LF | LF | LF | LF | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | F G J K M | FB | FB | FB | FB | FC | FC | FC | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | |
| 3,000 pF | 302 | F G J K M | FB | FB | FB | FB | FC | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | GB | GB | GB | GB | | | | | | | | | | | | |
| 3,600 pF | 362 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | |
| 4,300 pF | 432 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | F G J K M | FF | FF | FF | FF | FG | FG | FG | LF | LF | | | GB | GB | GD | GD | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| 5,100 pF | 512 | F G J K M | FB | FB | FB | FB | FG | FG | FG | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 5,600 pF | 562 | F G J K M | FB | FB | FB | FB | FG | FG | FG | | | | | GB | GB | GH | GH | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| 6,200 pF | 622 | F G J K M | FB | FB | FB | FB | FG | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 6,800 pF | 682 | F G J K M | FB | FB | FB | FB | FG | FB | FB | | | | | GB | GB | GJ | GJ | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 7,500 pF | 752 | F G J K M | FC | FC | FC | FC | FC | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 8,200 pF | 822 | F G J K M | FC | FC | FC | FC | FC | FB | FB | | | | | GB | GH | GB | GB | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 9,100 pF | 912 | F G J K M | FE | FE | FE | FE | FE | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 10,000 pF | 103 | F G J K M | FF | FF | FF | FF | FF | FB | FB | | | | | GB | GH | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 12,000 pF | 123 | F G J K M | FG | FG | FG | FG | FB | FB | FB | | | | | GB | GG | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 15,000 pF | 153 | F G J K M | FG | FG | FG | FG | FB | FC | FC | | | | | GB | GB | GB | GB | HB | HB | | | JE | JE | JB | | KE | KE | KE | KE |
| 18,000 pF | 183 | F G J K M | FB | FB | FB | FB | FB | FC | FC | | | | | GB | GB | GB | GB | HB | HE | | | JE | JE | JB | | KE | KE | | |
| 22,000 pF | 223 | F G J K M | FB | FB | FB | FB | FB | FF | FF | | | | | GB | GB | GB | GB | HB | HE | | | JE | JB | JB | | KE | KE | | |
| 27,000 pF | 273 | F G J K M | FB | FB | FB | FB | FB | FG | FG | | | | | GB | GB | GB | GB | HB | HG | | | JE | JB | JB | | KE | KE | | |
| 33,000 pF | 333 | F G J K M | FB | FB | FB | FB | FB | FH | FH | | | | | GB | GB | GB | GB | | | | | JB | JB | JB | | KE | | | |
| 39,000 pF | 393 | F G J K M | FB | FB | FB | FB | FE | FH | FH | | | | | GB | GB | GB | GB | | | | | JB | JB | JB | | | | | |
| 47,000 pF | 473 | F G J K M | FB | FB | FB | FB | FE | FJ | FJ | | | | | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 56,000 pF | 563 | F G J K M | FB | FB | FB | FB | FF | | | | | | | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 68,000 pF | 683 | F G J K M | FB | FB | FB | FC | FG | | | | | | | GB | GB | GK | GK | | | | | JB | JB | JB | | | | | |
| 82,000 pF | 823 | F G J K M | FC | FC | FC | FF | FH | | | | | | | GB | GB | GM | GM | | | | | JB | JB | JB | | | | | |
| 0.10 µF | 104 | F G J K M | FE | FE | FE | FG | FM | | | | | | | GB | GD | GM | GM | | | | | JB | JB | JD | | | | | |
| 0.12 µF | 124 | F G J K M | FG | FG | FG | FH | | | | | | | | GB | GH | | | | | | | JB | JB | JD | | | | | |
| 0.15 µF | 154 | F G J K M | FH | FH | FH | FM | | | | | | | | GD | GN | | | | | | | JB | JB | JG | | | | | |
| 0.18 µF | 184 | F G J K M | FJ | FJ | FJ | | | | | | | | | GH | | | | | | | | JB | JD | JG | | | | | |
| 0.22 µF | 224 | F G J K M | FK | FK | FK | | | | | | | | | GK | | | | | | | | JB | JD | JL | | | | | |
| 0.27 µF | 274 | F G J K M | | | | | | | | | | | | | | | | | | | | JB | JF | | | | | | |
| 0.33 µF | 334 | F G J K M | | | | | | | | | | | | | | | | | | | | JD | JG | | | | | | |
| 0.39 µF | 394 | F G J K M | | | | | | | | | | | | | | | | | | | | JG | | | | | | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | | | | | | | | JG | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91).*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| AB | 0201 | 0.30 ± 0.03 | 15,000 | 0 | 0 | 0 |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| BD | 0402 | 0.55 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| CH | 0603 | 0.85 ± 0.07 | 4,000 | 10,000 | 0 | 0 |
| DM | 0805 | 0.70 ± 0.20 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| NC | 1706 | 1.00 ± 0.15 | 0 | 0 | 4,000 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JG | 2220 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0201 | 0603 | 0.38 | 0.56 | 0.52 | 1.80 | 1.00 | 0.33 | 0.46 | 0.42 | 1.50 | 0.80 | 0.28 | 0.36 | 0.32 | 1.20 | 0.60 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

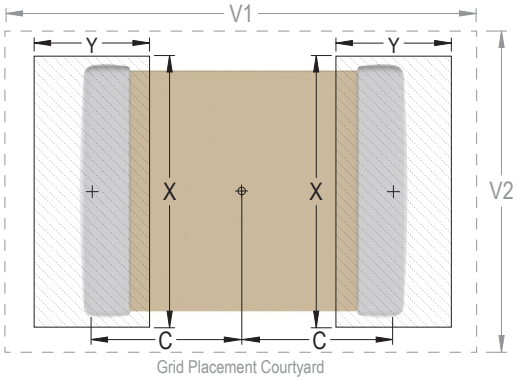
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

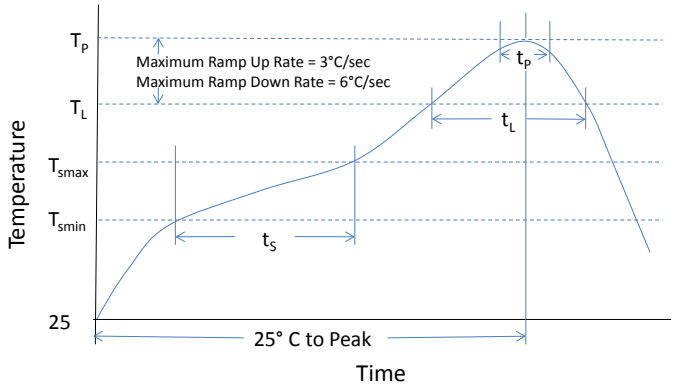
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



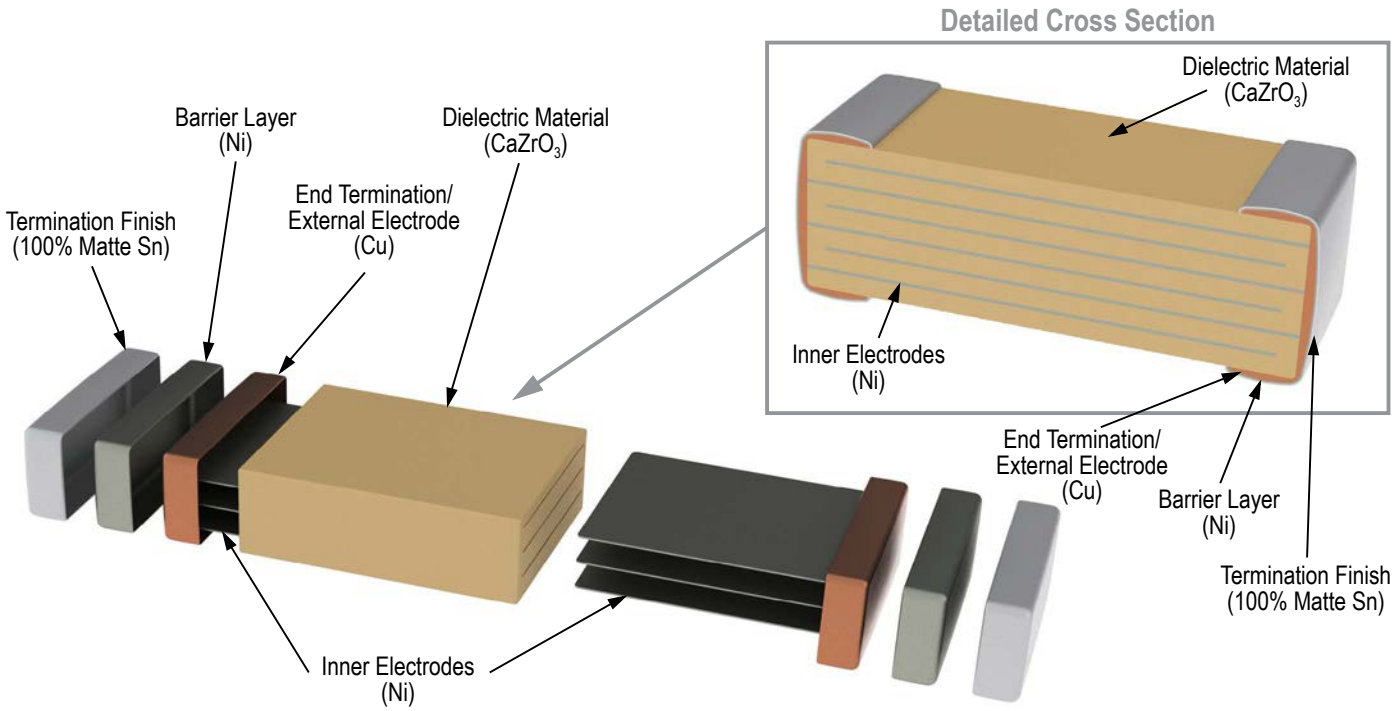
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# X7R Dielectric, 6.3 – 250 VDC (Commercial Grade)

## Overview

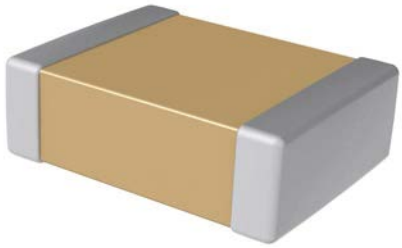
KEMET's X7R dielectric features a 125°C maximum operating temperature and is considered "temperature stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS, and REACH Compliant
- Temperature stable dielectric
- EIA 0402, 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 35 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 10 pF to 47 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include decoupling, bypass, filtering and transient voltage suppression.



## Ordering Information

| C | 1206 | C | 106 | M | 4 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/ Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | C = Standard | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

[1] *Flexible termination option is available. Please see FT-CAP product bulletin C1013_X7R_FT-CAP_SMD.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

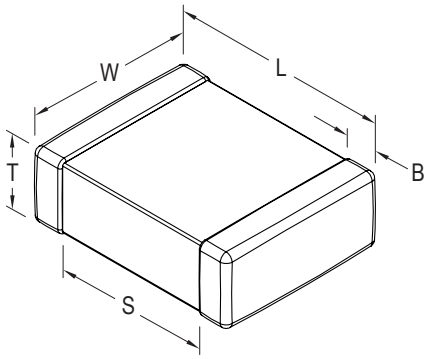
| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210[1] | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (0.185) ±0.50 (0.020) | 2.00 (0.079) ±0.20 (0.008) | | 0.60 (0.024) ±0.35 (0.014) | | |
| 1812 | 4532 | 4.50 (0.177) ±0.30 (0.012) | 3.20 (0.126) ±0.30 (0.012) | | 0.60 (0.024) ±0.35 (0.014) | | |
| 1825 | 4564 | 4.50 (0.177) ±0.30 (0.012) | 6.40 (0.252) ±0.40 (0.016) | | 0.60 (0.024) ±0.35 (0.014) | | |
| 2220 | 5650 | 5.70 (0.224) ±0.40 (0.016) | 5.00 (0.197) ±0.40 (0.016) | | 0.60 (0.024) ±0.35 (0.014) | | |
| 2225 | 5664 | 5.60 (0.220) ±0.40 (0.016) | 6.40 (0.248) ±0.40 (0.016) | | 0.60 (0.024) ±0.35 (0.014) | | |

*[1] For capacitance values ≥ 4.7 µF add 0.02 (0.001) to the width tolerance dimension and 0.10 (0.004) to the length tolerance dimension.*

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | See Dissipation Factor Limit Table |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*
*120 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | | |
|---|---|---|---|---|---|---|
| Dielectric | Case Size | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | 0402 | < 16 | All | 7.5 | ± 20% | 10% of Initial Limit |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | | 3.0 | | |
| | 0603 | < 16 | < 1.0 µF | 7.5 | | |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | | 3.0 | | |
| | | < 16 | ≥ 1.0 µF | 20.0 | | |
| | | 16 / 25 | | | | |
| | 0805 | < 16 | < 2.2 µF | 7.5 | | |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | < 1.0 µF | 3.0 | | |
| | | < 16 | ≥ 2.2 µF | 20.0 | | |
| | | 16 / 25 | | | | |
| | | > 25 | ≥ 1.0 µF | | | |
| | 1206 | < 16 | < 10 µF | 7.5 | | |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | | 3.0 | | |
| | | 35 / 50 | ≥ 2.2 µF | 20.0 | | |
| | | < 16 | ≥ 10 µF | | | |
| | | 16 / 25 | | | | |
| | 1210 | < 16 | < 22 µF | 7.5 | | |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | | 3.0 | | |
| | | < 16 | ≥ 22 µF | 20.0 | | |
| | | 16 / 25 | | | | |
| | 1808-2225 | < 16 | All | 7.5 | | |
| | | 16 / 25 | | 5.0 | | |
| | | > 25 | | 3.5 | | |

## Dissipation Factor (DF) Limit Table

| EIA Case Size | Rated DC Voltage | Capacitance | Dissipation Factor (Maximum %) |
|---|---|---|---|
| 0402 | < 16 | All | 5.0 |
| | 16 | | 3.5 |
| | 25 | < 0.1 µF | 3.5 |
| | 25 | ≥ 0.1 µF | 10.0 |
| | > 25 | All | 2.5 |
| 0603 | < 16 | < 1.0 µF | 5.0 |
| | 16 / 25 | | 3.5 |
| | > 25 | | 2.5 |
| | < 16 | ≥ 1.0 µF | 10.0 |
| | 16 / 25 | | |
| 0805 | < 16 | < 2.2 µF | 5.0 |
| | 16 / 25 | | 3.5 |
| | > 25 | < 1.0 µF | 2.5 |
| | < 16 | ≥ 2.2 µF | 10.0 |
| | 16 / 25 | | |
| | > 25 | ≥ 1.0 µF | |
| 1206 | < 16 | < 10 µF | 5.0 |
| | 16 / 25 | | 3.5 |
| | > 25 | | 2.5 |
| | 35 / 50 | ≥ 2.2 µF | 10.0 |
| | < 16 | ≥ 10 µF | 10.0 |
| | 16 / 25 | | |
| 1210 | < 16 | < 22 µF | 5.0 |
| | 16 / 25 | | 3.5 |
| | > 25 | | 2.5 |
| | < 16 | ≥ 22 µF | 10.0 |
| | 16 / 25 | | |
| 1808-2225 | < 16 | All | 5.0 |
| | 16 / 25 | | 3.5 |
| | > 25 | | 2.5 |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 - 20 pF* | 100 - 200* | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 22 pF | 220 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DM | DM | DM | DM | DM | DM | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 24 - 91pF | 240 - 910* | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 100 - 150 pF** | 101 - 151** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 180 - 820 pF** | 181 - 821** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | |
| 1000pF | 102 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1200 pF | 122 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1500 pF | 152 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1800 pF | 182 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 2200 pF | 222 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 2700 pF | 272 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 3300 pF | 332 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 3900 pF | 392 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 4700 pF | 472 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 5600 pF | 562 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 6800 pF | 682 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 8200 pF | 822 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 10000 pF | 103 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 12000 pF | 123 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 15000 pF | 153 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 18000 pF | 183 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 22000 pF | 223 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 27000 pF | 273 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 33000 pF | 333 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 39000 pF | 393 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EC | EB | EB |
| 47000 pF | 473 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CJ | CF | | DO | DO | DO | DO | DO | DO | DE | DG | | EB | EB | EB | EB | EB | EB | EC | ED | ED |
| 56000 pF | 563 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | DG | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 68000 pF | 683 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 82000 pF | 823 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 0.1 µF | 104 | J K M | BB | BB | BB | BB[1] | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | EB | EB | EM | EM |
| 0.12 µF | 124 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DP | DG | | | EC | EC | EC | EC | EC | EC | EC | EG | |
| 0.15 µF | 154 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DP | DG | | | EC | EC | EC | EC | EC | EC | EC | EG | |
| 0.18 µF | 184 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DG | DG | DG | | | EC | EC | EC | EC | EC | EC | EC | | |
| 0.22 µF | 224 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DG | DG | DG | | | EC | EC | EC | EC | EC | EC | EC | | |
| 0.27 µF | 274 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EC | EM | | |
| 0.33 µF | 334 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DP | DP | | | | EB | EB | EB | EB | EC | EC | EG | | |
| 0.39 µF | 394 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DE | DE | | | | EB | EB | EB | EB | EC | EC | EG | | |
| 0.47 µF | 474 | J K M | | | | | | CF | CF | CF | CG[1] | | | | DG | DG | DG | DG | DE | DE | | | | EC | EC | EC | EC | EC | EC | EG | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | DH | | | | ED | ED | ED | ED | EC | EC | EM | | |
| 0.68 µF | 684 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | DH | | | | EE | EE | EE | EE | ED | ED | EM | | |
| 0.82 µF | 824 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | | EF | EF | EF | EF | ED | ED | EH | | |
| 1 µF | 105 | J K M | | | | | | CG[1] | CG[1] | CG[1] | CD[1] | | | | DP | DP | DP | DG | DG[1] | DG[1] | | | | EP | EP | EP | EP | ED | ED | EH | | |
| 1.2 µF | 125 | J K M | | | | | | | | | | | | | DE | DE | DE | | | | | | | ED | ED | ED | EG | EH | EH | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | | ED | ED | ED | EG | EH | EH | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | | ED | ED | ED | EF | EH | EH | | | |
| 2.2 µF | 225 | J K M | | | | | | CG[1] | CG[1] | | | | | | DG | DG | DG | DG[1] | | | | | | EH | EH | EH[1] | EH[1] | EH | EH | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

*xx[1] Available only in K, M tolerance.*

*xx[2] Available only in M tolerance.*

## Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EH | | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | DG[1] | DG[1] | DG[1] | | | | | | | EH[1] | EH[1] | EH[1] | EH[1] | EH[1] | EH[1] | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | DG[1] | DG[1] | | | | | | | | EH | EH | EH | EH[1] | | | | | |
| 22 µF | 226 | J K M | | | | | | | | | | | | | | | | | | | | | | EH[1] | EH[1] | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |

## Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 - 91 pF* | 100 - 910* | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 11 pF | 110 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 12 pF | 120 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 13 pF | 130 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 15 pF | 150 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 16 pF | 160 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 18 pF | 180 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 20 pF | 200 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 22 pF | 220 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 24 pF | 240 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 27 pF | 270 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 30 pF | 300 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 33 pF | 330 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 36 pF | 360 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 39 pF | 390 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 43 pF | 430 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 47 pF | 470 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 51 pF | 510 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 56 pF | 560 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

*xx[1] Available only in K, M tolerance.*

*xx[2] Available only in M tolerance.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62 pF | 620 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 68 pF | 680 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 75 pF | 750 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 82 pF | 820 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 91 pF | 910 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 100 - 270 pF** | 101 - 271** | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 110 pF | 111 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 120 pF | 121 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 130 pF | 131 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 150 pF | 151 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 180 pF | 181 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 220 pF | 221 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 270 pF | 271 | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | | | | | |
| 470 - 1,200 pF** | 471 - 122** | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 560 pF | 561 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 680 pF | 681 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 820 pF | 821 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,200 pF | 122 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | HB | HB | HB | | | | | | | | | | |
| 4,700 pF | 472 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GD | | HB | HB | HB | | | | | | | KE | KE | KE | |
| 5,600 pF | 562 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GH | | HB | HB | HB | | | | | | | KE | KE | KE | |
| 6,800 pF | 682 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HB | | JE | JE | JE | | | KE | KE | KE | |
| 8,200 pF | 822 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HB | | JE | JE | JE | | | KE | KE | KE | |
| 10,000 pF | 103 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HE | | JE | JE | JE | | | KE | KE | KE | |
| 12,000 pF | 123 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HE | | JE | JE | JE | | | KE | KE | KE | |
| 15,000 pF | 153 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | | | JE | JE | JE | | | KE | KE | KE | |
| 18,000 pF | 183 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HE | | | JE | JE | JE | | | KE | KE | | |
| 22,000 pF | 223 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | | KE | KE | | |
| 27,000 pF | 273 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | | KE | KE | | |
| 33,000 pF | 333 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | KE | | | |
| 39,000 pF | 393 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 47,000 pF | 473 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 56,000 pF | 563 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 68,000 pF | 683 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 82,000 pF | 823 | J K M | FB | FB | FB | FB | FB | FC | FF | FF | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | | | | |
| 0.10 µF | 104 | J K M | FB | FB | FB | FB | FB | FD | FG | FG | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.12 µF | 124 | J K M | FB | FB | FB | FB | FB | FD | FH | FH | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

*xx[1] Available only in K, M tolerance.*

*xx[2] Available only in M tolerance.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | J K M | FC | FC | FC | FC | FC | FD | FM | FM | LD | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.18 µF | 184 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | LD | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.22 µF | 224 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.27 µF | 274 | J K M | FC | FC | FC | FC | FC | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.33 µF | 334 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.39 µF | 394 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.47 µF | 474 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GJ | GJ | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KD | KD |
| 0.56 µF | 564 | J K M | FD | FD | FD | FD | FD | FF | | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JC | JD | JD | KB | KC | KD | KD |
| 0.68 µF | 684 | J K M | FD | FD | FD | FD | FD | FG | | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JD | JD | JD | KB | KC | KD | KD |
| 0.82 µF | 824 | J K M | FF | FF | FF | FF | FF | FL | | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KC | KE | KE |
| 1.0 µF | 105 | J K M | FH | FH | FH | FH | FH | FM | | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KD | KE | KE |
| 1.2 µF | 125 | J K M | FH | FH | FH | FH | FG | FH | | | | | | GB | GB | GB | | | HB | | | | JC | JC | | | | KB | KE | KE | KE |
| 1.5 µF | 155 | J K M | FH | FH | FH | FH | FG | FM | | | | | | GC | GC | GC | | | HC | | | | JC | JC | | | | KC | | | |
| 1.8 µF | 185 | J K M | FH | FH | FH | FH | FG | FJ | | | | | | GE | GE | GE | | | HD | | | | JD | JD | | | | KD | | | |
| 2.2 µF | 225 | J K M | FJ | FJ | FJ | FJ | FG | FT[1] | | | | | | GO | GO | GO[1] | | | HF | | | | JF | JF | | | | KD | | | |
| 2.7 µF | 275 | J K M | FE | FE | FE | FG | FH | | | | | | | GJ | GJ | GJ | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | FF | FF | FF | FM | FM | | | | | | | GL | GL | GL | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | FG | FG | FG | FG | FK | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | FC | FC | FC | FG | FS | | | | | | | GK | GK | | | | | | | | JF | JF | | | | | | | |
| 5.6 µF | 565 | J K M | FF | FF | FF | FH | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | FG | FG | FG | FM | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | FH | FH | FH | FK | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | FT[1] | FT[1] | FT[1] | FS[1] | FS[1] | | | | | | | GK | | | | | | | | | JF | JO | | | | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | FM | FM | | | | | | | | | | | | | | | | | | | JO | JO | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | FS | FS | FS[1] | FS[1] | | | | | | | | | | | | | | | | | JO | | | | | | | | |
| 47 µF | 476 | J K M | FS[1] | FS[2] | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

*xx[1] Available only in K, M tolerance.*

*xx[2] Available only in M tolerance.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07* | 4,000 | 15,000 | 0 | 0 |
| CG | 0603 | 0.80 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| CD | 0603 | 0.80 ± 0.15 | 4,000 | 10,000 | 0 | 0 |
| CJ | 0603 | 0.80 ± 0.15* | 4,000 | 15,000 | 0 | 0 |
| DM | 0805 | 0.70 ± 0.20* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DO | 0805 | 0.80 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EP | 1206 | 1.20 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FT | 1210 | 1.90 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| NA | 1706 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| NC | 1706 | 1.00 ± 0.15 | 0 | 0 | 4,000 | 10,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HC | 1825 | 1.15 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities cont'd

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| KB | 2225 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*

*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

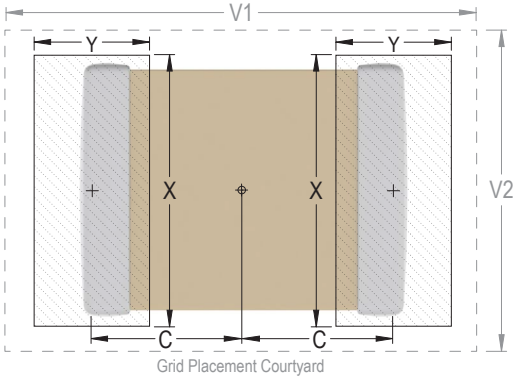
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

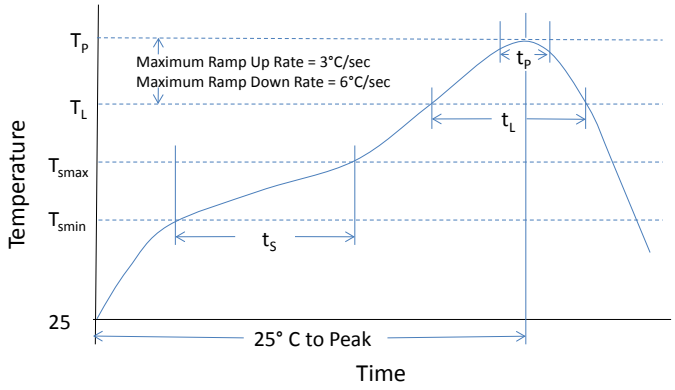
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C with 2 X rated voltage applied excluding the following: |

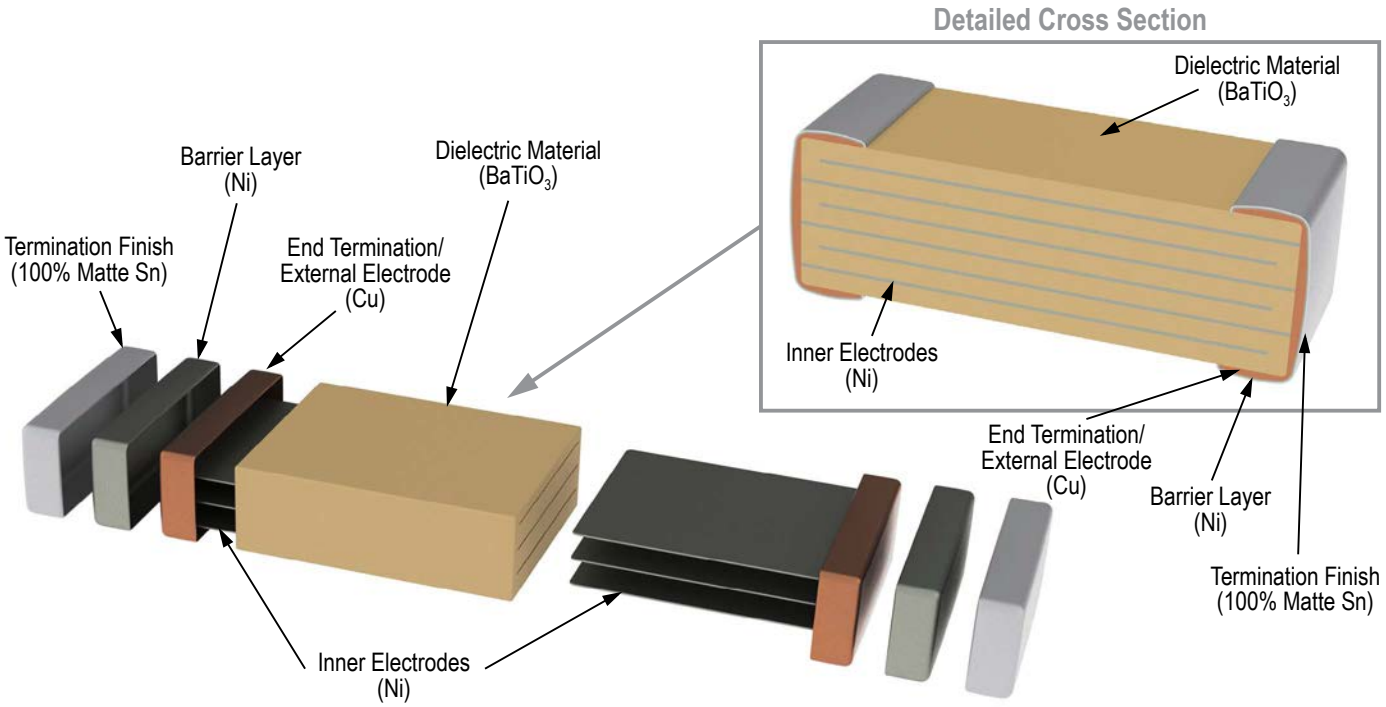
| Case Size | Capacitance | Applied Voltage |
|---|---|---|
| 0603 & 0805 | ≥ 1.0 µF | 1.5 X |
| 1206 & 1210 | ≥ 10 µF | |

| | | |
|---|---|---|
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)



# X5R Dielectric, 4 – 50 VDC (Commercial Grade)

## Overview

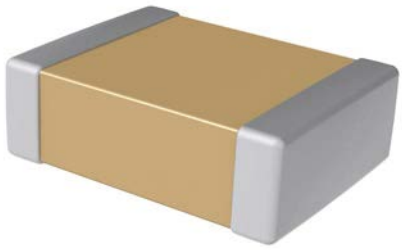
KEMET's X5R dielectric features an 85°C maximum operating temperature and is considered "semi-stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes X5R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X5R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +85°C.

## Benefits

- −55°C to +85°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- Temperature stable dielectric
- EIA 0201, 0402, 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 4 V, 6.3 V, 10 V, 16 V, 25 V, 35 V, and 50 V
- Capacitance offerings ranging from 0.01 µF to 100 µF
- Available capacitance tolerances of ±10% and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability

## Applications

Typical applications include decoupling, bypass, and filtering.



## Ordering Information

| C | 1206 | C | 107 | M | 9 | P | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C–Spec) |
| | 0201<br>0402<br>0603<br>0805<br>1206<br>1210 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | 7 = 4<br>9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50 | P = X5R | A = N/A | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

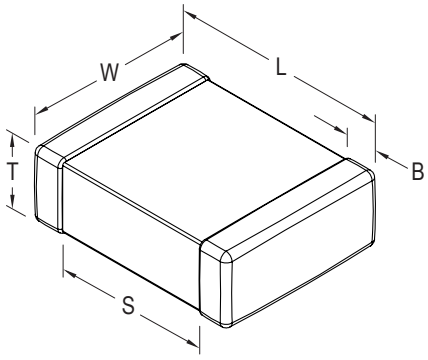
| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0201 | 0603 | 0.60 (0.024) ±0.03 (0.001) | 0.30 (0.012) ±0.03 (0.001) | See Table 2 for Thickness | 0.15 (0.006) ±0.05 (0.002) | N/A | Solder Reflow Only |
| 0402[1] | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206[2] | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210[3] | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

*[1] For capacitance values ≥ 4.7 µF add 0.15 (0.006) to the width and length tolerance dimensions.*

*[2] For capacitance values ≥ 22 µF add 0.10 (0.004) to the positive bandwidth tolerance dimension.*

*[3] For capacitance values ≥ 22 µF add 0.10 (0.004) to the length and width tolerance dimension and add 0.15 (0.006) to the positive bandwidth tolerance dimension.*

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +85°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 5.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | See Dissipation Factor Limit Table |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*
*120 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X5R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 25 | < 2.2 µF | 7.5 | | |
| | | ≥ 2.2 µF | 20.0 | | |
| | < 25 | < 0.56 µF | 7.5 | | |
| | < 25 | ≥ 0.56 µF | 20.0 | | |

## Dissipation Factor Limit Table

| Rated DC Voltage | Capacitance | Dissipation Factor (Maximum %) |
|---|---|---|
| > 25 | All | 2.5 |
| 25 | < 2.2 µF | 5.0 |
| | ≥ 2.2 µF | 10.0 |
| < 25 | < 0.56 µF | 5.0 |
| | ≥ 0.56 µF | 10.0 |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ | 100 Megohm Microfarads |
|---|---|---|---|
| 0201 | N/A | ALL | N/A |
| 0402 | < .012 µF | ≥ .012 µF < 1.0 µF | ≥ 1.0 µF |
| 0603 | < .047 µF | ≥ .047 µf < 1.0 µF | ≥ 1.0 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF < 1.0 µF | ≥ 1.0 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF < 1.0 µF | ≥ 1.0 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF < 1.0 µF | ≥ 1.0 µF |
| 1812 | < 2.2 µF | ≥ 2.2 µF | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0201 – 0805 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C0201C | | | | C0402C | | | | | | C0603C | | | | | | C0805C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 7 | 9 | 8 | 4 | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 |
| | | Rated Voltage (VDC) | | 4 | 6.3 | 10 | 16 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | K | M | AB | AB | AB | AB | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 12,000 pF | 123 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 15,000 pF | 153 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 18,000 pF | 183 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 22,000 pF | 223 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 27,000 pF | 273 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 33,000 pF | 333 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 39,000 pF | 393 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 47,000 pF | 473 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 56,000 pF | 563 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 68,000 pF | 683 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 82,000 pF | 823 | K | M | | | | | BB | BB | BB | BB | | | | | | | | | | | | | | |
| 0.10 µF | 104 | K | M | AB | AB | | | BB | BB | BB | BB | | | CG | CG | CG | CG | CG | | | | | | | |
| 0.12 µF | 124 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 0.18 µF | 184 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 0.22 µF | 224 | K | M | | | | | BB | BB | | | | | CG | CG | CG | CG | | | | | | | | |
| 0.27 µF | 274 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | | | | | | |
| 0.33 µF | 334 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | | | | | | |
| 0.39 µF | 394 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | | | | | | |
| 0.47 µF | 474 | K | M | | | | | BB | BB | | | | | CG | CG | CG | CG | CG | | DG | DG | DG | DG | DG | |
| 0.56 µF | 564 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | DP | DP | DP | DP | DP | |
| 0.68 µF | 684 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | DP | DP | DP | DP | DE | |
| 0.82 µF | 824 | K | M | | | | | | | | | | | CG | CG | CG | CG | | | DF | DF | DF | DF | DF | |
| 1.0 µF | 105 | K | M | | | | | BB | BB | BB | BB | | | CG | CG | CG | CG | CJ | | DP | DP | DP | DP | DG | DG |
| 1.2 µF | 125 | K | M | | | | | | | | | | | | | | | | | DN | DN | DN | DN | | |
| 1.5 µF | 155 | K | M | | | | | | | | | | | | | | | | | DN | DN | DN | DN | | |
| 1.8 µF | 185 | K | M | | | | | | | | | | | | | | | | | DP | DP | DP | DP | | |
| 2.2 µF | 225 | K | M | | | | | BB | BB | BB[1] | | | | CG | CG | CG | CG | | | DG | DG | DG | DG | DG | |
| 2.7 µF | 275 | K | M | | | | | | | | | | | | | | | | | DL | DL | DL | DL | | |
| 3.3 µF | 335 | K | M | | | | | BB[1] | | | | | | CG | CG | | | | | DL | DL | DL | DG | | |
| 3.9 µF | 395 | K | M | | | | | | | | | | | | | | | | | DG | DG | DG | DG | | |
| 4.7 µF | 475 | K | M | | | | | BE[1] | BE[1] | | | | | CG | CG | CG | | | | DG | DG | DG | DG | DG | |
| 5.6 µF | 565 | K | M | | | | | | | | | | | | | | | | | DG | DG | DG | | | |
| 6.8 µF | 685 | K | M | | | | | | | | | | | | | | | | | DG | DG | DG | | | |
| 8.2 µF | 825 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | K | M | | | | | BF[1] | BF[1] | | | | | CG[1] | CG[1] | CG[1] | | | | DG | DG | DG | DG | DH | |
| 12 µF | 126 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 18 µF | 186 | K | M | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | K | M | | | | | | | | | | | | | | | | | DG | DG | DH[1] | | | |
| 47 µF | 476 | K | M | | | | | | | | | | | | | | | | | DH[1] | DH[1] | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 4 | 6.3 | 10 | 16 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 |
| | | Voltage Code | | 7 | 9 | 8 | 4 | 7 | 9 | 8 | 3 | 5 | 4 | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 |
| | | Case Size/Series | | C0201C | | | | C0402C | | | | | | C0603C | | | | | | C0805C | | | | | |

xx[1] Available only in M tolerance.

# Table 1 – Capacitance Range/Selection Waterfall (1206 – 1812 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C1206C | | | | | C1210C | | | | | | C1812C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 6 | 5 | 3 | 6 | 5 |
| | | Rated Voltage (VDC) | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 35 | 50 | 25 | 35 | 50 |
| | | Cap Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | |
| 0.27 µF | 274 | K | M | EB | EB | EB | EB | | | | | | | | | | |
| 0.33 µF | 334 | K | M | EB | EB | EB | EB | | | | | | | | | | |
| 0.39 µF | 394 | K | M | EB | EB | EB | EB | | FD | FD | FD | FD | FD | | | | |
| 0.47 µF | 474 | K | M | EC | EC | EC | EC | | FD | FD | FD | FD | FD | | | | |
| 0.56 µF | 564 | K | M | ED | ED | ED | ED | | FD | FD | FD | FD | FD | | | | |
| 0.68 µF | 684 | K | M | EE | EE | EE | EE | | FD | FD | FD | FD | FD | | | | |
| 0.82 µF | 824 | K | M | EF | EF | EF | EF | | FF | FF | FF | FF | FF | | | | |
| 1.0 µF | 105 | K | M | EP | EP | EP | EP | | FH | FH | FH | FH | FH | FH | | | |
| 1.2 µF | 125 | K | M | EC | EC | EC | EC | | FD | FD | FD | FD | | | | | |
| 1.5 µF | 155 | K | M | EC | EC | EC | EC | | FD | FD | FD | FD | | | | | |
| 1.8 µF | 185 | K | M | EC | EC | EC | EC | | FD | FD | FD | FD | | | | | |
| 2.2 µF | 225 | K | M | EC | EC | EC | EC | | FJ | FJ | FJ | FJ | | | | | |
| 2.7 µF | 275 | K | M | EF | EF | EF | EF | | FG | FG | FG | FG | | | | | |
| 3.3 µF | 335 | K | M | EH | EH | EH | EH | | FH | FH | FH | FH | | | | | |
| 3.9 µF | 395 | K | M | ED | ED | ED | ED | | FJ | FJ | FJ | FJ | | | | | |
| 4.7 µF | 475 | K | M | EH | EH | EH | EH | EH | FT | FT | FT | FT | | | | | |
| 5.6 µF | 565 | K | M | EK | EK | EH | | | FG | FG | FG | FE | | | | | |
| 6.8 µF | 685 | K | M | EK | EK | EH | | | FJ | FJ | FJ | FJ | | | | | |
| 8.2 µF | 825 | K | M | ED | ED | EH | | | FK | FK | FK | FG | | | | | |
| 10 µF | 106 | K | M | EH | EH | EH | EH | | FT | FT | FT | FT | FT | FS | GK | | |
| 12 µF | 126 | K | M | | | | | | FD | FD | FG | | | | | | |
| 15 µF | 156 | K | M | | | | | | FF | FF | FG | | | | | | |
| 18 µF | 186 | K | M | | | | | | FG | FG | FH | | | | | | |
| 22 µF | 226 | K | M | EH | EH[1] | EH[1] | | | FS | FS | FS | FS | | | | | |
| 47 µF | 476 | K | M | EH[1] | EH[1] | | | | FS[1] | FS[1] | FS[1] | | | | | | |
| 100 µF | 107 | K | M | EH[1] | | | | | FS[1] | FS[1] | FS[1] | | | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 35 | 50 | 25 | 35 | 50 |
| | | Voltage Code | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 6 | 5 | 3 | 6 | 5 |
| | | Case Size/Series | | C1206C | | | | | C1210C | | | | | | C1812C | | |

xx[1] Available only in M tolerance.

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| AB | 0201 | 0.30 ± 0.03 | 15,000 | 0 | 0 | 0 |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| BE | 0402 | 0.50 ± 0.15 | 10,000 | 50,000 | 0 | 0 |
| BF | 0402 | 0.50 ± 0.20 | 10,000 | 50,000 | 0 | 0 |
| CG | 0603 | 0.80 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| CJ | 0603 | 0.80 ± 0.15* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DL | 0805 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EK | 1206 | 0.80 ± 0.10 | 0 | 0 | 2,000 | 8,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EP | 1206 | 1.20 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FT | 1210 | 1.90 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0201 | 0603 | 0.38 | 0.56 | 0.52 | 1.80 | 1.00 | 0.33 | 0.46 | 0.42 | 1.50 | 0.80 | 0.28 | 0.36 | 0.32 | 1.20 | 0.60 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |

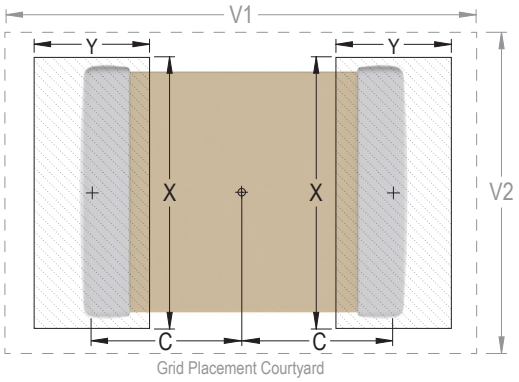
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

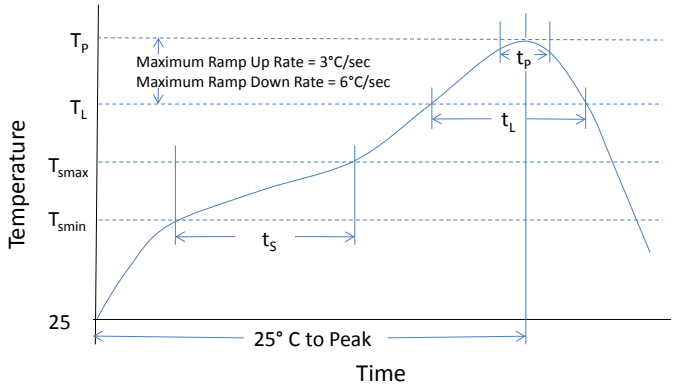
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



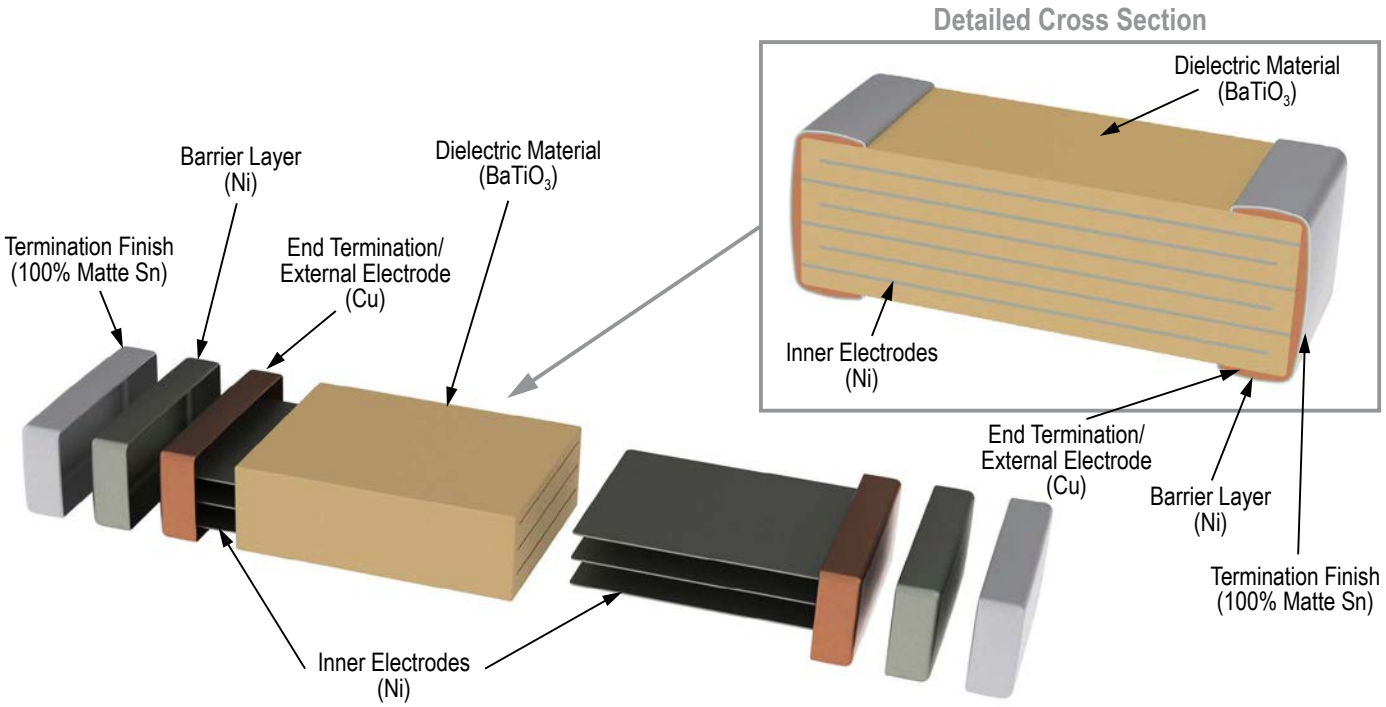
## Table 4 – Performance & Reliability: Test Methods and Conditions

<table>
<tr><th>Stress</th><th>Reference</th><th>Test or Inspection Method</th></tr>
<tr><td>Terminal Strength</td><td>JIS–C–6429</td><td>Appendix 1, Note: Force of 1.8 kg for 60 seconds.</td></tr>
<tr><td>Board Flex</td><td>JIS–C–6429</td><td>Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum).</td></tr>
<tr><td rowspan="4">Solderability</td><td rowspan="4">J–STD–002</td><td>Magnification 50 X. Conditions:</td></tr>
<tr><td>a) Method B, 4 hours at 155°C, dry heat at 235°C</td></tr>
<tr><td>b) Method B at 215°C category 3</td></tr>
<tr><td>c) Method D, category 3 at 260°C</td></tr>
<tr><td>Temperature Cycling</td><td>JESD22 Method JA–104</td><td>1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td rowspan="2">Biased Humidity</td><td rowspan="2">MIL–STD–202 Method 103</td><td>Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Moisture Resistance</td><td>MIL–STD–202 Method 106</td><td>t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Thermal Shock</td><td>MIL–STD–202 Method 107</td><td>−55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air.</td></tr>
<tr><td>High Temperature Life</td><td>MIL–STD–202 Method 108 /EIA–198</td><td>1,000 hours at 85°C with 2 X rated voltage applied excluding the following:
<table>
<tr><th>Case Size</th><th>Capacitance</th><th>Applied Voltage</th></tr>
<tr><td>0402</td><td>≥ 0.22 µF</td><td rowspan="5">1.5 X</td></tr>
<tr><td>0603</td><td>≥ 1.0 µF</td></tr>
<tr><td>0805</td><td>≥ 4.7 µF</td></tr>
<tr><td>1206</td><td>≥ 2.2 µF</td></tr>
<tr><td>1210</td><td>≥ 10 µF</td></tr>
</table></td></tr>
<tr><td>Storage Life</td><td>MIL–STD–202 Method 108</td><td>150°C, 0 VDC for 1,000 hours.</td></tr>
<tr><td>Vibration</td><td>MIL–STD–202 Method 204</td><td>5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz</td></tr>
<tr><td>Mechanical Shock</td><td>MIL–STD–202 Method 213</td><td>Figure 1 of Method 213, Condition F.</td></tr>
<tr><td>Resistance to Solvents</td><td>MIL–STD–202 Method 215</td><td>Add aqueous wash chemical, OKEM Clean or equivalent.</td></tr>
</table>

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)



# Z5U Dielectric, 50 – 100 VDC (Commercial Grade)

## Overview

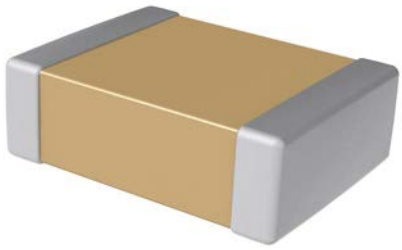
KEMET's Z5U dielectric features an 85°C maximum operating temperature and is considered "general-purpose." The Electronics Components, Assemblies & Materials Association (EIA) characterizes Z5U dielectric as a Class III material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling or other applications in which dielectric losses, high insulation resistance and capacitance stability are not of major importance. Z5U exhibits a predictable change in capacitance with respect to time and voltage and displays wide variations in capacitance with reference to ambient temperature. Capacitance change is limited to +22%, −56% from +10°C to +85°C.

## Benefits

- +10°C to +85°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, 1812, 1825, and 2225 case sizes
- DC voltage ratings of 50 and 100 V
- Capacitance offerings ranging from 6,800 pF to 2.2 µF
- Available capacitance tolerances of ±20% and +80%/-20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability

## Applications

Typical applications include limited temperature, decoupling and bypass.



## Ordering Information

| C | 1825 | C | 225 | M | 5 | U | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1812<br>1825<br>2225 | C = Standard | Two significant digits + number of zeros | M = ±20%<br>Z = +80%/-20 | 5 = 50<br>1 = 100 | U = Z5U | A = N/A | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

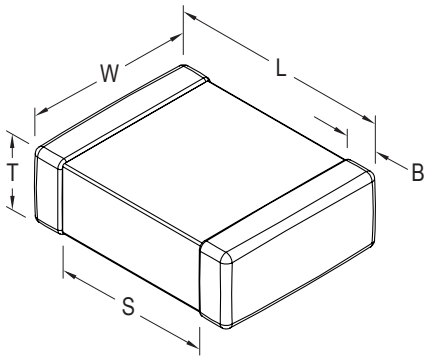
| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -10°C to +85°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | +22%, -56% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 7.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 4.0% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 100 megohm microfarads or 10GΩ<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*

*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Z5U | > 25 | All | 5.0 | ±30% | 10% of Initial Limit |
| | 25 | | 7.5 | | |

# Table 1 – Capacitance Range/Selection Waterfall (0805 – 2225 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C0805C | | C1206C | | C1210C | | C1812C | | C1825C | | C2225C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | |
| 6,800 pF | 682 | M | Z | DN | DN | | | | | | | | | | |
| 8,200 pF | 822 | M | Z | DN | DN | | | | | | | | | | |
| 10,000 pF | 103 | M | Z | DN | DN | EB | EB | | | | | | | | |
| 12,000 pF | 123 | M | Z | DN | | EB | EB | | | | | | | | |
| 15,000 pF | 153 | M | Z | DN | | EB | EB | | | | | | | | |
| 18,000 pF | 183 | M | Z | DN | | EB | EB | | | | | | | | |
| 22,000 pF | 223 | M | Z | DN | | EB | EB | | | | | | | | |
| 27,000 pF | 273 | M | Z | DN | | EB | EB | | | | | | | | |
| 33,000 pF | 333 | M | Z | DN | | EB | EB | | | | | | | | |
| 39,000 pF | 393 | M | Z | DN | | EB | EC | | | | | | | | |
| 47,000 pF | 473 | M | Z | DN | | EB | EC | FB | FB | | | | | | |
| 56,000 pF | 563 | M | Z | DP | | EB | EB | FB | FB | | | | | | |
| 68,000 pF | 683 | M | Z | DP | | EB | EB | FB | FB | | | | | | |
| 82,000 pF | 823 | M | Z | DP | | EB | EB | FB | FC | GB | GB | | | | |
| 0.10 µF | 104 | M | Z | DN | | EB | EB | FB | FD | GB | GB | | | | |
| 0.12 µF | 124 | M | Z | | | EC | | FB | FD | GB | GB | | | | |
| 0.15 µF | 154 | M | Z | | | EC | | FC | FD | GB | GB | | | | |
| 0.18 µF | 184 | M | Z | | | EC | | FC | | GB | | HB | HB | | |
| 0.22 µF | 224 | M | Z | | | EC | | FC | | GB | | HB | HB | | |
| 0.27 µF | 274 | M | Z | | | | | FC | | GB | | HB | HB | | |
| 0.33 µF | 334 | M | Z | | | | | FD | | GB | | HB | HB | KB | KC |
| 0.39 µF | 394 | M | Z | | | | | FD | | GB | | HB | HB | KB | KC |
| 0.47 µF | 474 | M | Z | | | | | FD | | GB | | HB | | KB | KC |
| 0.56 µF | 564 | M | Z | | | | | FD | | GC | | HB | | KB | |
| 0.68 µF | 684 | M | Z | | | | | FD | | GC | | HB | | KB | |
| 0.82 µF | 824 | M | Z | | | | | FF | | GE | | HB | | KB | |
| 1.0 µF | 105 | M | Z | | | | | FH | | GE | | HB | | KB | |
| 1.2 µF | 125 | M | Z | | | | | | | | | HB | | KB | |
| 1.5 µF | 155 | M | Z | | | | | | | | | HC | | KC | |
| 1.8 µF | 185 | M | Z | | | | | | | | | HD | | KD | |
| 2.2 µF | 225 | M | Z | | | | | | | | | HF | | KD | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 | 50 | 100 |
| | | Voltage Code | | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | | C0805C | | C1206C | | C1210C | | C1812C | | C1825C | | C2225C | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HC | 1825 | 1.15 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KB | 2225 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC-7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

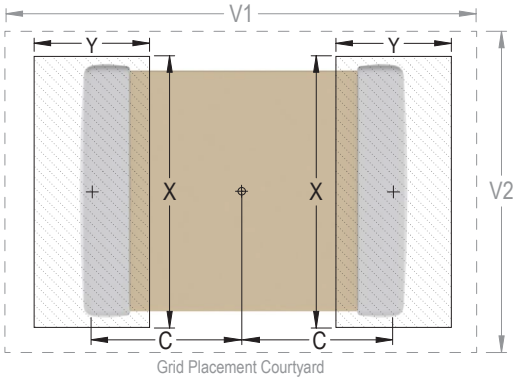
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

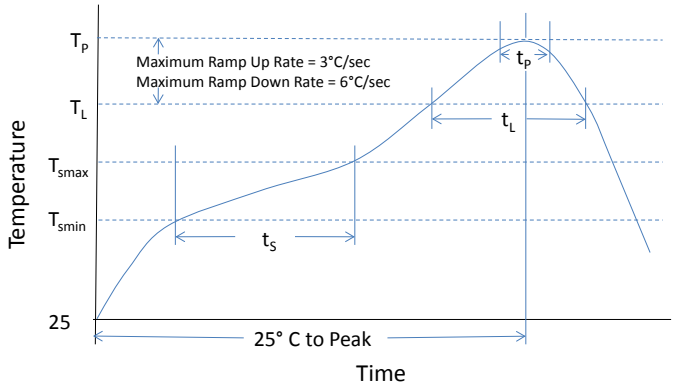
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



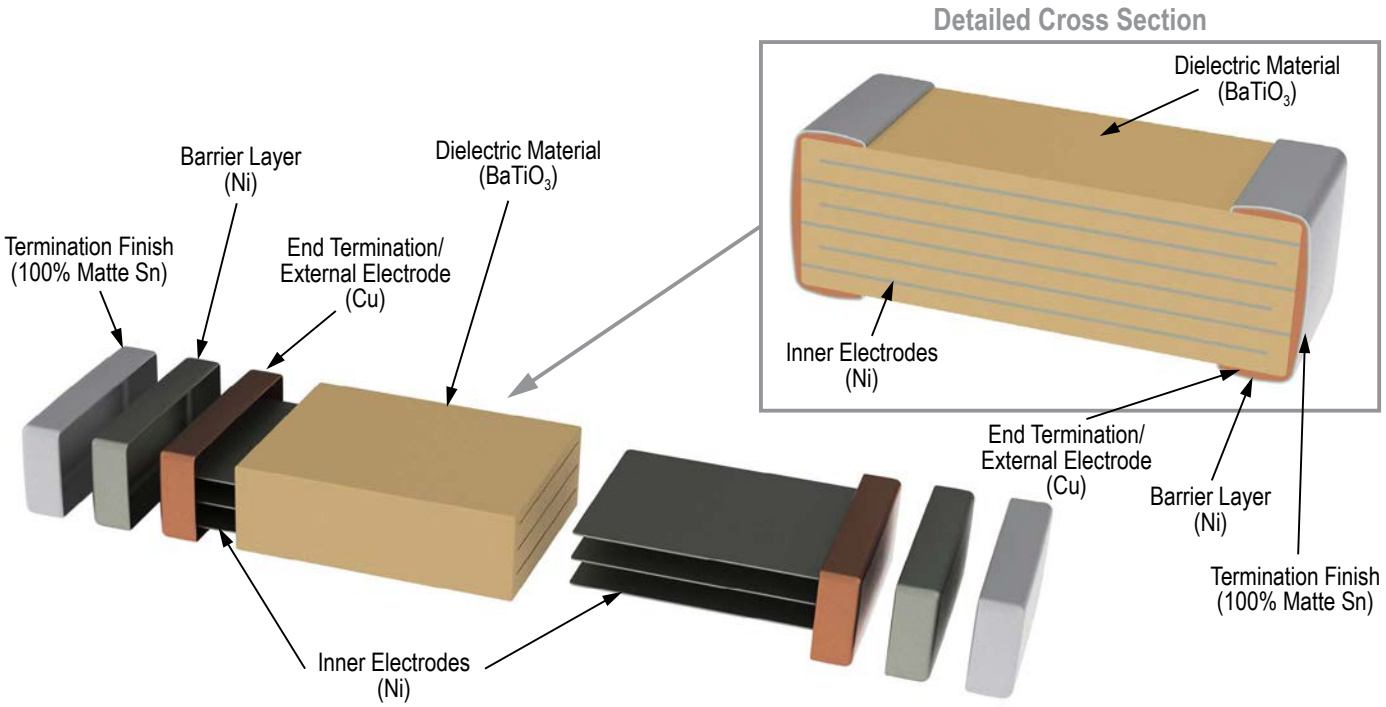
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)



# Y5V Dielectric, 6.3 – 50 VDC (Commercial Grade)

## Overview

KEMET's Y5V dielectric features an 85°C maximum operating temperature and is considered "general-purpose." The Electronics Components, Assemblies & Materials Association (EIA) characterizes Y5V dielectric as a Class III material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling or other applications in which dielectric losses, high insulation resistance and capacitance stability are not of major importance. Y5V exhibits a predictable change in capacitance with respect to time and voltage and displays wide variations in capacitance with reference to ambient temperature. Capacitance change is limited to +22%, −82% from −30°C to +85°C.

## Benefits

- −30°C to +85°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, and 1210 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.022 µF to 22 µF
- Available capacitance tolerance of +80%/−20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish that allowing for excellent solderability

## Applications

Typical applications include limited temperature, decoupling and bypass.

## Ordering Information

| C | 1210 | C | 226 | Z | 4 | V | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210 | C = Standard | Two significant digits + number of zeros | Z = +80%/-20%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | V = Y5V | A = N/A | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

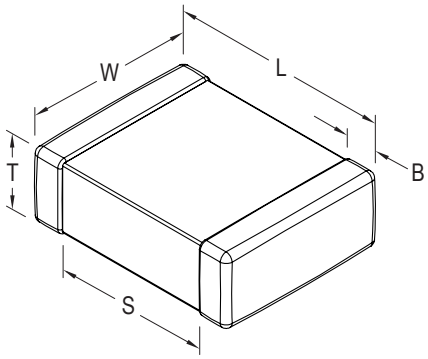
| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thick-ness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -30°C to +85°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | +22%, -82% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 7.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 10% (6.3V & 10V), 7% (16V & 25V) and 5% (50V ) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*

*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Y5V | > 25 | All | 7.5 | ±30% | 10% of Initial Limit |
| | 16/25 | | 10.0 | | |
| | < 16 | | 15.0 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 100 Megohm Microfarads or 10 GΩ | 50 Megohm Microfarads or 10 GΩ |
|---|---|---|
| All | ≥ 16 V | ≤ 10 V |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1210 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C0402C | | | C0603C | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 9 | 8 | 4 | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Rated Voltage (VDC) | | 6.3 | 10 | 16 | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 22,000 pF | 223 | M | Z | BB | BB | BB | CF | CF | CF | CF | DN | DN | DN | DN | DN | | | | | | | | | | |
| 27,000 pF | 273 | M | Z | BB | BB | BB | CF | CF | CF | CF | DN | DN | DN | DN | DN | | | | | | | | | | |
| 33,000 pF | 333 | M | Z | BB | BB | BB | CF | CF | CF | CF | DN | DN | DN | DN | DN | | | | | | | | | | |
| 39,000 pF | 393 | M | Z | BB | BB | BB | CF | CF | CF | CF | DP | DP | DP | DP | DP | | | | | | | | | | |
| 47,000 pF | 473 | M | Z | BB | BB | BB | CF | CF | CF | CF | DO | DO | DO | DO | DO | | | | | | | | | | |
| 56,000 pF | 563 | M | Z | BB | BB | BB | CF | CF | CF | CF | DP | DP | DP | DP | DP | | | | | | | | | | |
| 68,000 pF | 683 | M | Z | BB | BB | BB | CF | CF | CF | CF | DP | DP | DP | DP | DP | | | | | | | | | | |
| 82,000 pF | 823 | M | Z | BB | BB | BB | CF | CF | CF | CF | DP | DP | DP | DP | DP | | | | | | | | | | |
| 0.10 µF | 104 | M | Z | BB | BB | BB | CG | CG | CG | CG | DN | DN | DN | DN | DN | | | | | | | | | | |
| 0.12 µF | 124 | M | Z | | | | CG | CG | CG | CG | DN | DN | DN | DN | | | | | | | | | | | |
| 0.15 µF | 154 | M | Z | | | | CG | CG | CG | CG | DN | DN | DN | DN | | | | | | | | | | | |
| 0.18 µF | 184 | M | Z | | | | CG | CG | CG | CG | DN | DN | DN | DN | | | | | | | | | | | |
| 0.22 µF | 224 | M | Z | BB | | | CG | CG | CG | CG | DN | DN | DN | DN | DG | EC | EC | EC | EC | | FD | FD | FD | FD | FD |
| 0.27 µF | 274 | M | Z | | | | CG | CG | CG | CG | DN | DN | DN | DN | | EB | EB | EB | EB | | FD | FD | FD | FD | FD |
| 0.33 µF | 334 | M | Z | | | | CG | CG | CG | CG | DG | DG | DG | DG | | EB | EB | EB | EB | | FD | FD | FD | FD | FD |
| 0.39 µF | 394 | M | Z | | | | CG | CG | CG | | DN | DN | DN | DN | | EB | EB | EB | EB | | FD | FD | FD | FD | FD |
| 0.47 µF | 474 | M | Z | BB | | | CG | CG | CG | | DG | DG | DG | DG | | EC | EC | EC | EC | | FD | FD | FD | FD | FD |
| 0.56 µF | 564 | M | Z | | | | CG | CG | | | DP | DP | DP | DP | | EB | EB | EB | EB | | FD | FD | FD | FD | FD |
| 0.68 µF | 684 | M | Z | | | | CG | CG | | | DP | DP | DP | DG | | EB | EB | EB | EB | | FD | FD | FD | FD | FD |
| 0.82 µF | 824 | M | Z | | | | CG | CG | | | DG | DG | DG | DG | | EB | EB | EB | EB | | FF | FF | FF | FF | FF |
| 1.0 µF | 105 | M | Z | BB | BB | | CG | CG | CG | CG | DP | DP | DP | DG | DG | EP | EP | EP | EP | | FH | FH | FH | FH | FH |
| 1.2 µF | 125 | M | Z | | | | | | | | DN | DN | DN | | | EC | EC | EC | | | FD | FD | FD | | |
| 1.5 µF | 155 | M | Z | | | | | | | | DN | DN | DN | | | EC | EC | EC | | | FD | FD | FD | | |
| 1.8 µF | 185 | M | Z | | | | | | | | DP | DP | DP | | | ED | ED | ED | | | FD | FD | FD | | |
| 2.2 µF | 225 | M | Z | BB | BB | | | | | | DG | DG | DG | | | EC | EC | EC | | | FJ | FJ | FJ | | |
| 3.3 µF | 335 | M | Z | | | | | | | | DL | DL | DG | | | EH | EH | EH | | | FE | FE | FE | | |
| 4.7 µF | 475 | M | Z | | | | | | | | DG | DG | DG | | | EM² | EM² | EM² | | | FT | FT | FT | | |
| 5.6 µF | 565 | M | Z | | | | | | | | DF | DF | | | | EJ | EJ | EJ | | | FG | FG | FG | | |
| 6.8 µF | 685 | M | Z | | | | | | | | DG | DG | | | | EJ | EJ | | | | FH | FH | FH | | |
| 10 µF | 106 | M | Z | | | | | | | | DG | DG | | | | EH | EH | EH | EH | | FH² | FH² | FH² | | |
| 15 µF | 156 | M | Z | | | | | | | | | | | | | | | | | | FH | FH | FH | | |
| 22 µF | 226 | M | Z | | | | | | | | | | | | | EH | EH | | | | FT² | FT² | FS | FS | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 6.3 | 10 | 16 | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Voltage Code | | 9 | 8 | 4 | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Case Size/ Series | | C0402C | | | C0603C | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |

*xx² Only available in Z tolerance.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07* | 4,000 | 15,000 | 0 | 0 |
| CG | 0603 | 0.80 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DO | 0805 | 0.80 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DL | 0805 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EP | 1206 | 1.20 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FT | 1210 | 1.90 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC-7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |

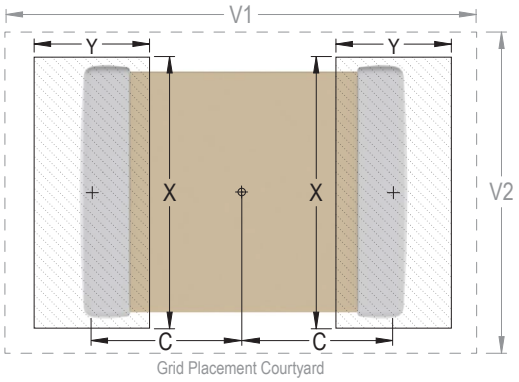
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

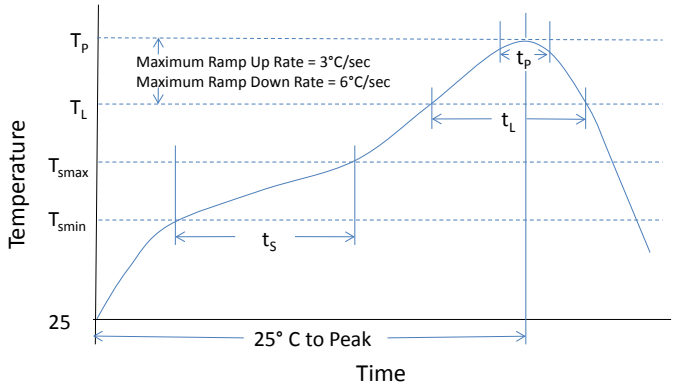
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



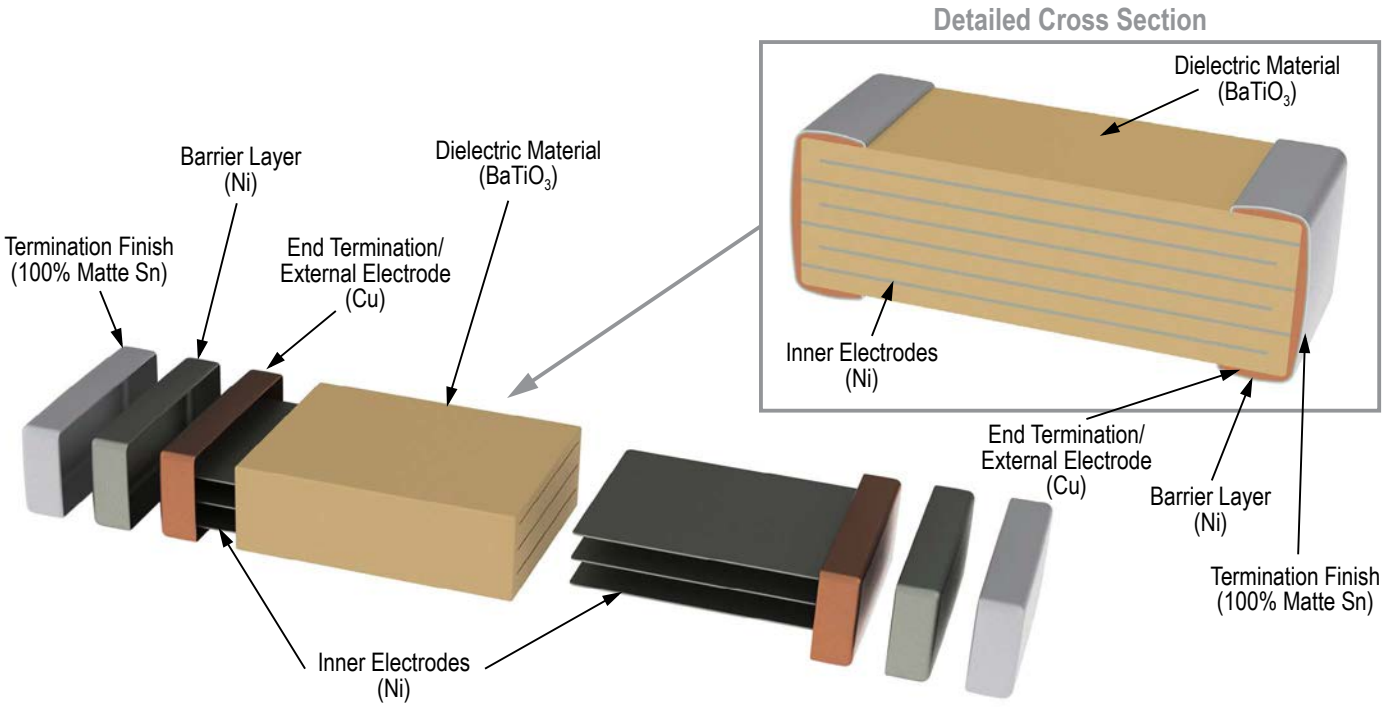
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Capacitor Array, C0G Dielectric, 10 – 200 VDC (Commercial & Automotive Grade)

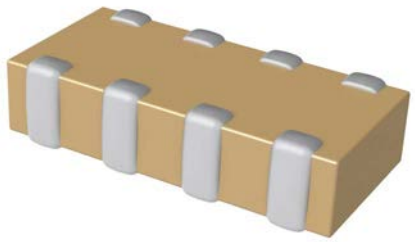
## Overview

KEMET's Ceramic Chip Capacitor Array in C0G dielectric is an advanced passive technology where multiple capacitor elements are integrated into one common monolithic structure. Array technology promotes reduced placement costs and increased throughput. This is achieved by alternatively placing one device rather than two or four discrete devices. Use of capacitor arrays also saves board space which translates into increased board density and more functions per board. Arrays consume only a portion of the space required for standard chips resulting in savings in inventory and pick/place machine positions.

For added reliability, KEMET's Flexible Termination technology has been incorporated in order to provides superior flex performance. This technology was developed to address flex cracks, which are the primary failure mode of MLCCs and typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible Termination technology inhibits the transfer of board stress to the rigid body of the MLCC, therefore mitigating flex cracks which can result in low IR or short circuit failures.

KEMET's C0G dielectric features a 125°C maximum operating temperature and is considered "stable. "The Electronics Industries Alliance (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/ºC from −55°C to +125°C.

KEMET automotive grade array capacitors meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| CA | 06 | 4 | X | 104 | K | 4 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|---|
| Ceramic Array | Case Size (L" x W")[1] | Number of Capacitors | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 05 = 0508<br>06 = 0612 | 2 = 2<br>4 = 4 | X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% minimum Pb content) | See "Packaging C-Spec Ordering Options Table" below |

*[1] All previous reference to metric case dimension "1632" has been replaced with an inch standard reference of "0612". Please reference all new designs using the "0612" nomenclature. "CA064" replaces "C1632" in the ordering code.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*

*[2] SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel (Embossed Plastic Tape) / Unmarked | 7210 |
| **Automotive Grade**[2] | |
| 7" Reel | AUTO |
| 13" Reel/Embossed Plastic/Unmarked | AUTO7210 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[2] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[2] All Automotive packaging C-Specs listed exclude the option to laser mark components. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Saves both circuit board and inventory space
- Reduces placement costs and increases throughput
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0508 (2-element) and 0612 (4-element) case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, and 200 V
- Capacitance offerings ranging from 10 pF to 2,200 pF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Commercial and Automotive (AEC–Q200) grades available

## Applications

Typical applications include those that can benefit from board area savings, cost savings and overall volumetric reduction such as telecommunications, computers, handheld devices and automotive. Flexible termination technology benefits applications subject to high levels of board flexure or temperature cycling.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

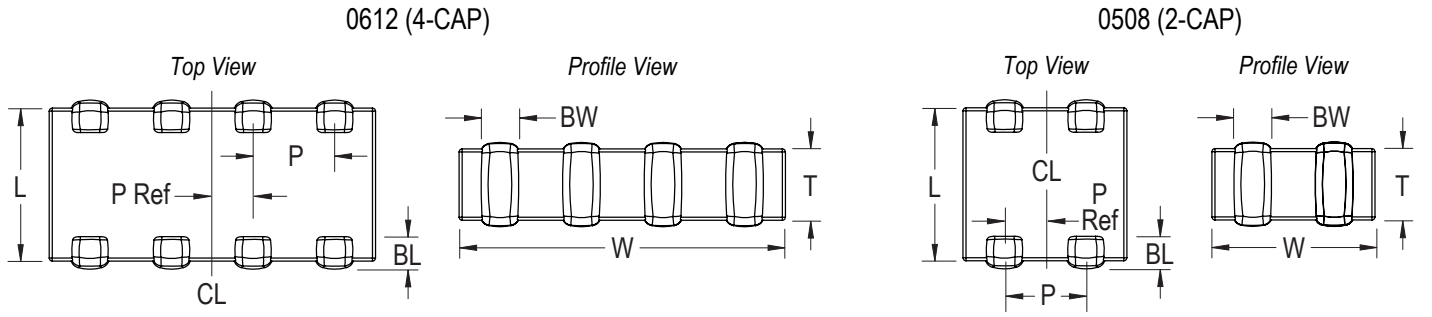
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | BW Bandwidth | BL Bandlength | T Thickness | P Pitch | P Reference |
|---|---|---|---|---|---|---|---|---|
| 0508 | 1220 | 1.30 (0.051) ±0.15 (0.006) | 2.10 (0.083) ±0.15 (0.006) | 0.53 (0.021) ±0.08 (0.003) | 0.30 (0.012) ±0.20 (0.008) | See Table 2 for Thickness | 1.00 (0.039) ±0.10 (0.004) | 0.50 (0.020) ±0.10 (0.004) |
| 0612 | 1632 | 1.60 (0.063) ±0.20 (0.008) | 3.20 (0.126) ±0.20 (0.008) | 0.40 (0.016) ±0.20 (0.008) | 0.30 (0.012) ±0.20 (0.008) | | 0.80 (0.031) ±0.10 (0.004) | 0.40 (0.016) ±0.05 (0.002) |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and Dissipation Factor (DF) measured under the following conditions:*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1 – Capacitance Range/Selection Waterfall (0508 – 0612 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | | C0508X (CA052X 2-Cap Case Size) | | | | | C0612X (CA064X 4-Cap Case Size) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | |
| 10 pF | 100 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 12 pF | 120 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 15 pF | 150 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 18 pF | 180 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 22 pF | 220 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 27 pF | 270 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 33 pF | 330 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 39 pF | 390 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 47 pF | 470 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 56 pF | 560 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 68 pF | 680 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 82 pF | 820 | J | K | M | | | | | | MA | MA | MA | MA | MA | MA |
| 100 pF | 101 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | |
| 120 pF | 121 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | |
| 150 pF | 151 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | |
| 180 pF | 181 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | |
| 220 pF | 221 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | | |
| 270 pF | 271 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | | |
| 330 pF | 331 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | | |
| 390 pF | 391 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | | |
| 470 pF | 471 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | | |
| 560 pF | 561 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 680 pF | 681 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 820 pF | 821 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,000 pF | 102 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,100 pF | 112 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,200 pF | 122 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,300 pF | 132 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,500 pF | 152 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,600 pF | 162 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 1,800 pF | 182 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 2,000 pF | 202 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| 2,200 pF | 222 | J | K | M | PA | PA | PA | PA | PA | | | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Case Size/Series | | | C0508X (CA052X 2-Cap Case Size) | | | | | C0612X (CA064X 4-Cap Case Size) | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| PA | 0508 | 0.80 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| MA | 0612 | 0.80 ± 0.10 | 0 | 0 | 4,000 | 10,000 |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

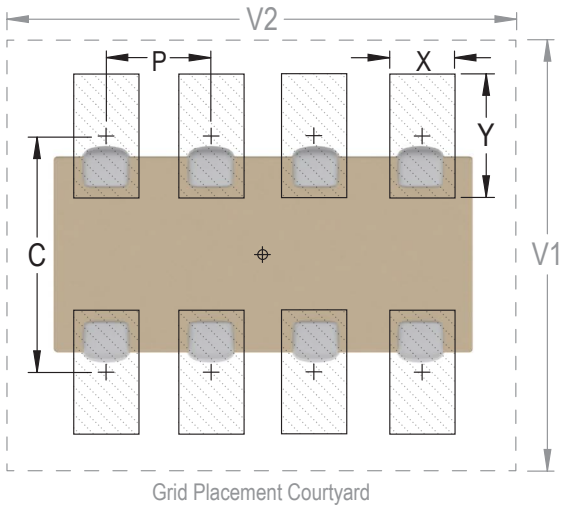
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Array Land Pattern Design Recommendations per IPC-7351

| EIA SIZE CODE | METRIC SIZE CODE | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | P | V1 | V2 | C | Y | X | P | V1 | V2 | C | Y | X | P | V1 | V2 |
| 0508/CA052 | 1220 | 1.60 | 1.00 | 0.55 | 1.00 | 3.50 | 3.30 | 1.50 | 0.90 | 0.50 | 1.00 | 2.90 | 2.80 | 1.40 | 0.75 | 0.45 | 1.00 | 2.40 | 2.50 |
| 0612/CA064 | 1632 | 1.80 | 1.10 | 0.50 | 0.80 | 3.90 | 4.40 | 1.80 | 0.95 | 0.50 | 0.80 | 3.30 | 3.90 | 1.70 | 0.85 | 0.40 | 0.80 | 2.80 | 3.60 |

***Density Level A:*** *For low-density product applications. Provides a wider process window for reflow solder processes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 0612 case size.*



# Soldering Process

### Recommended Soldering Technique:

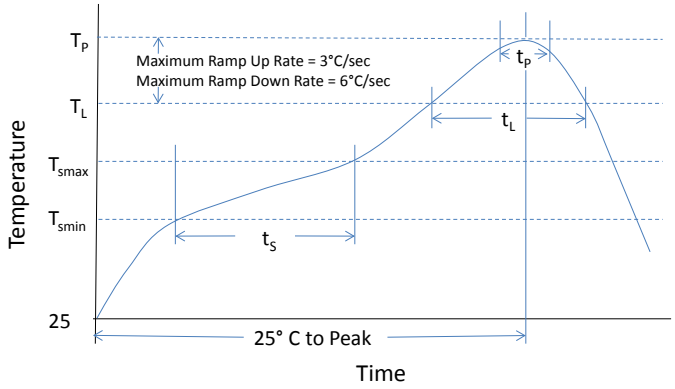
- Solder reflow only

### Recommended Reflow Soldering Profile:

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



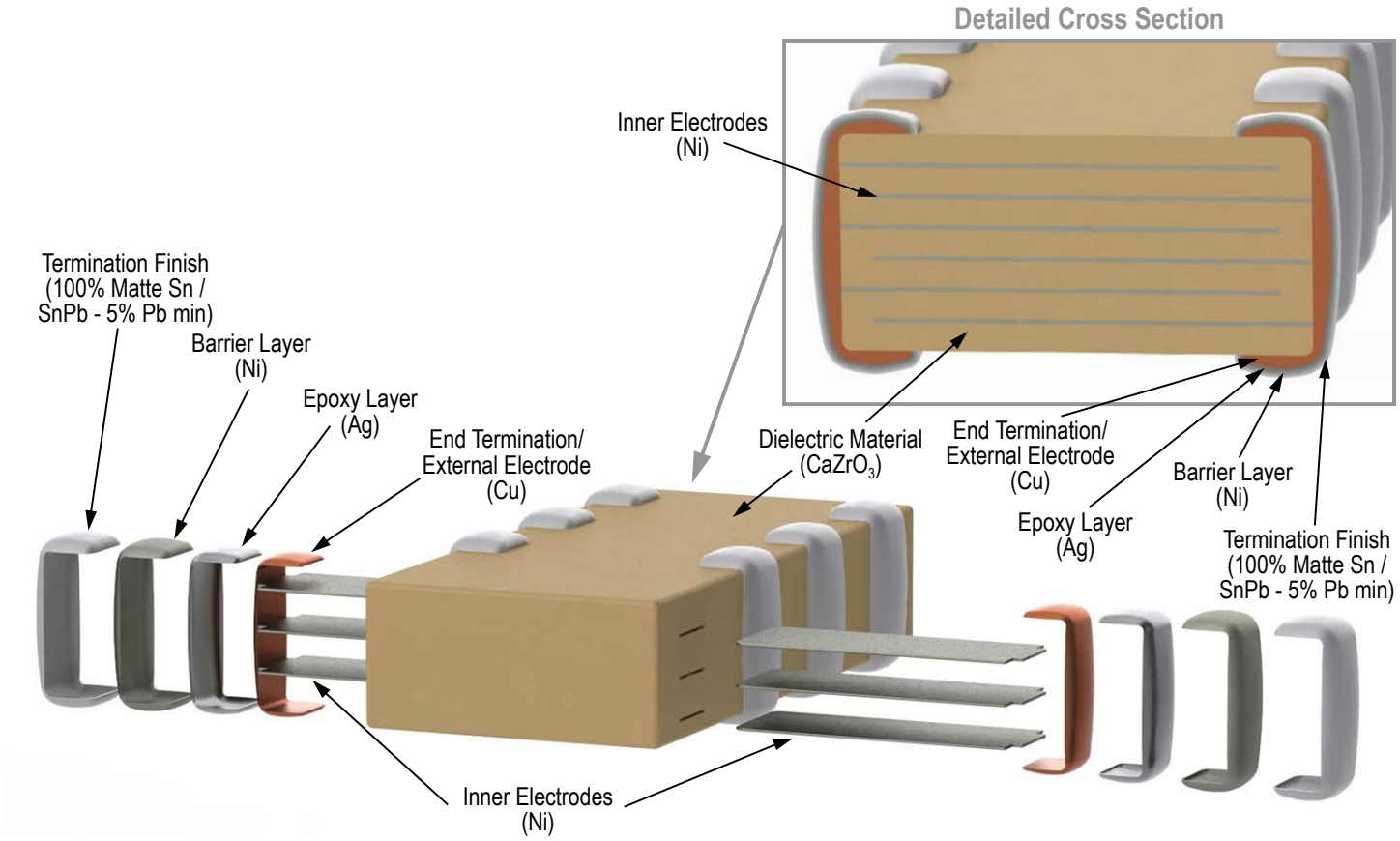
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Capacitor Array, X7R Dielectric, 10 – 200 VDC (Commercial & Automotive Grade)

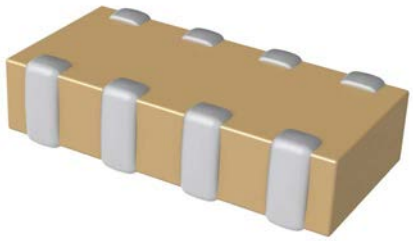
## Overview

KEMET's Ceramic Chip Capacitor Array in X7R dielectric is an advanced passive technology where multiple capacitor elements are integrated into one common monolithic structure. Array technology promotes reduced placement costs and increased throughput. This is achieved by alternatively placing one device rather than two or four discrete devices. Use of capacitor arrays also saves board space which translates into increased board density and more functions per board. Arrays consume only a portion of the space required for standard chips resulting in savings in inventory and pick/place machine positions.

For added reliability, KEMET's Flexible Termination technology has been incorporated in order to provides superior flex performance. This technology was developed to address flex cracks, which are the primary failure mode of MLCCs and typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible Termination technology inhibits the transfer of board stress to the rigid body of the MLCC, therefore mitigating flex cracks which can result in low IR or short circuit failures.

KEMET's X7R dielectric features a 125°C maximum operating temperature and is considered "temperature stable." The Electronics Industries Alliance (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

KEMET automotive grade array capacitors meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| CA | 06 | 4 | X | 104 | K | 4 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|---|
| Ceramic Array | Case Size (L" x W")[1] | Number of Capacitors | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 05 = 0508<br>06 = 0612 | 2 = 2<br>4 = 4 | X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% minimum Pb content) | See "Packaging C-Spec Ordering Options Table" below |

*[1] All previous reference to metric case dimension "1632" has been replaced with an inch standard reference of "0612". Please reference all new designs using the "0612" nomenclature. "CA064" replaces "C1632" in the ordering code.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*

*[2] SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel (Embossed Plastic Tape) / Unmarked | 7210 |
| **Automotive Grade**[2] | |
| 7" Reel | AUTO |
| 13" Reel/Embossed Plastic/Unmarked | AUTO7210 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[2] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[2] All Automotive packaging C-Specs listed exclude the option to laser mark components. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Saves both circuit board and inventory space
- Reduces placement costs and increases throughput
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0508 (2-element) and 0612 (4-element) case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, and 200 V
- Capacitance offerings ranging from 330 pF – 0.22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Commercial and Automotive (AEC–Q200) grades available

## Applications

Typical applications include those that can benefit from board area savings, cost savings and overall volumetric reduction such as telecommunications, computers, handheld devices and automotive. Flexible termination technology benefits applications subject to high levels of board flexure or temperature cycling.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

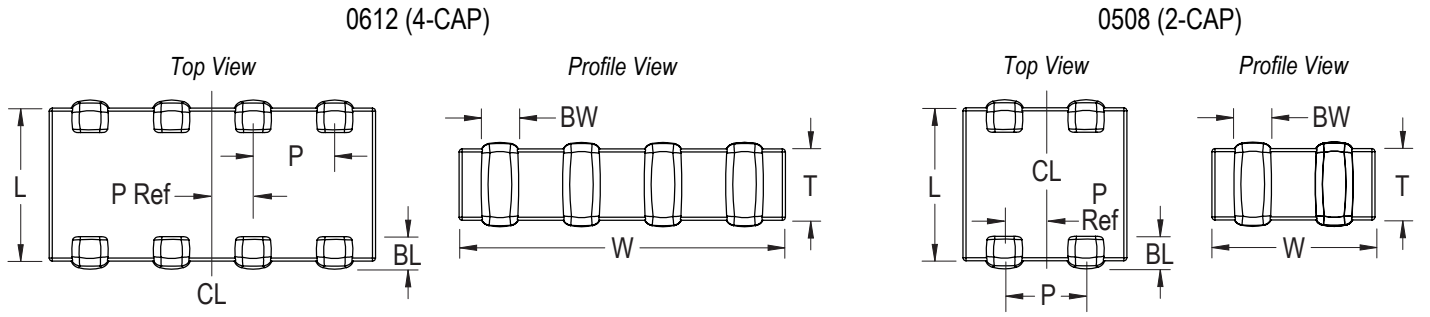
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | BW Bandwidth | BL Bandlength | T Thickness | P Pitch | P Reference |
|---|---|---|---|---|---|---|---|---|
| 0508 | 1220 | 1.30 (0.051) ±0.15 (0.006) | 2.10 (0.083) ±0.15 (0.006) | 0.53 (0.021) ±0.08 (0.003) | 0.30 (0.012) ±0.20 (0.008) | See Table 2 for Thickness | 1.00 (0.039) ±0.10 (0.004) | 0.50 (0.020) ±0.10 (0.004) |
| 0612 | 1632 | 1.60 (0.063) ±0.20 (0.008) | 3.20 (0.126) ±0.20 (0.008) | 0.40 (0.016) ±0.20 (0.008) | 0.30 (0.012) ±0.20 (0.008) | | 0.80 (0.031) ±0.10 (0.004) | 0.40 (0.016) ±0.05 (0.002) |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | See Dissipation Factor Limit Table |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100GΩ<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | < 16 | All | 7.5 | ± 20% | 10% of Initial Limit |
| | 16/25 | All | 5.0 | | |
| | 50 | ≤ 0.02 µF | 3.0 | | |
| | | > 0.02 µF | 5.0 | | |
| | > 50 | All | 3.0 | | |

## Dissipation Factor Limit Table

| Rated DC Voltage | Capacitance | Dissipation Factor (Maximum %) |
|---|---|---|
| < 16 | All | 5.0 |
| 16/25 | All | 3.5 |
| 50 | ≤ 0.022 µF | 2.5 |
| | > 0.022 µF | 3.5 |
| > 50 | All | 2.5 |

# Table 1 – Capacitance Range/Selection Waterfall (0508 – 0612 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | | C0508C/X (CA052C/X 2-Cap Case Size) | | | | | C0612C/X (CA064C/X 4-Cap Case Size) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | |
| 330 pF | 331 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 390 pF | 391 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 470 pF | 471 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 560 pF | 561 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 680 pF | 681 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 820 pF | 821 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 1,000 pF | 102 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 1,200 pF | 122 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 1,500 pF | 152 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 1,800 pF | 182 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 2,200 pF | 222 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 2,700 pF | 272 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 3,300 pF | 332 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 3,900 pF | 392 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 4,700 pF | 472 | J | K | M | PA | PA | PA | PA | PA | MA | MA | MA | MA | MA | MA |
| 5,600 pF | 562 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | MA |
| 6,800 pF | 682 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | MA |
| 8,200 pF | 822 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | MA |
| 10,000 pF | 103 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | MA |
| 12,000 pF | 123 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | |
| 15,000 pF | 153 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | |
| 18,000 pF | 183 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | |
| 22,000 pF | 223 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | MA | |
| 27,000 pF | 273 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | | |
| 33,000 pF | 333 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | | |
| 39,000 pF | 393 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | | |
| 47,000 pF | 473 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | MA | | |
| 56,000 pF | 563 | J | K | M | PA | PA | PA | PA | | MA | MA | MA | | | |
| 68,000 pF | 683 | J | K | M | PA | PA | PA | PA | | MA | MA | | | | |
| 82,000 pF | 823 | J | K | M | PA | PA | PA | PA | | MA | MA | | | | |
| 0.10 µF | 104 | J | K | M | PA | PA | PA | PA | | MA | MA | | | | |
| 0.15 µF | 154 | J | K | M | PA | | | | | | | | | | |
| 0.22 µF | 224 | J | K | M | PA | | | | | | | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Case Size/Series | | | C0508C/X (CA052C/X 2-Cap Case Size) | | | | | C0612C/X (CA064C/X 4-Cap Case Size) | | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| PA | 0508 | 0.80 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| MA | 0612 | 0.80 ± 0.10 | 0 | 0 | 4,000 | 10,000 |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

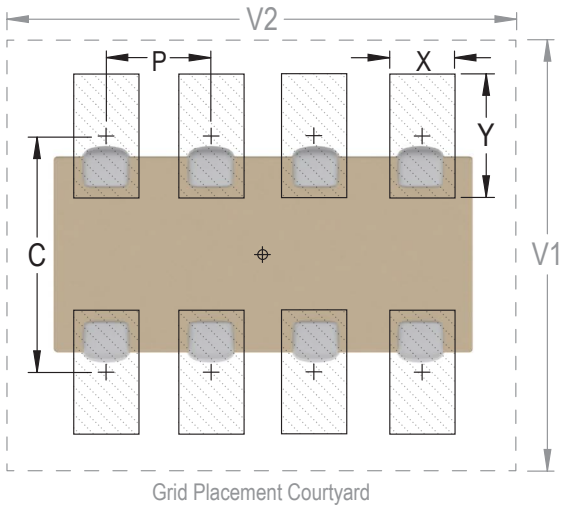
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Array Land Pattern Design Recommendations per IPC–7351

| EIA SIZE CODE | METRIC SIZE CODE | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | P | V1 | V2 | C | Y | X | P | V1 | V2 | C | Y | X | P | V1 | V2 |
| 0508/CA052 | 1220 | 1.60 | 1.00 | 0.55 | 1.00 | 3.50 | 3.30 | 1.50 | 0.90 | 0.50 | 1.00 | 2.90 | 2.80 | 1.40 | 0.75 | 0.45 | 1.00 | 2.40 | 2.50 |
| 0612/CA064 | 1632 | 1.80 | 1.10 | 0.50 | 0.80 | 3.90 | 4.40 | 1.80 | 0.95 | 0.50 | 0.80 | 3.30 | 3.90 | 1.70 | 0.85 | 0.40 | 0.80 | 2.80 | 3.60 |

***Density Level A:*** *For low-density product applications. Provides a wider process window for reflow solder processes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 0612 case size.*



# Soldering Process

### Recommended Soldering Technique:

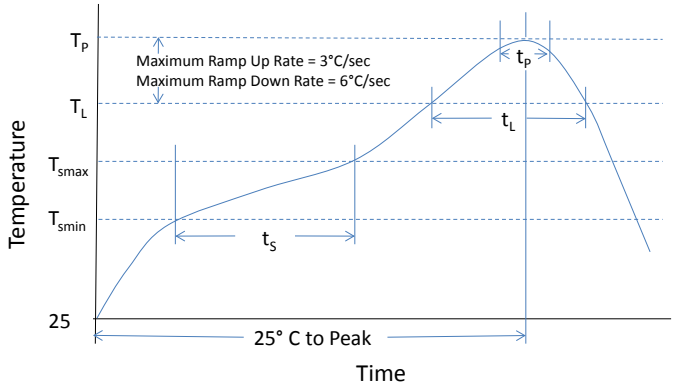
- Solder reflow only

### Recommended Reflow Soldering Profile:

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



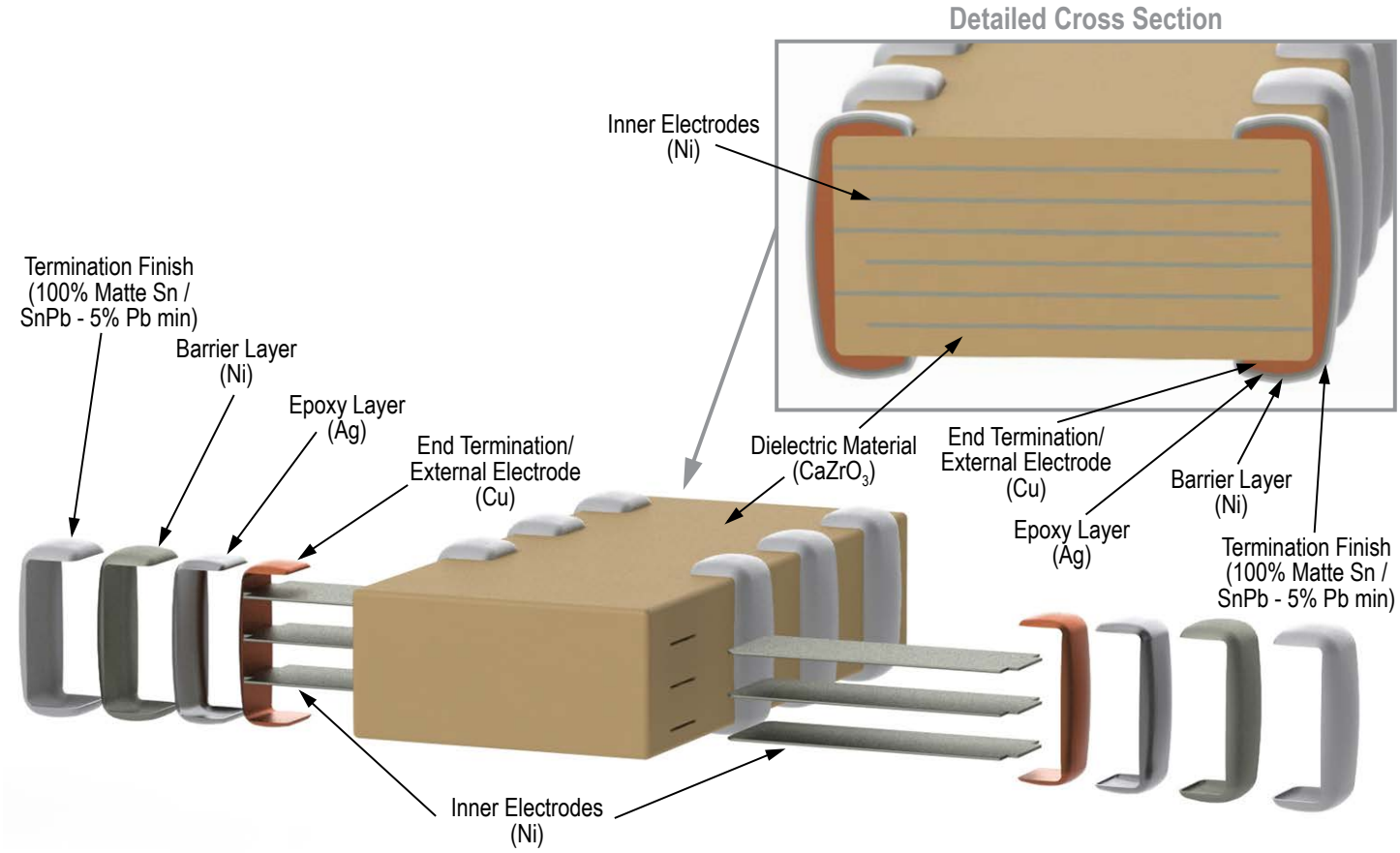
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

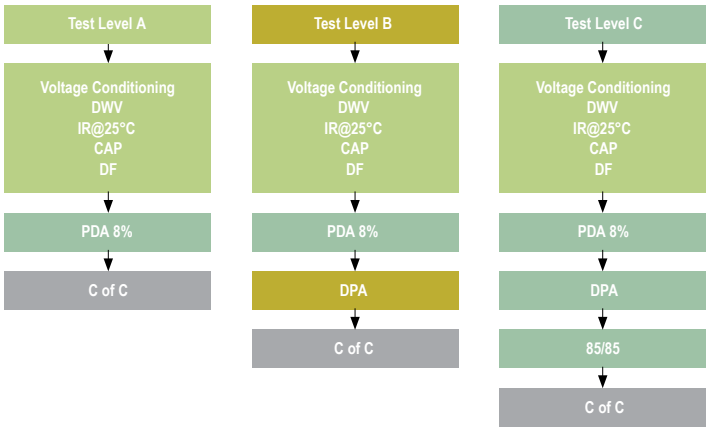
## Construction



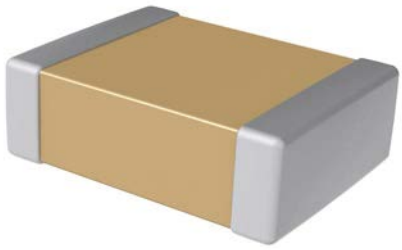
# Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, C0G Dielectric, 10 – 250 VDC

## Overview

KEMET's COTS program is an extension of KEMET knowledge of high reliability test regimes and requirements. KEMET regularly supplies "up-screened" products by working with customer drawings and imposing specified design and test requirements. The COTS program offers the same high quality and high reliability components as up-screened products, but at a lower cost to the customer. This is accomplished by eliminating the need for customer-specific drawings to achieve the reliability level required for customer applications. A series of tests and inspections have been selected to provide the accelerated conditioning and 100% screening necessary to eliminate infant mortal failures from the population.




KEMET's C0G dielectric features a 125°C maximum operating temperature and is considered "stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/ºC from −55°C to +125°C.



All COTS testing includes voltage conditioning and post-electrical testing as per MIL–PRF–55681. For enhanced reliability, KEMET also provides the following test level options and conformance certifications:

## Ordering Information

| C | 1206 | T | 104 | K | 5 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812<br>2220 | T = COTS | Two significant digits + number of zeros Use 9 for 1.0 – 9.9 pF Use 8 for 0.5 – .99 pF ex. 2.2 pF = 229 ex. 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ± 1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | G = C0G | A = Testing per MIL–PRF–55681 PDA 8%<br>B= Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469<br>C = Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469, Humidity per MIL–STD–202, Method 103, Condition A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

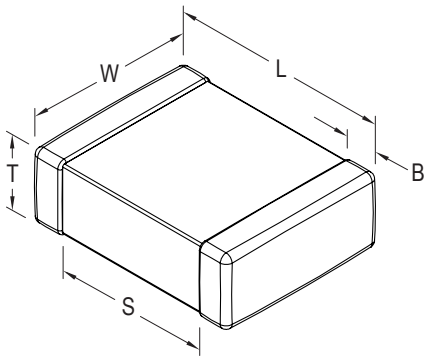
## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- Voltage conditioning and post-electrical testing per MIL–PRF–55681, Paragraph 4.8.3.1, Standard Voltage Conditioning
- Destructive Physical Analysis (DPA) per EIA–469
- Humidity, steady state, low voltage (85/85) per MIL–STD–202, Method 103, Condition A
- RoHS Compliant (excluding SnPb end metallization option)
- EIA 0402, 0603, 0805, 1206, 1210, 1812, and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 0.5 pF up to 0.47 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- Certificate of compliance
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies and into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- SnPb end metallization option available upon request (5% Pb minimum)

## Applications

Typical applications include military, space quality and high reliability electronics.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and Dissipation Factor (DF) measured under the following conditions:*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 0805 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C0402T | | | | | | | C0603T | | | | | | | C0805T | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 0.50 & 0.75 pF | 508 & 758 | B C D | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 10 - 91 pF* | 100 - 910* | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 100 pF | 101 | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 110 - 180 pF* | 111 -181* | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 200 - 270 pF* | 201 - 271* | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 300 pF | 301 | F G J K M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 330 pF | 331 | F G J K M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 360 pF | 361 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 390 pF | 391 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 430 pF | 431 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 470 pF | 471 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP |
| 510 - 820 pF* | 511 - 821* | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 910 pF | 911 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP |
| 1,000 pF | 102 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP |
| 1,100 pF | 112 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 1,200 pF | 122 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 1,300 pF | 132 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,500 pF | 152 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,600 pF | 162 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,800 pF | 182 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 2,000 pF | 202 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 2,200 pF | 222 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 2,400 pF | 242 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN |
| 2,700 pF | 272 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN |
| 3,000 pF | 302 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN |
| 3,300 pF | 332 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN |
| 3,600 pF | 362 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DP | DP |
| 3,900 pF | 392 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 4,300 pF | 432 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 4,700 pF | 472 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 5,100 pF | 512 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DE | DE | DE | DE | DN | DP | DP |
| 5,600 pF | 562 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DP | DP |
| 6,200 pF | 622 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG |
| 6,800 pF | 682 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG |
| 7,500 pF | 752 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG |
| 8,200 pF | 822 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG |
| 9,100 pF | 912 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | | |
| 10,000 pF | 103 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DP | | |
| 12,000 pF | 123 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DE | | |
| 15,000 pF | 153 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DP | DG | | |
| 18,000 pF | 183 | F G J K M | | | | | | | | | | | | | | | DN | DN | DN | DP | | | |
| 22,000 pF | 223 | F G J K M | | | | | | | | | | | | | | | DP | DP | DP | DF | | | |
| 27,000 pF | 273 | F G J K M | | | | | | | | | | | | | | | DF | DF | DF | | | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| 47,000 pF | 473 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | C0402T | | | | | | | C0603T | | | | | | | C0805T | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C1206T | | | | | | | C1210T | | | | | | | C1812T | | | | C2220T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 10 - 91 pF* | 100 - 910* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 100 - 430 pF* | 101 - 431* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 470 - 910 pF* | 471 - 911* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,000 pF | 102 | F G J K M | EB | EB | EB | EB | EB | EE | EE | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,100 pF | 112 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,200 pF | 122 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,300 pF | 132 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | | | |
| 1,500 pF | 152 | F G J K M | EB | EB | EB | EB | ED | EC | EC | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 1,600 pF | 162 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 1,800 pF | 182 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 2,000 pF | 202 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FC | FE | FE | GB | GB | GB | GB | | | |
| 2,200 pF | 222 | F G J K M | EB | EB | EB | EB | EE | EE | ED | FB | FB | FB | FB | FC | FG | FG | GB | GB | GB | GB | | | |
| 2,400 pF | 242 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FC | FC | FC | | | | | | | |
| 2,700 pF | 272 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FC | FC | FC | GB | GB | GB | GB | | | |
| 3,000 pF | 302 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FB | FB | FB | FB | FC | FF | FF | | | | | | | |
| 3,300 pF | 332 | F G J K M | EC | EC | EC | EC | EE | EB | EB | FB | FB | FB | FB | FF | FF | FF | GB | GB | GB | GB | | | |
| 3,600 pF | 362 | F G J K M | EC | EC | EC | EC | EE | EB | EB | FB | FB | FB | FB | FF | FF | FF | | | | | | | |
| 3,900 pF | 392 | F G J K M | EC | EC | EC | EC | EF | EB | EB | FB | FB | FB | FB | FF | FF | FF | GB | GB | GB | GB | | | |
| 4,300 pF | 432 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FB | FB | FB | FB | FF | FF | FF | | | | | | | |
| 4,700 pF | 472 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FF | FF | FF | FF | FG | FG | FG | GB | GB | GD | GD | | | |
| 5,100 pF | 512 | F G J K M | ED | ED | ED | ED | ED | EB | EB | FB | FB | FB | FB | FG | FG | FG | | | | | | | |
| 5,600 pF | 562 | F G J K M | ED | ED | ED | ED | ED | EB | EB | FB | FB | FB | FB | FG | FG | FG | GB | GB | GH | GH | | | |
| 6,200 pF | 622 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FG | FB | FB | | | | | | | |
| 6,800 pF | 682 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FG | FB | FB | GB | GB | GJ | GJ | JE | JE | JB |
| 7,500 pF | 752 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FC | FC | FC | FC | FC | FB | FB | | | | | | | |
| 8,200 pF | 822 | F G J K M | EC | EC | EC | EC | EB | EC | EC | FC | FC | FC | FC | FC | FB | FB | GB | GH | GB | GB | JE | JE | JB |
| 9,100 pF | 912 | F G J K M | EC | EC | EC | EC | EB | EC | EC | FE | FE | FE | FE | FE | FB | FB | | | | | | | |
| 10,000 pF | 103 | F G J K M | ED | ED | ED | ED | EB | EC | EC | FF | FF | FF | FF | FF | FB | FB | GB | GH | GB | GB | JE | JE | JB |
| 12,000 pF | 123 | F G J K M | EB | EB | EB | EB | EB | ED | ED | FG | FG | FG | FG | FB | FB | FB | GB | GG | GB | GB | JE | JE | JB |
| 15,000 pF | 153 | F G J K M | EB | EB | EB | EB | EB | EF | EF | FG | FG | FG | FG | FB | FC | FC | GB | GB | GB | GB | JE | JE | JB |
| 18,000 pF | 183 | F G J K M | EB | EB | EB | EB | EB | EH | EH | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | JE | JE | JB |
| 22,000 pF | 223 | F G J K M | EB | EB | EB | EB | EC | EH | EH | FB | FB | FB | FB | FB | FF | FF | GB | GB | GB | GB | JE | JB | JB |
| 27,000 pF | 273 | F G J K M | EB | EB | EB | EB | EE | | | FB | FB | FB | FB | FB | FG | FG | GB | GB | GB | GB | JE | JB | JB |
| 33,000 pF | 333 | F G J K M | EB | EB | EB | EB | EE | | | FB | FB | FB | FB | FB | FH | FH | GB | GB | GB | GB | JB | JB | JB |
| 39,000 pF | 393 | F G J K M | EC | EC | EC | EE | EH | | | FB | FB | FB | FB | FE | FH | FH | GB | GB | GB | GB | JB | JB | JB |
| 47,000 pF | 473 | F G J K M | EC | EC | EC | EE | EH | | | FB | FB | FB | FB | FE | FJ | FJ | GB | GB | GD | GD | JB | JB | JB |
| 56,000 pF | 563 | F G J K M | ED | ED | ED | EF | | | | FB | FB | FB | FB | FF | | | GB | GB | GD | GD | JB | JB | JB |
| 68,000 pF | 683 | F G J K M | EF | EF | EF | EH | | | | FB | FB | FB | FC | FG | | | GB | GB | GK | GK | JB | JB | JB |
| 82,000 pF | 823 | F G J K M | EH | EH | EH | EH | | | | FC | FC | FC | FF | FH | | | GB | GB | GM | GM | JB | JB | JB |
| 0.10 µF | 104 | F G J K M | EH | EH | EH | | | | | FE | FE | FE | FG | FM | | | GB | GD | GM | GM | JB | JB | JD |
| 0.12 µF | 124 | F G J K M | | | | | | | | FG | FG | FG | FH | | | | GB | GH | | | JB | JB | JD |
| 0.15 µF | 154 | F G J K M | | | | | | | | FH | FH | FH | FM | | | | GD | GN | | | JB | JB | JG |
| 0.18 µF | 184 | F G J K M | | | | | | | | FJ | FJ | FJ | | | | | GH | | | | JB | JD | JG |
| 0.22 µF | 224 | F G J K M | | | | | | | | FK | FK | FK | | | | | GK | | | | JB | JD | JL |
| 0.27 µF | 274 | F G J K M | | | | | | | | | | | | | | | | | | | JB | JF | |
| 0.33 µF | 334 | F G J K M | | | | | | | | | | | | | | | | | | | JD | JG | |
| 0.39 µF | 394 | F G J K M | | | | | | | | | | | | | | | | | | | JG | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | | | | | | | JG | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 |
| | | Case Size/Series | C1206T | | | | | | | C1210T | | | | | | | C1812T | | | | C2220T | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 402 | 0.50 ± 0.05 | 10000 | 50000 | 0 | 0 |
| BD | 402 | 0.55 ± 0.05 | 10000 | 50000 | 0 | 0 |
| CF | 603 | 0.80 ± 0.07 | 4000 | 15000 | 0 | 0 |
| CH | 603 | 0.85 ± 0.07 | 4000 | 10000 | 0 | 0 |
| DN | 805 | 0.78 ± 0.10 | 4000 | 15000 | 0 | 0 |
| DP | 805 | 0.90 ± 0.10 | 4000 | 15000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JG | 2220 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |

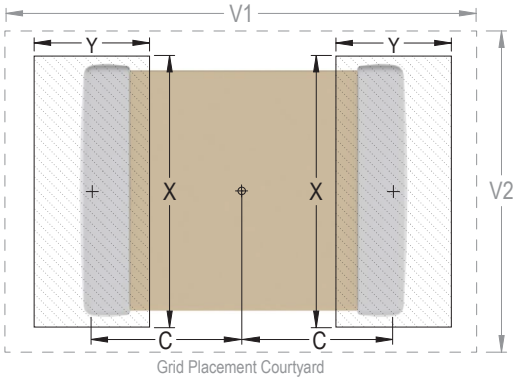
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

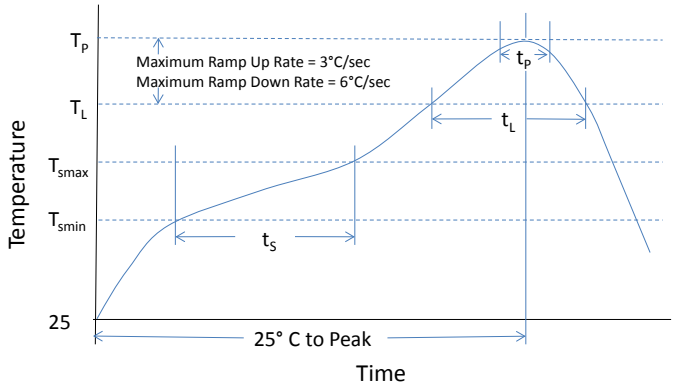
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



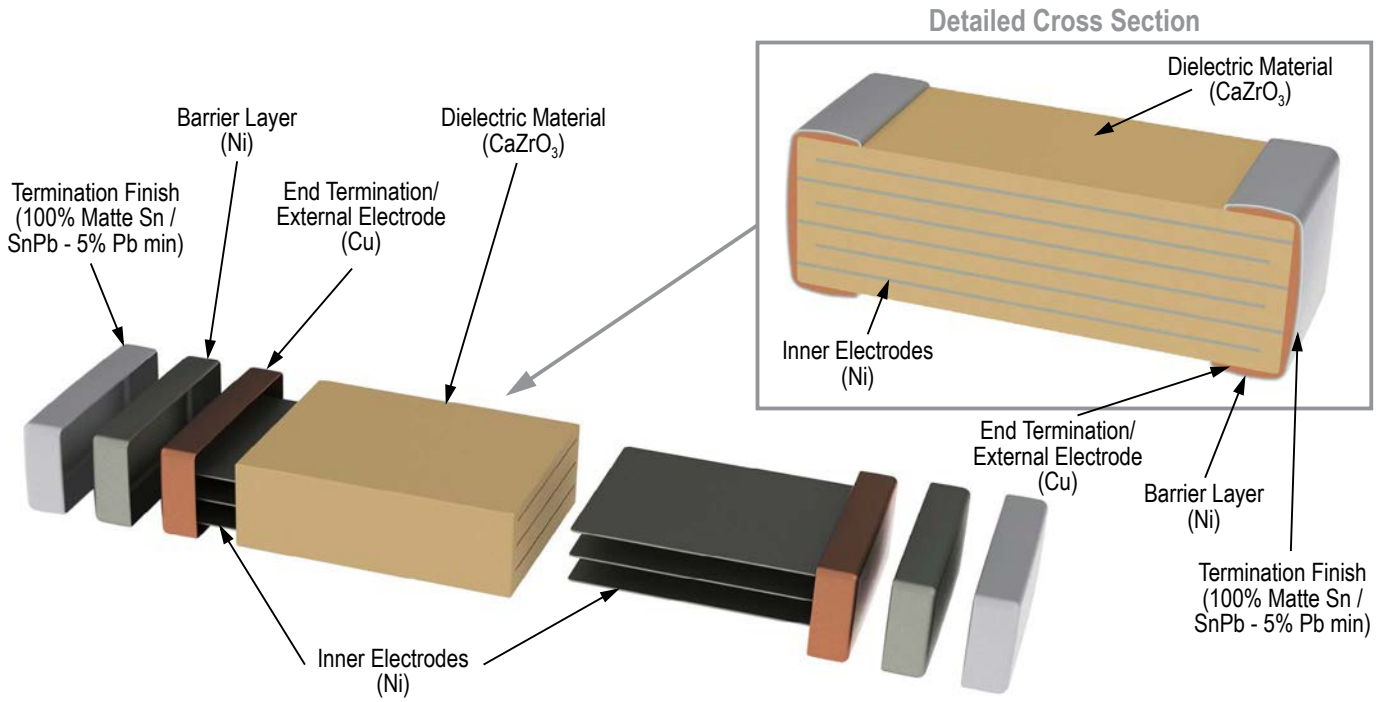
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

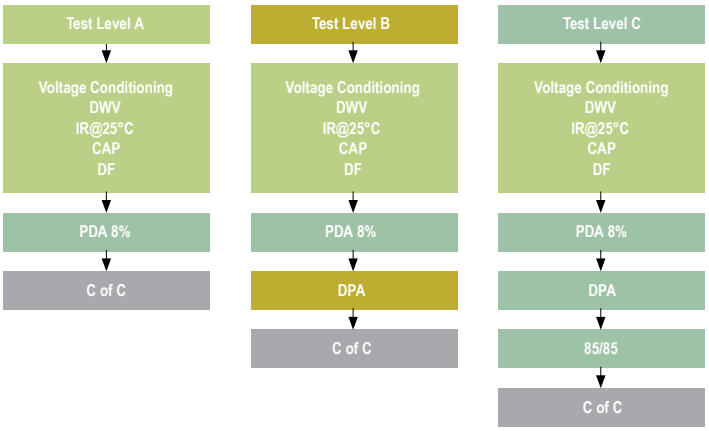
- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

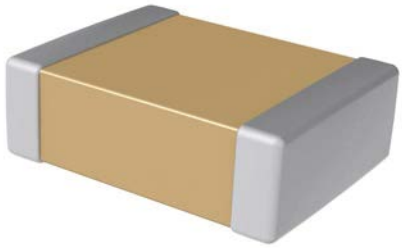
# Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, X7R Dielectric, 6.3 – 250 VDC

## Overview

KEMET's COTS program is an extension of KEMET knowledge of high reliability test regimes and requirements. KEMET regularly supplies "up-screened" products by working with customer drawings and imposing specified design and test requirements. The COTS program offers the same high quality and high reliability components as up-screened products, but at a lower cost to the customer. This is accomplished by eliminating the need for customer-specific drawings to achieve the reliability level required for customer applications. A series of tests and inspections have been selected to provide the accelerated conditioning and 100% screening necessary to eliminate infant mortal failures from the population.




KEMET's X7R dielectric features a 125°C maximum operating temperature and is considered "temperature stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.



All COTS testing includes voltage conditioning and post-electrical testing as per MIL–PRF–55681. For enhanced reliability, KEMET also provides the following test level options and conformance certifications:

## Ordering Information

| C | 1210 | T | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812<br>2220 | T = COTS | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = Testing per MIL–PRF–55681 PDA 8%<br>B= Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469<br>C = Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469, Humidity per MIL–STD–202, Method 103, Condition A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

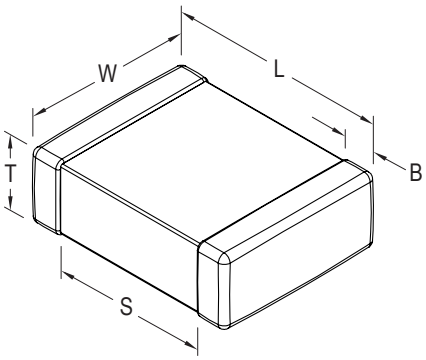
## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- Voltage conditioning and post-electrical testing per MIL–PRF–55681
- Destructive Physical Analysis (DPA) per EIA–469
- Biased humidity testing (85/85) per MIL–STD–202
- Certificate of Compliance
- Temperature stable dielectric
- EIA 0402, 0603, 0805, 1206, 1210, 1812, and 2220 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 10 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include military, space quality and high reliability electronics.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210[1] | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

*[1] For capacitance values ≥ 4.7 µF add 0.02 (0.001) to the width tolerance dimension and 0.10 (0.004) to the length tolerance dimension.*

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | |
| 100 – 150 pF** | 101 – 151** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | |
| 180 – 820 pF** | 181 – 821** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | |
| 1,000 pF | 102 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,200 pF | 122 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,500 pF | 152 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,800 pF | 182 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 2,200 pF | 222 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 2,700 pF | 272 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 3,300 pF | 332 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 3,900 pF | 392 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 4,700 pF | 472 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 5,600 pF | 562 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 6,800 pF | 682 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 8,200 pF | 822 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 10,000 pF | 103 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 12,000 pF | 123 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 15,000 pF | 153 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 18,000 pF | 183 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 22,000 pF | 223 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 27,000 pF | 273 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB |
| 33,000 pF | 333 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB |
| 39,000 pF | 393 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EC | EB | EB |
| 47,000 pF | 473 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DE | DG | | EB | EB | EB | EB | EB | EC | ED | ED |
| 56,000 pF | 563 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | DG | | EB | EB | EB | EB | EB | EB | ED | ED |
| 68,000 pF | 683 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | ED | ED |
| 82,000 pF | 823 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | ED | ED |
| 0.10 µF | 104 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | EB | EM | EM |
| 0.12 µF | 124 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | EG | |
| 0.15 µF | 154 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | EG | |
| 0.18 µF | 184 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | | |
| 0.22 µF | 224 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | | |
| 0.27 µF | 274 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EM | | |
| 0.33 µF | 334 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EG | | |
| 0.39 µF | 394 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DE | | | | EB | EB | EB | EB | EC | EG | | |
| 0.47 µF | 474 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DE | | | | EC | EC | EC | EC | EC | EG | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | | | | ED | ED | ED | ED | EC | | | |
| 0.68 µF | 684 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | | | | EE | EE | EE | EE | ED | | | |
| 0.82 µF | 824 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | EF | EF | EF | EF | ED | | | |
| 1.0 µF | 105 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | EF | EF | EF | EG | ED | | | |
| 1.2 µF | 125 | J K M | | | | | | | | | | | | | DE | DE | DE | | | | | | ED | ED | ED | EG | EH | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | EF | EF | EF | EG | EH | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | ED | ED | ED | EF | EH | | | |
| 2.2 µF | 225 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | ED | ED | ED | EF | EH | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EH | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

**Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 1B – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 - 91 pF* | 100 - 910* | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | |
| 100 - 270 pF** | 101 - 391** | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | |
| 470 - 820 pF** | 471 - 821** | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,000 pF | 102 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,200 pF | 122 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,500 pF | 152 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,800 pF | 182 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 2,200 pF | 222 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 2,700 pF | 272 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 3,300 pF | 332 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | |
| 3,900 pF | 392 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | |
| 4,700 pF | 472 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GD | | | | | | | | | | |
| 5,600 pF | 562 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GH | | | | | | | | | | |
| 6,800 pF | 682 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 8,200 pF | 822 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 10,000 pF | 103 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 12,000 pF | 123 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 15,000 pF | 153 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 18,000 pF | 183 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 22,000 pF | 223 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | |
| 27,000 pF | 273 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 39,000 pF | 393 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 47,000 pF | 473 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 56,000 pF | 563 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 68,000 pF | 683 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 82,000 pF | 823 | J K M | FB | FB | FB | FB | FB | FC | FF | FF | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.10 µF | 104 | J K M | FB | FB | FB | FB | FB | FD | FG | FG | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.12 µF | 124 | J K M | FB | FB | FB | FB | FB | FD | FH | FH | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.15 µF | 154 | J K M | FC | FC | FC | FC | FC | FD | FM | FM | LD | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.18 µF | 184 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | LD | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.22 µF | 224 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.27 µF | 274 | J K M | FC | FC | FC | FC | FC | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC |
| 0.33 µF | 334 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC |
| 0.39 µF | 394 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HD | HD | HD | HD | JC | JC | JC | JC | JC |
| 0.47 µF | 474 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GJ | GJ | HD | HD | HD | HD | JC | JC | JC | JC | JC |
| 0.56 µF | 564 | J K M | FD | FD | FD | FD | FD | FF | | | | | | GC | GC | GG | | | HD | HD | HD | HD | JC | JD | JD | JD | JD |
| 0.68 µF | 684 | J K M | FD | FD | FD | FD | FD | FG | | | | | | GC | GC | GG | | | HD | HD | HD | HD | JC | JD | JD | JD | JD |
| 0.82 µF | 824 | J K M | FF | FF | FF | FF | FF | FL | | | | | | GE | GE | GG | | | HF | HF | HF | HF | JC | JF | JF | JF | JF |
| 1.0 µF | 105 | J K M | FH | FH | FH | FH | FH | FM | | | | | | GE | GE | GG | | | HF | HF | HF | HF | JC | JF | JF | JF | JF |
| 1.2 µF | 125 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JC | JC | | | |
| 1.5 µF | 155 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JC | JC | | | |
| 1.8 µF | 185 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JD | JD | | | |
| 2.2 µF | 225 | J K M | FJ | FJ | FJ | FJ | FG | | | | | | | GO | GO | | | | | | | | JF | JF | | | |
| 2.7 µF | 275 | J K M | FE | FE | FE | FG | FH | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | FF | FF | FF | FM | FM | | | | | | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | FG | FG | FG | FG | FK | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | FC | FC | FC | FG | FS | | | | | | | GK | GK | | | | | | | | JF | JF | | | |
| 5.6 µF | 565 | J K M | FF | FF | FF | FH | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | FG | FG | FG | FM | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | FH | FH | FH | FK | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | FH | FH | FH | FS | | | | | | | | GK | | | | | | | | | JF | JO | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | | | | | | | | JO | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | FS | FS | | | | | | | | | | | | | | | | | | | JO | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |

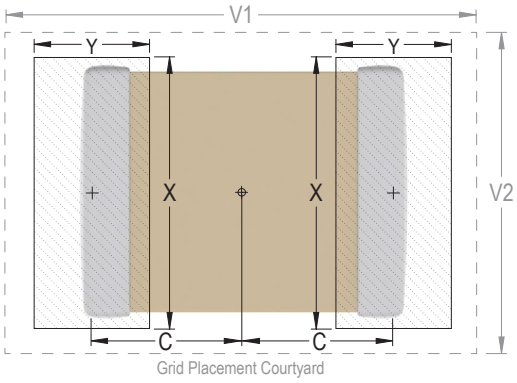
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

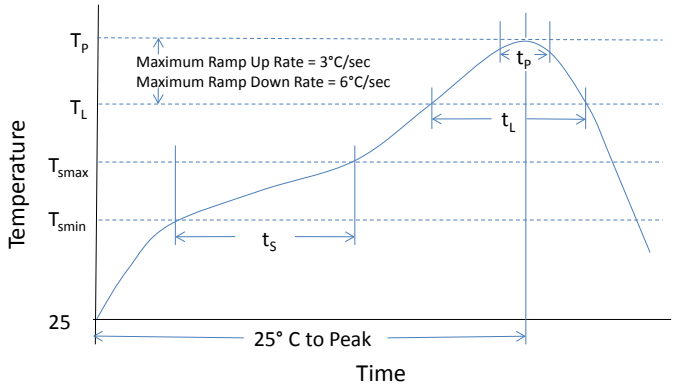
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



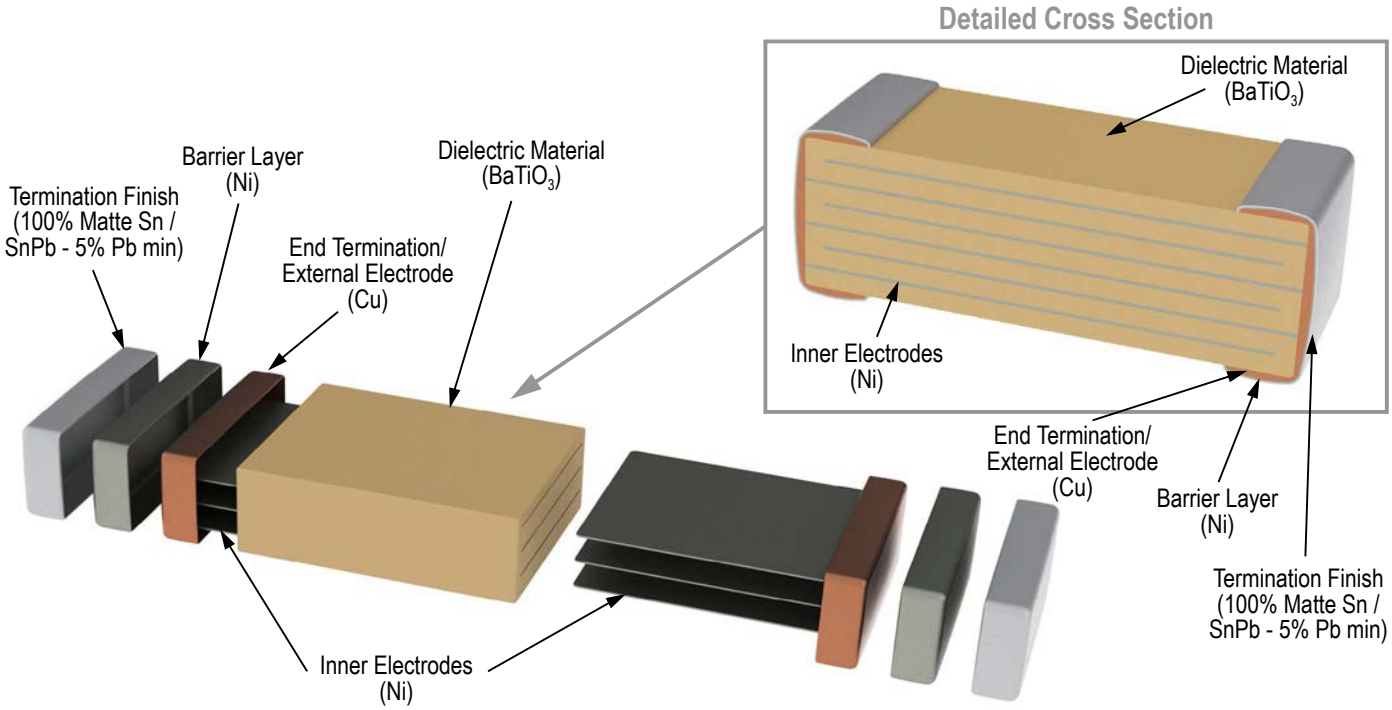
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# Telecom "Tip and Ring," X7R Dielectric, 250 VDC (Commercial Grade)

## Overview

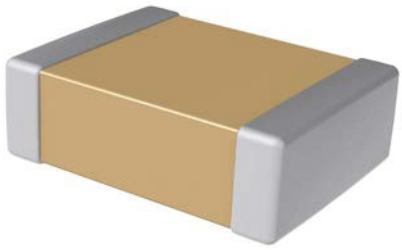
KEMET's 250V DC Tip and Ring MLCCs in X7R dielectric are designed and rated for telecommunication ringer circuits where the capacitor is used to block -48V to -52V DC of line voltage and pass a 16-25 Hz AC signal pulse of 70 Vrms to 90 Vrms. Serving as an excellent replacement for high voltage leaded film devices, these smaller surface mount technology footprints save valuable board space which is critical when creating new designs.

KEMET Tip and Ring capacitors feature a 125°C maximum operating temperature and are considered "temperature stable." The Electronics Industries Alliance (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R dielectric exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

These devices are able to withstand today's higher lead-free reflow processing temperatures and offer superior high frequency filtering characteristics and low ESR.

## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, 1812, 1825, 2220, and 2225 case sizes
- DC voltage rating of 250 V
- Capacitance offerings ranging from 1,000 pF to 6.8 µF
- Available capacitance tolerances of ±10% and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish that allows for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request



## Ordering Information

| C | 1825 | C | 105 | K | A | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1812<br>1825<br>2220<br>2225 | C = Standard<br>X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Applications

Typical applications include telecommunication ringing circuits, switch mode power supply snubber circuits, high voltage DC blocking and high voltage coupling. Markets include telephone lines, analog and digital modems, facsimile machines, wireless base stations, cable and digital video recording set-top boxes, satellite dishes, high voltage power supply, DC/DC converters, and Ethernet, POS and ATM hardware.

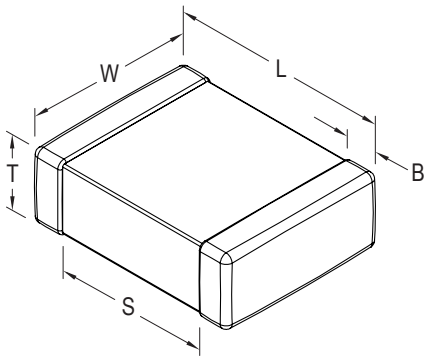
## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35(.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60(.102) ± 0.30(.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0805 – 2225 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | | C0805C | C1206C | C1210C | C1812C | C1825C | C2220C | C2225C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | A | A | A | A | A | A | A |
| | | Rated Voltage (VDC) | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | |
| 180 pF | 181 | J | K | M | DR | | | | | | |
| 220 pF | 221 | J | K | M | DR | | | | | | |
| 270 pF | 271 | J | K | M | DR | | | | | | |
| 330 pF | 331 | J | K | M | DR | | | | | | |
| 390 pF | 391 | J | K | M | DR | | | | | | |
| 470 pF | 471 | J | K | M | DR | | | | | | |
| 560 pF | 561 | J | K | M | DR | | | | | | |
| 680 pF | 681 | J | K | M | DR | | | | | | |
| 820 pF | 821 | J | K | M | DR | | | | | | |
| 1,000 pF | 102 | J | K | M | DR | EQ | | | | | |
| 1,200 pF | 122 | J | K | M | DR | EQ | | | | | |
| 1,500 pF | 152 | J | K | M | DR | EQ | | | | | |
| 1,800 pF | 182 | J | K | M | DR | EQ | | | | | |
| 2,200 pF | 222 | J | K | M | DR | EQ | FN | | | | |
| 2,700 pF | 272 | J | K | M | DR | EQ | FN | | | | |
| 3,300 pF | 332 | J | K | M | DR | EQ | FN | | | | |
| 3,900 pF | 392 | J | K | M | DR | EQ | FN | | | | |
| 4,700 pF | 472 | J | K | M | DR | EQ | FN | | | | |
| 5,600 pF | 562 | J | K | M | DR | EQ | FN | | | | |
| 6,800 pF | 682 | J | K | M | DR | EQ | FN | GB | | | |
| 8,200 pF | 822 | J | K | M | DR | EQ | FN | GB | | | |
| 10,000 pF | 103 | J | K | M | DR | EQ | FN | GB | | | |
| 12,000 pF | 123 | J | K | M | DR | EQ | FN | GB | | | |
| 15,000 pF | 153 | J | K | M | DR | EQ | FN | GB | | | |
| 18,000 pF | 183 | J | K | M | DR | EQ | FN | GB | | | |
| 22,000 pF | 223 | J | K | M | DR | EQ | FN | GB | HB | | |
| 27,000 pF | 273 | J | K | M | | EQ | FN | GB | HB | | |
| 33,000 pF | 333 | J | K | M | | EQ | FN | GB | HB | | |
| 39,000 pF | 393 | J | K | M | | EQ | FN | GB | HB | | |
| 47,000 pF | 473 | J | K | M | | ES | FQ | GB | HB | | KC |
| 56,000 pF | 563 | J | K | M | | ES | FQ | GB | HB | | KC |
| 68,000 pF | 683 | J | K | M | | ES | FQ | GB | HB | | KC |
| 82,000 pF | 823 | J | K | M | | ES | FA | GB | HB | JC | KC |
| 0.10 µF | 104 | J | K | M | | EM | FZ | GB | HB | JC | KC |
| 0.12 µF | 124 | J | K | M | | | FU | GB | HB | JC | KC |
| 0.15 µF | 154 | J | K | M | | | FM | GE | HB | JC | KC |
| 0.18 µF | 184 | J | K | M | | | FK | GG | HB | JC | KC |
| 0.22 µF | 224 | J | K | M | | | FK | GG | HB | JC | KC |
| 0.27 µF | 274 | J | K | M | | | | GG | HB | JC | KC |
| 0.33 µF | 334 | J | K | M | | | | GG | HB | JC | KC |
| 0.39 µF | 394 | J | K | M | | | | GG | HD | JC | KC |
| 0.47 µF | 474 | J | K | M | | | | GJ | HD | JC | KD |
| 0.56 µF | 564 | J | K | M | | | | | HD | JD | KD |
| 0.68 µF | 684 | J | K | M | | | | | HD | JD | KD |
| 0.82 µF | 824 | J | K | M | | | | | HF | JF | KE |
| 1.0 µF | 105 | J | K | M | | | | | HF | JF | KE |
| 1.2 µF | 125 | J | K | M | | | | | | | KE |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | Voltage Code | | | A | A | A | A | A | A | A |
| | | Case Size/Series | | | C0805C | C1206C | C1210C | C1812C | C1825C | C2220C | C2225C |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

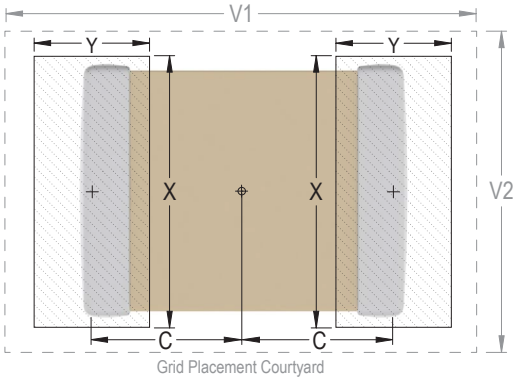
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

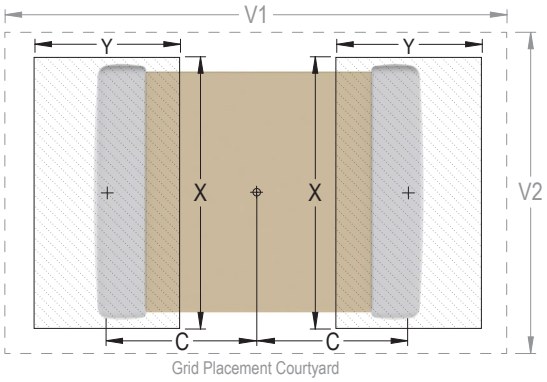


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

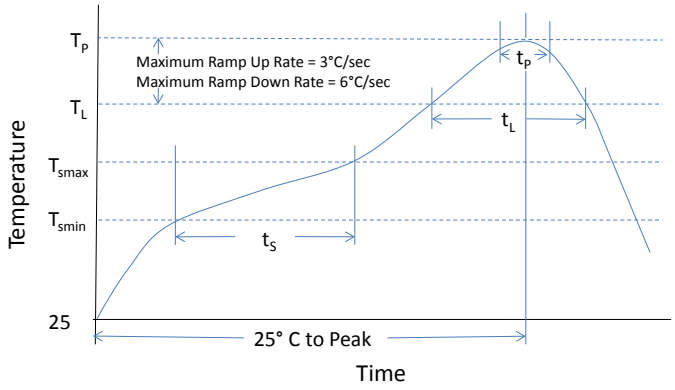
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



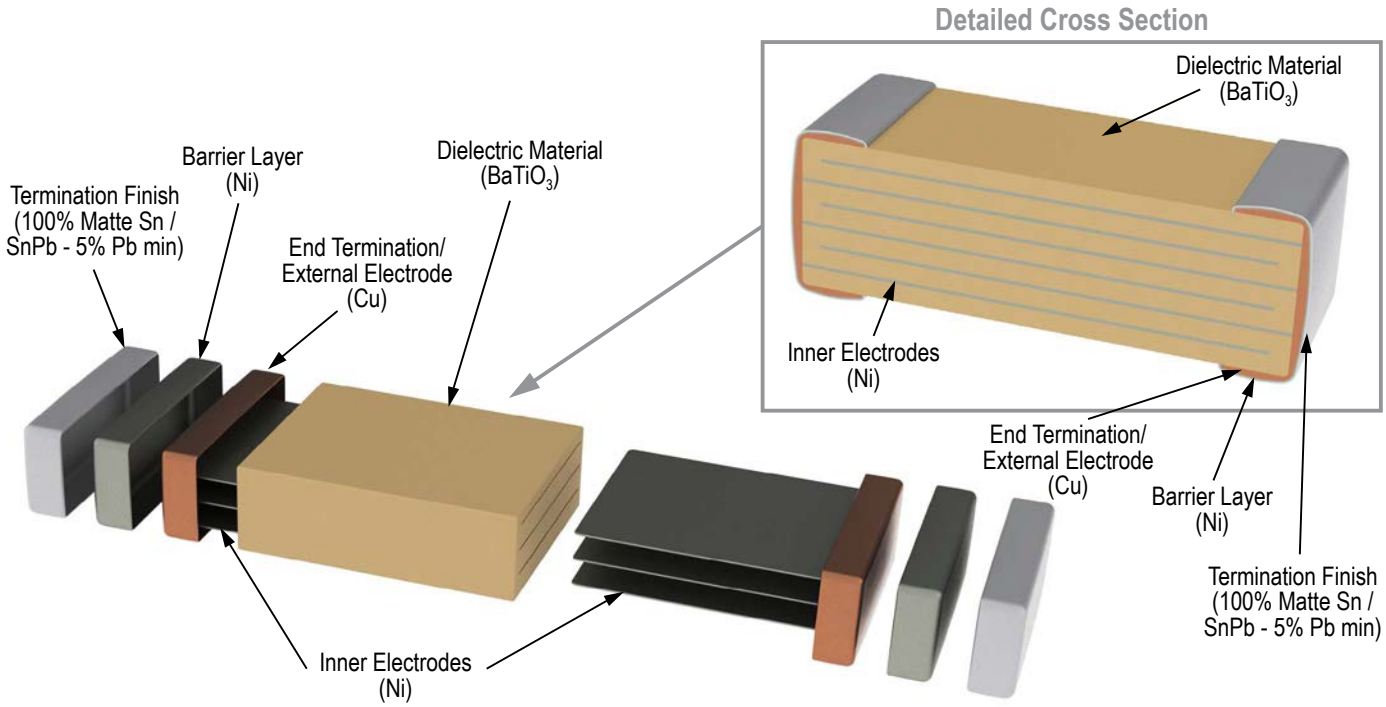
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

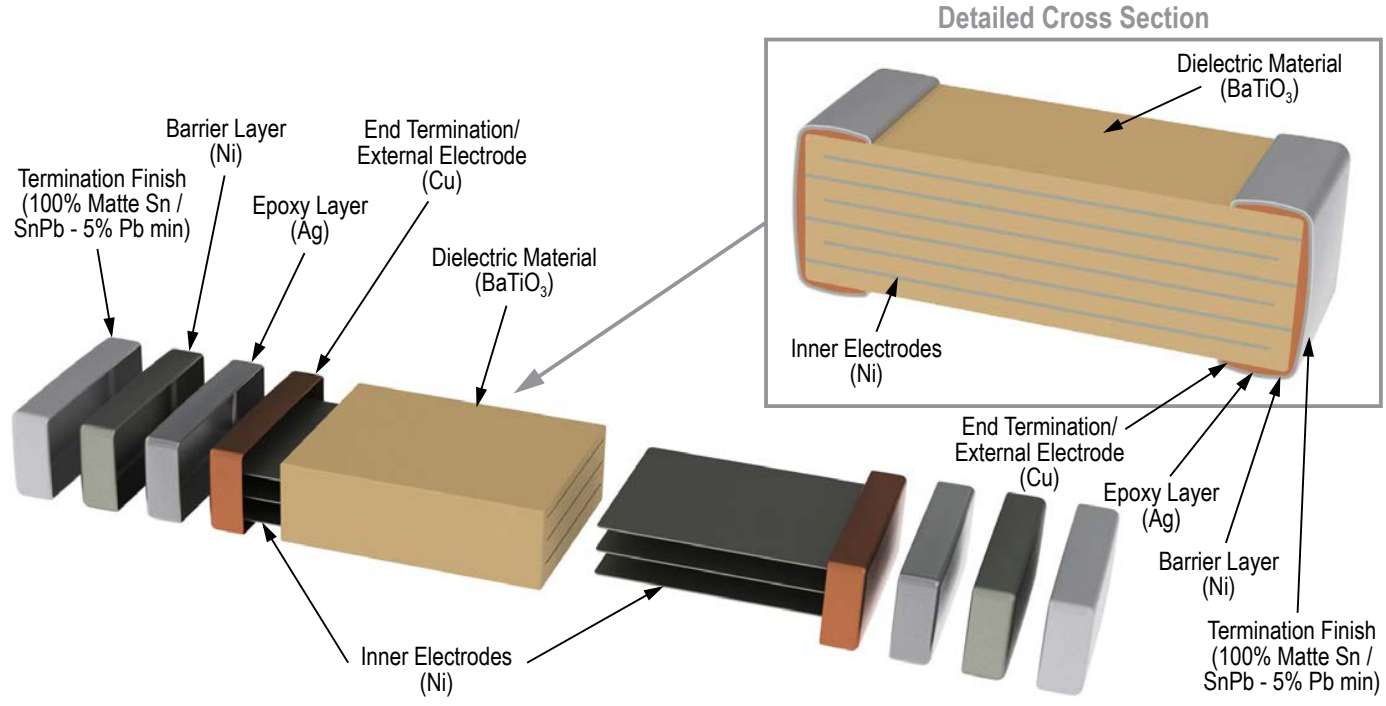
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



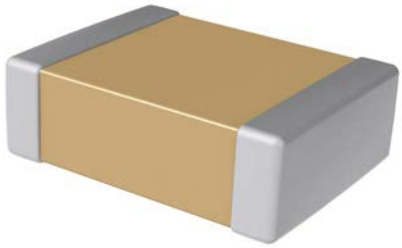
# Open Mode Design (FO-CAP), X7R Dielectric, 16 – 200 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Ceramic Open Mode capacitor in X7R dielectric is designed to significantly minimize the probability of a low IR or short circuit condition when forced to failure in a board stress flex situation, thus reducing the potential for catastrophic failure. The Open Mode capacitor may experience a drop in capacitance; however, a short is unlikely because a crack will not typically propagate across counter electrodes within the device's "active area." Since there will not be any current leakage associated with a typical Open Mode flex crack, there is no localized heating and therefore little chance for a catastrophic and potentially costly failure event.

Driven by the demand for a more robust and reliable component, the Open Mode capacitor was designed for critical applications where higher operating temperatures and mechanical stress are a concern. These capacitors are widely used in automotive circuits as well as power supplies (input and output filters) and general electronic applications.

Concerned with flex cracks resulting from excessive tensile and shear stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. When combined with flexible termination technology these devices offer the ultimate level of protection against a low IR or short circuit condition. Open Mode devices compliment KEMET's Floating Electrode (FE-CAP) and Floating Electrode with Flexible Termination (FF-CAP) product lines by providing a fail-safe design optimized for mid to high range capacitance values. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.



## Ordering Information

| C | 1210 | J | 685 | K | 3 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1812 | F = Open Mode<br>J = Open Mode with Flexible Termination | Two significant digits + number of zeros | K = ±10%<br>M = ±20% | 4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Open Mode/fail open design
- Mid to high capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 16 V, 25 V, 50 V, 100 V, and 200 V
- Capacitance offerings ranging from 1,000 pF to 6.8 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- Commercial and Automotive (AEC–Q200) grades available
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request

## Applications

Typical applications include input side filtering (power plane/bus), high current (battery line) and circuits that cannot be fused to open when short circuits occur due to flex cracks. Markets include automotive applications that are directly connected to the battery and/or involve conversion to a 42 V system and raw power input side filtering in power conversion.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

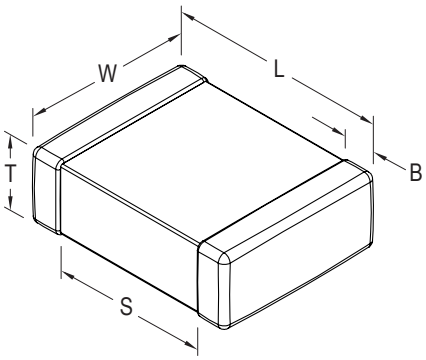
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0805 – 1812 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C0805F | | | | | C1206F | | | | | C1210F | | | | | C1812F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,200 pF | 122 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,500 pF | 152 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,800 pF | 182 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 2,200 pF | 222 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 2,700 pF | 272 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 3,300 pF | 332 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 3,900 pF | 392 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 4,700 pF | 472 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 5,600 pF | 562 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 6,800 pF | 682 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 8,200 pF | 822 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 10,000 pF | 103 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 12,000 pF | 123 | K | M | DP | DP | DP | DP | DG | | | | | | | | | | | | | | |
| 15,000 pF | 153 | K | M | DP | DP | DP | DP | DG | | | | | | | | | | | | | | |
| 18,000 pF | 183 | K | M | DP | DP | DP | DP | | EC | EC | EC | EC | EC | | | | | | | | | |
| 22,000 pF | 223 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 27,000 pF | 273 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 33,000 pF | 333 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 39,000 pF | 393 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 47,000 pF | 473 | K | M | DP | DP | DP | DE | | EC | EC | EC | EC | EG | | | | | | GB | GB | GB | GB |
| 56,000 pF | 563 | K | M | DP | DP | DP | | | EC | EC | EC | EC | EG | | | | | | GB | GB | GB | GB |
| 68,000 pF | 683 | K | M | DP | DP | DG | DG | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FD | GB | GB | GB | GB |
| 82,000 pF | 823 | K | M | DP | DP | DG | | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FD | GB | GB | GB | GB |
| 0.10 µF | 104 | K | M | DG | DG | DG | | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FG | GB | GB | GB | GB |
| 0.12 µF | 124 | K | M | DG | DG | | | | EC | EC | EC | EC | | FD | FD | FD | FD | FG | GB | GB | GB | GB |
| 0.15 µF | 154 | K | M | DG | DG | | | | EC | EC | EC | EG | | FD | FD | FD | FD | FH | GB | GB | GB | GB |
| 0.18 µF | 184 | K | M | DG | DG | | | | EC | EC | EC | EG | | FD | FD | FD | FD | FH | GB | GB | GB | GB |
| 0.22 µF | 224 | K | M | DG | DP | DG | | | EC | EC | EC | ED | | FD | FD | FD | FG | FS | GB | GB | GB | GC |
| 0.27 µF | 274 | K | M | DP | DP | | | | EC | EC | EC | | | FD | FD | FD | FG | | GB | GB | GB | GF |
| 0.33 µF | 334 | K | M | DP | DG | | | | EG | EG | EG | EG | | FD | FD | FD | FH | | GB | GB | GB | GK |
| 0.39 µF | 394 | K | M | DP | DG | | | | EG | EG | | | | FD | FD | FG | FH | | GB | GB | GB | GL |
| 0.47 µF | 474 | K | M | DE | DG | | | | EG | EG | EC | | | FD | FD | FG | FJ | | GB | GB | GC | |
| 0.56 µF | 564 | K | M | | | | | | EG | | | | | FD | FD | FG | FR | | GB | GB | GD | |
| 0.68 µF | 684 | K | M | DG | | | | | EG | | | | | FD | FG | FH | FR | | GD | GD | GF | |
| 0.82 µF | 824 | K | M | | | | | | EG | | | | | FD | FG | FH | FR | | GD | GD | GK | |
| 1.0 µF | 105 | K | M | | | | | | EG | EC | EH | | | FD | FH | FJ | FS | | GN | GN | GM | |
| 1.2 µF | 125 | K | M | | | | | | | | | | | FG | | | | | | | | |
| 1.5 µF | 155 | K | M | | | | | | | | | | | FH | | | | | | | | |
| 1.8 µF | 185 | K | M | | | | | | | | | | | FH | | | | | | | | |
| 2.2 µF | 225 | K | M | | | | | | EC | EH | | | | FJ | FM | FM | | | | | | |
| 2.7 µF | 275 | K | M | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | K | M | | | | | | | | | | | FM | | | | | | | | |
| 3.9 µF | 395 | K | M | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | K | M | | | | | | EH | | | | | FG | FM | | | | GK | GK | | |
| 6.8 µF | 685 | K | M | | | | | | | | | | | FS | FS | | | | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 3 | 5 | 1 | 2 |
| | | Case Size/ Series | | C0805F | | | | | C1206F | | | | | C1210F | | | | | C1812F | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FR | 1210 | 2.25 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

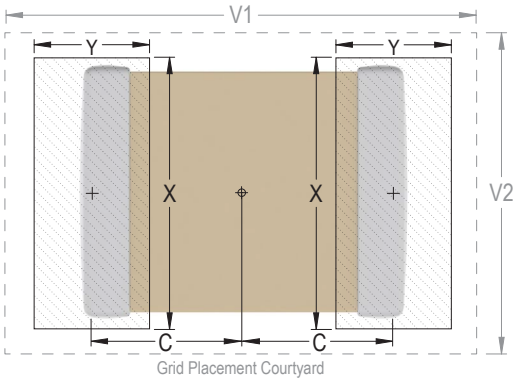
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

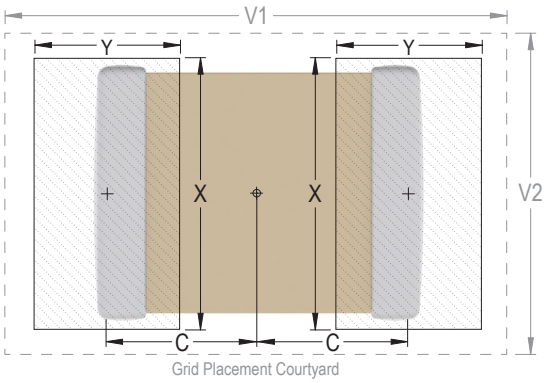


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

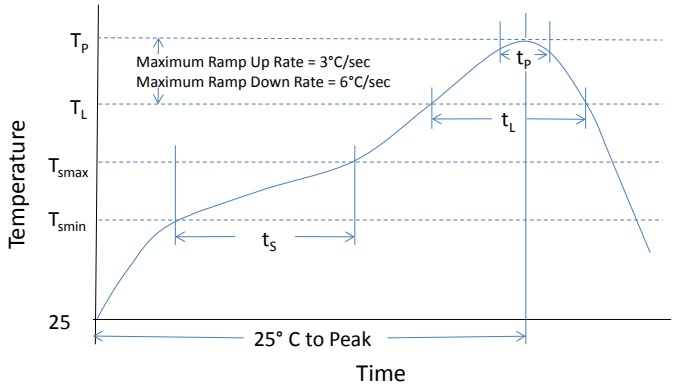
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



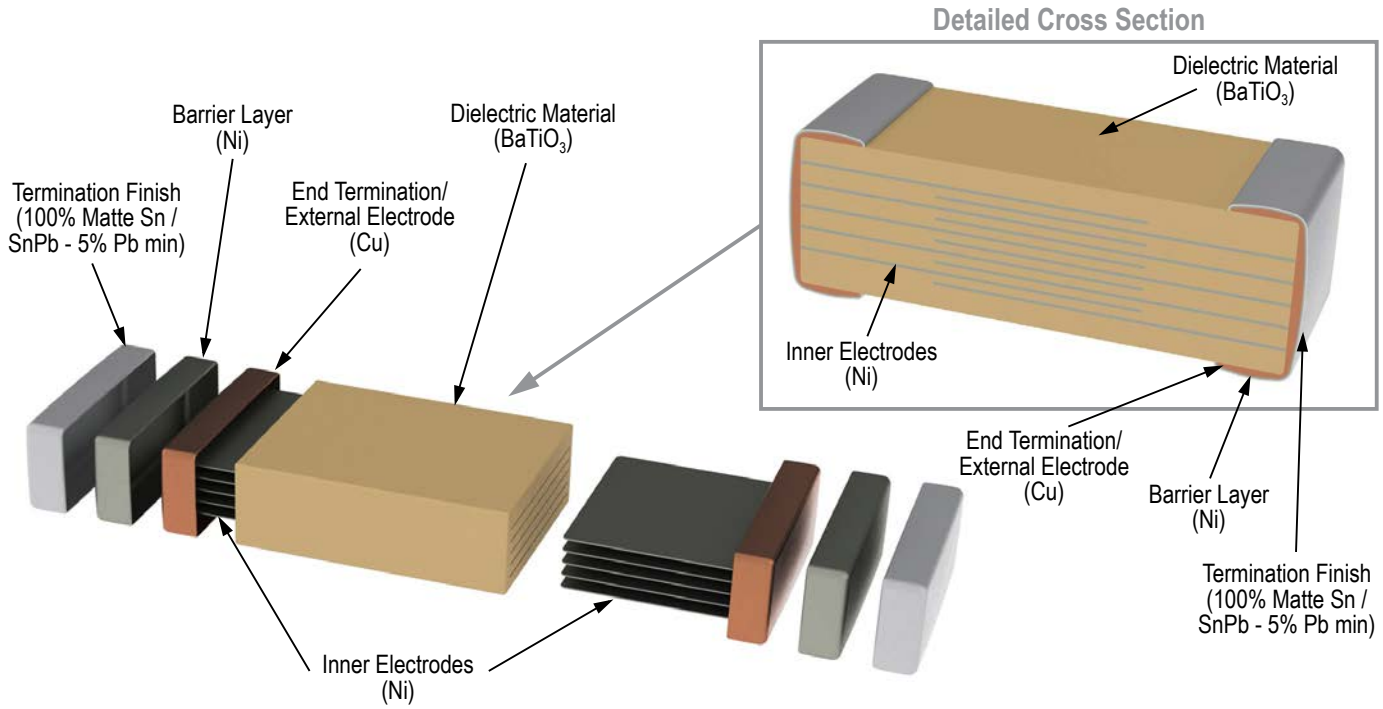
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

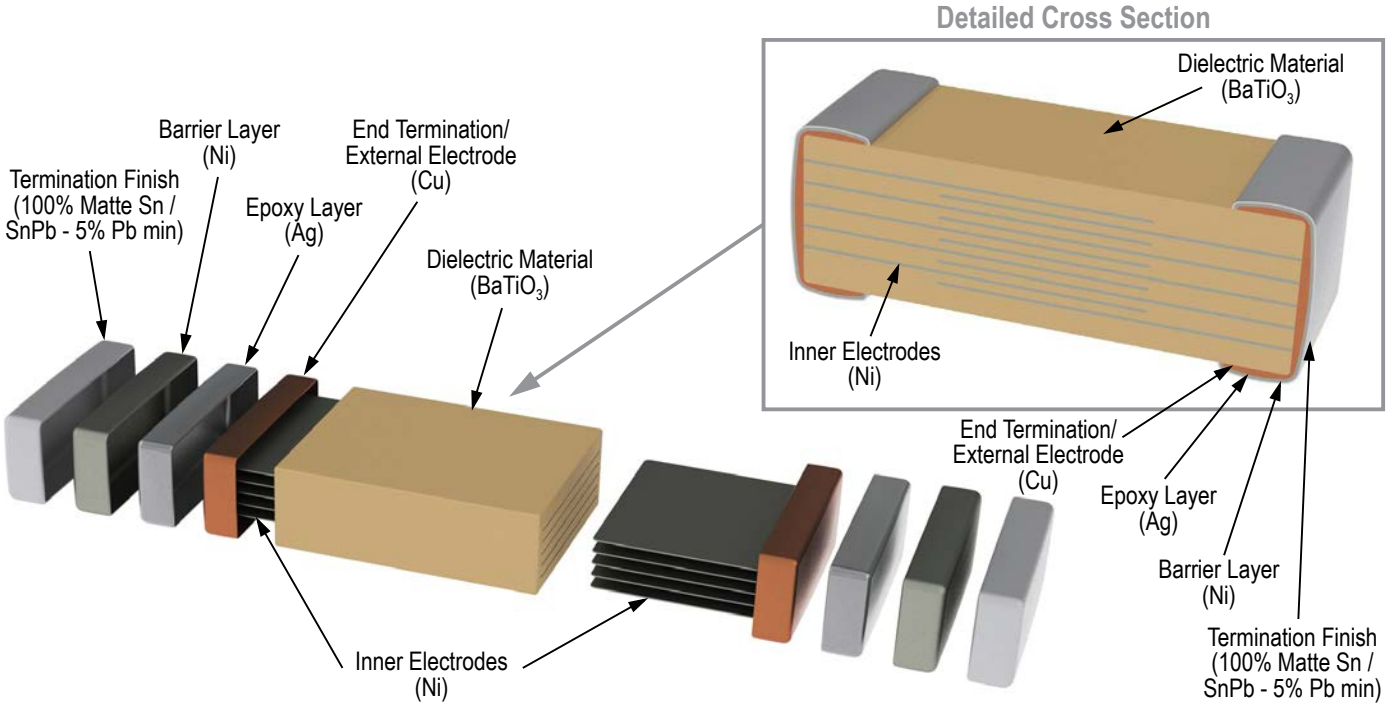
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# Floating Electrode Design (FE-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade)

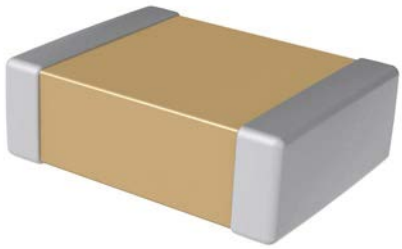
## Overview

KEMET's Floating Electrode (FE-CAP) multilayer ceramic capacitor in X7R dielectric utilizes a cascading internal electrode design configured to form multiple capacitors in series within a single monolithic structure. This unique configuration results in enhanced voltage and ESD performance over standard capacitor designs while allowing for a fail-open condition if mechanically damaged (cracked). If damaged, the device may experience a drop in capacitance but a short is unlikely. The FE-CAP is designed to reduce the likelihood of a low IR or short circuit condition and the chance for a catastrophic and potentially costly failure event.

Driven by the demand for a more robust and reliable component, the FE-CAP was designed for critical applications where higher operating temperatures and mechanical stress are a concern. These capacitors are manufactured in state of the art ISO/TS 16949:2009 certified facilities and are widely used in power supplies (input and output filters) and general electronic applications.

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. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 0805 | S | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812 | S = Floating Electrode | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Floating Electrode/fail open design
- Low to mid capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 150 pF to 0.22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial and Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

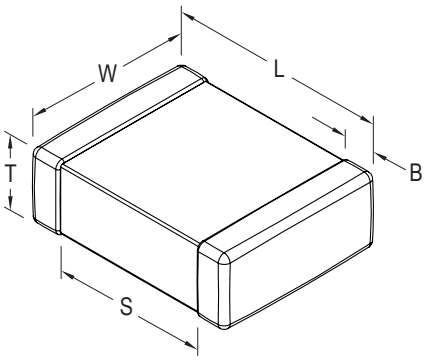
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ± 0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ± 0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (.126) ±0.20 (.008) | 1.60 (0.063) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ±0.20 (.008) | 2.50 (0.098) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ±0.30 (.012) | 3.20 (0.126) ± 0.30 (0.012) | | 0.60 (0.024) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4 , Performance and Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 0805 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C0402S | | | | | C0603S | | | | | | | C0805S | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 150 pF | 151 | J | K | M | BB | BB | BB | BB | BB | | | | | | | | | | | | | | | |
| 180 pF | 181 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 220 pF | 221 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 270 pF | 271 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 330 pF | 331 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 390 pF | 391 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 470 pF | 471 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 560 pF | 561 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 680 pF | 681 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 820 pF | 821 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,000 pF | 102 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,200 pF | 122 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,500 pF | 152 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,800 pF | 182 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 2,200 pF | 222 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 2,700 pF | 272 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 3,300 pF | 332 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 3,900 pF | 392 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 4,700 pF | 472 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 5,600 pF | 562 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 6,800 pF | 682 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 8,200 pF | 822 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 10,000 pF | 103 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | DN |
| 12,000 pF | 123 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | DN |
| 15,000 pF | 153 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 18,000 pF | 183 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 22,000 pF | 223 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 27,000 pF | 273 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 33,000 pF | 333 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 39,000 pF | 393 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 47,000 pF | 473 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | | | | | | DP | DP | DP | DP | DP | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | | | | | | DP | DP | DP | DP | DP | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | | | | | | DG | DG | DG | DG | DG | | | |
| 0.10 µF | 104 | J | K | M | | | | | | | | | | | | | DG | DG | DG | DG | DG | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | | | C0402S | | | | | C0603S | | | | | | | C0805S | | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1206 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C1206S | | | | | | | | C1210S | | | | | | | | C1812S | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,200 pF | 122 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,500 pF | 152 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,800 pF | 182 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 2,700 pF | 272 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 3,300 pF | 332 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 3,900 pF | 392 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 4,700 pF | 472 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 5,600 pF | 562 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 6,800 pF | 682 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 8,200 pF | 822 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 10,000 pF | 103 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 12,000 pF | 123 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 15,000 pF | 153 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 18,000 pF | 183 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 22,000 pF | 223 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 27,000 pF | 273 | J | K | M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 33,000 pF | 333 | J | K | M | EB | EB | EB | EB | EB | EB | | | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 39,000 pF | 393 | J | K | M | EB | EB | EB | EB | EB | EC | | | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 47,000 pF | 473 | J | K | M | EB | EB | EB | EB | EB | EC | | | FB | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | GB |
| 56,000 pF | 563 | J | K | M | EB | EB | EB | EB | EB | EB | | | FB | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | GB |
| 68,000 pF | 683 | J | K | M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FB | | | GB | GB | GB | GB | GB |
| 82,000 pF | 823 | J | K | M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FC | | | GB | GB | GB | GB | GB |
| 0.10 µF | 104 | J | K | M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FC | | | GB | GB | GB | GB | GB |
| 0.12 µF | 124 | J | K | M | EC | EC | EC | EC | EC | | | | FB | FB | FB | FB | FB | | | | GB | GB | GB | GB | GB |
| 0.15 µF | 154 | J | K | M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| 0.18 µF | 184 | J | K | M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| 0.22 µF | 224 | J | K | M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | | | C1206S | | | | | | | | C1210S | | | | | | | | C1812S | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

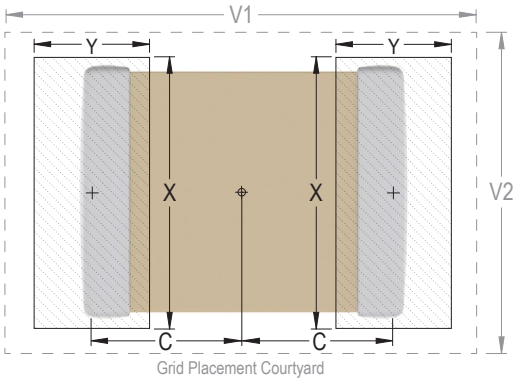
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

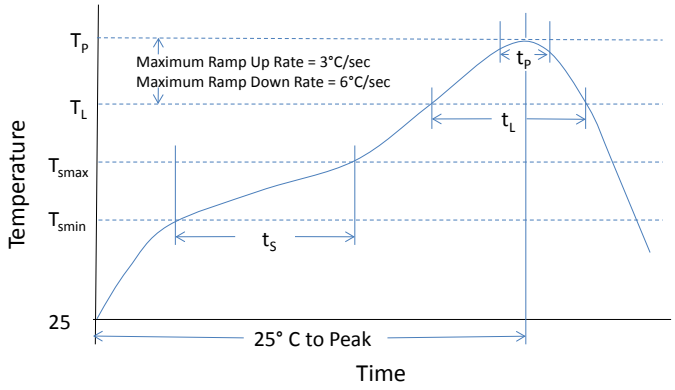
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



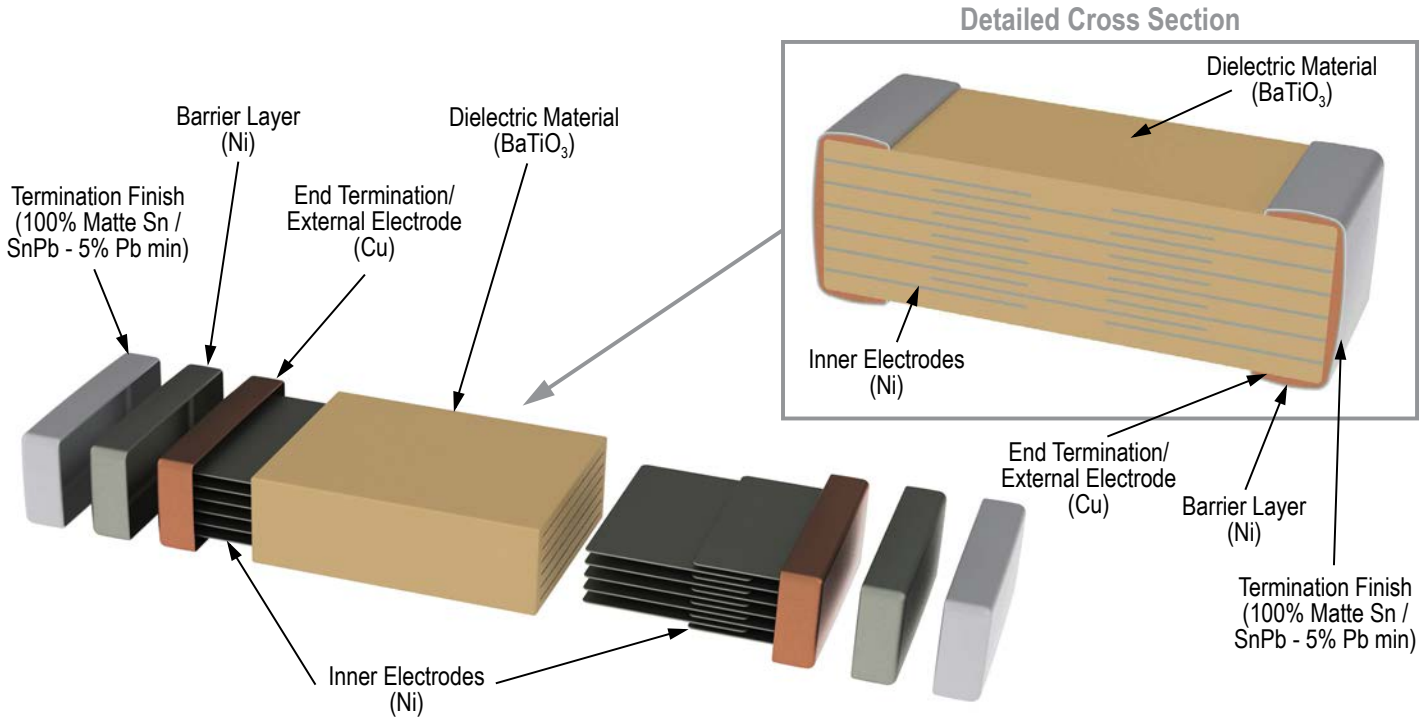
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# Flexible Termination System (FT-CAP), C0G Dielectric, 10 – 250 VDC (Commercial & Automotive Grade)

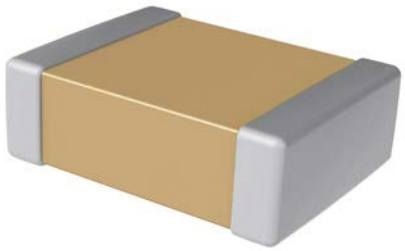
## Overview

KEMET's Flexible Termination (FT-CAP) Multilayer Ceramic Capacitor in C0G dielectric incorporates a unique, flexible termination system that is integrated with KEMET's standard termination materials. A conductive silver epoxy is utilized between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed in order to address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible termination technology inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures.

Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. FT-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Floating Electrode with Flexible Termination (FF-CAP), and KEMET Power Solutions (KPS) product lines by providing a complete portfolio of flex mitigation solutions.

Combined with the stability of C0G dielectric and designed to accommodate all capacitance requirements, these flex-robust devices are RoHS Compliant, offer up to 5 mm of flex-bend capability and exhibit no change in capacitance with respect to time and voltage. Capacitance change with reference to ambient temperature is limited to ±30 ppm/ºC from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1206 | X | 563 | J | 3 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1812<br>1825<br>2220<br>2225 | X = Flexible Termination | Two significant digits + number of zeros.<br>Use 9 for 1.0 – 9.9 pF<br>Use 8 for 0.5 – .99 pF<br>e.g., 2.2 pF = 229<br>e.g., 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked / 2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked / 2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 0.5 pF up to 0.47 µF
- Available capacitance tolerances of ±0.10pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies and into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- Commercial & Automotive (AEC–Q200) Grades available
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, decoupling, bypass, filtering, transient voltage suppression and blocking, as well as energy storage in critical and safety relevant circuits without (integrated) current limitation, including those subject to high levels of board flexure or temperature cycling.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

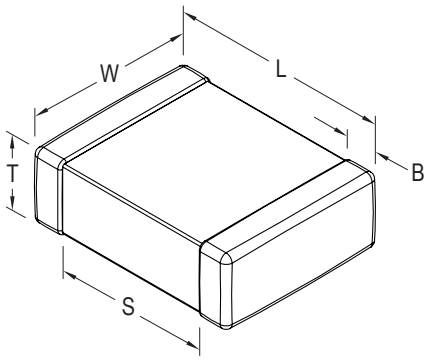
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.064) ± 0.17 (.007) | 0.80 (.032) ±0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit at 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds at 25°C) |

*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*

*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*

*[3]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and Dissipation Factor (DF) measured under the following conditions:*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1206 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | | | | | | C0603X | | | | | | | C0805X | | | | | | | C1206X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 0.50 & 0.75 pF | 508 & 758 | B | C | D | | | | | | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B | C | D | | | | | | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 10 - 91 pF* | 100 - 910* | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 100 pF | 101 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 110 - 180 pF* | 111 - 181* | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 200 - 300 pF* | 201 - 301* | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 330 pF | 331 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 360 pF | 361 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 390 pF | 391 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 430 pF | 431 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 470 pF | 471 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DD | DD | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 510 pF | 511 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 560 pF | 561 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 620 pF | 621 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 680 pF | 681 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 750 pF | 751 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 820 pF | 821 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 910 pF | 911 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DD | DD | DD | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 1,000 pF | 102 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DD | DD | DD | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 1,100 pF | 112 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 1,200 pF | 122 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 1,300 pF | 132 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DD | DD | DD | DD | DD | DR | DR | EQ | EQ | EQ | EQ | ER | ER | ER |
| 1,500 pF | 152 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DD | DD | DD | DD | DD | DR | DR | EQ | EQ | EQ | EQ | ES | ER | ER |
| 1,600 pF | 162 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DD | DD | DD | DD | DD | DR | DR | EQ | EQ | EQ | EQ | ES | ES | ES |
| 1,800 pF | 182 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DD | DD | DD | DD | DD | DR | DR | EQ | EQ | EQ | EQ | ES | ES | ES |
| 2,000 pF | 202 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | ES | ES | ES |
| 2,200 pF | 222 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | CH | CH | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | ET | ET | ET |
| 2,400 pF | 242 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | ER | ER | ER |
| 2,700 pF | 272 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | ER | ER | ER |
| 3,000 pF | 302 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DR | DR | DR | ER | ER | ER | ER | ER | EQ | EQ |
| 3,300 pF | 332 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DR | DR | DR | ER | ER | ER | ER | ET | EQ | EQ |
| 3,600 pF | 362 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DR | DD | DD | ER | ER | ER | ER | ET | EQ | EQ |
| 3,900 pF | 392 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DS | DS | DS | DS | DR | DD | DD | ER | ER | ER | ER | EF | EQ | EQ |
| 4,300 pF | 432 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DS | DS | DS | DS | DR | DD | DD | ER | ER | ER | ER | ER | EQ | EQ |
| 4,700 pF | 472 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DS | DS | DS | DS | DR | DD | DD | ER | ER | ER | ER | ER | EQ | EQ |
| 5,100 pF | 512 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | | | | DS | DS | DS | DS | DR | DD | DD | ES | ES | ES | ES | ES | EQ | EQ |
| 5,600 pF | 562 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DR | DD | DD | ES | ES | ES | ES | ES | EQ | EQ |
| 6,200 pF | 622 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DR | DG | DG | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 6,800 pF | 682 | | | | F | G | J | K | M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DR | DG | DG | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 7,500 pF | 752 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DR | DR | DG | DG | EQ | EQ | EQ | EQ | EQ | EQ | EQ |
| 8,200 pF | 822 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DR | DR | DG | DG | ER | ER | ER | ER | EQ | ER | ER |
| 9,100 pF | 912 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DR | DR | | | ER | ER | ER | ER | EQ | ER | ER |
| 10,000 pF | 103 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DR | DD | | | ES | ES | ES | ES | EQ | ER | ER |
| 12,000 pF | 123 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DR | DS | | | EQ | EQ | EQ | EQ | EQ | ES | ES |
| 15,000 pF | 153 | | | | F | G | J | K | M | CJ | CJ | CJ | | | | | DR | DR | DR | DD | DG | | | EQ | EQ | EQ | EQ | EQ | EF | EF |
| 18,000 pF | 183 | | | | F | G | J | K | M | | | | | | | | DR | DR | DR | DD | | | | EQ | EQ | EQ | EQ | EQ | EH | EH |
| 22,000 pF | 223 | | | | F | G | J | K | M | | | | | | | | DD | DD | DD | DF | | | | EQ | EQ | EQ | EQ | ER | EH | EH |
| 27,000 pF | 273 | | | | F | G | J | K | M | | | | | | | | DF | DF | DF | | | | | EQ | EQ | EQ | EQ | ET | | |
| 33,000 pF | 333 | | | | F | G | J | K | M | | | | | | | | DG | DG | DG | | | | | EQ | EQ | EQ | EQ | ET | | |
| 39,000 pF | 393 | | | | F | G | J | K | M | | | | | | | | DG | DG | DG | | | | | ER | ER | ER | ET | EH | | |
| 47,000 pF | 473 | | | | F | G | J | K | M | | | | | | | | DG | DG | DG | | | | | ER | ER | ER | ET | EH | | |
| 56,000 pF | 563 | | | | F | G | J | K | M | | | | | | | | | | | | | | | ES | ES | ES | EF | | | |
| 68,000 pF | 683 | | | | F | G | J | K | M | | | | | | | | | | | | | | | EF | EF | EF | EH | | | |
| 82,000 pF | 823 | | | | F | G | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | | |
| 0.10 µF | 104 | | | | F | G | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | | | | | | | | C0603X | | | | | | | C0805X | | | | | | | C1206X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C1210X | | | | | | | C1812X | | | | C1825X | | | | C2220X | | | | C2225X | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | FN | FN | FN | FN | FN | FN | FN | | | | | | | | | | | | | | | | |
| 10 - 91 pF* | 100 - 910* | F G J K M | FN | FN | FN | FN | FN | FN | FN | | | | | | | | | | | | | | | | |
| 100 - 430 pF* | 101 - 431* | F G J K M | FN | FN | FN | FN | FN | FN | FN | | | | | | | | | | | | | | | | |
| 470 - 910 pF* | 471 - 911* | F G J K M | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,000 pF | 102 | F G J K M | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,300 pF | 132 | F G J K M | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,500 pF | 152 | F G J K M | FN | FN | FN | FN | FN | FE | FE | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,600 pF | 162 | F G J K M | FN | FN | FN | FN | FN | FE | FE | GB | GB | GB | GB | | | | | | | | | | | | |
| 1,800 pF | 182 | F G J K M | FN | FN | FN | FN | FN | FE | FE | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,000 pF | 202 | F G J K M | FN | FN | FN | FN | FQ | FE | FE | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,200 pF | 222 | F G J K M | FN | FN | FN | FN | FQ | FZ | FZ | GB | GB | GB | GB | | | | | | | | | | | | |
| 2,400 pF | 242 | F G J K M | FN | FN | FN | FN | FQ | FQ | FQ | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | F G J K M | FN | FN | FN | FN | FQ | FQ | FQ | GB | GB | GB | GB | | | | | | | | | | | | |
| 3,000 pF | 302 | F G J K M | FN | FN | FN | FN | FQ | FA | FA | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | F G J K M | FN | FN | FN | FN | FA | FA | FA | GB | GB | GB | GB | | | | | | | | | | | | |
| 3,600 pF | 362 | F G J K M | FN | FN | FN | FN | FA | FA | FA | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | F G J K M | FN | FN | FN | FN | FA | FA | FA | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | |
| 4,300 pF | 432 | F G J K M | FN | FN | FN | FN | FA | FA | FA | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | F G J K M | FA | FA | FA | FA | FZ | FZ | FZ | GB | GB | GD | GD | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| 5,100 pF | 512 | F G J K M | FN | FN | FN | FN | FZ | FZ | FZ | | | | | | | | | | | | | KE | KE | KE | KE |
| 5,600 pF | 562 | F G J K M | FN | FN | FN | FN | FZ | FZ | FZ | GB | GB | GH | GH | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| 6,200 pF | 622 | F G J K M | FN | FN | FN | FN | FZ | FN | FN | | | | | | | | | | | | | KE | KE | KE | KE |
| 6,800 pF | 682 | F G J K M | FN | FN | FN | FN | FZ | FN | FN | GB | GB | GJ | GJ | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 7,500 pF | 752 | F G J K M | FQ | FQ | FQ | FQ | FQ | FN | FN | | | | | | | | | | | | | KE | KE | KE | KE |
| 8,200 pF | 822 | F G J K M | FQ | FQ | FQ | FQ | FQ | FN | FN | GB | GH | GB | GB | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 9,100 pF | 912 | F G J K M | FE | FE | FE | FE | FE | FN | FN | | | | | | | | | | | | | KE | KE | KE | KE |
| 10,000 pF | 103 | F G J K M | FA | FA | FA | FA | FA | FN | FN | GB | GH | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 12,000 pF | 123 | F G J K M | FZ | FZ | FZ | FZ | FN | FN | FN | GB | GG | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 15,000 pF | 153 | F G J K M | FZ | FZ | FZ | FZ | FN | FQ | FQ | GB | GB | GB | GB | HB | HB | | | JE | JE | JB | | KE | KE | KE | KE |
| 18,000 pF | 183 | F G J K M | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | HB | HE | | | JE | JE | JB | | KE | KE | | |
| 22,000 pF | 223 | F G J K M | FN | FN | FN | FN | FN | FA | FA | GB | GB | GB | GB | HB | HE | | | JE | JB | JB | | KE | KE | | |
| 27,000 pF | 273 | F G J K M | FN | FN | FN | FN | FN | FZ | FZ | GB | GB | GB | GB | HB | HG | | | JE | JB | JB | | KE | KE | | |
| 33,000 pF | 333 | F G J K M | FN | FN | FN | FN | FN | FU | FU | GB | GB | GB | GB | | | | | JB | JB | JB | | KE | | | |
| 39,000 pF | 393 | F G J K M | FN | FN | FN | FN | FE | FU | FU | GB | GB | GB | GB | | | | | JB | JB | JB | | | | | |
| 47,000 pF | 473 | F G J K M | FN | FN | FN | FN | FE | FJ | FJ | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 56,000 pF | 563 | F G J K M | FN | FN | FN | FN | FA | | | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 68,000 pF | 683 | F G J K M | FN | FN | FN | FQ | FZ | | | GB | GB | GK | GK | | | | | JB | JB | JB | | | | | |
| 82,000 pF | 823 | F G J K M | FQ | FQ | FQ | FA | FU | | | GB | GB | GM | GM | | | | | JB | JB | JB | | | | | |
| 0.10 µF | 104 | F G J K M | FE | FE | FE | FZ | FM | | | GB | GD | GM | GM | | | | | JB | JB | JD | | | | | |
| 0.12 µF | 124 | F G J K M | FZ | FZ | FZ | FU | | | | GB | GH | | | | | | | JB | JB | JD | | | | | |
| 0.15 µF | 154 | F G J K M | FU | FU | FU | FM | | | | GD | GN | | | | | | | JB | JB | JG | | | | | |
| 0.18 µF | 184 | F G J K M | FJ | FJ | FJ | | | | | GH | | | | | | | | JB | JD | JG | | | | | |
| 0.22 µF | 224 | F G J K M | FK | FK | FK | | | | | GK | | | | | | | | JB | JD | | | | | | |
| 0.27 µF | 274 | F G J K M | | | | | | | | | | | | | | | | JB | JF | | | | | | |
| 0.33 µF | 334 | F G J K M | | | | | | | | | | | | | | | | JD | JG | | | | | | |
| 0.39 µF | 394 | F G J K M | | | | | | | | | | | | | | | | JG | | | | | | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | | | | JG | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | | 200 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | | 2 | 5 | 1 | 2 | A |
| | | Case Size/Series | C1210X | | | | | | | C1812X | | | | C1825X | | | | C2220X | | | | C2225X | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| CH | 0603 | 0.85 ± 0.07 | 4,000 | 10,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DS | 0805 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ET | 1206 | 1.10 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JG | 2220 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

[1] *The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*

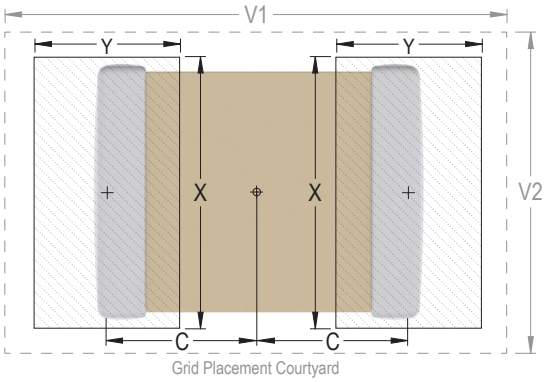
[2] *A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351 (mm)

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

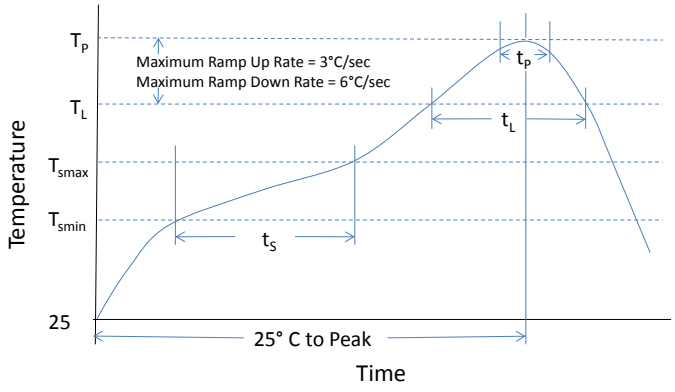
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



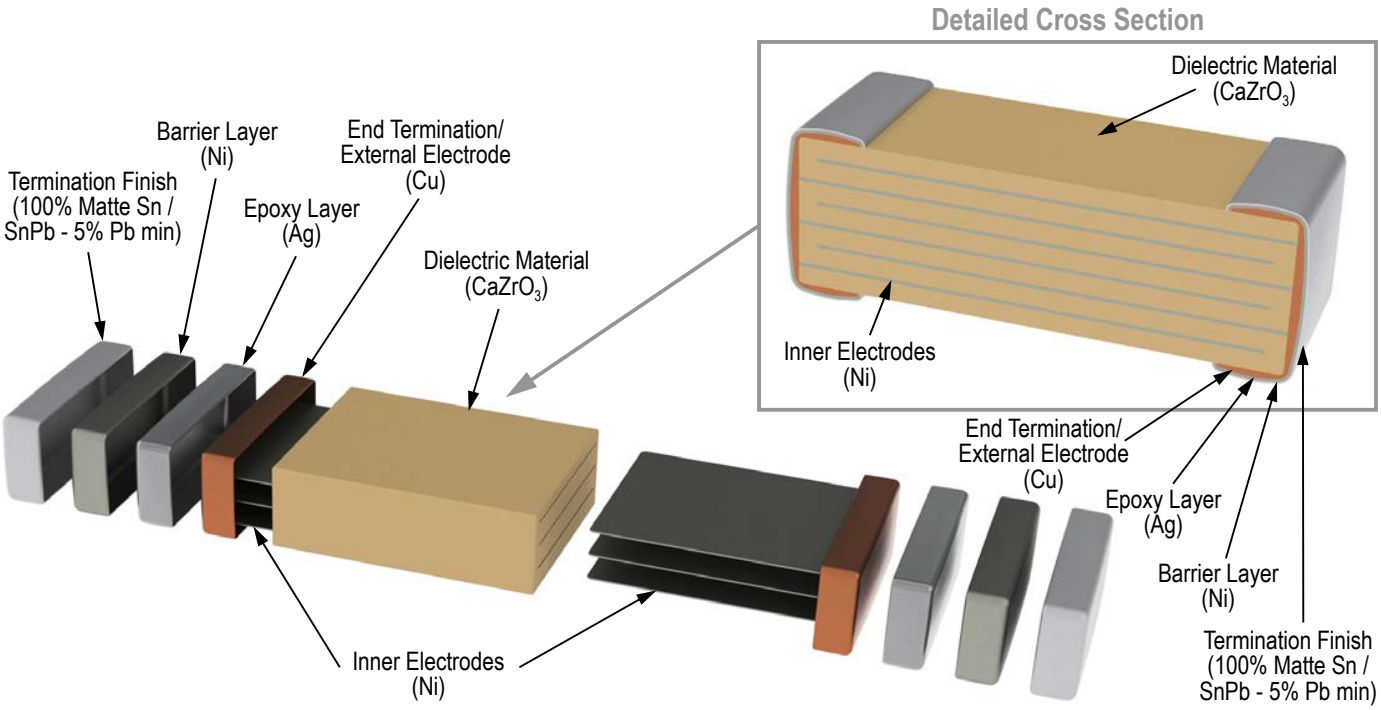
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Flexible Termination System (FT-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial Grade)

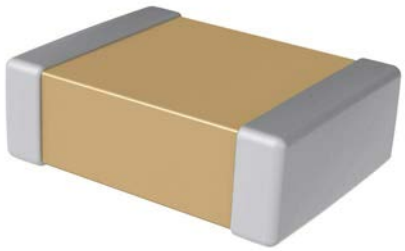
## Overview

KEMET's Flexible Termination (FT-CAP) multilayer ceramic capacitor in X7R dielectric incorporates a unique, flexible termination system that is integrated with KEMET's standard termination materials. A conductive silver epoxy is utilized between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed in order to address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible termination technology inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures.

Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. FT-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Floating Electrode with Flexible Termination (FF-CAP) and KEMET Power Solutions (KPS) product lines by providing a complete portfolio of flex mitigation solutions.

Combined with the stability of an X7R dielectric and designed to accommodate all capacitance requirements, these flex-robust devices are RoHS-compliant, offer up to 5 mm of flex-bend capability and exhibit a predictable change in capacitance with respect to time and voltage. Capacitance change with reference to ambient temperature is limited to ±15% from −55°C to +125°C.

In addition to commercial grade, automotive grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1206 | X | 106 | K | 4 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec)[2] |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

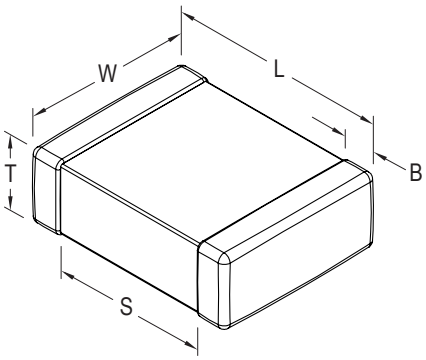
## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- High capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 180 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Automotive (AEC-Q200) grade available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 180 pF | 181 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 220 pF | 221 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 270 pF | 271 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 470 pF | 471 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | |
| 560 pF | 561 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 680 pF | 681 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 820 pF | 821 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,200 pF | 122 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,500 pF | 152 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,800 pF | 182 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 2,200 pF | 222 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 2,700 pF | 272 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 3,300 pF | 332 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 3,900 pF | 392 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 4,700 pF | 472 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 5,600 pF | 562 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 6,800 pF | 682 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 8,200 pF | 822 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 10,000 pF | 103 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 12,000 pF | 123 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 15,000 pF | 153 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 18,000 pF | 183 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 22,000 pF | 223 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 27,000 pF | 273 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 33,000 pF | 333 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 39,000 pF | 393 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | ER | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 47,000 pF | 473 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DS | DG | | EQ | EQ | EQ | EQ | EQ | ER | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 56,000 pF | 563 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | DG | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 68,000 pF | 683 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 82,000 pF | 823 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FQ | FA | FA |
| 0.10 µF | 104 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | EM | EM | FN | FN | FN | FN | FN | FX | FZ | FZ |
| 0.12 µF | 124 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DD | DG | | | ER | ER | ER | ER | ER | ER | EU | | FN | FN | FN | FN | FN | FX | FU | FU |
| 0.15 µF | 154 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DD | DG | | | ER | ER | ER | ER | ER | ER | EU | | FQ | FQ | FQ | FQ | FQ | FX | FM | FM |
| 0.18 µF | 184 | J K M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DG | DG | | | ER | ER | ER | ER | ER | ER | | | FQ | FQ | FQ | FQ | FQ | FX | FK | FK |
| 0.22 µF | 224 | J K M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DG | DG | | | ER | ER | ER | ER | ER | ER | | | FQ | FQ | FQ | FQ | FQ | FX | FK | FK |
| 0.27 µF | 274 | J K M | CJ | CJ | CJ | | | | | DD | DD | DD | DD | DD | | | | EQ | EQ | EQ | EQ | ER | EM | | | FQ | FQ | FQ | FQ | FQ | FX | | |
| 0.33 µF | 334 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DD | | | | EQ | EQ | EQ | EQ | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.39 µF | 394 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DS | | | | EQ | EQ | EQ | EQ | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.47 µF | 474 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DS | | | | ER | ER | ER | ER | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.56 µF | 564 | J K M | | | | | | | | DD | DD | DD | DG | DH | | | | ES | ES | ES | ES | ER | | | | FX | FX | FX | FX | FX | FA | | |
| 0.68 µF | 684 | J K M | | | | | | | | DD | DD | DD | DG | DH | | | | ET | ET | ET | ET | ES | | | | FX | FX | FX | FX | FX | FZ | | |
| 0.82 µF | 824 | J K M | | | | | | | | DD | DD | DD | DG | | | | | EF | EF | EF | EF | ES | | | | FA | FA | FA | FA | FA | FL | | |
| 1.0 µF | 105 | J K M | | | | | | | | DD | DD | DD | DG | | | | | EF | EF | EF | EU | ES | | | | FU | FU | FU | FU | FU | FM | | |
| 1.2 µF | 125 | J K M | | | | | | | | DS | DS | DS | | | | | | ES | ES | ES | EU | EH | | | | FU | FU | FU | FU | FZ | | | |
| 1.5 µF | 155 | J K M | | | | | | | | DG | DG | DG | | | | | | EF | EF | EF | EU | EH | | | | FU | FU | FU | FU | FZ | | | |
| 1.8 µF | 185 | J K M | | | | | | | | DG | DG | DG | | | | | | ES | ES | ES | EF | EH | | | | FU | FU | FU | FU | FZ | | | |
| 2.2 µF | 225 | J K M | | | | | | | | DG | DG | DG | | | | | | ES | ES | ES | EF | EH | | | | FJ | FJ | FJ | FJ | FZ | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | | FE | FE | FE | FZ | FU | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | ES | ES | ES | EH | | | | | FA | FA | FA | FM | FM | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | FZ | FZ | FZ | FZ | FK | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | FQ | FQ | FQ | FZ | FS | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FA | FA | FA | FU | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |

## Table 1A – Capacitance Range/Selection Waterfall (0603 – 1210 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FZ | FZ | FZ | FM | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FU | FU | FU | FK | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FU | FU | FU | FS | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | FS | FS | | | | | | |
| 22 µF | 226 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |

## Table 1B – Capacitance Range/Selection Waterfall (1808 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J K M | LD | LD | LD | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J K M | LD | LD | LD | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 8,200 pF | 822 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 10,000 pF | 103 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 12,000 pF | 123 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 18,000 pF | 183 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 22,000 pF | 223 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 27,000 pF | 273 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 33,000 pF | 333 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 39,000 pF | 393 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 47,000 pF | 473 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 56,000 pF | 563 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 68,000 pF | 683 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 82,000 pF | 823 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.10 µF | 104 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.12 µF | 124 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.15 µF | 154 | J K M | LD | | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.18 µF | 184 | J K M | LD | | | | GB | GB | GB | GF | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.22 µF | 224 | J K M | | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.27 µF | 274 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.33 µF | 334 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.39 µF | 394 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.47 µF | 474 | J K M | | | | | GB | GB | GG | GJ | GJ | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KD | KD |
| 0.56 µF | 564 | J K M | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JC | JD | JD | KB | KC | KD | KD |
| 0.68 µF | 684 | J K M | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JD | JD | JD | KB | KC | KD | KD |
| 0.82 µF | 824 | J K M | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KC | KE | KE |
| 1.0 µF | 105 | J K M | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KD | KE | KE |
| 1.2 µF | 125 | J K M | | | | | | | | | | HB | | | | JC | JC | | | | KB | KE | KE | KE |
| Cap | Cap Code | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1808 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | HC | | | | JC | JC | | | | KC | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | HD | | | | JD | JD | | | | KD | | | |
| 2.2 µF | 225 | J K M | | | | | | | | | | HF | | | | JF | JF | | | | KD | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | | | | | GK | GK | | | | | | | | | | | | | | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | | | | | GK | | | | | | | | | JF | JO | | | | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | JO | JO | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | | | | | | | | | | | | | | JO | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DS | 0805 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ET | 1206 | 1.10 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FX | 1210 | 0.95 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HC | 1825 | 1.15 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| KB | 2225 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

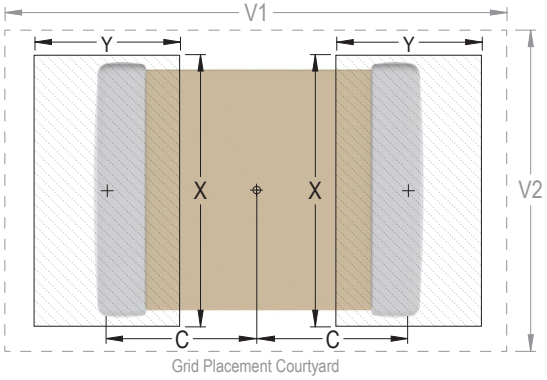
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

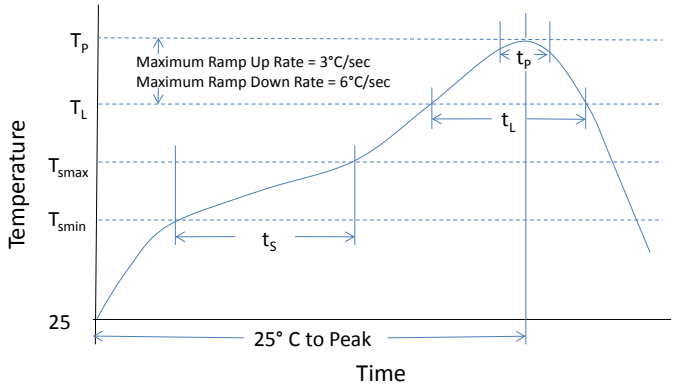
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



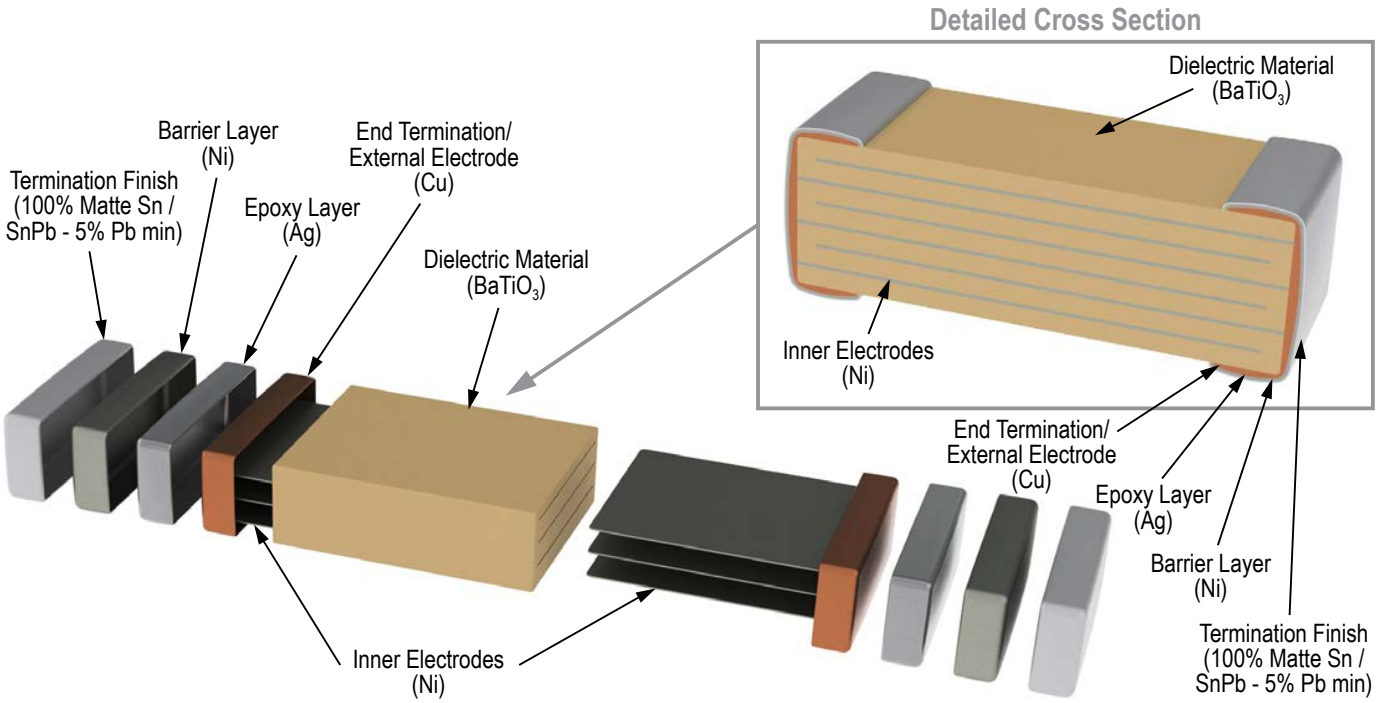
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



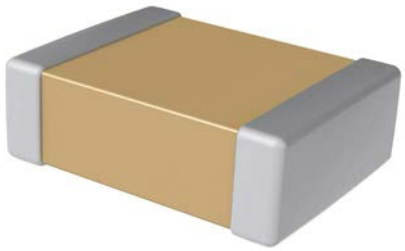
# Floating Electrode Design with Flexible Termination System (FF-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Floating Electrode with Flexible Termination capacitor (FF-CAP) combines two existing KEMET technologies– Floating Electrode and Flexible Termination. The floating electrode component utilizes a cascading internal electrode design configured to form multiple capacitors in series within a single monolithic structure. This unique configuration results in enhanced voltage and ESD performance over standard capacitor designs while allowing for a fail-open condition if mechanically damaged (cracked). The flexible termination component utilizes a conductive silver epoxy between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. Both technologies address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling.

Although neither technology can eliminate the potential for mechanical damage that may propagate during extreme environmental and/or handling conditions, the combination of these two technologies provide the ultimate level of protection against a low IR or short circuit condition. The FF-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Flexible Termination (FT-CAP) and KEMET Power Solutions (KPS) product lines by providing an ultimate fail-safe design optimized for low to mid range capacitance values. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 0805 | Y | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1812 | Y = Floating Electrode with Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Floating Electrode/fail open design
- Low to mid capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 180 pF to 0.22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial & Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

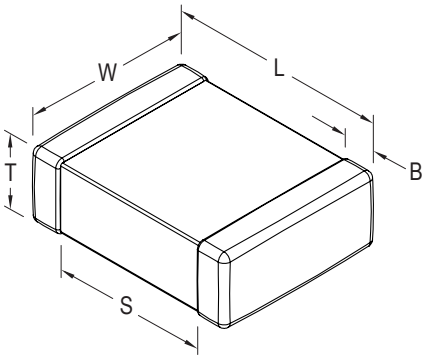
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 0805 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | | C0603Y | | | | | | | C0805Y | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | |
| 180 pF | 181 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 220 pF | 221 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 270 pF | 271 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 330 pF | 331 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 390 pF | 391 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 470 pF | 471 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 560 pF | 561 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 680 pF | 681 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 820 pF | 821 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,000 pF | 102 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,200 pF | 122 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,500 pF | 152 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,800 pF | 182 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 2,200 pF | 222 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 2,700 pF | 272 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 3,300 pF | 332 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 3,900 pF | 392 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 4,700 pF | 472 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 5,600 pF | 562 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 6,800 pF | 682 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 8,200 pF | 822 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 10,000 pF | 103 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | DR |
| 12,000 pF | 123 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | DR |
| 15,000 pF | 153 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 18,000 pF | 183 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 22,000 pF | 223 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 27,000 pF | 273 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 33,000 pF | 333 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 39,000 pF | 393 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 47,000 pF | 473 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | DD | DD | DD | DD | DD | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | DD | DD | DD | DD | DD | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | DG | DG | DG | DG | DG | | | |
| 0.10 µF | 104 | J | K | M | | | | | | | | DG | DG | DG | DG | DG | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | | | C0603Y | | | | | | | C0805Y | | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1206 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1206Y | | | | | | | | C1210Y | | | | | | | | C1812Y | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,200 pF | 122 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 2,700 pF | 272 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 3,300 pF | 332 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 3,900 pF | 392 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 4,700 pF | 472 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 5,600 pF | 562 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 6,800 pF | 682 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 8,200 pF | 822 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 10,000 pF | 103 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 12,000 pF | 123 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 15,000 pF | 153 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 18,000 pF | 183 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 22,000 pF | 223 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 27,000 pF | 273 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 33,000 pF | 333 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | | | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 39,000 pF | 393 | J K M | EQ | EQ | EQ | EQ | EQ | ER | | | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 47,000 pF | 473 | J K M | EQ | EQ | EQ | EQ | EQ | ER | | | FN | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | GB |
| 56,000 pF | 563 | J K M | EQ | EQ | EQ | EQ | EQ | EQ | | | FN | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | GB |
| 68,000 pF | 683 | J K M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FN | | | GB | GB | GB | GB | GB |
| 82,000 pF | 823 | J K M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FQ | | | GB | GB | GB | GB | GB |
| 0.10 µF | 104 | J K M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FX | | | GB | GB | GB | GB | GB |
| 0.12 µF | 124 | J K M | ER | ER | ER | ER | ER | | | | FN | FN | FN | FN | FN | | | | GB | GB | GB | GB | GB |
| 0.15 µF | 154 | J K M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| 0.18 µF | 184 | J K M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| 0.22 µF | 224 | J K M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1206Y | | | | | | | | C1210Y | | | | | | | | C1812Y | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FX | 1210 | 0.95 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

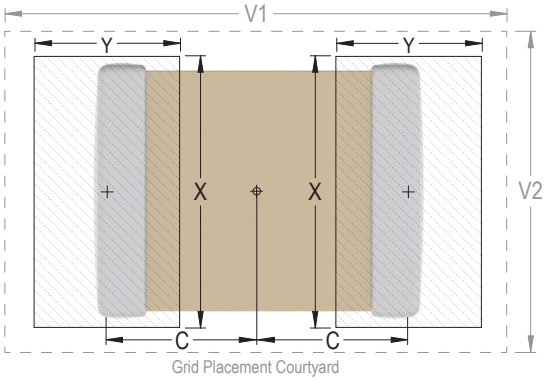
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

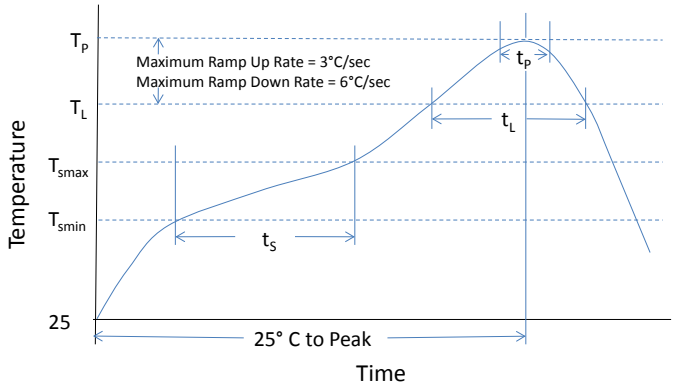
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



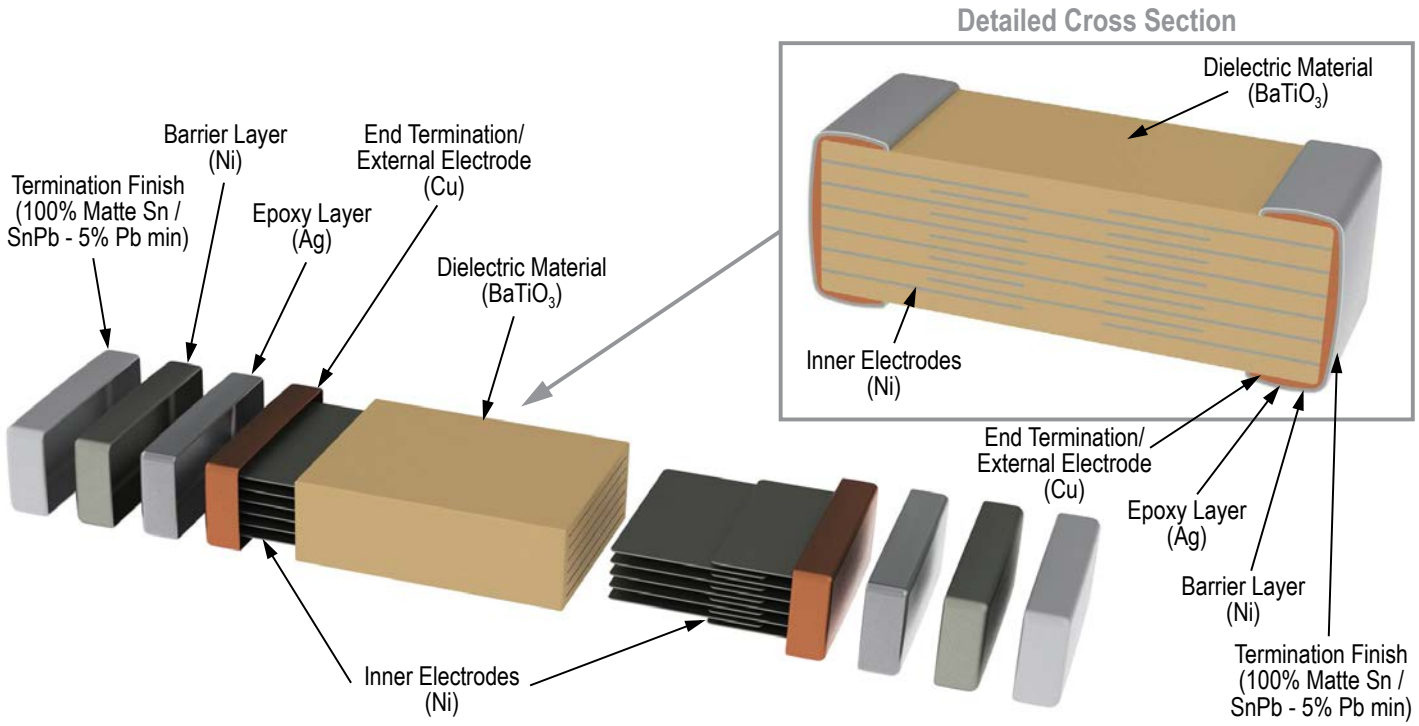
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# Flexible Termination System (FT-CAP), Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade)

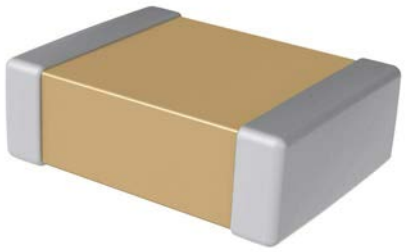
## Overview

KEMET's Flexible Termination (FT-CAP) Multilayer Ceramic Capacitor in Ultra-Stable X8R dielectric incorporates a unique, flexible termination system that is integrated with KEMET's standard termination materials. A conductive silver epoxy is utilized between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed in order to address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible termination technology inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures.

Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. FT-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Floating Electrode with Flexible Termination (FF-CAP), and KEMET Power Solutions (KPS) product lines by providing a complete portfolio of flex mitigation solutions.

Combined with the stability of KEMET's Ultra-Stable high temperature dielectric technology, these flex-robust devices are RoHS Compliant, offer up to 5 mm of flex-bend capability and feature a 150°C maximum operating temperature. Ultra-Stable X8R dielectric offers the same temperature capability as conventional X8R but without the capacitance loss due to applied DC voltage. These devices exhibit no change in capacitance with respect to voltage and boast a minimal change in capacitance with reference to ambient temperature. They are also suitable replacements for higher capacitance and larger footprint devices that fail to offer capacitance stability. Capacitance change with respect to temperature is limited to ±15% from −55°C to +150°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1206 | X | 104 | J | 3 | H | A | C | AUTO |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Reated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1812 | X = Flexible Termination | Two significant digits + number of zeros. | F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 3 = 25<br>5 = 50<br>1 = 100 | H = Ultra-Stable X8R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*

*[1] SnPb termination finish option is not available on Automotive Grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade[1]** | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade[3]** | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Superior flex performance (up to 5 mm)
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 25 V, 50 V, and 100 V
- Capacitance offerings ranging from 430 pF to 0.22 µF
- Available capacitance tolerances of ±1%, ±2%, ±5%, ±10%, and ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Non-polar device, minimizing installation concerns
- Commercial & Automotive (AEC–Q200) Grades available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include decoupling, bypass, filtering and transient voltage suppression in critical and safety relevant circuits without (integrated) current limitation including those subject to high levels of board flexure or temperature cycling.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

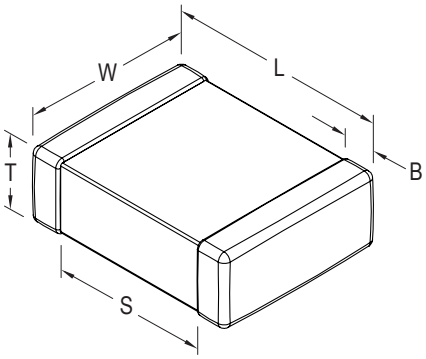
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ± 0.17 (0.007) | 0.80 (0.032) ± 0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ± 0.30 (0.012) | 1.25 (0.049) ± 0.30 (0.012) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ± 0.40 (0.016) | 1.60 (0.063) ± 0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ± 0.40 (0.016) | 2.60 (0.102) ± 0.30 (0.012) | | 0.60 (0.024) ± 0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.178) ± 0.40 (0.016) | 3.20 (0.126) ± 0.30 (0.012) | | 0.70 (0.028) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 ±0.2 Vrms if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Ultra-Stable X8R | All | All | 3.0 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | | | | C0603X | | | C0805X | | | C1206X | | | C1210X | | | C1812X | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | |
| 430 pF | 431 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 470 pF | 471 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 510 pF | 511 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 560 pF | 561 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 620 pF | 621 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 680 pF | 681 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 750 pF | 751 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 820 pF | 821 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 910 pF | 911 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,000 pF | 102 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,100 pF | 112 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,200 pF | 122 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,300 pF | 132 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,500 pF | 152 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,600 pF | 162 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,800 pF | 182 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 2,000 pF | 202 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,200 pF | 222 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,400 pF | 242 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,700 pF | 272 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,000 pF | 302 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,300 pF | 332 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,600 pF | 362 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,900 pF | 392 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 4,300 pF | 432 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 4,700 pF | 472 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 5,100 pF | 512 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 5,600 pF | 562 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 6,200 pF | 622 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 6,800 pF | 682 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 7,500 pF | 752 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 8,200 pF | 822 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 9,100 pF | 912 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 10,000 pF | 103 | F | G | J | K | M | CJ | | | DR | DR | DD | EQ | EQ | EQ | | | | | |
| 12,000 pF | 123 | F | G | J | K | M | | | | DR | DR | DS | EQ | EQ | EQ | FN | FN | FN | | |
| 15,000 pF | 153 | F | G | J | K | M | | | | DR | DD | DG | EQ | EQ | EQ | FN | FN | FN | GB | GB |
| 18,000 pF | 183 | F | G | J | K | M | | | | DR | DD | | EQ | EQ | EQ | FN | FN | FN | GB | GB |
| 22,000 pF | 223 | F | G | J | K | M | | | | DD | DF | | EQ | EQ | ER | FN | FN | FN | GB | GB |
| 27,000 pF | 273 | F | G | J | K | M | | | | DF | | | EQ | EQ | ET | FN | FN | FN | GB | GB |
| 33,000 pF | 333 | F | G | J | K | M | | | | DG | | | EQ | EQ | ET | FN | FN | FN | GB | GB |
| 47,000 pF | 473 | F | G | J | K | M | | | | | | | ER | ET | EH | FN | FN | FE | GB | GB |
| 56,000 pF | 563 | F | G | J | K | M | | | | | | | ES | EF | EH | FN | FN | FA | GB | GB |
| 68,000 pF | 683 | F | G | J | K | M | | | | | | | EF | EH | | FN | FQ | FZ | GB | GB |
| 82,000 pF | 823 | F | G | J | K | M | | | | | | | EH | EH | | FQ | FA | FU | GB | GB |
| 100,000 pF | 104 | F | G | J | K | M | | | | | | | EH | | | FE | FZ | FM | GB | GD |
| 120,000 pF | 124 | F | G | J | K | M | | | | | | | | | | FZ | FU | | GB | GH |
| 150,000 pF | 154 | F | G | J | K | M | | | | | | | | | | FU | FM | | GD | GN |
| 180,000 pF | 184 | F | G | J | K | M | | | | | | | | | | FJ | | | GH | |
| 220,000 pF | 224 | F | G | J | K | M | | | | | | | | | | | | | GK | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | | | | | C0603X | | | C0805X | | | C1206X | | | C1210X | | | C1812X | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DS | 0805 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ET | 1206 | 1.10 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

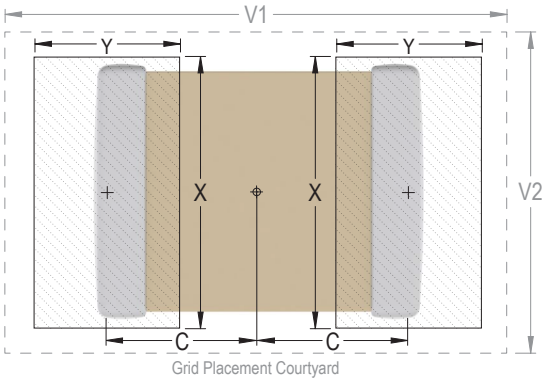
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351 (mm)

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

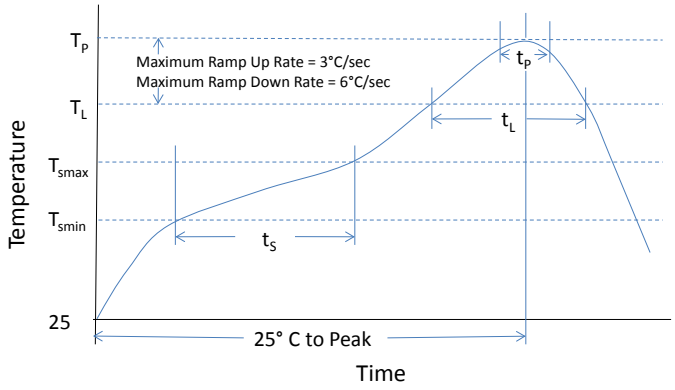
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



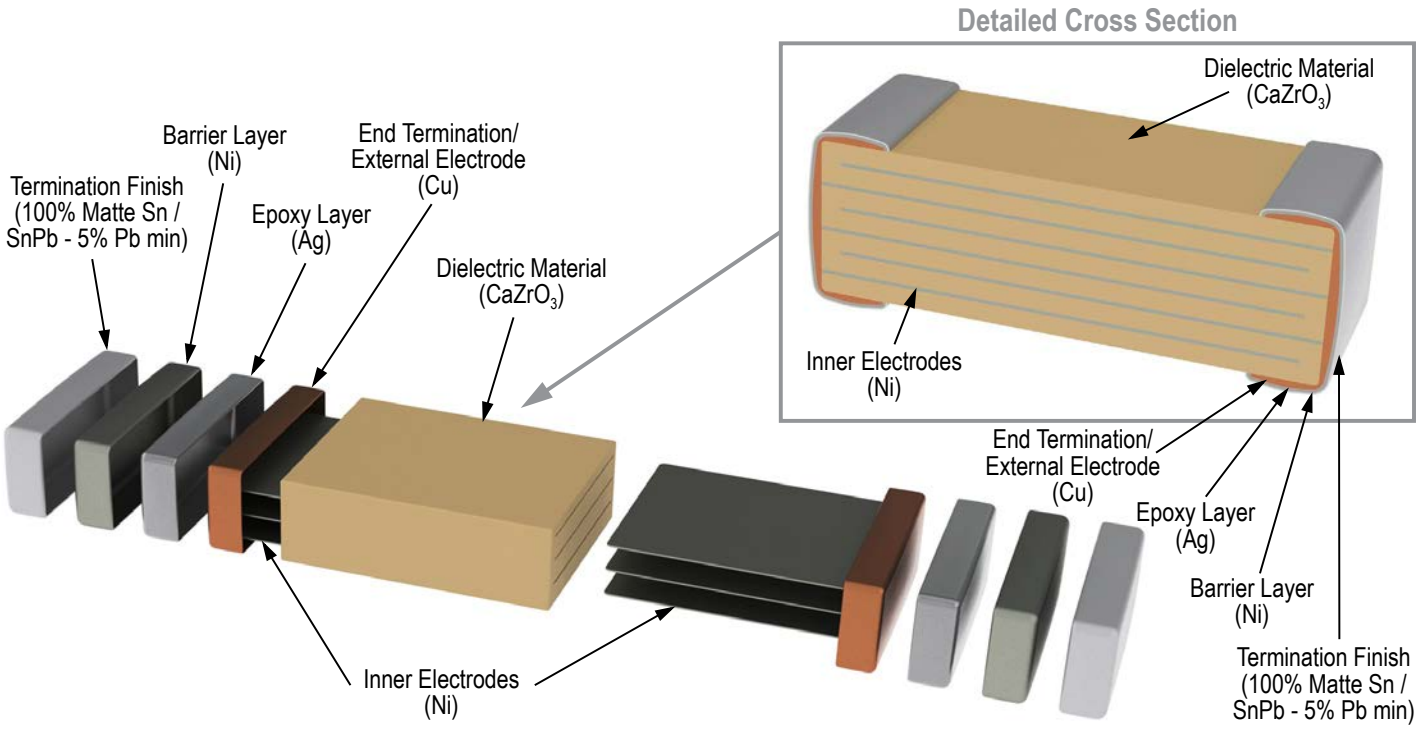
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

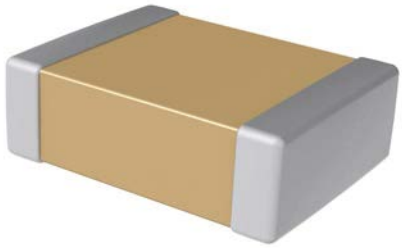
# High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET's X8L dielectric features a 150°C maximum operating temperature and is considered "general purpose high temperature." These components are fixed, ceramic dielectric capacitors suited for high temperature bypass and decoupling applications or frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X8L exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, −40% from 125°C to 150°C.

Driven by the demand for a more robust and reliable component, X8L dielectric capacitors were developed for critical applications where reliability at higher operating temperatures are a concern. These capacitors are widely used in automotive circuits as well as general high temperature applications. Concerned with flex cracks resulting from excessive tensile and shear stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

In addition to commercial grade, automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1210 | X | 106 | K | 8 | N | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210 | C = Standard<br>X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *The flexible termination option is not available on EIA 0402 case size product. "C" must be used in the 6th character position when ordering this case size.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*

[2] *SnPb termination finish option is not available on Automotive Grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, and 1210 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.012 µF to 10 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial & Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request

## Applications

Typical applications include use in extreme environments such as down-hole oil exploration, under-hood automotive, military and aerospace.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

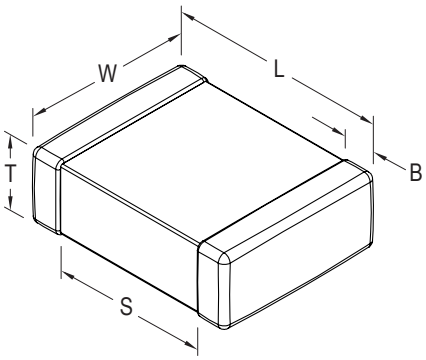
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Standard Termination – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

## Dimensions – Flexible Termination – Millimeters (Inches)

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ±0.17 (0.007) | 0.80 (0.032) ±0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.30 (0.012) | 1.25 (0.049) ±0.30 (0.012) | | 0.50 (0.020) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ±0.40 (0.016) | 1.60 (0.063) ±0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ±0.40 (0.016) | 2.60 (0.102) ±0.30(0.012) | | 0.60 (0.024) ±0.25 (0.010) | | Solder Reflow Only |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Insulation Resistance Limit Table (X8L Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < .012 µF | ≥ .012 µF |
| 0603 | < .047 µF | ≥ .047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 22,000 pF | 223 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 27,000 pF | 273 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 39,000 pF | 393 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | J | K | M | BB | BB | | | CF | CF | CF | CF | CF | | | | | | | | | | | | | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.12 µF | 124 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | J | K | M | | | | | CF | CF | CF | CF | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.18 µF | 184 | J | K | M | | | | | CF | CF | | | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.22 µF | 224 | J | K | M | | | | | CF | CF | | | | DP | DP | DP | DP | DG | | | | | | | | | | |
| 0.27 µF | 274 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.33 µF | 334 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.39 µF | 394 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | | | | | | FD | FD | FD | FD | FD |
| 0.47 µF | 474 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | EG | EG | EG | EG | EG | FD | FD | FD | FD | FD |
| 0.56 µF | 564 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FF | FF | FF | FF | FF |
| 0.68 µF | 684 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FG | FG | FG | FG | FG |
| 0.82 µF | 824 | J | K | M | | | | | | | | | | DG | DG | DG | | | | | | | | FL | FL | FL | FL | FL |
| 1.0 µF | 105 | J | K | M | | | | | | | | | | DG | DG | DG | | | ED | ED | ED | ED | | FM | FM | FM | FM | FM |
| 1.2 µF | 125 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.5 µF | 155 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.8 µF | 185 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.2 µF | 225 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.7 µF | 275 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FH | FH | |
| 3.3 µF | 335 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FM | FM | FM | FM | |
| 3.9 µF | 395 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FK | FK | |
| 4.7 µF | 475 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FS | FS | |
| 5.6 µF | 565 | J | K | M | | | | | | | | | | | | | | | | | | | | FH | FH | FH | | |
| 6.8 µF | 685 | J | K | M | | | | | | | | | | | | | | | | | | | | FM | FM | FM | | |
| 8.2 µF | 825 | J | K | M | | | | | | | | | | | | | | | | | | | | FK | FK | FK | | |
| 10 µF | 106 | J | K | M | | | | | | | | | | | | | | | | | | | | FS | FS | FS | | |
| Cap | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Case Size/Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

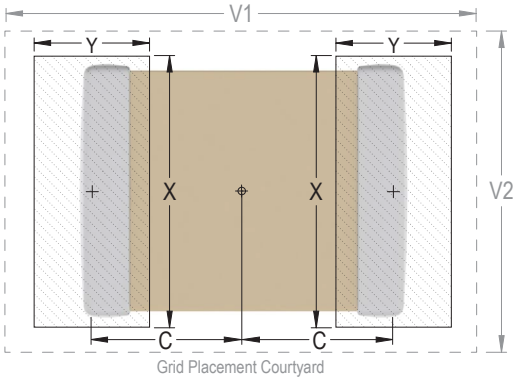
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

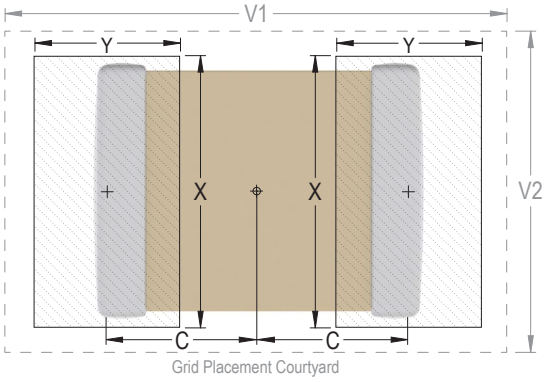


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.65 | 1.90 | 5.90 | 2.90 | 1.50 | 1.45 | 1.80 | 5.00 | 2.30 | 1.40 | 1.25 | 1.70 | 4.30 | 2.00 |
| 1210 | 3225 | 1.60 | 1.65 | 2.80 | 5.90 | 3.80 | 1.50 | 1.45 | 2.70 | 5.00 | 3.20 | 1.40 | 1.25 | 2.60 | 4.30 | 2.90 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

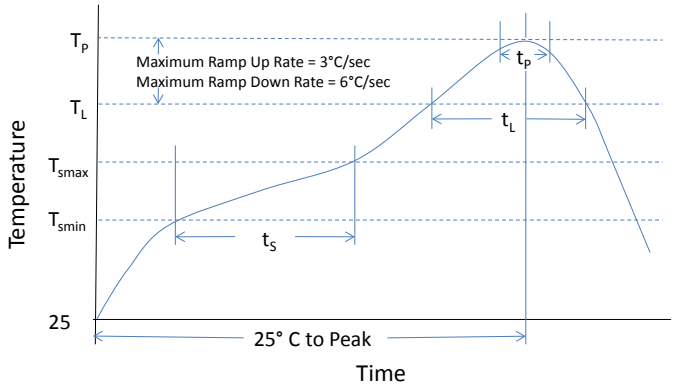
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



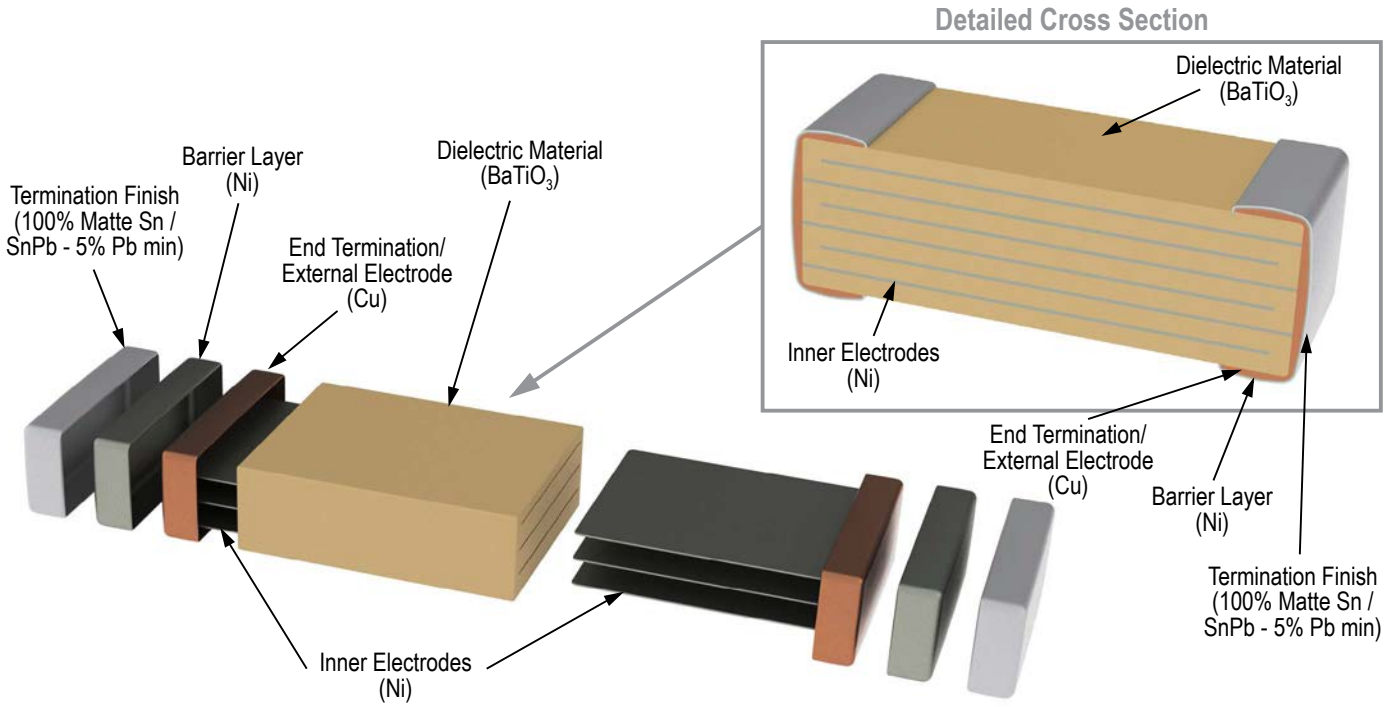
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

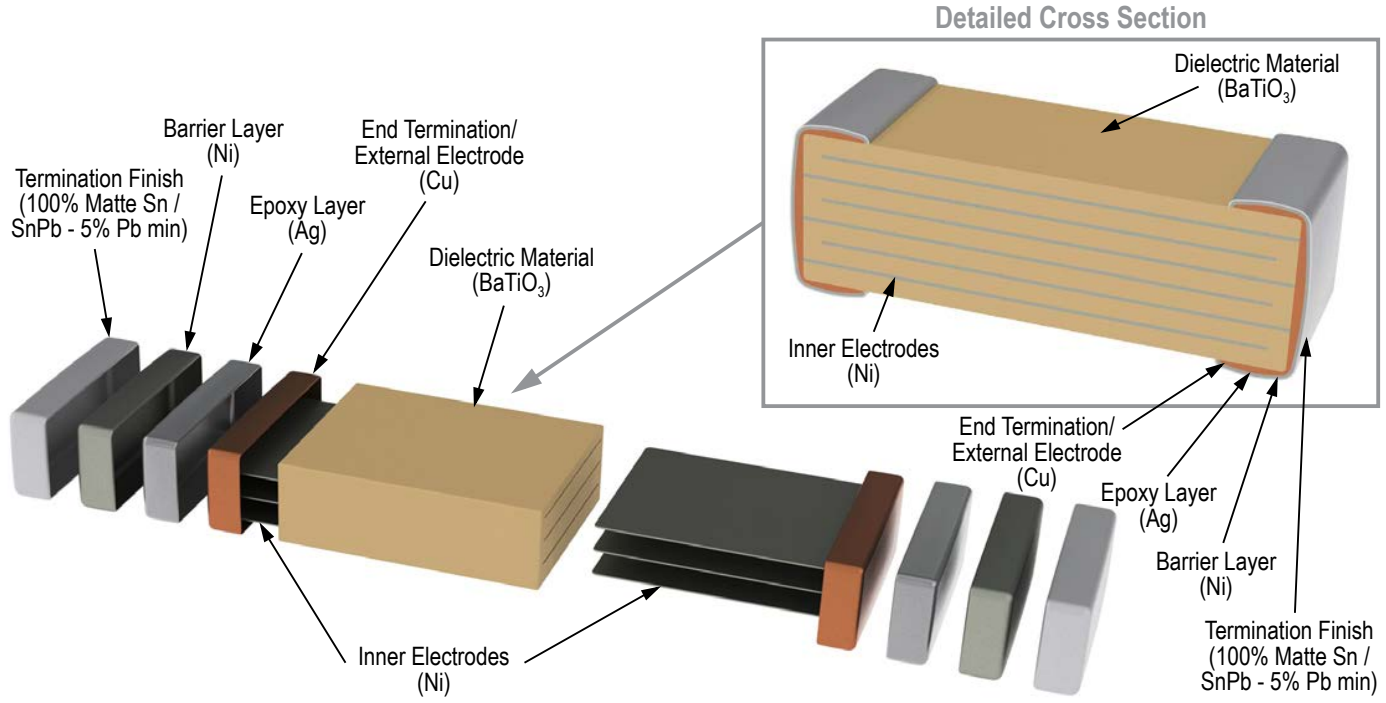
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# High Voltage with Flexible Termination System (HV FT-CAP), C0G Dielectric, 500 – 3,000 VDC (Commercial Grade)

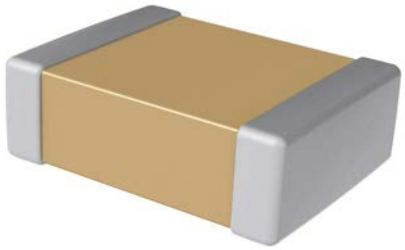
## Overview

KEMET's High Voltage with Flexible Termination (HV FT-CAP) surface mount MLCCs in C0G dielectric address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Featuring several of the highest CV (capacitance/voltage) values available in the industry, these devices utilize a pliable and conductive silver epoxy between the base metal and nickel barrier layers of the termination system. The addition of this epoxy layer inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

KEMET's high voltage surface mount MLCCs in C0G dielectric feature a 125°C maximum operating temperature and offer the most stable voltage and temperature performance of all ceramic dielectric materials. C0G (NP0) dielectric capacitors exhibit no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +125°C.

These devices exhibit low ESR at high frequencies and find conventional use as snubbers or filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage MLCC's the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 2225 | X | 393 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X= Flexible Termination | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

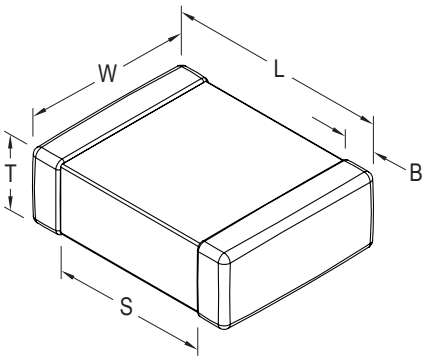
## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220 and 2225 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV and 3 KV
- Capacitance offerings ranging from 1 pF to 39 nF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10% and ±20%
- No piezoelectric noise
- Extremely low ESR & ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies & into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- Automotive (AEC-Q200) grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1,000 V<br>120% of rated voltage for voltage rating of ≥ 1,000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit at 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 seconds at 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*

*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*

*[3] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 169* | B C D | DG | DG | DG | | | | | | | | | | | LB | LB | LB | LB | LB | LB | LB |
| 10 pF | 100 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 11 pF | 110 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 12 pF | 120 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 13 pF | 130 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 15 pF | 150 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 16 pF | 160 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 18 pF | 180 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 20 pF | 200 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 22 pF | 220 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 24 pF | 240 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 27 pF | 270 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 30 pF | 300 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 33 pF | 330 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 36 pF | 360 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 39 pF | 390 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 43 pF | 430 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 47 pF | 470 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 51 pF | 510 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 56 pF | 560 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 62 pF | 620 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 68 pF | 680 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 75 pF | 750 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 82 pF | 820 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 91 pF | 910 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 100 pF | 101 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB |
| 110 pF | 111 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB |
| 120 pF | 121 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LB |
| 130 pF | 131 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LC |
| 150 pF | 151 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LC |
| 160 pF | 161 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | LC |
| 180 pF | 181 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | LC |
| 200 pF | 201 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | |
| 220 pF | 221 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | |
| 240 pF | 241 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LB | LC | LC | |
| 270 pF | 271 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 300 pF | 301 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 330 pF | 331 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 360 pF | 361 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FS | LA | LA | LA | LB | LA | LC | |
| 390 pF | 391 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FS | LA | LA | LA | LB | LA | LC | |
| 430 pF | 431 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 470 pF | 471 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 510 pF | 511 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 560 pF | 561 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 620 pF | 621 | F G J K M | DG | | | ES | ES | EU | | | FZ | FM | FM | FS | FS | LA | LB | LB | LA | LC | | |
| 680 pF | 681 | F G J K M | DG | | | ES | ES | EU | | | FZ | FM | FM | FS | FS | LB | LB | LB | LA | LC | | |
| 750 pF | 751 | F G J K M | DG | | | ES | EF | EU | | | FZ | FM | FM | FM | | LB | LB | LB | LA | | | |
| 820 pF | 821 | F G J K M | DG | | | ES | EF | EU | | | FZ | FM | FM | FM | | LB | LB | LB | LA | | | |
| 910 pF | 911 | F G J K M | | | | ES | EF | EU | | | FM | FM | FM | FY | | LB | LB | LB | LA | | | |
| 1,000 pF | 102 | F G J K M | | | | ES | EF | EU | | | FM | FM | FM | FY | | LB | LB | LB | LB | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | | | | EF | EU | | | | FM | FK | FK | FS | | LC | LC | LC | LB | | | |
| 1,200 pF | 122 | F G J K M | | | | EF | EU | | | | FM | FK | FK | FS | | LC | LC | LC | LC | | | |
| 1,300 pF | 132 | F G J K M | | | | EF | EU | | | | FM | FS | FS | | | LC | LC | LC | LC | | | |
| 1,500 pF | 152 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | LC | | | |
| 1,600 pF | 162 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 2,000 pF | 202 | F G J K M | | | | EU | EQ | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,200 pF | 222 | F G J K M | | | | EU | EQ | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,400 pF | 242 | F G J K M | | | | EU | EQ | | | | FS | FL | FS | | | LC | LA | LB | | | | |
| 2,700 pF | 272 | F G J K M | | | | EU | EQ | | | | FS | FL | FS | | | LC | LA | LC | | | | |
| 3,000 pF | 302 | F G J K M | | | | EQ | EQ | | | | FS | FL | | | | LA | LA | | | | | |
| 3,300 pF | 332 | F G J K M | | | | EQ | EQ | | | | FS | FM | | | | LA | LA | | | | | |
| 3,600 pF | 362 | F G J K M | | | | ER | ER | | | | FL | FM | | | | LA | LB | | | | | |
| 3,900 pF | 392 | F G J K M | | | | ER | ER | | | | FL | FY | | | | LA | LB | | | | | |
| 4,300 pF | 432 | F G J K M | | | | ES | ES | | | | FM | FY | | | | LA | LC | | | | | |
| 4,700 pF | 472 | F G J K M | | | | ES | ES | | | | FM | FY | | | | LA | LC | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | | | |
| 5,200 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| 8,200pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | 100 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 11 pF | 110 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 12 pF | 120 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 13 pF | 130 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 15 pF | 150 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 16 pF | 160 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 18 pF | 180 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 20 pF | 200 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 22 pF | 220 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 24 pF | 240 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 27 pF | 270 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 30 pF | 300 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 33 pF | 330 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 36 pF | 360 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 39 pF | 390 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 43 pF | 430 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 47 pF | 470 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 51 pF | 510 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 56 pF | 560 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 62 pF | 620 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 68 pF | 680 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 75 pF | 750 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 82 pF | 820 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 91 pF | 910 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 100 pF | 101 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 110 pF | 111 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 120 pF | 121 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 130 pF | 131 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 150 pF | 151 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 160 pF | 161 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 180 pF | 181 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 200 pF | 201 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 220 pF | 221 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 240 pF | 241 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 270 pF | 271 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 300 pF | 301 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 330 pF | 331 | F G J K M | GH | GH | GH | GH | GH | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 360 pF | 361 | F G J K M | GK | GK | GK | GK | GH | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 390 pF | 391 | F G J K M | GK | GK | GK | GK | GK | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 430 pF | 431 | F G J K M | GK | GK | GK | GK | GK | GK | | | | | | | | HJ | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KE | KF |
| 470 pF | 471 | F G J K M | GK | GK | GK | GK | GK | GK | | | | | | | | HJ | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 510 pF | 511 | F G J K M | GH | GH | GH | GK | GH | GM | | | | | | | | HJ | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 560 pF | 561 | F G J K M | GH | GH | GH | GK | GH | GM | | | | | | | | HJ | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KE | KF |
| 620 pF | 621 | F G J K M | GH | GH | GH | GH | GK | GH | GM | | | | | | | HK | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 680 pF | 681 | F G J K M | GH | GH | GH | GK | GH | GO | | | | | | | | HK | JE | JE | JE | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 750 pF | 751 | F G J K M | GH | GH | GH | GK | GK | | | | | | | | | | JE | JE | JE | JK | JK | JK | JL | KE | KE | KE | KF | KE | KF | KH |
| 820 pF | 821 | F G J K M | GH | GH | GH | GK | GK | | | | | | | | | | JE | JE | JE | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 910 pF | 911 | F G J K M | GH | GH | GH | GH | GM | | | | | | | | | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 1,000 pF | 102 | F G J K M | GH | GH | GH | GH | GM | | | | | | | | | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 1,100 pF | 112 | F G J K M | GH | GK | GK | GH | GO | | | | | | | | HJ | | JE | JK | JK | JK | JK | JK | | KE | KE | KE | KF | KF | KF | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | GH | GK | GK | GH | GO | | | | | | | | HJ | | JE | JK | JK | JK | JK | JL | | KE | KE | KE | KF | KF | KF | |
| 1,300 pF | 132 | F G J K M | GH | GK | GK | GH | GO | | | | | | | HE | HJ | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,500 pF | 152 | F G J K M | GK | GK | GK | GK | GO | | | | | | | HE | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,600 pF | 162 | F G J K M | GK | GK | GK | GK | | | | | | | | HG | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KE | KH | |
| 1,800 pF | 182 | F G J K M | GK | GK | GK | GM | | | | | | | | HG | | | JE | JK | JK | JK | JE | JN | | KE | KE | KE | KF | KE | KH | |
| 2,000 pF | 202 | F G J K M | GK | GK | GK | GM | | | | | | | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KE | KJ | |
| 2,200 pF | 222 | F G J K M | GK | GK | GK | GO | | | | | | | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KF | KJ | |
| 2,400 pF | 242 | F G J K M | GK | GH | GK | GO | | | | | | | HE | HJ | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 2,700 pF | 272 | F G J K M | GK | GH | GK | GO | | | | | | | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,000 pF | 302 | F G J K M | GK | GH | GK | | | | | | | | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,300 pF | 332 | F G J K M | GK | GH | GK | | | | | | | | HG | | | | JK | JK | JK | JK | JN | | | KE | KE | KE | KE | KJ | | |
| 3,600 pF | 362 | F G J K M | GK | GH | GM | | | | | | | | HG | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 3,900 pF | 392 | F G J K M | GK | GH | GM | | | | | | | | HJ | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 4,300 pF | 432 | F G J K M | GH | GH | GO | | | | | | | | HJ | | | | JK | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 4,700 pF | 472 | F G J K M | GH | GH | GO | | | | | | | | HJ | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | | | | HE | HG | HK | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | | | | HE | HG | HK | | | | JK | JK | JK | JN | | | | KE | KF | KF | KH | | | |
| 6,200 pF | 622 | F G J K M | GH | GK | | | | | | | HE | HG | | | | | JK | JE | JE | JN | | | | KE | KF | KF | KJ | | | |
| 6,800 pF | 682 | F G J K M | GH | GM | | | | | | | HE | HJ | | | | | JK | JE | JK | JN | | | | KE | KF | KF | KJ | | | |
| 7,500 pF | 752 | F G J K M | GH | GM | | | | | | | HE | HJ | | | | | JK | JE | JK | | | | | KF | KE | KF | | | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | | | | HE | HJ | | | | | JK | JE | JL | | | | | KF | KE | KF | | | | |
| 9,100 pF | 912 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 10,000 pF | 103 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 12,000 pF | 123 | F G J K M | GO | | | | | | | HE | HG | | | | | | JE | JK | JN | | | | | KE | KE | KH | | | | |
| 15,000 pF | 153 | F G J K M | GO | | | | | | | HE | HJ | | | | | | JE | JL | | | | | | KE | KF | KJ | | | | |
| 18,000 pF | 183 | F G J K M | | | | | | | | HG | HK | | | | | | JE | JL | | | | | | KE | KH | | | | | |
| 22,000 pF | 223 | F G J K M | | | | | | | | HJ | | | | | | | JK | JN | | | | | | KF | KJ | | | | | |
| 27,000 pF | 273 | F G J K M | | | | | | | | HJ | | | | | | | JL | JN | | | | | | KF | KJ | | | | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | HK | | | | | | | JN | | | | | | | KH | | | | | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | | | | | | | | KJ | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4000 | 10000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

[1] *The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*

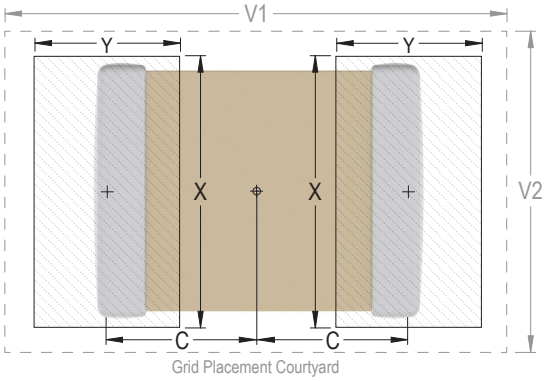
[2] *A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

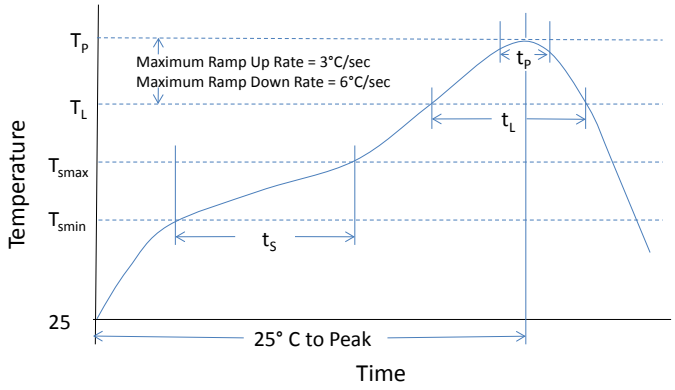
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



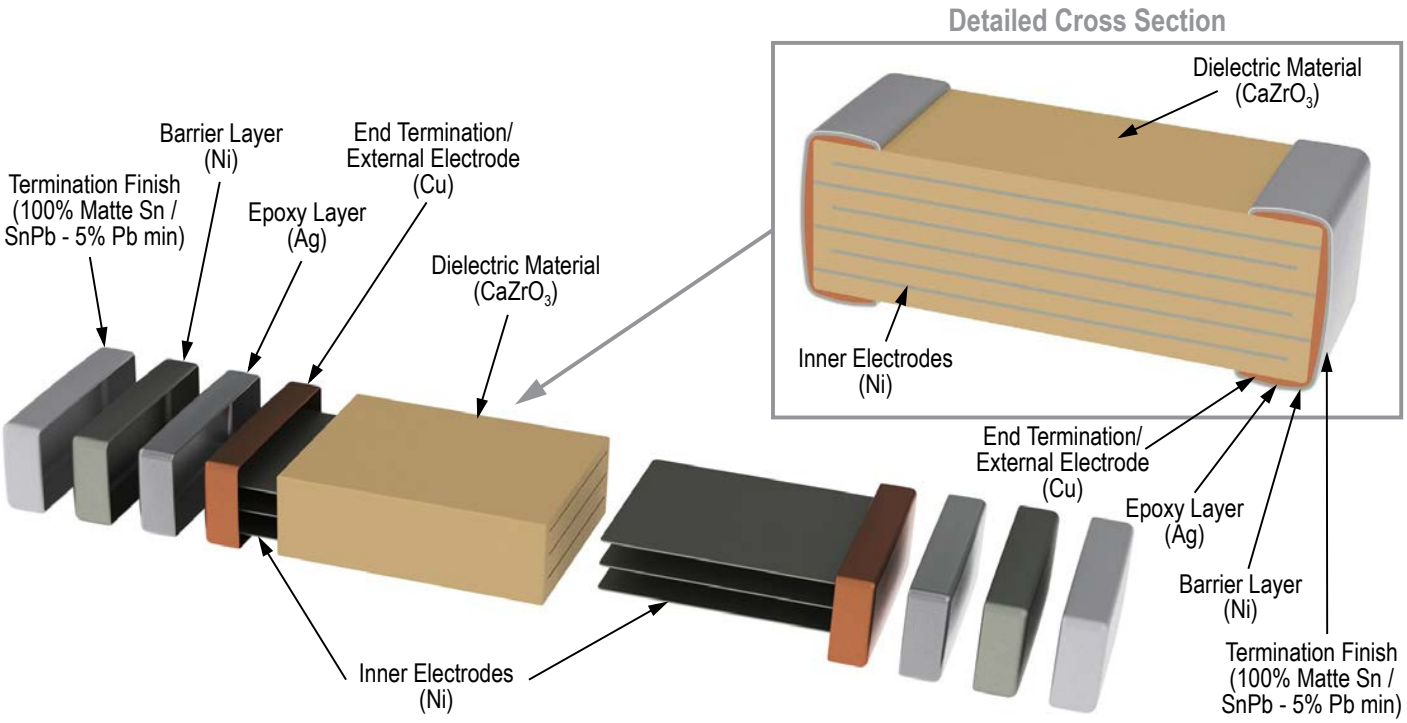
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# High Voltage with Flexible Termination System (HV FT-CAP) X7R Dielectric, 500 – 3,000 VDC (Commercial Grade)

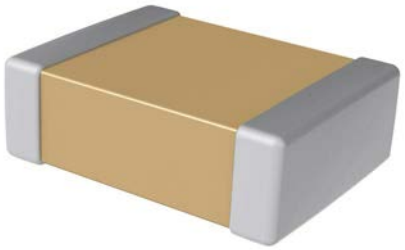
## Overview

KEMET's High Voltage with Flexible Termination (HV FT-CAP) surface mount MLCCs in X7R dielectric address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Featuring several of the highest CV (capacitance/voltage) values available in the industry, these devices utilize a pliable and conductive silver epoxy between the base metal and nickel barrier layers of the termination system. The addition of this epoxy layer inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

The HV FT-CAP offers low leakage current, exhibits low ESR at high frequencies and finds conventional use as snubbers or filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made them a preferred choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive(hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

Combined with the stability of an X7R dielectric and designed to accommodate all capacitance requirements, these flex-robust devices are RoHS-compliant, offer up to 5 mm of flex-bend capability and exhibits a predictable change in capacitance with respect to time and voltage. Capacitance change with reference to ambient temperature is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1210 | X | 154 | K | C | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X = Flexible Termination | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Benefits

- −55°C to +125°C operating temperature range
- Industry-leading CV values
- Superior flex performance (up to 5 mm)
- Exceptional performance at high frequencies
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV, and 3 KV
- Capacitance offerings ranging from 10 pF to 560 nF
- Available capacitance tolerances of ±5%, ±10% or ±20%
- Low ESR and ESL
- Non-polar device, minimizing installation concerns
- Automotive (AEC–Q200) Grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

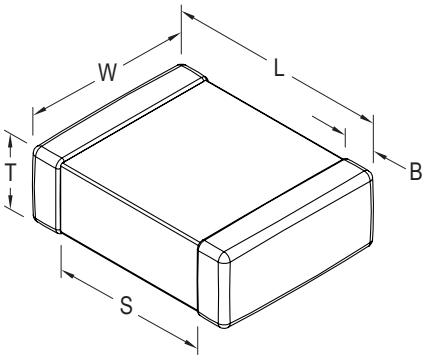
## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications. These capacitors and/or the assembled circuit board containing these capacitors may require a protective surface coating to prevent external surface arcing.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (%) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0603 | N/A | All |
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | 100 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 11 pF | 110 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 12 pF | 120 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 13 pF | 130 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 15 pF | 150 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 16 pF | 160 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 18 pF | 180 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 20 pF | 200 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 22 pF | 220 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 24 pF | 240 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 27 pF | 270 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 30 pF | 300 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 33 pF | 330 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 36 pF | 360 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 39 pF | 390 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 43 pF | 430 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 47 pF | 470 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 51 pF | 510 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 56 pF | 560 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 62 pF | 620 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 68 pF | 680 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 75 pF | 750 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 82 pF | 820 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 91 pF | 910 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 100 pF | 101 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 110 pF | 111 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 120 pF | 121 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LA | LA | LA | LA | LB | LC | LB | GG | GG | GG | GG | GG | GG | GK |
| 130 pF | 131 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 150 pF | 151 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 180 pF | 181 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 220 pF | 221 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 270 pF | 271 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FZ | FZ | FZ | FK | FK | LC | LC | LC | LC | LC | LC | LC | GK | GK | GK | GK | GK | GK | GK |
| 330 pF | 331 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FZ | FZ | FK | FK | LC | LC | LC | LC | LC | LC | LC | GK | GK | GK | GK | GK | GK | GK |
| 390 pF | 391 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FZ | FZ | FK | FS | LB | LB | LB | LB | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 470 pF | 471 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FM | FM | FS | FS | LB | LB | LB | LB | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 560 pF | 561 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FL | FL | FL | FL | FL | LB | LB | LB | LB | LB | LB | LC | GH | GH | GH | GH | GH | GK | GK |
| 680 pF | 681 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 820 pF | 821 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 1,000 pF | 102 | J K M | CG | CG | CG | DG | DG | DG | ES | ES | ES | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 1,200 pF | 122 | J K M | CG | CG | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LA | | GH | GH | GH | GH | GH | GK | GK |
| 1,500 pF | 152 | J K M | CG | CG | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LB | | GH | GH | GH | GH | GH | GK | |
| 1,800 pF | 182 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LC | | GH | GH | GH | GH | GH | GK | |
| 2,200 pF | 222 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LA | LA | LA | LB | LC | LC | | GH | GH | GH | GH | GH | GK | |
| 2,700 pF | 272 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FM | LA | LA | LA | LB | LC | | | GH | GH | GH | GH | GK | GM | |
| 3,300 pF | 332 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FM | LA | LA | LA | LB | LA | | | GH | GH | GH | GH | GK | GM | |
| 3,900 pF | 392 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LB | | | GH | GH | GH | GH | GK | GO | |
| 4,700 pF | 472 | J K M | | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LC | | | GH | GH | GH | GH | GH | GO | |
| 5,600 pF | 562 | J K M | | | | DG | DG | DG | ES | EF | EF | EF | | FL | FL | FL | FM | FK | LA | LB | LB | LC | | | | GH | GH | GH | GK | GK | | |
| 6,800 pF | 682 | J K M | | | | DG | DG | | EF | EF | EF | EF | | FL | FL | FL | FM | FS | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 8,200 pF | 822 | J K M | | | | DG | DG | | EF | EU | EU | EF | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 10,000 pF | 103 | J K M | | | | DG | DG | | EF | EU | EU | EU | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GO | | |
| 12,000 pF | 123 | J K M | | | | DG | DG | | EU | EJ | EJ | | | FL | FL | FL | FK | | LA | LC | LC | LB | | | | GH | GK | GK | GK | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

## Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | | | | DG | | | EU | EJ | EJ | | | FL | FL | FL | FL | | LA | LC | LC | LC | | | | GH | GK | GK | GH | | | |
| 18,000 pF | 183 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FL | FL | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 22,000 pF | 223 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FM | FM | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 27,000 pF | 273 | J K M | | | | | | | EJ | EJ | | | | FM | FK | FK | FK | | LA | LA | LA | | | | | GH | GB | GB | GO | | | |
| 33,000 pF | 333 | J K M | | | | | | | EJ | EJ | | | | FM | FZ | FU | FS | | LC | LA | LA | | | | | GH | GB | GB | GO | | | |
| 39,000 pF | 393 | J K M | | | | | | | EJ | | | | | FK | FZ | FU | FS | | LC | LA | LA | | | | | GH | GB | GB | | | | |
| 47,000 pF | 473 | J K M | | | | | | | EJ | | | | | FK | FU | FK | | | LC | LA | LB | | | | | GH | GB | GC | | | | |
| 56,000 pF | 563 | J K M | | | | | | | EJ | | | | | FZ | FU | FK | | | LC | LA | LB | | | | | GH | GB | GE | | | | |
| 62,000 pF | 623 | J K M | | | | | | | EJ | | | | | FZ | FK | FS | | | LA | LA | LC | | | | | GK | GB | GE | | | | |
| 68,000 pF | 683 | J K M | | | | | | | EJ | | | | | FZ | FK | FS | | | LA | LA | LC | | | | | GE | GE | GE | | | | |
| 82,000 pF | 823 | J K M | | | | | | | | | | | | FU | FK | | | | LA | LC | | | | | | GB | GE | GK | | | | |
| 0.10 µF | 104 | J K M | | | | | | | | | | | | FK | FS | | | | LA | LC | | | | | | GB | GH | GJ | | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | | | FK | | | | | LA | | | | | | | GE | GK | | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | | | FK | | | | | LB | | | | | | | GE | GN | | | | | |
| 0.18 µF | 184 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GF | | | | | | |
| 0.22 µF | 224 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GJ | | | | | | |
| 0.27 µF | 274 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GL | | | | | | |
| 0.33 µF | 334 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GS | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 1B – Capacitance Range/Selection Waterfall (1825 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 470 pF | 471 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | | | | | | | |
| 560 pF | 561 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | | | | | | | |
| 680 pF | 681 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 820 pF | 821 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,000 pF | 102 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,200 pF | 122 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,500 pF | 152 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,800 pF | 182 | J K M | HE | HE | HE | HE | HE | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 2,200 pF | 222 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 2,700 pF | 272 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KF | KE |
| 3,300 pF | 332 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KF | KE |
| 3,900 pF | 392 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KF | KE |
| 4,700 pF | 472 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KE | KF | KE |
| 5,600 pF | 562 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KE | KF | KE |
| 6,800 pF | 682 | J K M | HE | HE | HE | HE | HE | HJ | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KF | KE | KE |
| 8,200 pF | 822 | J K M | HE | HE | HE | HE | HE | HJ | | JE | JE | JE | JE | JK | JK | JK | KE | KE | KE | KE | KF | KF | KF |
| 10,000 pF | 103 | J K M | HE | HE | HE | HE | HJ | HK | | JE | JE | JE | JE | JL | JL | JL | KE | KE | KE | KE | KF | KH | KH |
| 12,000 pF | 123 | J K M | HE | HE | HE | HG | HJ | | | JE | JK | JK | JK | JL | JL | JL | KE | KE | KE | KE | KF | KH | KH |
| 15,000 pF | 153 | J K M | HE | HE | HE | HG | HK | | | JE | JK | JK | JK | JN | JN | JN | KE | KE | KE | KE | KF | KJ | KJ |
| 18,000 pF | 183 | J K M | HE | HE | HE | HG | | | | JE | JK | JK | JK | JN | | | KE | KE | KE | KE | KH | | |
| 22,000 pF | 223 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 27,000 pF | 273 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | KJ | | |
| 33,000 pF | 333 | J K M | HE | HG | HG | HE | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 39,000 pF | 393 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JE | | | | KE | KF | KF | KF | | | |
| 47,000 pF | 473 | J K M | HE | HG | HG | HJ | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 56,000 pF | 563 | J K M | HE | HG | HG | HJ | | | | JE | JE | JE | JL | | | | KE | KF | KF | KF | | | |
| 62,000 pF | 623 | J K M | HG | HG | HG | HK | | | | JE | JE | JE | JL | | | | KF | KF | KF | KH | | | |
| 68,000 pF | 683 | J K M | HG | HJ | HJ | HK | | | | JE | JK | JK | JL | | | | KE | KF | KF | KJ | | | |
| 82,000 pF | 823 | J K M | HG | HJ | HJ | | | | | JE | JL | JL | JN | | | | KE | KF | KF | KJ | | | |
| 0.10 µF | 104 | J K M | HG | HK | HK | | | | | JE | JN | JN | | | | | KE | KH | KH | KJ | | | |
| 0.12 µF | 124 | J K M | HG | HE | | | | | | JE | JN | JN | | | | | KE | KH | KH | | | | |
| 0.15 µF | 154 | J K M | HG | HE | | | | | | JK | JE | | | | | | KF | KJ | KJ | | | | |
| 0.18 µF | 184 | J K M | HG | HG | | | | | | JK | JE | | | | | | KF | KE | | | | | |
| 0.22 µF | 224 | J K M | HG | HJ | | | | | | JK | JK | | | | | | KF | KF | | | | | |
| 0.27 µF | 274 | J K M | HJ | HJ | | | | | | JK | JL | | | | | | KF | KH | | | | | |
| 0.33 µF | 334 | J K M | HJ | | | | | | | JL | JN | | | | | | KF | KH | | | | | |
| 0.39 µF | 394 | J K M | HK | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.47 µF | 474 | J K M | | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | | | KJ | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LE | 1808 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GS | 1812 | 2.10 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

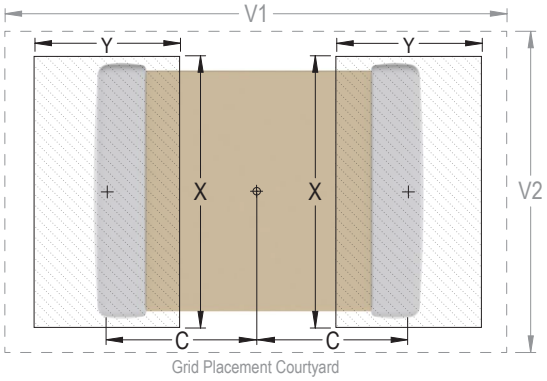
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

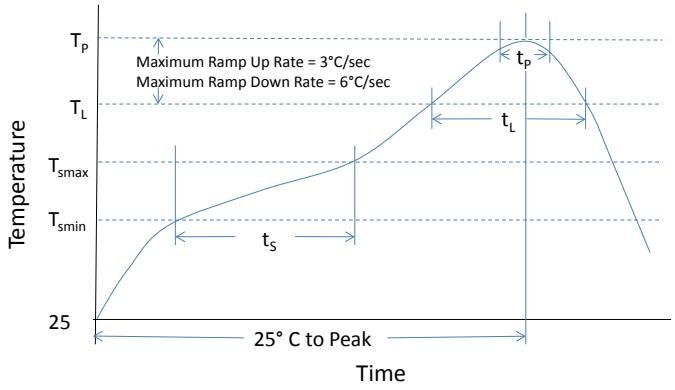
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



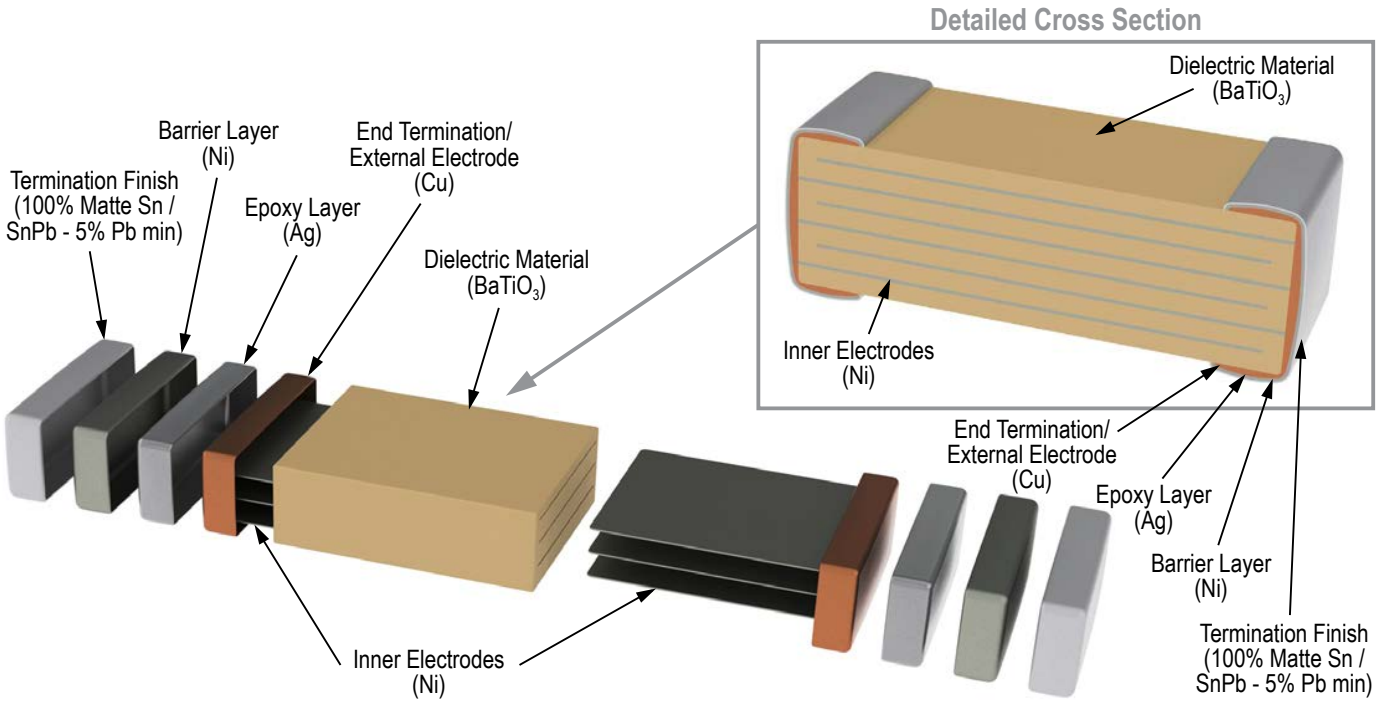
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# ArcShield™ Technology, High Voltage, X7R Dielectric, 500 – 1,000 VDC (Commercial & Automotive Grade)

## Overview

KEMET ArcShield high voltage surface mount capacitors in X7R dielectric are designed for use in high voltage applications susceptible to surface arcing (arc-over discharge).

The phenomenon of surface arcing is caused by a high voltage gradient between the two termination surfaces or between one of the termination surfaces and the counter internal electrode structure within the ceramic body. It occurs most frequently at application voltages that meet or exceed 300 V, in high humidity environments, and in chip sizes with minimal bandwidth separation (creepage distance). This phenomenon can either damage surrounding components or lead to a breakdown of the dielectric material, ultimately resulting in a short-circuit condition (catastrophic failure mode).

Patented ArcShield technology features KEMET's highly reliable base metal dielectric system combined with a unique internal shield electrode structure that is designed to suppress an arc-over event while increasing available capacitance. Developed on the principle of a partial Faraday cage, this internal system offers unrivaled performance and reliability when compared to external surface coating technologies.

For added reliability, KEMET's Flexible Termination technology is an available option that provides superior flex performance over standard termination systems. This technology was developed to address flex cracks, which are the primary failure mode of MLCCs and typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible Termination technology inhibits the transfer of board stress to the rigid body of the MLCC, therefore mitigating flex cracks which can result in low IR or short circuit failures.

KEMET's ArcShield high voltage surface mount MLCCs are available in Automotive Grade, which undergo stricter testing protocol and inspection criteria. Whether under-hood or in-cabin, these devices are designed for mission and safety-critical automotive circuits or applications requiring proven, reliable performance in harsh environments. Automotive Grade devices meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

## Ordering Information

| C | 0603 | W | 392 | K | C | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec)[2] |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | V = ArcShield<br>W = ArcShield with Flexible Termination | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% PB minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*

*[1, 2] SnPb termination finish option is not available on Automotive Grade product.*

*[2] Additional reeling or packaging options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- Patented technology
- Permanent internal arc protection
- Protective surface coating not required
- Base metal electrode (BME) dielectric system
- Industry leading CV values
- -55°C to +125°C operating temperature range
- Exceptional performance at high frequencies
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220 and 2225 case sizes
- DC voltage ratings of 500 V, 630 V and 1 KV
- Capacitance offerings ranging from 1,000 pF to 560 nF
- Available capacitance tolerances of ±5%, ±10% and ±20%
- Low ESR & ESL
- Non-polar device, minimizing installation concerns
- Commercial & Automotive (AEC-Q200) grades available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)
- Flexible Termination option available upon request

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting) applications.

## Application Notes

X7R dielectric is not recommended for AC line filtering or pulse applications.

## Qualification/Certification

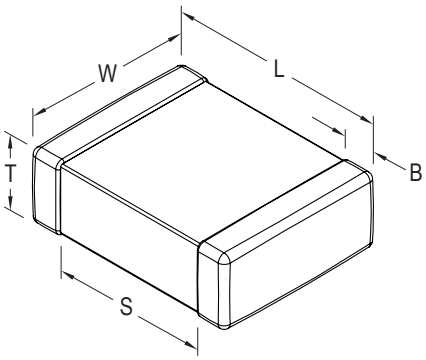
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.064) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 100 megohm microfarads or 10GΩ<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

# Table 1 – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603W/V | | | C0805W/V | | | C1206W/V | | | C1210W/V | | | C1808W/V | | | C1812W/V | | | C1825W/V | | C2220W/V | | C2225W/V | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | C | B | C | B |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 500 | 630 | 500 | 630 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | CG | CG | CG | | | | | | | | | | | | | | | | | | | | | |
| 1,200 pF | 122 | J K M | CG | CG | | | | | | | | | | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | CG | CG | | | | | | | | | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | CG | | | | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J K M | | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | J K M | | | | DG | DG | | EJ | EJ | EJ | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | | | | DG | | | EJ | EJ | EJ | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | J K M | | | | DG | | | EJ | EJ | EJ | | | | LE | LE | LE | | | | | | | | | |
| 22,000 pF | 223 | J K M | | | | DG | | | EJ | EJ | EJ | FZ | FZ | FZ | LE | LE | LE | | | | | | | | | |
| 27,000 pF | 273 | J K M | | | | | | | EJ | EJ | | FZ | FZ | FZ | LA | LA | LA | GB | GB | GB | | | | | | |
| 33,000 pF | 333 | J K M | | | | | | | EJ | EJ | | FZ | FZ | FU | LA | LA | LA | GB | GB | GB | | | | | | |
| 39,000 pF | 393 | J K M | | | | | | | EJ | | | FZ | FZ | FU | LA | LA | LA | GB | GB | GB | | | | | | |
| 47,000 pF | 473 | J K M | | | | | | | EJ | | | FZ | FU | FK | LA | LA | LB | GB | GB | GC | | | | | | |
| 56,000 pF | 563 | J K M | | | | | | | EJ | | | FZ | FU | FK | LA | LA | LB | GB | GB | GE | | | | | | |
| 62,000 pF | 623 | J K M | | | | | | | EJ | | | FZ | FK | FS | LA | LA | LC | GB | GB | GE | | | | | | |
| 68,000 pF | 683 | J K M | | | | | | | EJ | | | FZ | FK | FS | LA | LA | LC | GE | GE | GE | | | | | | |
| 82,000 pF | 823 | J K M | | | | | | | | | | FU | FK | | LA | LC | | GB | GE | GK | | | | | | |
| 0.10 µF | 104 | J K M | | | | | | | | | | FK | FS | | LA | LC | | GB | GH | GJ | | | | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | FK | | | LA | | | GE | GK | | HE | HE | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | FK | | | LB | | | GE | GN | | HE | HE | JE | JE | | |
| 0.18 µF | 184 | J K M | | | | | | | | | | | | | | | | GF | | | HE | HG | JE | JE | KF | KE |
| 0.22 µF | 224 | J K M | | | | | | | | | | | | | | | | GJ | | | HE | HJ | JK | JK | KE | KF |
| 0.27 µF | 274 | J K M | | | | | | | | | | | | | | | | GL | | | HJ | HJ | JK | JL | KF | KH |
| 0.33 µF | 334 | J K M | | | | | | | | | | | | | | | | GS | | | HJ | | JL | JN | KF | KH |
| 0.39 µF | 394 | J K M | | | | | | | | | | | | | | | | | | | HK | | JN | | KH | KJ |
| 0.47 µF | 474 | J K M | | | | | | | | | | | | | | | | | | | | | JN | | KH | KJ |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | | | | | | | | | | | KJ | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 500 | 630 | 500 | 630 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | C | B | C | B |
| | | Case Size/ Series | C0603W/V | | | C0805W/V | | | C1206W/V | | | C1210W/V | | | C1808W/V | | | C1812W/V | | | C1825W/V | | C2220W/V | | C2225W/V | |

*These products are protected under US Patent 8,885,319 B2, other patents pending, and any foreign counterparts.*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LE | 1808 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GS | 1812 | 2.10 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

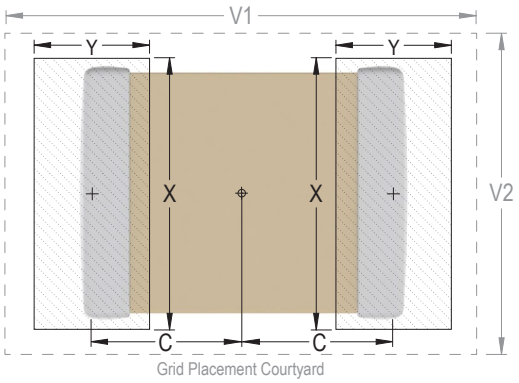
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 1.50 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

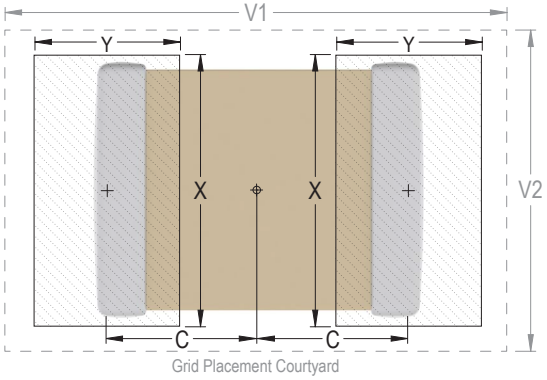


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

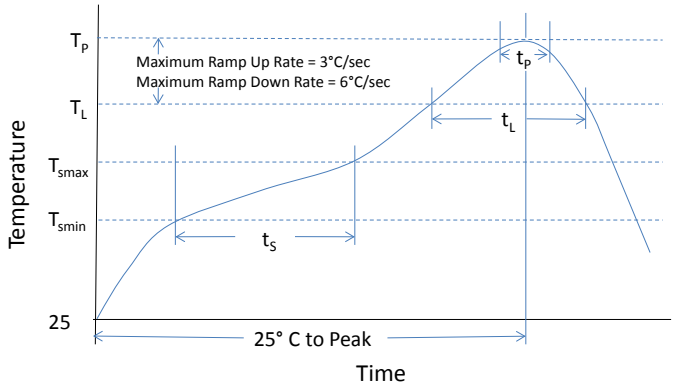
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



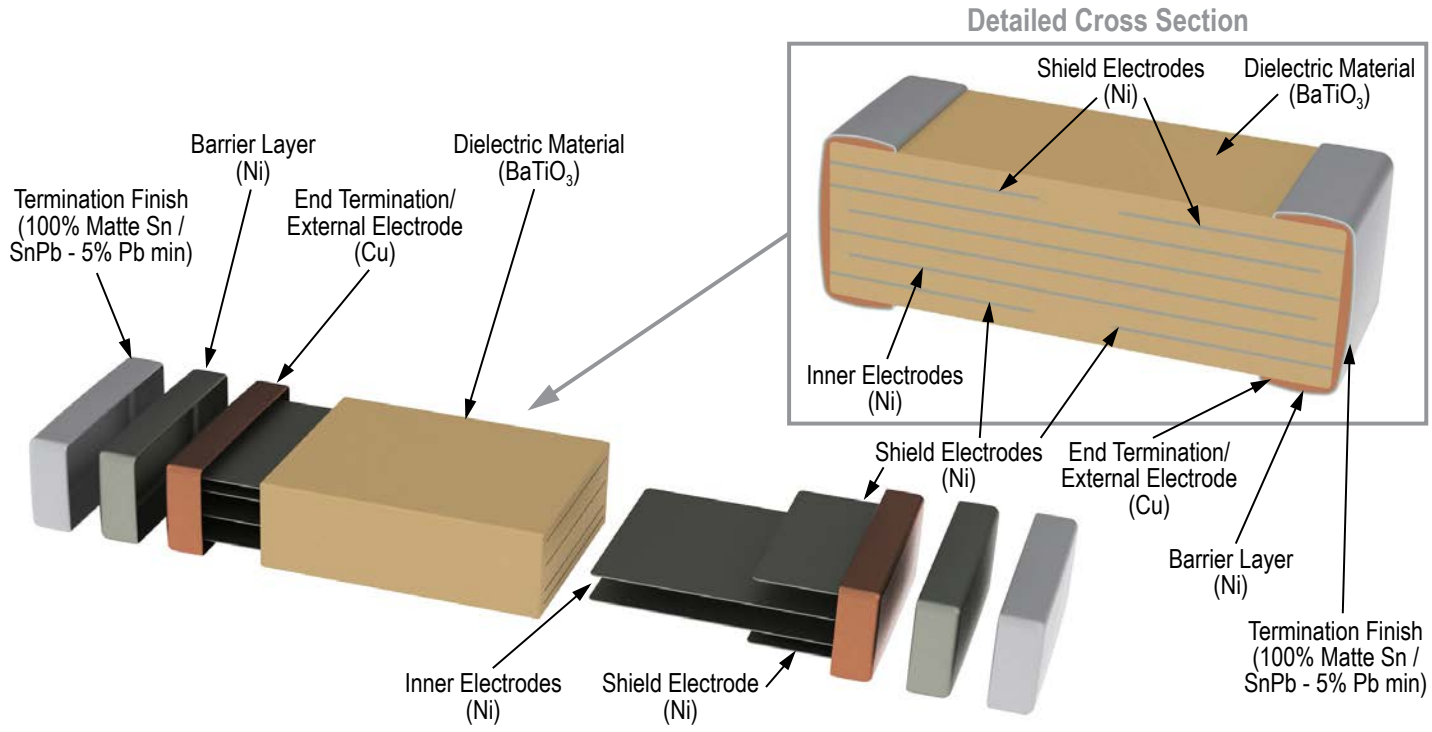
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (-55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Unpowered. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | -55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

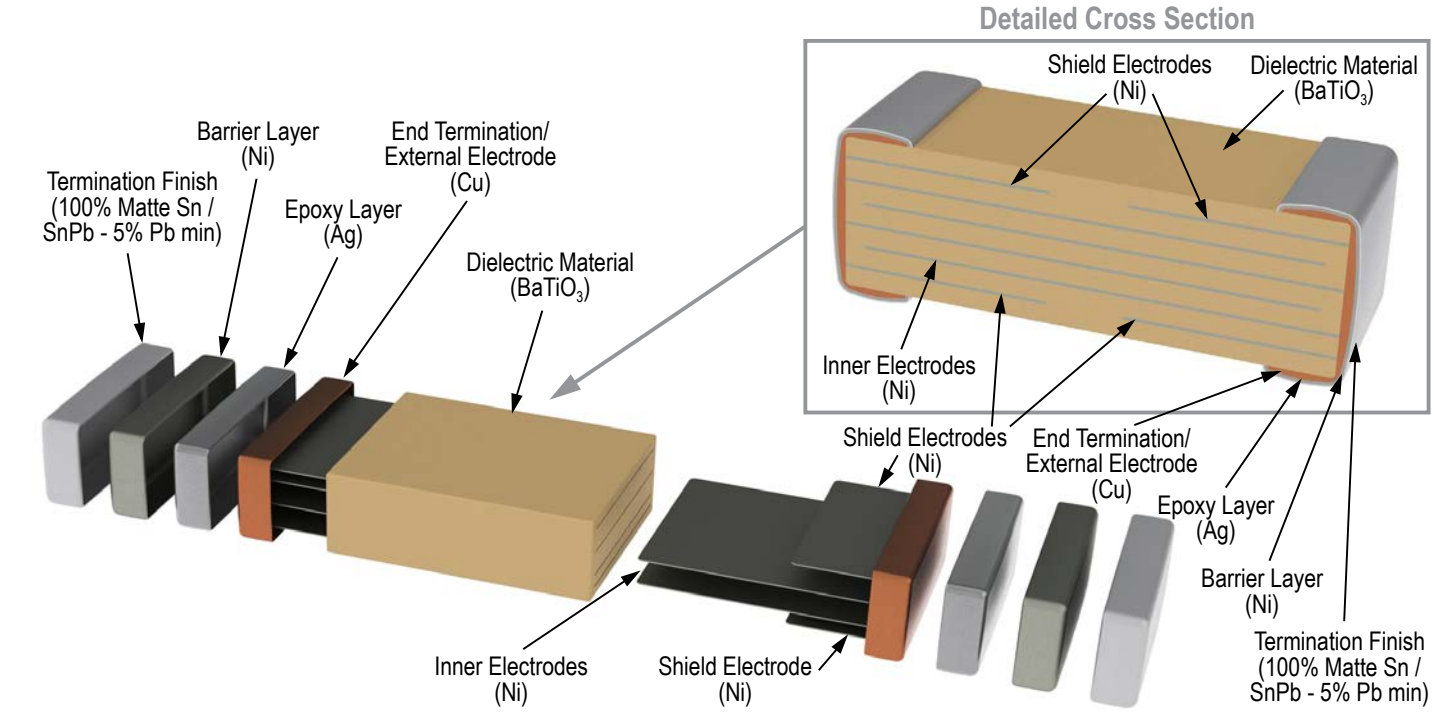
## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# KPS Series, X7R Dielectric, 10 – 250 VDC (Commercial Grade)

## Overview

KEMET Power Solutions (KPS) Commercial Series stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor/s from the printed circuit board, therefore offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. A two chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCCs devices. Providing up to 10 mm of board flex capability, KPS Series capacitors are environmentally friendly and in compliance with RoHS legislation. Available in X7R dielectric, these devices are capable of Pb-Free reflow profiles and provide lower ESR, ESL and higher ripple current capability when compared to other dielectric solutions.

Combined with the stability of an X7R dielectric, KEMET's KPS Series devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 1210, 1812, and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, and 250 V
- Capacitance offerings ranging from 0.1 µF up to 47 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings
- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible, microphonic noise
- Extremely low ESR and ESL

## Ordering Information

| C | 2220 | C | 106 | M | 5 | R | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 1210<br>1812<br>2220 | C = Standard | Two significant digits + number of zeros | K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>A = 250 | R = X7R | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape) / Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape) / Unmarked | 7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits cont'd

- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Tantalum and electrolytic alternative

## Applications

Typical applications include smoothing circuits, DC/DC converters, power supplies (input/output filters), noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Markets include industrial, military, automotive and telecom.

## Qualification/Certification

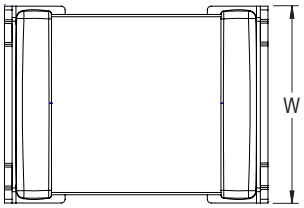
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

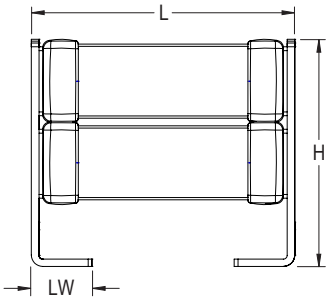
Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)

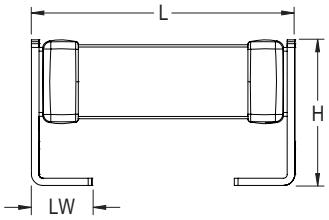
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Number of Chips | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 3.35 (.132) ±0.10 (.004) | 0.80 (.032) ±0.15 (.006) | Solder Reflow Only |
| | 1812 | 4532 | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.50 (.020) | 2.65 (.104) ±0.35 (.014) | 1.10 (.043) ±0.30 (.012) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | |
| Double | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 6.15 (.242) ±0.15 (.006) | 0.80 (.031) ±0.15 (.006) | |
| | 1812 | 4532 | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.10 (.043) ±0.30 (.012) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*

*120 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

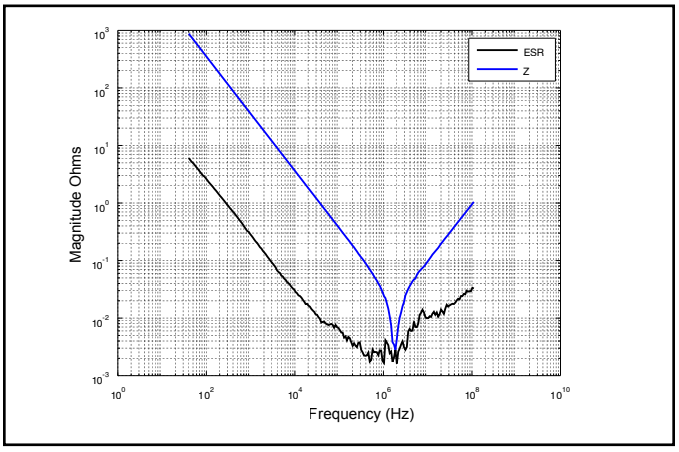
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

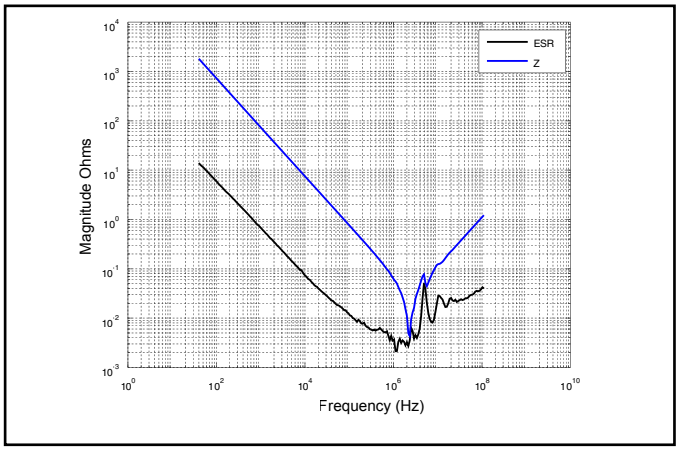
| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 2220 | < 10 µF | ≥ 10 µF |

## Electrical Characteristics

Z and ESR C1210C475M5R1C

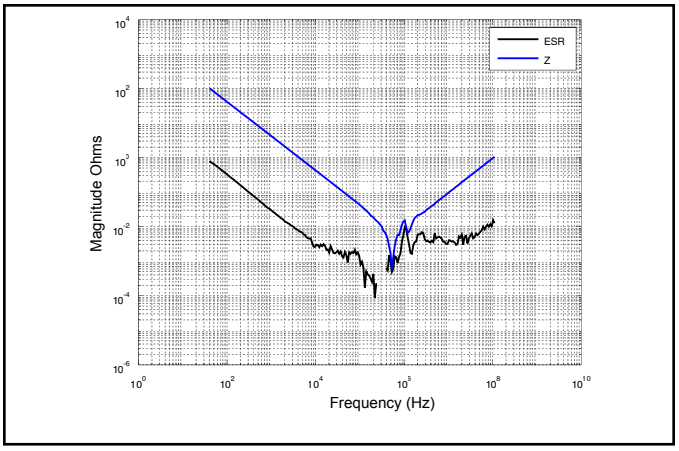



Z and ESR C2220C225MAR2C

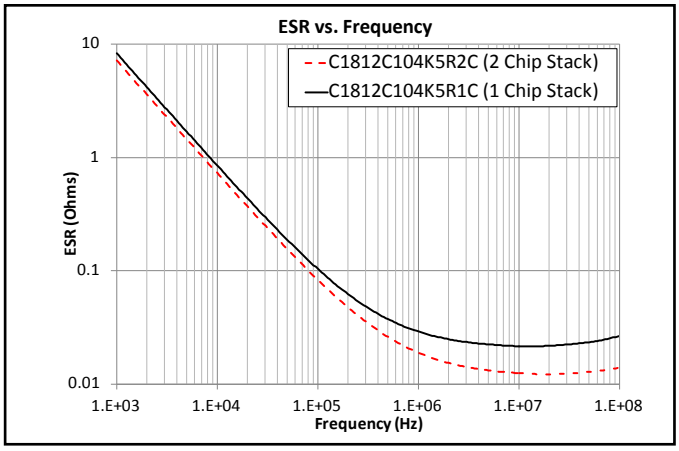


# Electrical Characteristics

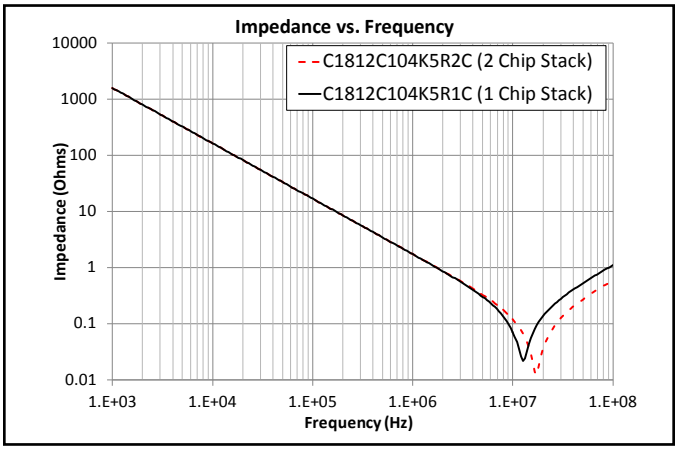
## Z and ESR C2220C476M3R2C



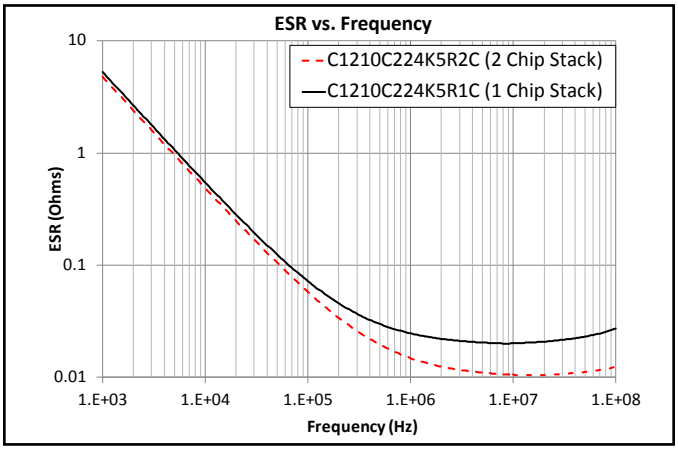

## ESR – 1812, .10 µF, 50 V X7R



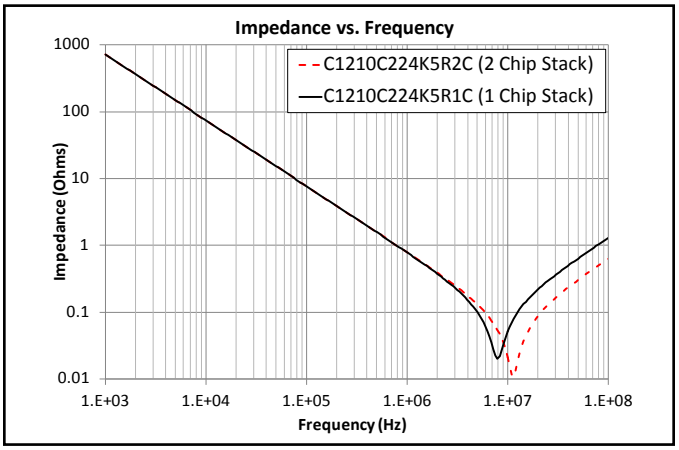

## Impedance – 1812, .10 µF, 50 V X7R




## ESR – 1210, .22 µF, 50 V X7R

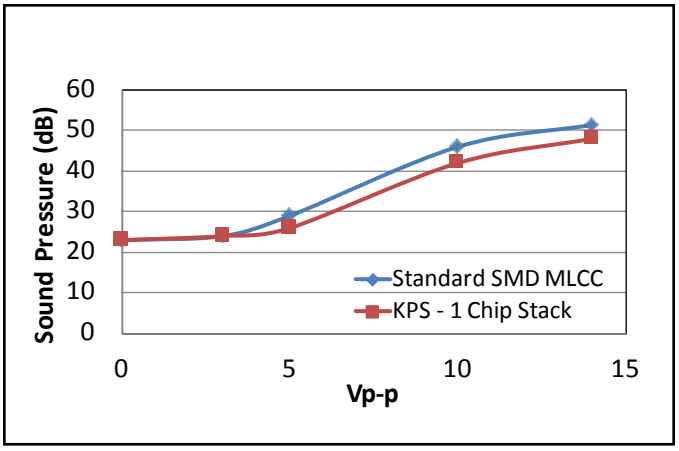



## Impedance – 1210, .22 µF, 50 V X7R

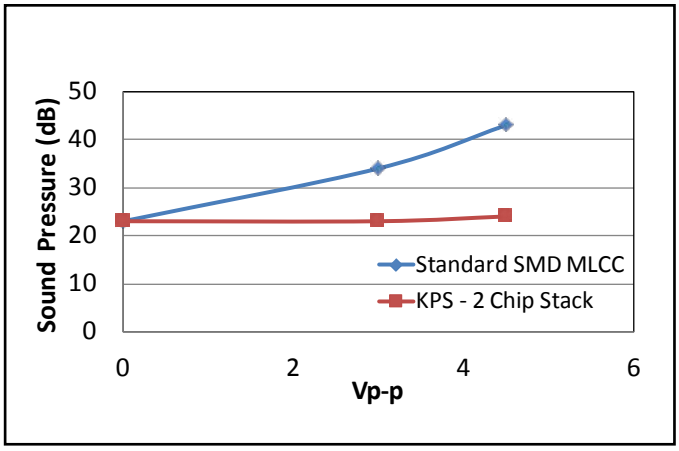


## Electrical Characteristics cont'd

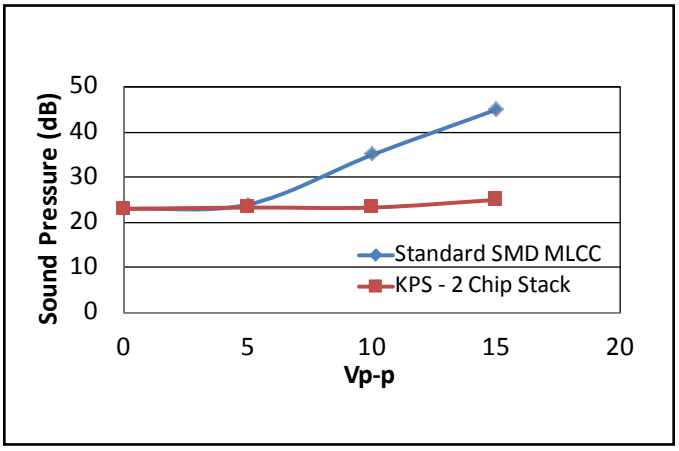
### Microphonics – 1210, 4.7 µF, 50 V, X7R



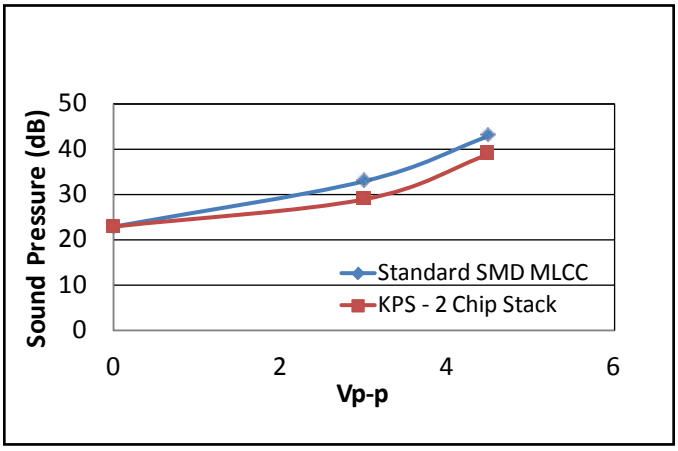

### Microphonics – 2220, 22 µF, 50 V, X7R




### Microphonics – 2220, 47 µF, 25 V, X7R

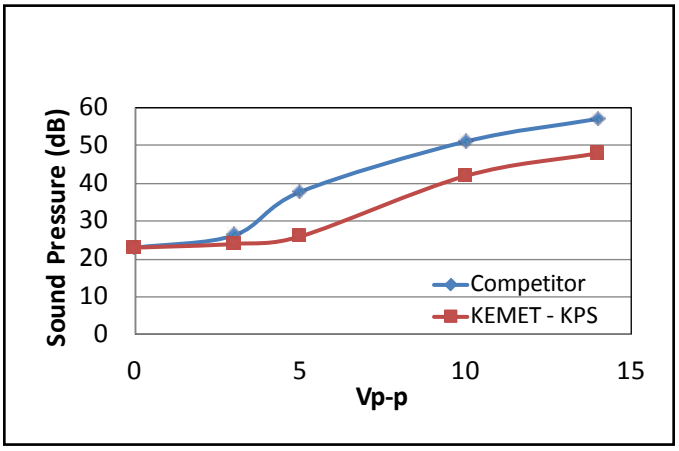



### Microphonics – 1210, 22 µF, 25 V, X7R

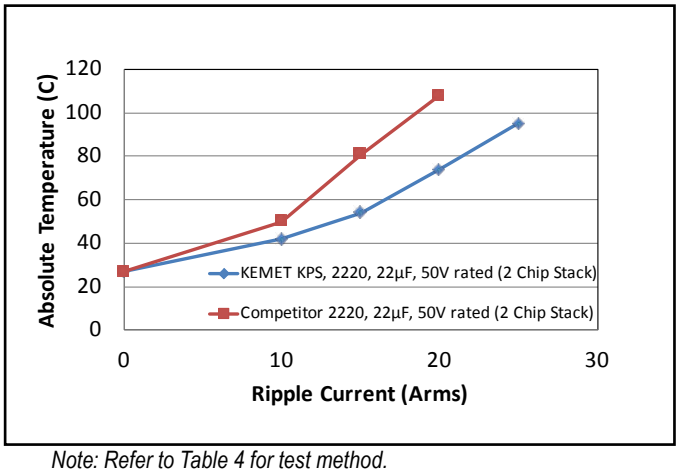



## Competitive Comparision

### Microphonics – 1210, 4.7 µF, 50 V, X7R



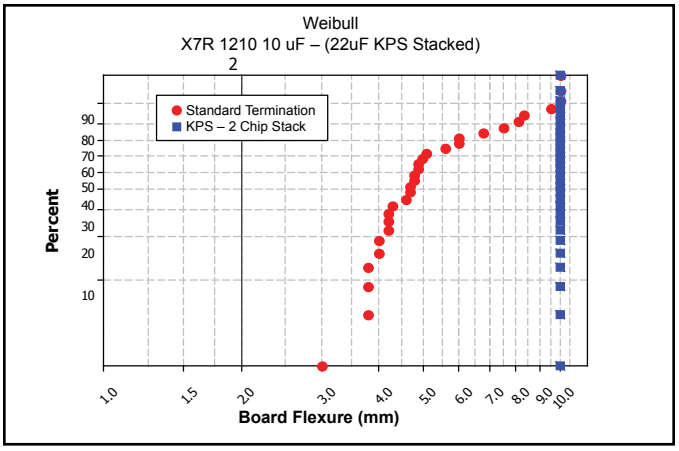

### Ripple Current (Arms) 2220, 22 µF, 50 V



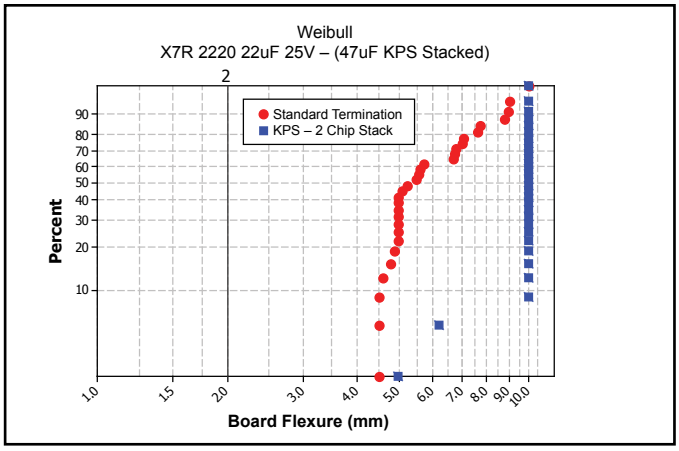

*Note: Refer to Table 4 for test method.*

# Electrical Characteristics cont'd

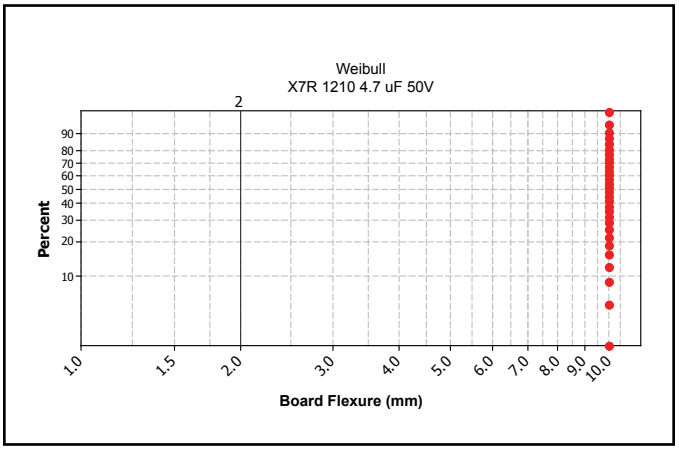
## Board Flex vs. Termination Type



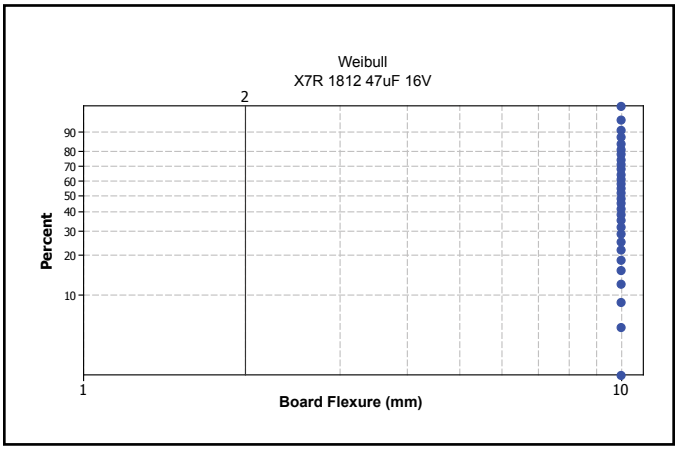

## Board Flex vs. Termination Type




## Board Flexure to 10 mm




## Board Flexure to 10 mm



## Table 1 – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | C1210C | | | | | | C1812C | | | | | C2220C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 8 | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A |
| | | Rated Voltage (VDC) | | 10 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | |
| **Single Chip Stack** | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | K | M | FV | FV | FV | FV | FV | FV | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 0.22 µF | 224 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 0.47 µF | 474 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 1.0 µF | 105 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | | JP | JP | JP | JP | JP |
| 2.2 µF | 225 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | | | JP | JP | JP | JP | |
| 3.3 µF | 335 | K | M | FV | FV | FV | FV | | | GP | GP | GP | | | JP | JP | JP | JP | |
| 4.7 µF | 475 | K | M | FV | FV | FV | FV | | | GP | GP | GP | | | JP | JP | JP | | |
| 10 µF | 106 | K | M | FV | FV | FV | | | | GP | GP | | | | JP | JP | JP | | |
| 15 µF | 156 | K | M | FV | | | | | | | | | | | JP | JP | | | |
| 22 µF | 226 | K | M | FV | | | | | | | | | | | JP | JP | | | |
| **Double Chip Stack** | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | | M | FW | FW | FW | FW | FW | FW | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 0.22 µF | 224 | | M | FW | FW | FW | FW | FW | FW | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 0.47 µF | 474 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 1.0 µF | 105 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 2.2 µF | 225 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | | JR | JR | JR | JR | JR |
| 3.3 µF | 335 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | | JR | JR | JR | JR | |
| 4.7 µF | 475 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | | | JR | JR | JR | JR | |
| 10 µF | 106 | | M | FW | FW | FW | FW | | | GR | GR | GR | | | JR | JR | JR | | |
| 22 µF | 226 | | M | FW | FW | FW | | | | GR | GR | | | | JR | JR | JR | | |
| 33 µF | 336 | | M | FW | | | | | | | | | | | JR | JR | | | |
| 47 µF | 476 | | M | FW | | | | | | | | | | | JR | JR | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | 10 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 |
| | | Voltage Code | | 8 | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A |
| | | Case Size/Series | | C1210C | | | | | | C1812C | | | | | C2220C | | | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

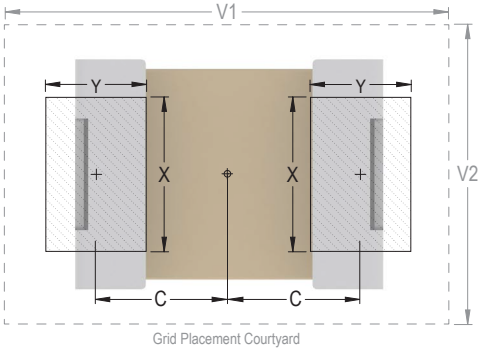
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FV | 1210 | 3.35 ± 0.10 | 0 | 0 | 600 | 2,000 |
| FW | 1210 | 6.15 ± 0.15 | 0 | 0 | 300 | 1,000 |
| GP | 1812 | 2.65 ± 0.35 | 0 | 0 | 500 | 2,000 |
| GR | 1812 | 5.00 ± 0.50 | 0 | 0 | 400 | 1,700 |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |
| Thickness Code | Case Size | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 1812 | 4532 | 2.20 | 1.35 | 2.87 | 6.70 | 4.50 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

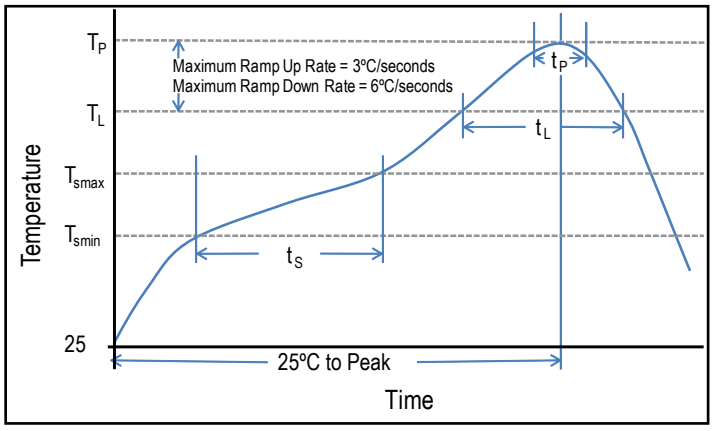
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



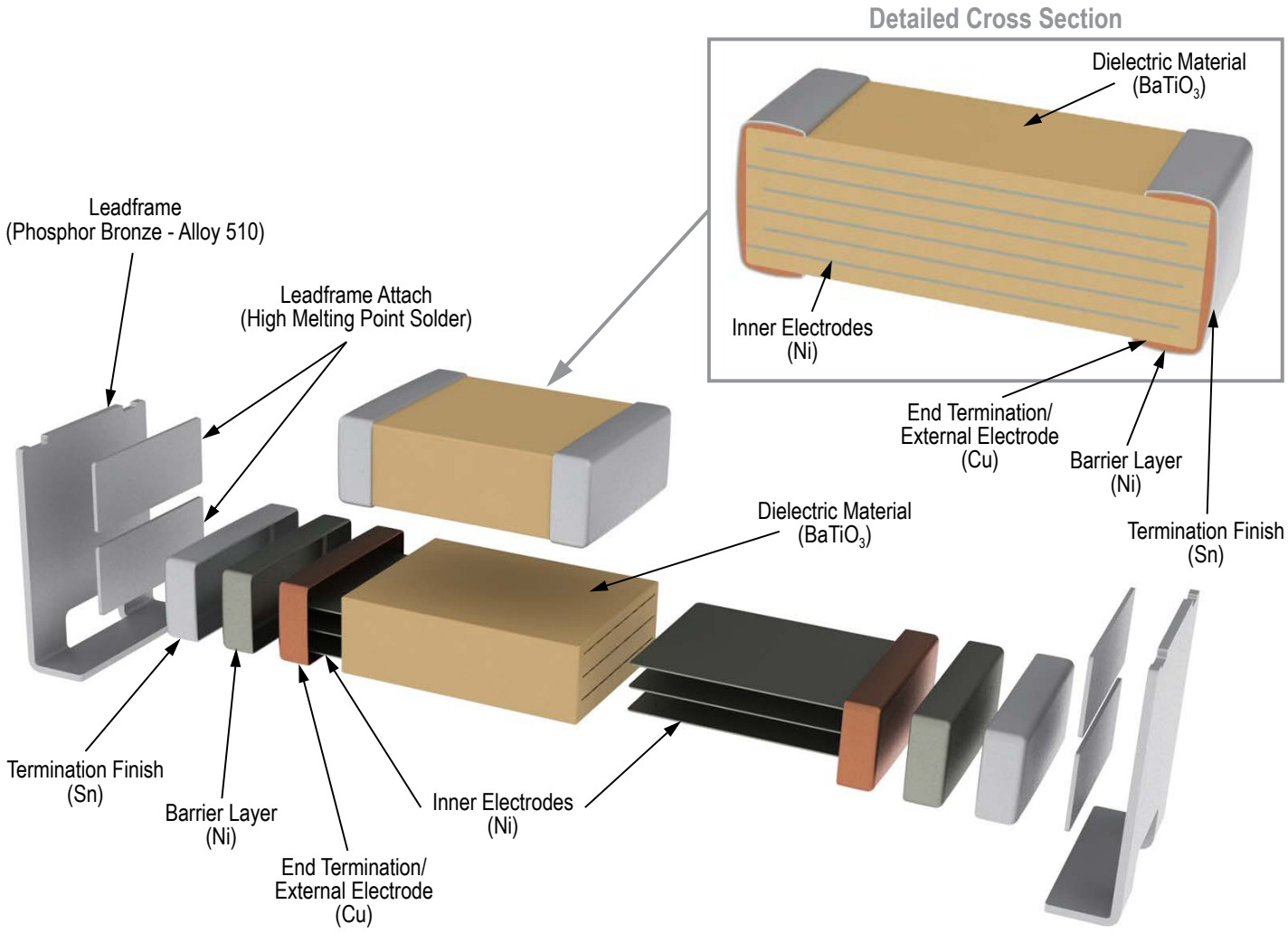
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C with 1.5X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB .031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade)

## Overview

KEMET Power Solutions (KPS) High Voltage stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series High Voltage capacitors are environmentally friendly and in compliance with RoHS legislation.

KEMET's KPS Series devices in X7R dielectric exhibit a predictable change in capacitance with respect to time and voltage, and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C. These devices are capable of Pb-Free reflow profiles and provide lower ESR, ESL and higher ripple current capability when compared to other dielectric solutions.

Conventional uses include both snubbers and filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage ceramic capacitors the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors, and test/diagnostic equipment.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 2220 case size
- DC voltage ratings of 500 V and 630 V
- Capacitance offerings ranging from 0.047 µF up to 1.0 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings

## Ordering Information

| C | 2220 | C | 105 | M | C | R | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | C = 500<br>B = 630 | R = X7R | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits cont'd

- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Film alternative

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications.

## Qualification/Certification

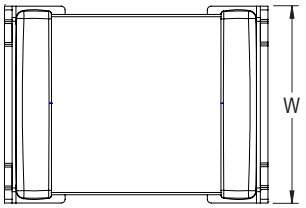
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4 , Performance and Reliability.

## Environmental Compliance

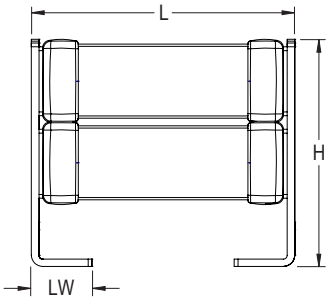
Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)

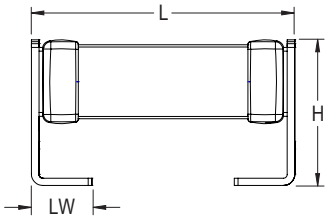
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Number of Chips | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | Solder Reflow Only |
| Double | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*

*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

## Table 1 – Capacitance Range/Selection Waterfall (2220 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | C2220C | | |
|---|---|---|---|---|---|---|
| | | Voltage Code | | C | B | D |
| | | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | |
| **Single Chip Stack** | | | | | | |
| 0.047 µF | 473 | K | M | JP | JP | |
| 0.10 µF | 104 | K | M | JP | JP | |
| 0.15 µF | 154 | K | M | JP | JP | |
| 0.22 µF | 224 | K | M | JP | JP | |
| 0.33 µF | 334 | K | M | JP | | |
| 0.47 µF | 474 | K | M | JP | | |
| **Double Chip Stack** | | | | | | |
| 0.10 µF | 104 | | M | JR | JR | |
| 0.22 µF | 224 | | M | JR | JR | |
| 0.33 µF | 334 | | M | JR | JR | |
| 0.47 µF | 474 | | M | JR | JR | |
| 0.68 µF | 684 | | M | JR | | |
| 1.0 µF | 105 | | M | JR | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Voltage Code | | C | B | D |
| | | Case Size/Series | | C2220C | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

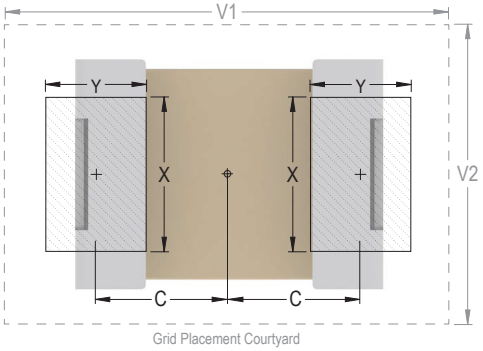
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 1812 | 4532 | 2.20 | 1.35 | 2.87 | 6.70 | 4.50 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

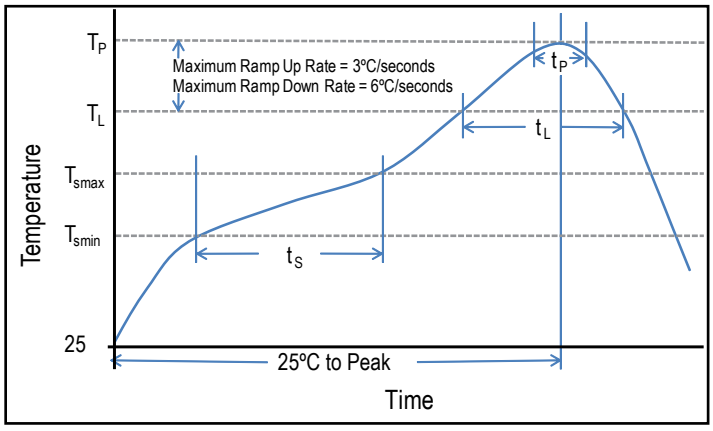
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



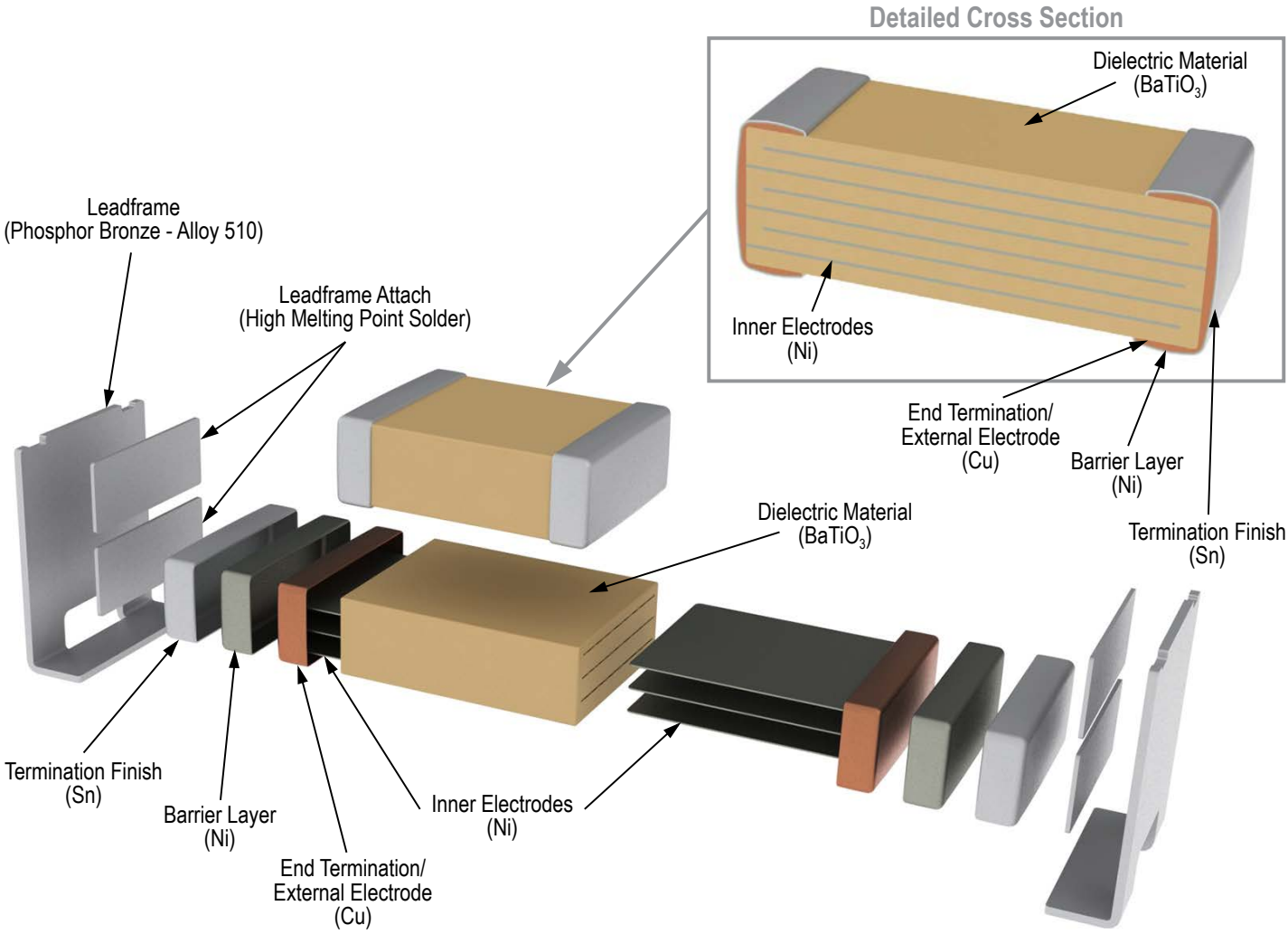
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET Power Solutions High Temperature (KPS HT) stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series capacitors are environmentally friendly and in compliance with RoHS legislation. Combined with X8L dielectric, these devices are capable of reliable operation up to 150°C and are well suited for high temperature filtering, bypass and decoupling applications.

X8L exhibits a predictable change in capacitance with respect to time and voltage, and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C, X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, -40% from 125°C to 150°C.

In addition to Commercial grade, Automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

## Benefits

- −55°C to +150°C operating temperature range
- Reliable and robust termination system
- EIA 1210 and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.47 µF up to 47 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings
- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability

## Ordering Information

| C | 2220 | C | 476 | M | 8 | N | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 1210<br>2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| **Commercial Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |
| **Automotive Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | AUTO |
| 13" Reel (Embossed Plastic Tape)/Unmarked | AUTO7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*
*[2] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

## Benefits

- Reduces audible, microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Tantalum and electrolytic alternative
- Commercial & Automotive (AEC-Q200) grades available

## Applications

Typical applications include smoothing circuits, DC/DC converters, power supplies (input/output filters), noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to extreme environments such as high temperature, high levels of board flexure and/or temperature cycling. Markets include industrial, aerospace, automotive, and telecom.

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

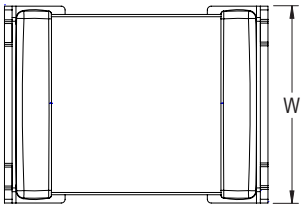
| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

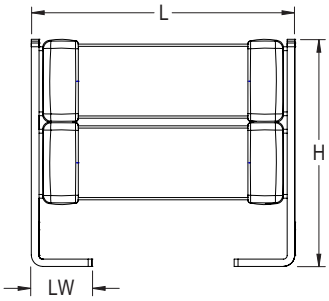
● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)

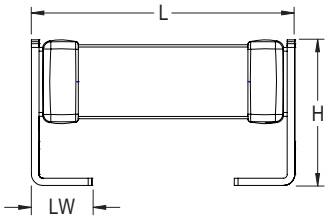
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Chip Stack | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 3.35 (.132) ±0.10 (.004) | 0.80 (.032) ±0.15 (.006) | Solder Reflow Only |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | |
| Double | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 6.15 (.242) ±0.15 (.006) | 0.80 (.031) ±0.15 (.006) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Table 1 – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | |
| **Single Chip Stack** | | | | | | | | | | | | | | | | |
| 0.47 µF | 474 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 1.0 µF | 105 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 2.2 µF | 225 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 3.3 µF | 335 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 4.7 µF | 475 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 10 µF | 106 | | K | M | | | | | | | JP | JP | JP | | | |
| 15 µF | 156 | | K | M | | | | | | | JP | | | | | |
| 22 µF | 226 | | K | M | | | | | | | JP | | | | | |
| **Double Chip Stack** | | | | | | | | | | | | | | | | |
| 1.0 µF | 105 | | | M | FW | FW | FW | FW | | | | | | | | |
| 2.2 µF | 225 | | | M | FW | FW | FW | FW | | | | | | | | |
| 3.3 µF | 335 | | | M | FW | FW | FW | | | | | | | | | |
| 4.7 µF | 475 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 10 µF | 106 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 22 µF | 226 | | | M | | | | | | | JR | JR | JR | | | |
| 33 µF | 336 | | | M | | | | | | | JR | | | | | |
| 47 µF | 476 | | | M | | | | | | | JR | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

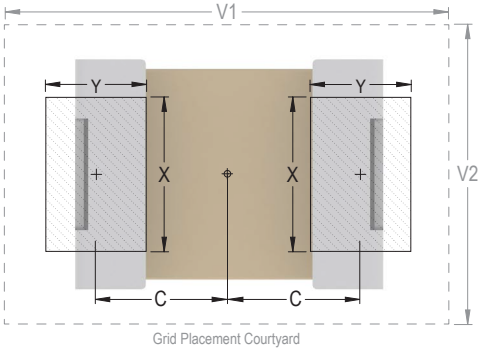
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FV | 1210 | 3.35 ± 0.10 | 0 | 0 | 600 | 2,000 |
| FW | 1210 | 6.15 ± 0.15 | 0 | 0 | 300 | 1,000 |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

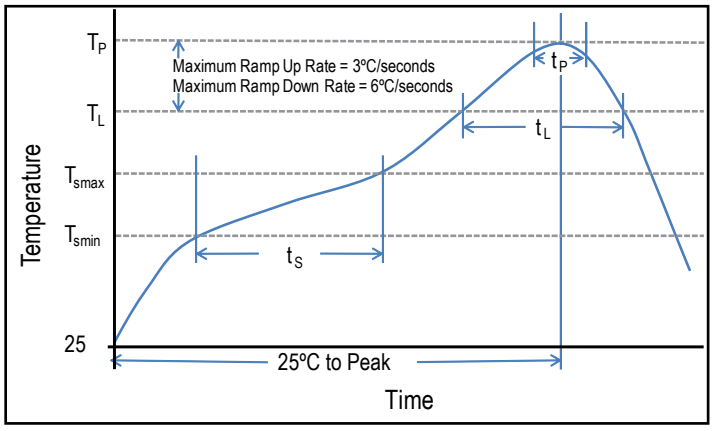
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



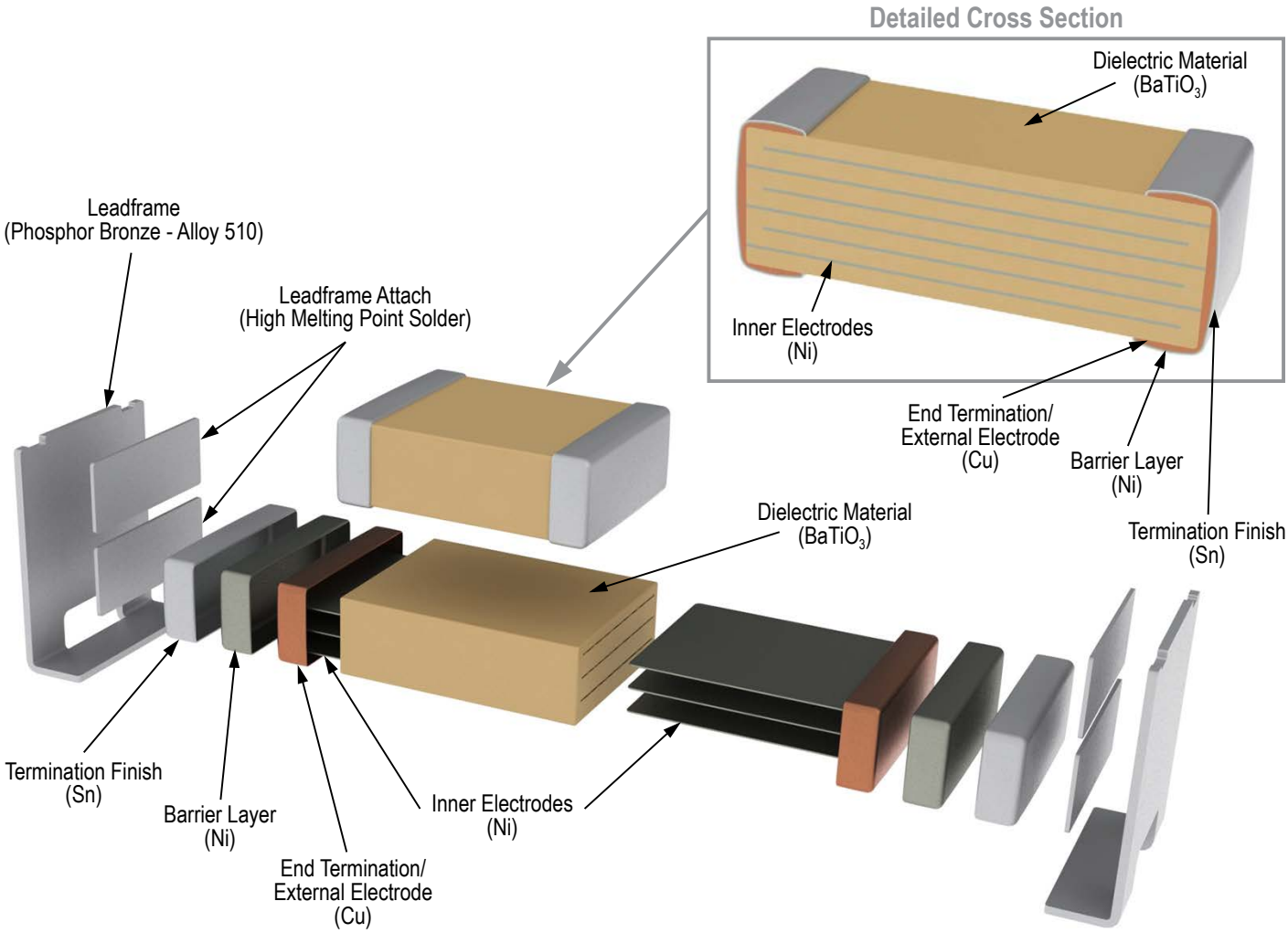
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150°C. Note: Number of cycles required- 300, maximum transfer time- 20 seconds, Dwell time- 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 150°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB .031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Commercial "L" Series, SnPb Termination, C0G Dielectric 10 – 250 VDC (Commercial Grade)

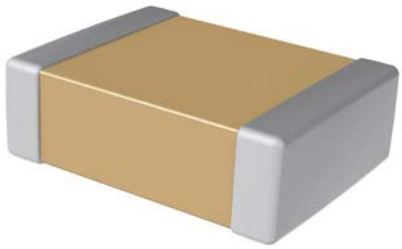
## Overview

KEMET's Commercial "L" Series with Tin/Lead Termination surface mount capacitors in C0G dielectric are designed to meet the needs of critical applications where tin/lead end metallization is required. KEMET's tin/lead electroplating process is designed to meet a 5% minimum lead content and address concerns for a more robust and reliable lead containing termination system. As the bulk of the electronics industry moves towards RoHS compliance, KEMET continues to provide tin/lead terminated products for military, aerospace and industrial applications and will ensure customers have a stable and long-term source of supply.

KEMET's C0G dielectric features a 125°C maximum operating temperature and is considered "stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/°C from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 0402, 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 0.5 pF up to 0.47 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%



## Ordering Information

| C | 1206 | C | 104 | J | 3 | G | A | L | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | C = Standard | Two significant digits + number of zeros.<br>Use 9 for 1.0 – 9.9 pF<br>Use 8 for 0.5 – .99 pF<br>ex. 2.2 pF = 229<br>ex. 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | G = C0G | A = N/A | L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

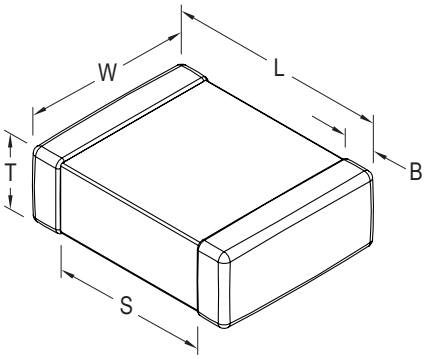
## Benefits cont'd

- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies and into the MHz range
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance change with respect to applied rated DC voltage
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- SnPb plated termination finish (5% Pb minimum)
- Flexible termination option available upon request
- Available for other surface mount products, additional dielectrics and higher voltage ratings upon request

## Applications

Typical applications include military, aerospace and other high reliability applications.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

These devices do not meet RoHS criteria due to the concentration of Lead (Pb) in the termination finish

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and Dissipation Factor (DF) measured under the following conditions:*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.50 & 0.75 pF | 508 & 758 | B C D | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | | | | | | |
| 1.0 – 9.1 pF* | 109 – 919* | B C D | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 10 – 20 pF* | 100 – 200* | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 22 pF | 220 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 24 – 91 pF* | 240 – 910* | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 100 pF | 101 | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 110 – 180 pF* | 111 – 181* | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 200 – 270 pF | 201 – 271* | F G J K M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 300 pF | 301 | F G J K M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 330 pF | 331 | F G J K M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 360 pF | 361 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 390 pF | 391 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 430 pF | 431 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 470 pF | 471 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 510 pF | 511 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 560 pF | 561 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 620 pF | 621 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 680 pF | 681 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 750 pF | 751 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 820 pF | 821 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 910 pF | 911 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 1,000 pF | 102 | F G J K M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EB | EB |
| 1,100 pF | 112 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1,200 pF | 122 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB |
| 1,300 pF | 132 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 1,500 pF | 152 | F G J K M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | EC | EC |
| 1,600 pF | 162 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 1,800 pF | 182 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 2,000 pF | 202 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | ED | ED | ED |
| 2,200 pF | 222 | F G J K M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EE | EE | EE |
| 2,400 pF | 242 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 2,700 pF | 272 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EC | EC | EC |
| 3,000 pF | 302 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN | EC | EC | EC | EC | EC | EB | EB |
| 3,300 pF | 332 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN | EC | EC | EC | EC | EE | EB | EB |
| 3,600 pF | 362 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DP | DP | EC | EC | EC | EC | EE | EB | EB |
| 3,900 pF | 392 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EF | EB | EB |
| 4,300 pF | 432 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EC | EB | EB |
| 4,700 pF | 472 | F G J K M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP | EC | EC | EC | EC | EC | EB | EB |
| 5,100 pF | 512 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DE | DE | DE | DE | DN | DP | DP | ED | ED | ED | ED | ED | EB | EB |
| 5,600 pF | 562 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DP | DP | ED | ED | ED | ED | ED | EB | EB |
| 6,200 pF | 622 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 6,800 pF | 682 | F G J K M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 7,500 pF | 752 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG | EB | EB | EB | EB | EB | EB | EB |
| 8,200 pF | 822 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG | EC | EC | EC | EC | EB | EC | EC |
| 9,100 pF | 912 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | | | EC | EC | EC | EC | EB | EC | EC |
| 10,000 pF | 103 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DP | | | ED | ED | ED | ED | EB | EC | EC |
| 12,000 pF | 123 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | ED | ED |
| 15,000 pF | 153 | F G J K M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DP | DG | | | EB | EB | EB | EB | EB | EF | EF |
| 18,000 pF | 183 | F G J K M | | | | | | | | | | | | | | | DN | DN | DN | DP | | | | EB | EB | EB | EB | EB | EH | EH |
| 22,000 pF | 223 | F G J K M | | | | | | | | | | | | | | | DP | DP | DP | DF | | | | EB | EB | EB | EB | EC | EH | EH |
| 27,000 pF | 273 | F G J K M | | | | | | | | | | | | | | | DF | DF | DF | | | | | EB | EB | EB | EB | EE | | |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | | EB | EB | EB | EB | EE | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | | EC | EC | EC | EE | EH | | |
| 47,000 pF | 473 | F G J K M | | | | | | | | | | | | | | | DG | DG | DG | | | | | EC | EC | EC | EE | EH | | |
| 56,000 pF | 563 | F G J K M | | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EF | | | |
| 68,000 pF | 683 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | |
| 82,000 pF | 823 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | EH | | | |
| 0.10 µF | 104 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | |
| 68,000 pF | 683 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | |
| 82,000 pF | 823 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | EH | | | |
| 0.10 µF | 104 | F G J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | C0402C | | | | | | | C0603C | | | | | | | C0805C | | | | | | | C1206C | | | | | | |

## Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 – 9.1 pF* | 109 – 919* | B C D | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | F G J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | |
| 100 – 300 pF* | 101 – 301* | F G J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | |
| 330 – 430 pF* | 331 – 431* | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | | | | | | | | | | | | | | | | | |
| 470 – 910 pF* | 471 – 911* | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,000 pF | 102 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,300 pF | 132 | F G J K M | FB | FB | FB | FB | FB | FC | FC | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,500 pF | 152 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,600 pF | 162 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 1,800 pF | 182 | F G J K M | FB | FB | FB | FB | FB | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 2,000 pF | 202 | F G J K M | FB | FB | FB | FB | FC | FE | FE | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 2,200 pF | 222 | F G J K M | FB | FB | FB | FB | FC | FG | FG | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 2,400 pF | 242 | F G J K M | FB | FB | FB | FB | FC | FC | FC | LF | LF | LF | LF | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | F G J K M | FB | FB | FB | FB | FC | FC | FC | LF | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | |
| 3,000 pF | 302 | F G J K M | FB | FB | FB | FB | FC | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | GB | GB | GB | GB | | | | | | | | | | | | | |
| 3,600 pF | 362 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 4,300 pF | 432 | F G J K M | FB | FB | FB | FB | FF | FF | FF | LF | LF | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | F G J K M | FF | FF | FF | FF | FG | FG | FG | LF | LF | | | GB | GB | GD | GD | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | FB | FB | FB | FB | FG | FG | FG | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 5,600 pF | 562 | F G J K M | FB | FB | FB | FB | FG | FG | FG | | | | | GB | GB | GH | GH | HB | HB | HB | HB | | | | | KE | KE | KE | KE |
| 6,200 pF | 622 | F G J K M | FB | FB | FB | FB | FG | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 6,800 pF | 682 | F G J K M | FB | FB | FB | FB | FG | FB | FB | | | | | GB | GB | GJ | GJ | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 7,500 pF | 752 | F G J K M | FC | FC | FC | FC | FC | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 8,200 pF | 822 | F G J K M | FC | FC | FC | FC | FC | FB | FB | | | | | GB | GH | GB | GB | HB | HB | HB | HB | JE | JE | JB | | KE | KE | KE | KE |
| 9,100 pF | 912 | F G J K M | FE | FE | FE | FE | FE | FB | FB | | | | | | | | | | | | | | | | | KE | KE | KE | KE |
| 10,000 pF | 103 | F G J K M | FF | FF | FF | FF | FF | FB | FB | | | | | GB | GH | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 12,000 pF | 123 | F G J K M | FG | FG | FG | FG | FB | FB | FB | | | | | GB | GG | GB | GB | HB | HB | HE | HE | JE | JE | JB | | KE | KE | KE | KE |
| 15,000 pF | 153 | F G J K M | FG | FG | FG | FG | FB | FC | FC | | | | | GB | GB | GB | GB | HB | HB | | | JE | JE | JB | | KE | KE | KE | KE |
| 18,000 pF | 183 | F G J K M | FB | FB | FB | FB | FB | FC | FC | | | | | GB | GB | GB | GB | HB | HE | | | JE | JE | JB | | KE | KE | | |
| 22,000 pF | 223 | F G J K M | FB | FB | FB | FB | FB | FF | FF | | | | | GB | GB | GB | GB | HB | HE | | | JE | JB | JB | | KE | KE | | |
| 27,000 pF | 273 | F G J K M | FB | FB | FB | FB | FB | FG | FG | | | | | GB | GB | GB | GB | HB | HG | | | JE | JB | JB | | KE | KE | | |
| 33,000 pF | 333 | F G J K M | FB | FB | FB | FB | FB | FH | FH | | | | | GB | GB | GB | GB | | | | | JB | JB | JB | | KE | | | |
| 39,000 pF | 393 | F G J K M | FB | FB | FB | FB | FE | FH | FH | | | | | GB | GB | GB | GB | | | | | JB | JB | JB | | | | | |
| 47,000 pF | 473 | F G J K M | FB | FB | FB | FB | FE | FJ | FJ | | | | | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 56,000 pF | 563 | F G J K M | FB | FB | FB | FB | FF | | | | | | | GB | GB | GD | GD | | | | | JB | JB | JB | | | | | |
| 68,000 pF | 683 | F G J K M | FB | FB | FB | FC | FG | | | | | | | GB | GB | GK | GK | | | | | JB | JB | JB | | | | | |
| 82,000 pF | 823 | F G J K M | FC | FC | FC | FF | FH | | | | | | | GB | GB | GM | GM | | | | | JB | JB | JB | | | | | |
| 0.10 µF | 104 | F G J K M | FE | FE | FE | FG | FM | | | | | | | GB | GD | GM | GM | | | | | JB | JB | JD | | | | | |
| 0.12 µF | 124 | F G J K M | FG | FG | FG | FH | | | | | | | | GB | GH | | | | | | | JB | JB | JD | | | | | |
| 0.15 µF | 154 | F G J K M | FH | FH | FH | FM | | | | | | | | GD | GN | | | | | | | JB | JB | JG | | | | | |
| 0.18 µF | 184 | F G J K M | FJ | FJ | FJ | | | | | | | | | GH | | | | | | | | JB | JD | JG | | | | | |
| 0.22 µF | 224 | F G J K M | FK | FK | FK | | | | | | | | | GK | | | | | | | | JB | JD | JL | | | | | |
| 0.27 µF | 274 | F G J K M | | | | | | | | | | | | | | | | | | | | JB | JF | | | | | | |
| 0.33 µF | 334 | F G J K M | | | | | | | | | | | | | | | | | | | | JD | JG | | | | | | |
| 0.39 µF | 394 | F G J K M | | | | | | | | | | | | | | | | | | | | JG | | | | | | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | | | | | | | | JG | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/Series | C1210C | | | | | | | C1808C | | | | C1812C | | | | C1825C | | | | C2220C | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| BD | 0402 | 0.55 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| CH | 0603 | 0.85 ± 0.07 | 4,000 | 10,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| NC | 1706 | 1.00 ± 0.15 | 0 | 0 | 4,000 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JG | 2220 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

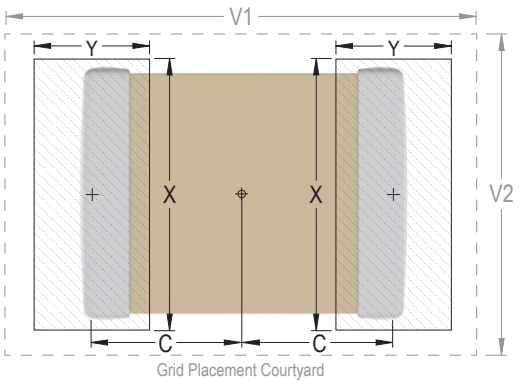
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

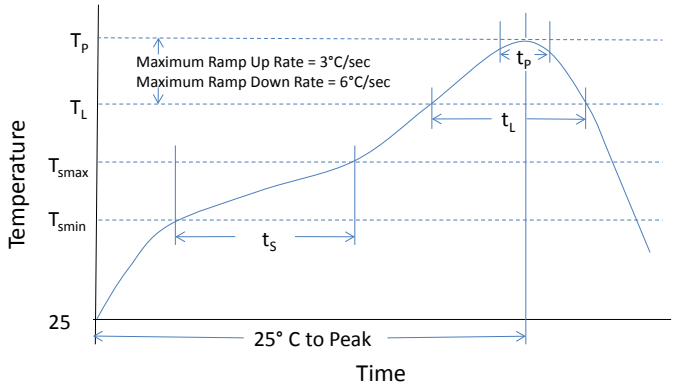
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



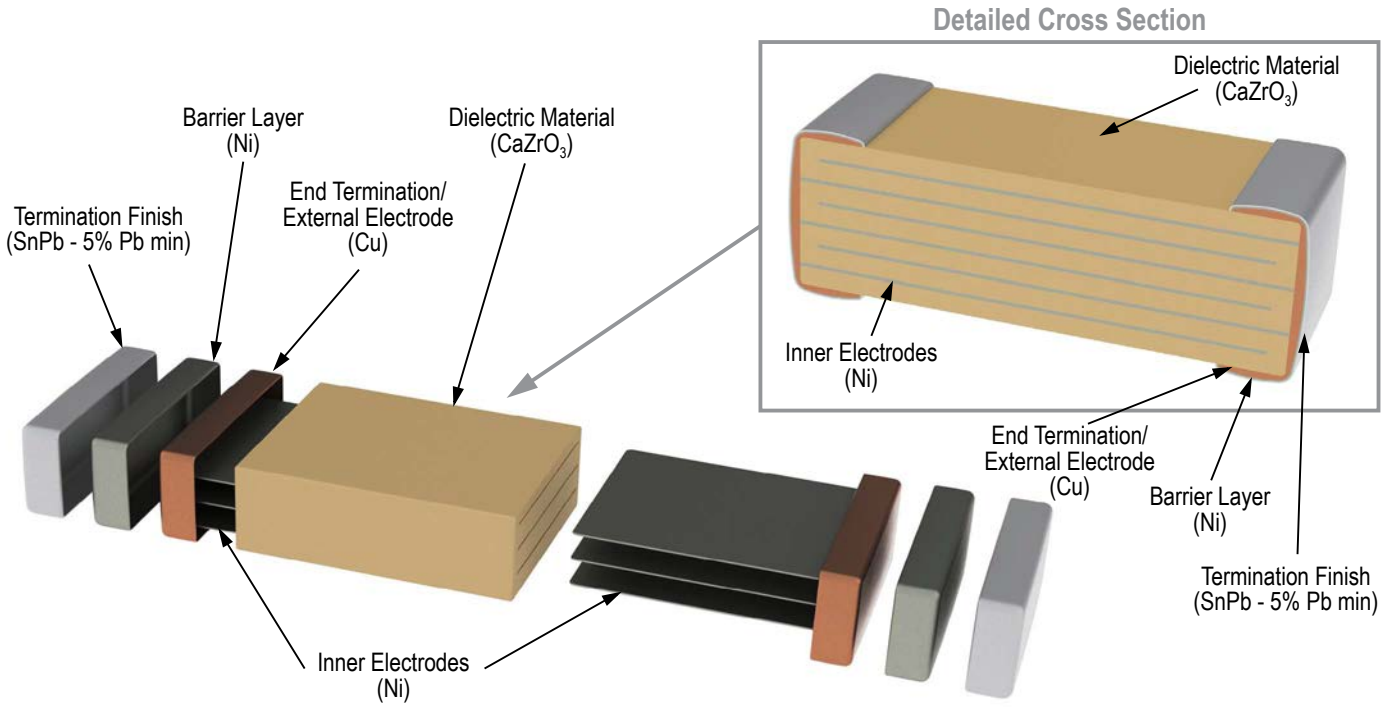
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Commercial "L" Series, SnPb Termination, X7R Dielectric 6.3V – 250 VDC (Commercial Grade)

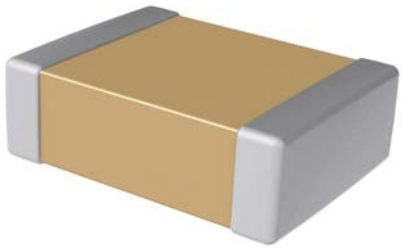
## Overview

KEMET's Commercial "L" Series with Tin/Lead Termination surface mount capacitors in X7R dielectric are designed to meet the needs of critical applications where tin/lead end metallization is required. KEMET's tin/lead electroplating process is designed to meet a 5% minimum lead content and address concerns for a more robust and reliable lead containing termination system. As the bulk of the electronics industry moves towards RoHS compliance, KEMET continues to provide tin/lead terminated products for military, aerospace and industrial applications and will ensure customers have a stable and long-term source of supply.

KEMET's X7R dielectric features a 125°C maximum operating temperature and is considered "temperature stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Temperature stable dielectric
- Reliable and robust termination system
- EIA 0402, 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V



## Ordering Information

| C | 1210 | C | 226 | K | 8 | R | A | L | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | C = Standard | Two Significant Digits + Number of Zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

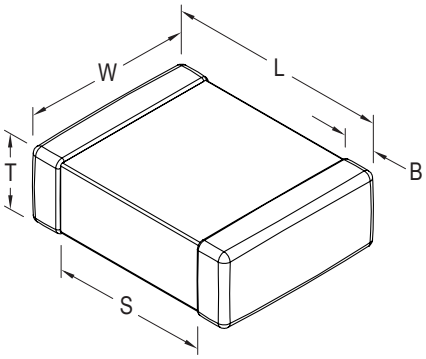
## Benefits cont'd

- Capacitance offerings ranging from 10 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- SnPb plated termination finish (5% Pb minimum)
- Flexible termination option available upon request
- Available for other surface mount products, additional dielectrics and higher voltage ratings upon request

## Applications

Typical applications include military, aerospace and other high reliability applications.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210[1] | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

*[1] For capacitance values ≥ 12 µF add 0.02 (0.001) to the width tolerance dimension*

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

These devices do not meet RoHS criteria due to the concentration of Lead (Pb) in the termination finish

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 100 – 150 pF** | 101 – 151** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | EB | |
| 180 – 820 pF** | 181 – 821** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | |
| 1000pF | 102 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1200 pF | 122 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1500 pF | 152 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 1800 pF | 182 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 2200 pF | 222 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 2700 pF | 272 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 3300 pF | 332 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 3900 pF | 392 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 4700 pF | 472 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 5600 pF | 562 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 6800 pF | 682 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 8200 pF | 822 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 10000 pF | 103 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 12000 pF | 123 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 15000 pF | 153 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 18000 pF | 183 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 22000 pF | 223 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 27000 pF | 273 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 33000 pF | 333 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB | EB |
| 39000 pF | 393 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EC | EB | EB |
| 47000 pF | 473 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DE | DG | | EB | EB | EB | EB | EB | EB | EC | ED | ED |
| 56000 pF | 563 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | DG | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 68000 pF | 683 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 82000 pF | 823 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | EB | ED | ED |
| 0.1 µF | 104 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | EB | EB | EM | EM |
| 0.12 µF | 124 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DP | DG | | | EC | EC | EC | EC | EC | EC | EC | EG | |
| 0.15 µF | 154 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DP | DG | | | EC | EC | EC | EC | EC | EC | EC | EG | |
| 0.18 µF | 184 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DG | DG | DG | | | EC | EC | EC | EC | EC | EC | EC | | |
| 0.22 µF | 224 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DG | DG | DG | | | EC | EC | EC | EC | EC | EC | EC | | |
| 0.27 µF | 274 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EC | EM | | |
| 0.33 µF | 334 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DP | DP | | | | EB | EB | EB | EB | EC | EC | EG | | |
| 0.39 µF | 394 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DE | DE | | | | EB | EB | EB | EB | EC | EC | EG | | |
| 0.47 µF | 474 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DE | DE | | | | EC | EC | EC | EC | EC | EC | EG | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | DH | | | | ED | ED | ED | ED | EC | EC | | | |
| 0.68 µF | 684 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | DH | | | | EE | EE | EE | EE | ED | ED | | | |
| 0.82 µF | 824 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | | EF | EF | EF | EF | ED | ED | | | |
| 1 µF | 105 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | | EF | EF | EF | EH | ED | ED | | | |
| 1.2 µF | 125 | J K M | | | | | | | | | | | | | DE | DE | DE | | | | | | | ED | ED | ED | EG | EH | EH | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | | ED | ED | ED | EG | EH | EH | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | | ED | ED | ED | EF | EH | EH | | | |
| 2.2 µF | 225 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | | ED | ED | ED | EF | EH | EH | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EH | | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 35 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 6 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402C | | | | | C0603C | | | | | | | C0805C | | | | | | | | | C1206C | | | | | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 100 – 270 pF** | 101 – 271** | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | | | | | |
| 470 – 1,200 pF** | 471 – 122** | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | HB | HB | HB | | | | | | | | | | |
| 4,700 pF | 472 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GD | | HB | HB | HB | | | | | | | KE | KE | KE | |
| 5,600 pF | 562 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GH | | HB | HB | HB | | | | | | | KE | KE | KE | |
| 6,800 pF | 682 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HB | | JE | JE | JE | | | KE | KE | KE | |
| 8,200 pF | 822 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HB | | JE | JE | JE | | | KE | KE | KE | |
| 10,000 pF | 103 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HE | | JE | JE | JE | | | KE | KE | KE | |
| 12,000 pF | 123 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | HE | | JE | JE | JE | | | KE | KE | KE | |
| 15,000 pF | 153 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HB | | | JE | JE | JE | | | KE | KE | KE | |
| 18,000 pF | 183 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | LD | GB | GB | GB | GB | GB | HB | HE | | | JE | JE | JE | | | KE | KE | | |
| 22,000 pF | 223 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | | KE | KE | | |
| 27,000 pF | 273 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | | KE | KE | | |
| 33,000 pF | 333 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | KE | | | |
| 39,000 pF | 393 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 47,000 pF | 473 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 56,000 pF | 563 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 68,000 pF | 683 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | | | | | |
| 82,000 pF | 823 | J K M | FB | FB | FB | FB | FB | FC | FF | FF | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | | | | |
| 0.10 µF | 104 | J K M | FB | FB | FB | FB | FB | FD | FG | FG | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.12 µF | 124 | J K M | FB | FB | FB | FB | FB | FD | FH | FH | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.15 µF | 154 | J K M | FC | FC | FC | FC | FC | FD | FM | FM | LD | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.18 µF | 184 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | LD | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.22 µF | 224 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.27 µF | 274 | J K M | FC | FC | FC | FC | FC | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.33 µF | 334 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.39 µF | 394 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.47 µF | 474 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GJ | GJ | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KD | KD |
| 0.56 µF | 564 | J K M | FD | FD | FD | FD | FD | FF | | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JC | JD | JD | KB | KC | KD | KD |
| 0.68 µF | 684 | J K M | FD | FD | FD | FD | FD | FG | | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JD | JD | JD | KB | KC | KD | KD |
| 0.82 µF | 824 | J K M | FF | FF | FF | FF | FF | FL | | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KC | KE | KE |
| 1.0 µF | 105 | J K M | FH | FH | FH | FH | FH | FM | | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KD | KE | KE |
| 1.2 µF | 125 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | HB | | | | JC | JC | | | | KB | KE | KE | KE |
| 1.5 µF | 155 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | HC | | | | JC | JC | | | | KC | | | |
| 1.8 µF | 185 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | HD | | | | JD | JD | | | | KD | | | |
| 2.2 µF | 225 | J K M | FJ | FJ | FJ | FJ | FG | | | | | | | GO | GO | | | | HF | | | | JF | JF | | | | KD | | | |
| 2.7 µF | 275 | J K M | FE | FE | FE | FG | FH | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | FF | FF | FF | FM | FM | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | FG | FG | FG | FG | FK | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | FC | FC | FC | FG | FS | | | | | | | GK | GK | | | | | | | | JF | JF | | | | | | | |
| 5.6 µF | 565 | J K M | FF | FF | FF | FH | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | FG | FG | FG | FM | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | FH | FH | FH | FK | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | FH[1] | FH[1] | FH[1] | FS | | | | | | | | GK | | | | | | | | | JF | JO | | | | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | FM | FM | | | | | | | | | | | | | | | | | | | JO | JO | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | FS | FS | | | | | | | | | | | | | | | | | | | JO | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210C | | | | | | | | C1808C | | | C1812C | | | | | C1825C | | | | C2220C | | | | | C2225C | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities cont'd

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| NA | 1706 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| NC | 1706 | 1.00 ± 0.15 | 0 | 0 | 4,000 | 10,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HC | 1825 | 1.15 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| KB | 2225 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

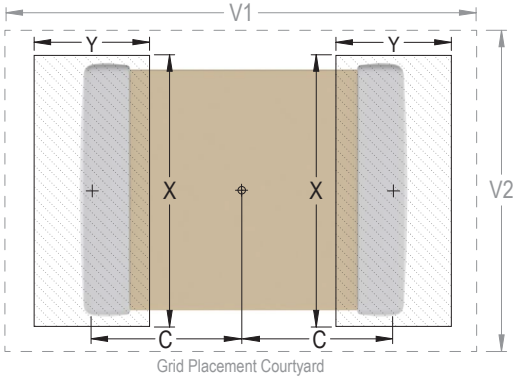
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

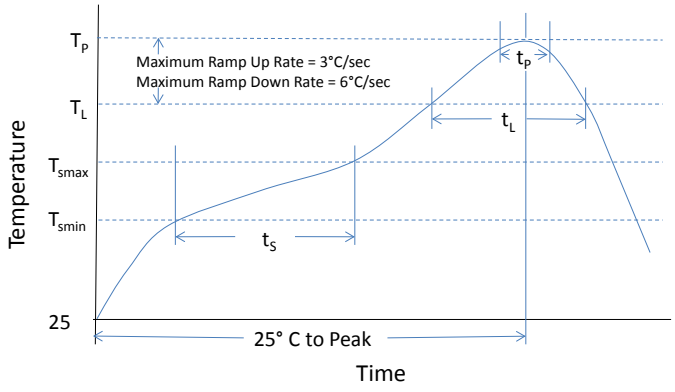
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



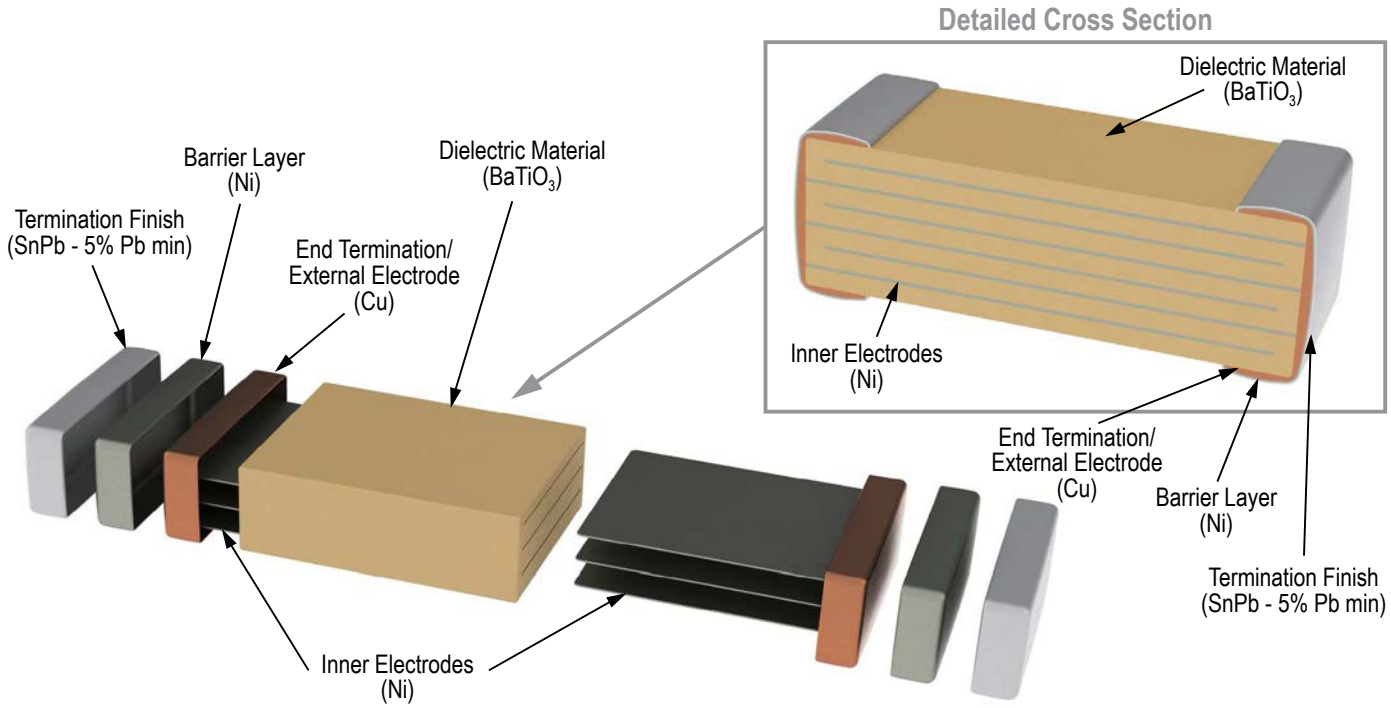
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# Commercial "L" Series, SnPb Termination, X5R Dielectric 4 – 50 VDC (Commercial Grade)

## Overview

KEMET's Commercial "L" Series with Tin/Lead Termination surface mount capacitors in X5R dielectric are designed to meet the needs of critical applications where tin/lead end metallization is required. KEMET's tin/lead electroplating process is designed to meet a 5% minimum lead content and address concerns for a more robust and reliable lead containing termination system. As the bulk of the electronics industry moves towards RoHS compliance, KEMET continues to provide tin/lead terminated products for military, aerospace and industrial applications and will ensure customers have a stable and long-term source of supply.

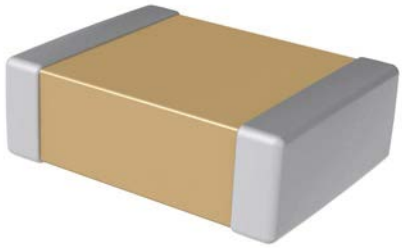
KEMET's X5R dielectric features an 85°C maximum operating temperature and is considered "semi-stable." The Electronics Industries Alliance (EIA) characterizes X5R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X5R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +85°C.

## Benefits

- −55°C to +85°C operating temperature range
- Temperature stable dielectric
- Reliable & robust termination system
- EIA 0402, 0603, 0805, 1206, and 1210 case sizes
- DC voltage ratings of 4 V, 6.3 V, 10 V, 16 V, 25 V, 35 V, and 50 V
- Capacitance offerings ranging from 12 nF to 22 µF
- Available capacitance tolerances of ±10% and ±20%
- Non-polar device, minimizing installation concerns
- SnPb plated termination finish (5% Pb minimum)
- SnPb plated termination finish option is available on other surface mount product series upon request.

## Applications

Typical applications include decoupling, bypass, and filtering. Markets include military, aerospace and industrial.



## Ordering Information

| C | 1210 | C | 106 | K | 4 | P | A | L | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C–Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | 7 = 4<br>9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50 | P = X5R | A = N/A | L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

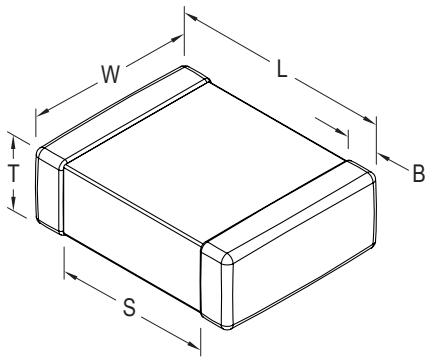
| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

These devices do not meet RoHS criteria due to the concentration of Lead (Pb) in the termination finish.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +85°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 5.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | See Dissipation Factor Limit Table |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1] Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*

*[2] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3] Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*

*120 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF*

*[4] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X5R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 25 | < 2.2 µF | 7.5 | | |
| | | ≥ 2.2 µF | 20.0 | | |
| | < 25 | < 0.56 µF | 7.5 | | |
| | < 25 | ≥ 0.56 µF | 20.0 | | |

## Dissipation Factor Limit Table

| Rated DC Voltage | Capacitance | Dissipation Factor (Maximum %) |
|---|---|---|
| > 25 | All | 2.5 |
| 25 | < 2.2 µF | 5.0 |
| | ≥ 2.2 µF | 10.0 |
| < 25 | < 0.56 µF | 5.0 |
| | ≥ 0.56 µF | 10.0 |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ | 100 Megohm Microfarads |
|---|---|---|---|
| 0201 | N/A | ALL | N/A |
| 0402 | < .012 µF | ≥ .012 µF < 1.0 µF | ≥ 1.0 µF |
| 0603 | < .047 µF | ≥ .047 µf < 1.0 µF | ≥ 1.0 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF < 1.0 µF | ≥ 1.0 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF < 1.0 µF | ≥ 1.0 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF < 1.0 µF | ≥ 1.0 µF |
| 1812 | < 2.2 µF | ≥ 2.2 µF | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | | C0402C | | | | | | C0603C | | | | | | C0805C | | | | | | C1206C | | | | | | C1210C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 6 | 5 |
| | | Rated Voltage (VDC) | | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 35 | 50 |
| | | Cap Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22,000 pF | 223 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27,000 pF | 273 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 39,000 pF | 393 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 56,000 pF | 563 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 68,000 pF | 683 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 82,000 pF | 823 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.12 µF | 124 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.18 µF | 184 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.22 µF | 224 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.27 µF | 274 | K | M | | | | | | | CG | CG | CG | CG | | | | | | | | | EB | EB | EB | EB | | | | | | | | |
| 0.33 µF | 334 | K | M | | | | | | | CG | CG | CG | CG | | | | | | | | | EB | EB | EB | EB | | | | | | | | |
| 0.39 µF | 394 | K | M | | | | | | | CG | CG | CG | CG | | | | | | | | | EB | EB | EB | EB | | FD | FD | FD | FD | FD | FD |
| 0.47 µF | 474 | K | M | | | | | | | CG | CG | CG | CG | | | DN | DN | DN | DN | DN | | EC | EC | EC | EC | | FD | FD | FD | FD | FD | FD |
| 0.56 µF | 564 | K | M | | | | | | | CG | CG | CG | CG | | | DP | DP | DP | DP | DP | | ED | ED | ED | ED | | FD | FD | FD | FD | FD | FD |
| 0.68 µF | 684 | K | M | | | | | | | CG | CG | CG | CG | | | DE | DE | DE | DE | DE | | EE | EE | EE | EE | | FD | FD | FD | FD | FD | FD |
| 0.82 µF | 824 | K | M | | | | | | | CG | CG | CG | CG | | | DF | DF | DF | DF | DF | | EF | EF | EF | EF | | FF | FF | FF | FF | FF | FF |
| 1.0 µF | 105 | K | M | | | | | | | CG | CG | CG | CG | | | DG | DG | DG | DG | DG | | EF | EF | EF | EH | | FH | FH | FH | FH | FH | FH |
| 1.2 µF | 125 | K | M | | | | | | | | | | | | | DN | DN | DN | DN | | | EC | EC | EC | EC | | FD | FD | FD | FD | | |
| 1.5 µF | 155 | K | M | | | | | | | | | | | | | DN | DN | DN | DN | | | EC | EC | EC | EC | | FD | FD | FD | FD | | |
| 1.8 µF | 185 | K | M | | | | | | | | | | | | | DP | DP | DP | DP | | | EC | EC | EC | EC | | FD | FD | FD | FD | | |
| 2.2 µF | 225 | K | M | | | | | | | | | | | | | DP | DP | DP | DP | | | EE | EE | EE | EE | | FG | FG | FG | FG | | |
| 2.7 µF | 275 | K | M | | | | | | | | | | | | | DL | DL | DL | DL | | | EF | EF | EF | EF | | FG | FG | FG | FG | | |
| 3.3 µF | 335 | K | M | | | | | | | | | | | | | DE | DE | DE | DH | | | EH | EH | EH | EH | | FH | FH | FH | FH | FM | FM |
| 3.9 µF | 395 | K | M | | | | | | | | | | | | | DH | DH | DH | DH | | | EH | EH | EH | EH | | FJ | FJ | FJ | FJ | FK | FK |
| 4.7 µF | 475 | K | M | | | | | | | | | | | | | DH | DH | DH | DG | | | EH | EH | EH | EH | | FK | FK | FK | FE | FS | FS |
| 5.6 µF | 565 | K | M | | | | | | | | | | | | | DH | DH | DH | | | | EK | EK | EH | | | FG | FG | FG | FE | | |
| 6.8 µF | 685 | K | M | | | | | | | | | | | | | DH | DH | DH | | | | EK | EK | EH | | | FJ | FJ | FJ | FJ | | |
| 8.2 µF | 825 | K | M | | | | | | | | | | | | | | | | | | | ED | ED | EH | | | FK | FK | FK | FG | | |
| 10 µF | 106 | K | M | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | FK | FK | FK | FH | | |
| 12 µF | 126 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 µF | 186 | K | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | K | M | | | | | | | | | | | | | | | | | | | | | | | | FH | FH | FJ | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 4 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 35 | 50 |
| | | Voltage Code | | 7 | 9 | 8 | 3 | 5 | 4 | 7 | 9 | 8 | 4 | 3 | 5 | 7 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 6 | 5 |
| | | Case Size/ Series | | C0402C | | | | | | C0603C | | | | | | C0805C | | | | | | C1206C | | | | | C1210C | | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DL | 0805 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EK | 1206 | 0.80 ± 0.10 | 0 | 0 | 2,000 | 8,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

[1] *The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*

[2] *A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |

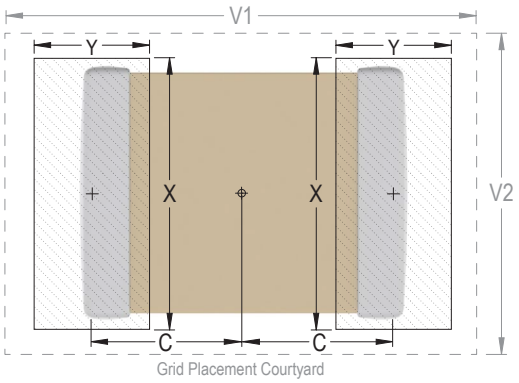
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

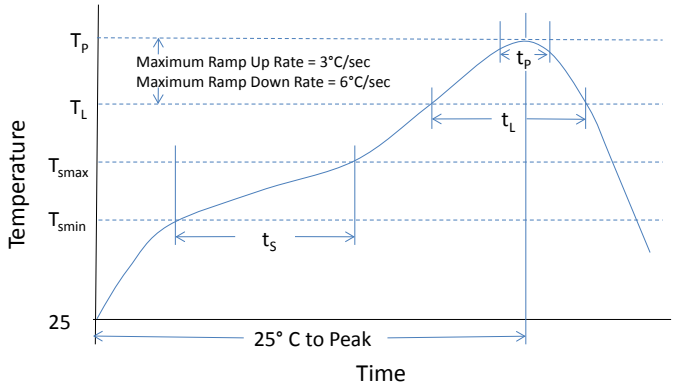
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



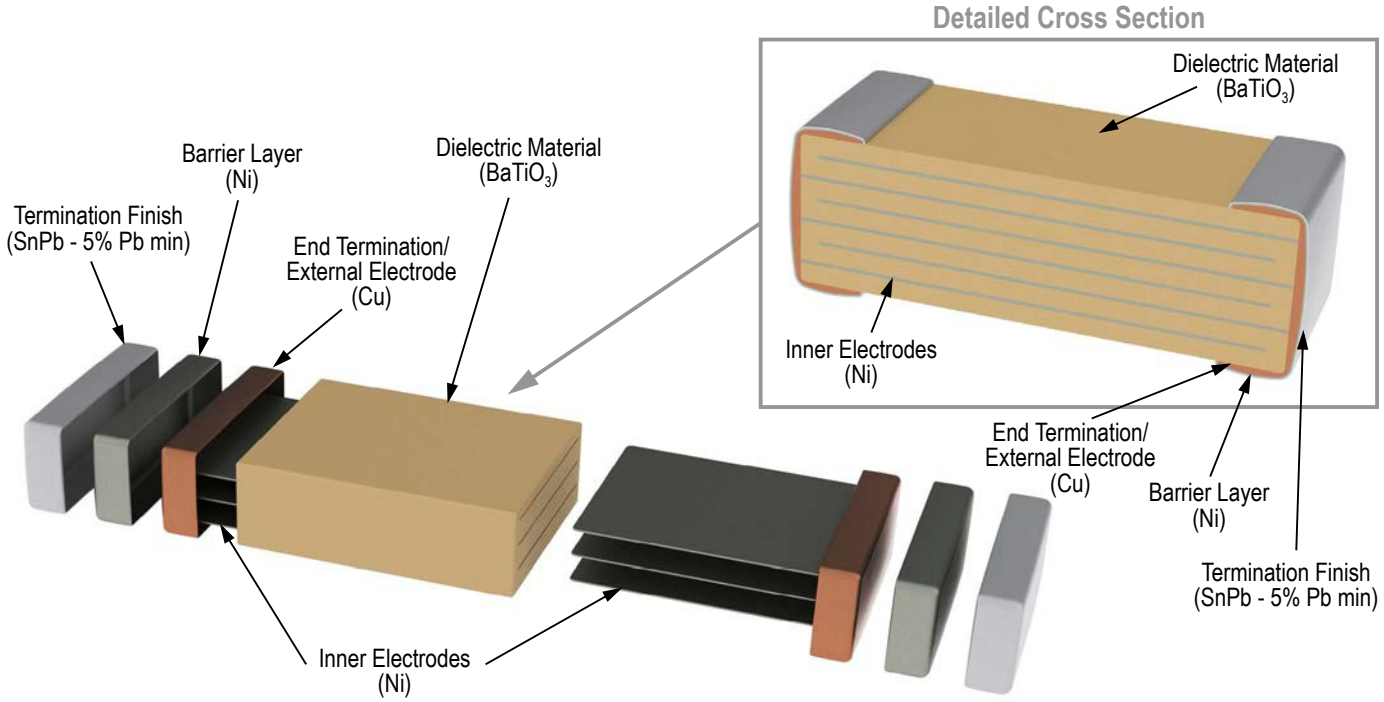
## Table 4 – Performance & Reliability: Test Methods and Conditions

<table>
<tr><th>Stress</th><th>Reference</th><th>Test or Inspection Method</th></tr>
<tr><td>Terminal Strength</td><td>JIS–C–6429</td><td>Appendix 1, Note: Force of 1.8 kg for 60 seconds.</td></tr>
<tr><td>Board Flex</td><td>JIS–C–6429</td><td>Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum).</td></tr>
<tr><td rowspan="4">Solderability</td><td rowspan="4">J–STD–002</td><td>Magnification 50 X. Conditions:</td></tr>
<tr><td>a) Method B, 4 hours at 155°C, dry heat at 235°C</td></tr>
<tr><td>b) Method B at 215°C category 3</td></tr>
<tr><td>c) Method D, category 3 at 260°C</td></tr>
<tr><td>Temperature Cycling</td><td>JESD22 Method JA–104</td><td>1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td rowspan="2">Biased Humidity</td><td rowspan="2">MIL–STD–202 Method 103</td><td>Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Moisture Resistance</td><td>MIL–STD–202 Method 106</td><td>t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Thermal Shock</td><td>MIL–STD–202 Method 107</td><td>−55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air.</td></tr>
<tr><td>High Temperature Life</td><td>MIL–STD–202 Method 108 /EIA–198</td><td>1,000 hours at 85°C with 2 X rated voltage applied excluding the following:
<table>
<tr><th>Case Size</th><th>Capacitance</th><th>Applied Voltage</th></tr>
<tr><td>0402</td><td>≥ 0.22 µF</td><td rowspan="5">1.5 X</td></tr>
<tr><td>0603</td><td>≥ 1.0 µF</td></tr>
<tr><td>0805</td><td>≥ 4.7 µF</td></tr>
<tr><td>1206</td><td>≥ 2.2 µF</td></tr>
<tr><td>1210</td><td>≥ 10 µF</td></tr>
</table></td></tr>
<tr><td>Storage Life</td><td>MIL–STD–202 Method 108</td><td>150°C, 0 VDC for 1,000 hours.</td></tr>
<tr><td>Vibration</td><td>MIL–STD–202 Method 204</td><td>5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz</td></tr>
<tr><td>Mechanical Shock</td><td>MIL–STD–202 Method 213</td><td>Figure 1 of Method 213, Condition F.</td></tr>
<tr><td>Resistance to Solvents</td><td>MIL–STD–202 Method 215</td><td>Add aqueous wash chemical, OKEM Clean or equivalent.</td></tr>
</table>

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

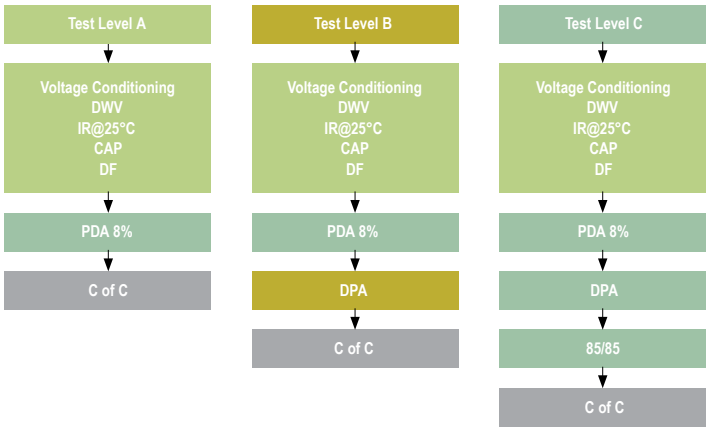
## Construction (Typical)



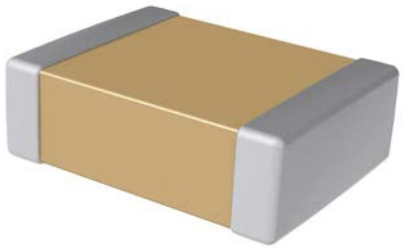
# Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, C0G Dielectric, 10 – 250 VDC

## Overview

KEMET's COTS program is an extension of KEMET knowledge of high reliability test regimes and requirements. KEMET regularly supplies "up-screened" products by working with customer drawings and imposing specified design and test requirements. The COTS program offers the same high quality and high reliability components as up-screened products, but at a lower cost to the customer. This is accomplished by eliminating the need for customer-specific drawings to achieve the reliability level required for customer applications. A series of tests and inspections have been selected to provide the accelerated conditioning and 100% screening necessary to eliminate infant mortal failures from the population.




KEMET's C0G dielectric features a 125°C maximum operating temperature and is considered "stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/ºC from −55°C to +125°C.



All COTS testing includes voltage conditioning and post-electrical testing as per MIL–PRF–55681. For enhanced reliability, KEMET also provides the following test level options and conformance certifications:

## Ordering Information

| C | 1206 | T | 104 | K | 5 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812<br>2220 | T = COTS | Two significant digits + number of zeros Use 9 for 1.0 – 9.9 pF Use 8 for 0.5 – .99 pF ex. 2.2 pF = 229 ex. 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ± 1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>6 = 35<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | G = C0G | A = Testing per MIL–PRF–55681 PDA 8%<br>B= Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469<br>C = Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469, Humidity per MIL–STD–202, Method 103, Condition A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

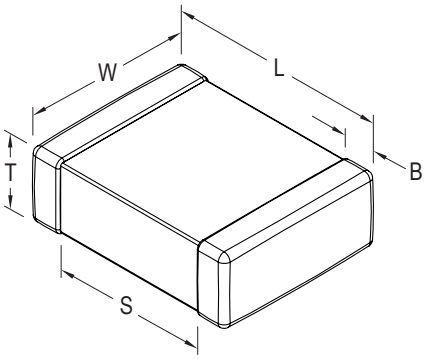
## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- Voltage conditioning and post-electrical testing per MIL–PRF–55681, Paragraph 4.8.3.1, Standard Voltage Conditioning
- Destructive Physical Analysis (DPA) per EIA–469
- Humidity, steady state, low voltage (85/85) per MIL–STD–202, Method 103, Condition A
- RoHS Compliant (excluding SnPb end metallization option)
- EIA 0402, 0603, 0805, 1206, 1210, 1812, and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 0.5 pF up to 0.47 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- Certificate of compliance
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies and into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- SnPb end metallization option available upon request (5% Pb minimum)

## Applications

Typical applications include military, space quality and high reliability electronics.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and Dissipation Factor (DF) measured under the following conditions:*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 0805 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | | | | | | C0402T | | | | | | | C0603T | | | | | | | C0805T | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 0.50 & 0.75 pF | 508 & 758 | B | C | D | | | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 1.0 - 9.1 pF* | 109 - 919* | B | C | D | | | | | | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 10 - 91 pF* | 100 - 910* | | | | F | G | J | K | M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 100 pF | 101 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 110 - 180 pF* | 111 -181* | | | | F | G | J | K | M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 200 - 270 pF* | 201 - 271* | | | | F | G | J | K | M | BB | BB | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 300 pF | 301 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 330 pF | 331 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | BD | BD | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 360 pF | 361 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 390 pF | 391 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 430 pF | 431 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 470 pF | 471 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DP | DP |
| 510 - 820 pF* | 511 - 821* | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN |
| 910 pF | 911 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP |
| 1,000 pF | 102 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DP | DP | DP |
| 1,100 pF | 112 | | | | F | G | J | K | M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 1,200 pF | 122 | | | | F | G | J | K | M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 1,300 pF | 132 | | | | F | G | J | K | M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,500 pF | 152 | | | | F | G | J | K | M | BB | BB | BB | BB | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,600 pF | 162 | | | | F | G | J | K | M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 1,800 pF | 182 | | | | F | G | J | K | M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DP | DP | DP | DP | DP | DN | DN |
| 2,000 pF | 202 | | | | F | G | J | K | M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 2,200 pF | 222 | | | | F | G | J | K | M | BB | BB | BB | | | | | CF | CF | CF | CF | CF | CH | CH | DN | DN | DN | DN | DN | DN | DN |
| 2,400 pF | 242 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN |
| 2,700 pF | 272 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN |
| 3,000 pF | 302 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN |
| 3,300 pF | 332 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DN | DN |
| 3,600 pF | 362 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DN | DP | DP |
| 3,900 pF | 392 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 4,300 pF | 432 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 4,700 pF | 472 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | DP | DP |
| 5,100 pF | 512 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | | | | DE | DE | DE | DE | DN | DP | DP |
| 5,600 pF | 562 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DP | DP |
| 6,200 pF | 622 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG |
| 6,800 pF | 682 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DN | DG | DG |
| 7,500 pF | 752 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG |
| 8,200 pF | 822 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | DG | DG |
| 9,100 pF | 912 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DN | | |
| 10,000 pF | 103 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DP | | |
| 12,000 pF | 123 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DN | DE | | |
| 15,000 pF | 153 | | | | F | G | J | K | M | | | | | | | | CF | CF | CF | | | | | DN | DN | DN | DP | DG | | |
| 18,000 pF | 183 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DN | DN | DN | DP | | | |
| 22,000 pF | 223 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DP | DP | DP | DF | | | |
| 27,000 pF | 273 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DF | DF | DF | | | | |
| 33,000 pF | 333 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| 39,000 pF | 393 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| 47,000 pF | 473 | | | | F | G | J | K | M | | | | | | | | | | | | | | | DG | DG | DG | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | | | | | | | | C0402T | | | | | | | C0603T | | | | | | | C0805T | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C1206T | | | | | | | C1210T | | | | | | | C1812T | | | | C2220T | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 10 - 91 pF* | 100 - 910* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 100 - 430 pF* | 101 - 431* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | | | | | | | |
| 470 - 910 pF* | 471 - 911* | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,000 pF | 102 | F G J K M | EB | EB | EB | EB | EB | EE | EE | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,100 pF | 112 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,200 pF | 122 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | | | |
| 1,300 pF | 132 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | | | |
| 1,500 pF | 152 | F G J K M | EB | EB | EB | EB | ED | EC | EC | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 1,600 pF | 162 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 1,800 pF | 182 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FB | FE | FE | GB | GB | GB | GB | | | |
| 2,000 pF | 202 | F G J K M | EB | EB | EB | EB | ED | ED | ED | FB | FB | FB | FB | FC | FE | FE | GB | GB | GB | GB | | | |
| 2,200 pF | 222 | F G J K M | EB | EB | EB | EB | EE | EE | ED | FB | FB | FB | FB | FC | FG | FG | GB | GB | GB | GB | | | |
| 2,400 pF | 242 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FC | FC | FC | | | | | | | |
| 2,700 pF | 272 | F G J K M | EB | EB | EB | EB | EC | EC | EC | FB | FB | FB | FB | FC | FC | FC | GB | GB | GB | GB | | | |
| 3,000 pF | 302 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FB | FB | FB | FB | FC | FF | FF | | | | | | | |
| 3,300 pF | 332 | F G J K M | EC | EC | EC | EC | EE | EB | EB | FB | FB | FB | FB | FF | FF | FF | GB | GB | GB | GB | | | |
| 3,600 pF | 362 | F G J K M | EC | EC | EC | EC | EE | EB | EB | FB | FB | FB | FB | FF | FF | FF | | | | | | | |
| 3,900 pF | 392 | F G J K M | EC | EC | EC | EC | EF | EB | EB | FB | FB | FB | FB | FF | FF | FF | GB | GB | GB | GB | | | |
| 4,300 pF | 432 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FB | FB | FB | FB | FF | FF | FF | | | | | | | |
| 4,700 pF | 472 | F G J K M | EC | EC | EC | EC | EC | EB | EB | FF | FF | FF | FF | FG | FG | FG | GB | GB | GD | GD | | | |
| 5,100 pF | 512 | F G J K M | ED | ED | ED | ED | ED | EB | EB | FB | FB | FB | FB | FG | FG | FG | | | | | | | |
| 5,600 pF | 562 | F G J K M | ED | ED | ED | ED | ED | EB | EB | FB | FB | FB | FB | FG | FG | FG | GB | GB | GH | GH | | | |
| 6,200 pF | 622 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FG | FB | FB | | | | | | | |
| 6,800 pF | 682 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FG | FB | FB | GB | GB | GJ | GJ | JE | JE | JB |
| 7,500 pF | 752 | F G J K M | EB | EB | EB | EB | EB | EB | EB | FC | FC | FC | FC | FC | FB | FB | | | | | | | |
| 8,200 pF | 822 | F G J K M | EC | EC | EC | EC | EB | EC | EC | FC | FC | FC | FC | FC | FB | FB | GB | GH | GB | GB | JE | JE | JB |
| 9,100 pF | 912 | F G J K M | EC | EC | EC | EC | EB | EC | EC | FE | FE | FE | FE | FE | FB | FB | | | | | | | |
| 10,000 pF | 103 | F G J K M | ED | ED | ED | ED | EB | EC | EC | FF | FF | FF | FF | FF | FB | FB | GB | GH | GB | GB | JE | JE | JB |
| 12,000 pF | 123 | F G J K M | EB | EB | EB | EB | EB | ED | ED | FG | FG | FG | FG | FB | FB | FB | GB | GG | GB | GB | JE | JE | JB |
| 15,000 pF | 153 | F G J K M | EB | EB | EB | EB | EB | EF | EF | FG | FG | FG | FG | FB | FC | FC | GB | GB | GB | GB | JE | JE | JB |
| 18,000 pF | 183 | F G J K M | EB | EB | EB | EB | EB | EH | EH | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | JE | JE | JB |
| 22,000 pF | 223 | F G J K M | EB | EB | EB | EB | EC | EH | EH | FB | FB | FB | FB | FB | FF | FF | GB | GB | GB | GB | JE | JB | JB |
| 27,000 pF | 273 | F G J K M | EB | EB | EB | EB | EE | | | FB | FB | FB | FB | FB | FG | FG | GB | GB | GB | GB | JE | JB | JB |
| 33,000 pF | 333 | F G J K M | EB | EB | EB | EB | EE | | | FB | FB | FB | FB | FB | FH | FH | GB | GB | GB | GB | JB | JB | JB |
| 39,000 pF | 393 | F G J K M | EC | EC | EC | EE | EH | | | FB | FB | FB | FB | FE | FH | FH | GB | GB | GB | GB | JB | JB | JB |
| 47,000 pF | 473 | F G J K M | EC | EC | EC | EE | EH | | | FB | FB | FB | FB | FE | FJ | FJ | GB | GB | GD | GD | JB | JB | JB |
| 56,000 pF | 563 | F G J K M | ED | ED | ED | EF | | | | FB | FB | FB | FB | FF | | | GB | GB | GD | GD | JB | JB | JB |
| 68,000 pF | 683 | F G J K M | EF | EF | EF | EH | | | | FB | FB | FB | FC | FG | | | GB | GB | GK | GK | JB | JB | JB |
| 82,000 pF | 823 | F G J K M | EH | EH | EH | EH | | | | FC | FC | FC | FF | FH | | | GB | GB | GM | GM | JB | JB | JB |
| 0.10 µF | 104 | F G J K M | EH | EH | EH | | | | | FE | FE | FE | FG | FM | | | GB | GD | GM | GM | JB | JB | JD |
| 0.12 µF | 124 | F G J K M | | | | | | | | FG | FG | FG | FH | | | | GB | GH | | | JB | JB | JD |
| 0.15 µF | 154 | F G J K M | | | | | | | | FH | FH | FH | FM | | | | GD | GN | | | JB | JB | JG |
| 0.18 µF | 184 | F G J K M | | | | | | | | FJ | FJ | FJ | | | | | GH | | | | JB | JD | JG |
| 0.22 µF | 224 | F G J K M | | | | | | | | FK | FK | FK | | | | | GK | | | | JB | JD | JL |
| 0.27 µF | 274 | F G J K M | | | | | | | | | | | | | | | | | | | JB | JF | |
| 0.33 µF | 334 | F G J K M | | | | | | | | | | | | | | | | | | | JD | JG | |
| 0.39 µF | 394 | F G J K M | | | | | | | | | | | | | | | | | | | JG | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | | | | | | | JG | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 50 | 100 | 200 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | A | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 5 | 1 | 2 |
| | | Case Size/Series | C1206T | | | | | | | C1210T | | | | | | | C1812T | | | | C2220T | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 & 7,670,981, other patents pending, and any foreign counterparts.*

# Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 402 | 0.50 ± 0.05 | 10000 | 50000 | 0 | 0 |
| BD | 402 | 0.55 ± 0.05 | 10000 | 50000 | 0 | 0 |
| CF | 603 | 0.80 ± 0.07 | 4000 | 15000 | 0 | 0 |
| CH | 603 | 0.85 ± 0.07 | 4000 | 10000 | 0 | 0 |
| DN | 805 | 0.78 ± 0.10 | 4000 | 15000 | 0 | 0 |
| DP | 805 | 0.90 ± 0.10 | 4000 | 15000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JG | 2220 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |

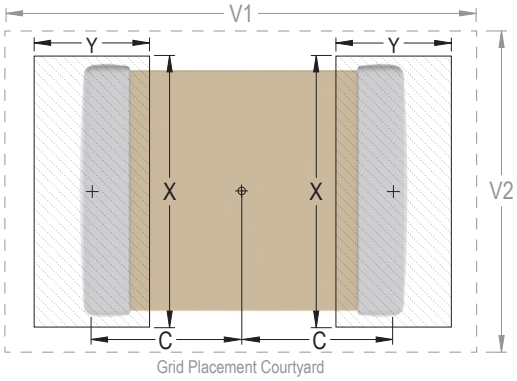
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

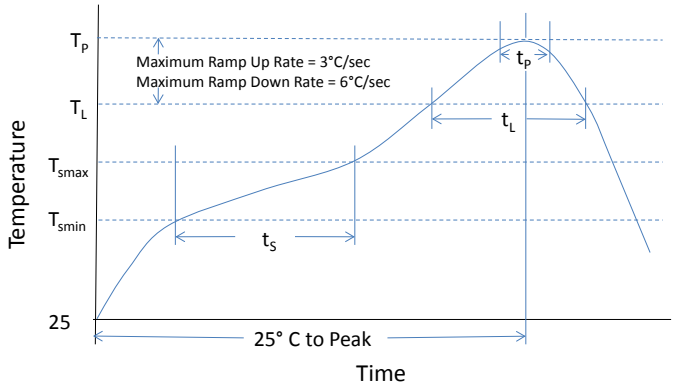
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



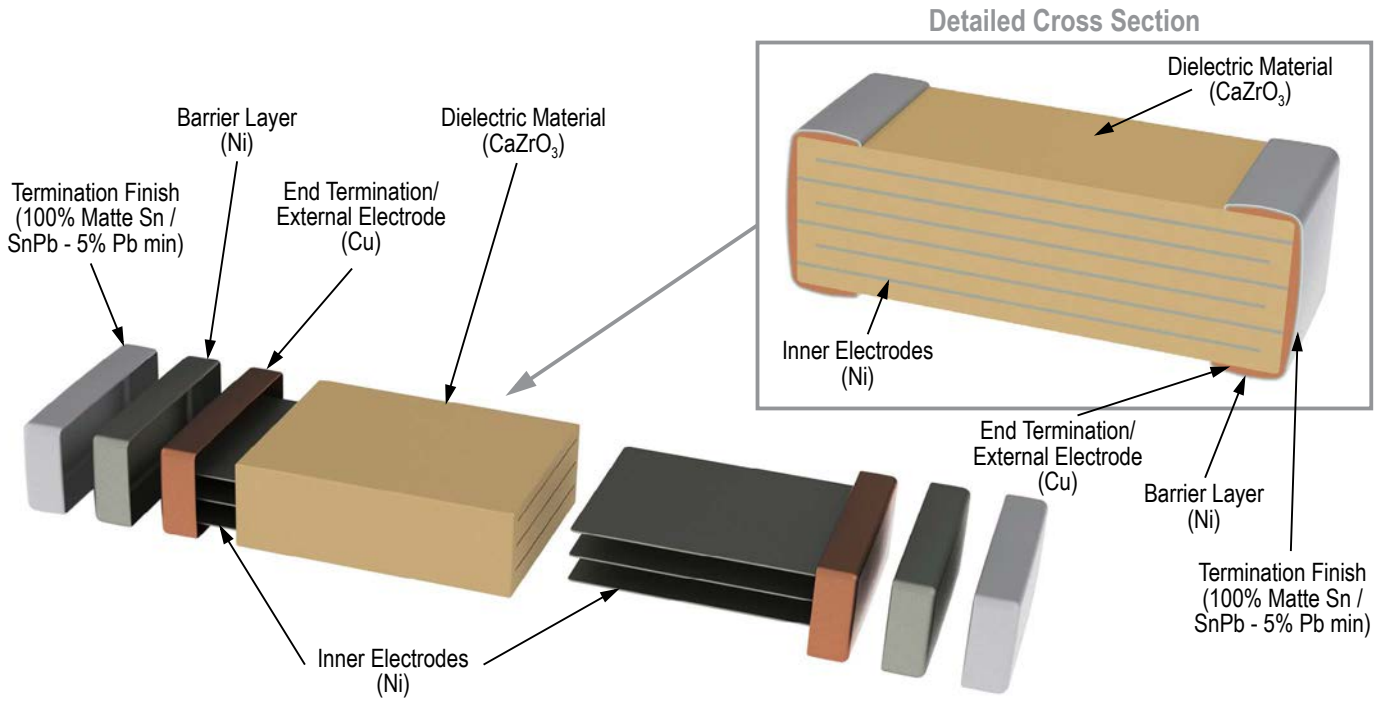
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

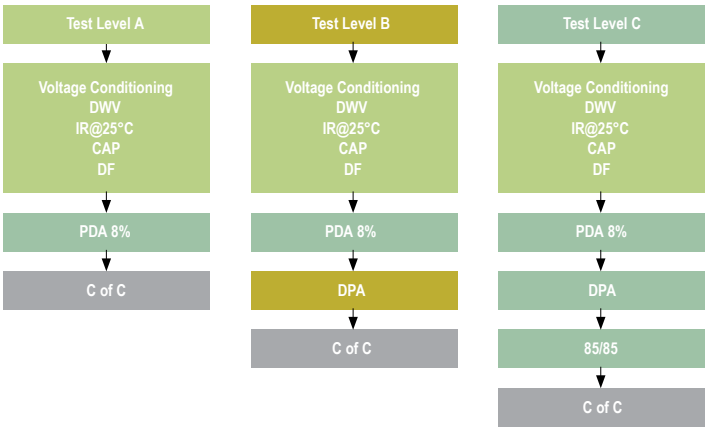
- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

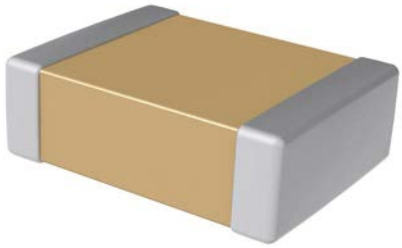
# Commercial Off-The-Shelf (COTS) for Higher Reliability Applications, X7R Dielectric, 6.3 – 250 VDC

## Overview

KEMET's COTS program is an extension of KEMET knowledge of high reliability test regimes and requirements. KEMET regularly supplies "up-screened" products by working with customer drawings and imposing specified design and test requirements. The COTS program offers the same high quality and high reliability components as up-screened products, but at a lower cost to the customer. This is accomplished by eliminating the need for customer-specific drawings to achieve the reliability level required for customer applications. A series of tests and inspections have been selected to provide the accelerated conditioning and 100% screening necessary to eliminate infant mortal failures from the population.




KEMET's X7R dielectric features a 125°C maximum operating temperature and is considered "temperature stable." The Electronics Components, Assemblies & Materials Association (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.



All COTS testing includes voltage conditioning and post-electrical testing as per MIL–PRF–55681. For enhanced reliability, KEMET also provides the following test level options and conformance certifications:

## Ordering Information

| C | 1210 | T | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812<br>2220 | T = COTS | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = Testing per MIL–PRF–55681 PDA 8%<br>B= Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469<br>C = Testing per MIL–PRF–55681 PDA 8%, DPA per EIA–469, Humidity per MIL–STD–202, Method 103, Condition A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

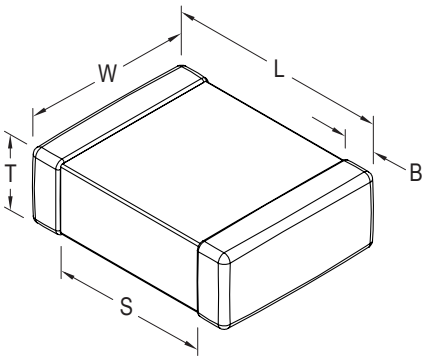
## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- Voltage conditioning and post-electrical testing per MIL–PRF–55681
- Destructive Physical Analysis (DPA) per EIA–469
- Biased humidity testing (85/85) per MIL–STD–202
- Certificate of Compliance
- Temperature stable dielectric
- EIA 0402, 0603, 0805, 1206, 1210, 1812, and 2220 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 10 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include military, space quality and high reliability electronics.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ± 0.05 (.002) | 0.50 (.020) ± 0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ± 0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210[1] | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

*[1] For capacitance values ≥ 4.7 µF add 0.02 (0.001) to the width tolerance dimension and 0.10 (0.004) to the length tolerance dimension.*

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 – 91 pF* | 100 – 910* | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | |
| 100 – 150 pF** | 101 – 151** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB | EB | |
| 180 – 820 pF** | 181 – 821** | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | |
| 1,000 pF | 102 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,200 pF | 122 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,500 pF | 152 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 1,800 pF | 182 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 2,200 pF | 222 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 2,700 pF | 272 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 3,300 pF | 332 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 3,900 pF | 392 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 4,700 pF | 472 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 5,600 pF | 562 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 6,800 pF | 682 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 8,200 pF | 822 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 10,000 pF | 103 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 12,000 pF | 123 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 15,000 pF | 153 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 18,000 pF | 183 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 22,000 pF | 223 | J K M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DN | DN | EB | EB | EB | EB | EB | EB | EB | EB |
| 27,000 pF | 273 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB |
| 33,000 pF | 333 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EB | EB | EB |
| 39,000 pF | 393 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | DE | | EB | EB | EB | EB | EB | EC | EB | EB |
| 47,000 pF | 473 | J K M | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DE | DG | | EB | EB | EB | EB | EB | EC | ED | ED |
| 56,000 pF | 563 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | DG | | EB | EB | EB | EB | EB | EB | ED | ED |
| 68,000 pF | 683 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | ED | ED |
| 82,000 pF | 823 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DP | DP | DP | DP | DP | DE | | | EB | EB | EB | EB | EB | EB | ED | ED |
| 0.10 µF | 104 | J K M | BB | BB | BB | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DE | | | EB | EB | EB | EB | EB | EB | EM | EM |
| 0.12 µF | 124 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | EG | |
| 0.15 µF | 154 | J K M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | EG | |
| 0.18 µF | 184 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | | |
| 0.22 µF | 224 | J K M | | | | | | CF | CF | CF | CF | | | | DN | DN | DN | DN | DP | DG | | | EC | EC | EC | EC | EC | EC | | |
| 0.27 µF | 274 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EM | | |
| 0.33 µF | 334 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DP | | | | EB | EB | EB | EB | EC | EG | | |
| 0.39 µF | 394 | J K M | | | | | | CF | CF | CF | | | | | DG | DG | DG | DG | DE | | | | EB | EB | EB | EB | EC | EG | | |
| 0.47 µF | 474 | J K M | | | | | | CF | CF | CF | | | | | DP | DP | DP | DP | DE | | | | EC | EC | EC | EC | EC | EG | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | | | | ED | ED | ED | ED | EC | | | |
| 0.68 µF | 684 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | DH | | | | EE | EE | EE | EE | ED | | | |
| 0.82 µF | 824 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | EF | EF | EF | EF | ED | | | |
| 1.0 µF | 105 | J K M | | | | | | | | | | | | | DP | DP | DP | DG | | | | | EF | EF | EF | EG | ED | | | |
| 1.2 µF | 125 | J K M | | | | | | | | | | | | | DE | DE | DE | | | | | | ED | ED | ED | EG | EH | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | EF | EF | EF | EG | EH | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | ED | ED | ED | EF | EH | | | |
| 2.2 µF | 225 | J K M | | | | | | | | | | | | | DG | DG | DG | | | | | | ED | ED | ED | EF | EH | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | ED | ED | ED | EH | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

**Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0402T | | | | | C0603T | | | | | | | C0805T | | | | | | | | C1206T | | | | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 1B – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 - 91 pF* | 100 - 910* | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | |
| 100 - 270 pF** | 101 - 391** | J K M | FB | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | | | | | | | | | | | | | | |
| 470 - 820 pF** | 471 - 821** | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,000 pF | 102 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,200 pF | 122 | J K M | FB | FB | FB | FB | FB | FB | FB | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,500 pF | 152 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 1,800 pF | 182 | J K M | FB | FB | FB | FB | FB | FB | FE | | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 2,200 pF | 222 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 2,700 pF | 272 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | LF | GB | GB | GB | GB | | | | | | | | | | |
| 3,300 pF | 332 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | |
| 3,900 pF | 392 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LF | LF | | GB | GB | GB | GB | | | | | | | | | | |
| 4,700 pF | 472 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GD | | | | | | | | | | |
| 5,600 pF | 562 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GH | | | | | | | | | | |
| 6,800 pF | 682 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 8,200 pF | 822 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 10,000 pF | 103 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 12,000 pF | 123 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 15,000 pF | 153 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 18,000 pF | 183 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | | | | | JE | JE | JE | | |
| 22,000 pF | 223 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | |
| 27,000 pF | 273 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JE | JE | JE | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |

*Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 39,000 pF | 393 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 47,000 pF | 473 | J K M | FB | FB | FB | FB | FB | FB | FB | FB | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 56,000 pF | 563 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | LD | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 68,000 pF | 683 | J K M | FB | FB | FB | FB | FB | FB | FC | FC | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JB | | |
| 82,000 pF | 823 | J K M | FB | FB | FB | FB | FB | FC | FF | FF | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.10 µF | 104 | J K M | FB | FB | FB | FB | FB | FD | FG | FG | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.12 µF | 124 | J K M | FB | FB | FB | FB | FB | FD | FH | FH | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.15 µF | 154 | J K M | FC | FC | FC | FC | FC | FD | FM | FM | LD | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.18 µF | 184 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | LD | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.22 µF | 224 | J K M | FC | FC | FC | FC | FC | FD | FK | FK | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JB | JB | JC | JC | JC |
| 0.27 µF | 274 | J K M | FC | FC | FC | FC | FC | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC |
| 0.33 µF | 334 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC |
| 0.39 µF | 394 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GG | GG | HD | HD | HD | HD | JC | JC | JC | JC | JC |
| 0.47 µF | 474 | J K M | FD | FD | FD | FD | FD | FD | | | | | | GB | GB | GG | GJ | GJ | HD | HD | HD | HD | JC | JC | JC | JC | JC |
| 0.56 µF | 564 | J K M | FD | FD | FD | FD | FD | FF | | | | | | GC | GC | GG | | | HD | HD | HD | HD | JC | JD | JD | JD | JD |
| 0.68 µF | 684 | J K M | FD | FD | FD | FD | FD | FG | | | | | | GC | GC | GG | | | HD | HD | HD | HD | JC | JD | JD | JD | JD |
| 0.82 µF | 824 | J K M | FF | FF | FF | FF | FF | FL | | | | | | GE | GE | GG | | | HF | HF | HF | HF | JC | JF | JF | JF | JF |
| 1.0 µF | 105 | J K M | FH | FH | FH | FH | FH | FM | | | | | | GE | GE | GG | | | HF | HF | HF | HF | JC | JF | JF | JF | JF |
| 1.2 µF | 125 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JC | JC | | | |
| 1.5 µF | 155 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JC | JC | | | |
| 1.8 µF | 185 | J K M | FH | FH | FH | FH | FG | | | | | | | | | | | | | | | | JD | JD | | | |
| 2.2 µF | 225 | J K M | FJ | FJ | FJ | FJ | FG | | | | | | | GO | GO | | | | | | | | JF | JF | | | |
| 2.7 µF | 275 | J K M | FE | FE | FE | FG | FH | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | FF | FF | FF | FM | FM | | | | | | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | FG | FG | FG | FG | FK | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | FC | FC | FC | FG | FS | | | | | | | GK | GK | | | | | | | | JF | JF | | | |
| 5.6 µF | 565 | J K M | FF | FF | FF | FH | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | FG | FG | FG | FM | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | FH | FH | FH | FK | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | FH | FH | FH | FS | | | | | | | | GK | | | | | | | | | JF | JO | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | | | | | | | | JO | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | FS | FS | | | | | | | | | | | | | | | | | | | JO | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1210T | | | | | | | | C1808T | | | C1812T | | | | | C1825T | | | | C2220T | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
***Capacitance range Includes E12 decade values only. (i.e., 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68 and 82)*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LF | 1808 | 1.00 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JB | 2220 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |

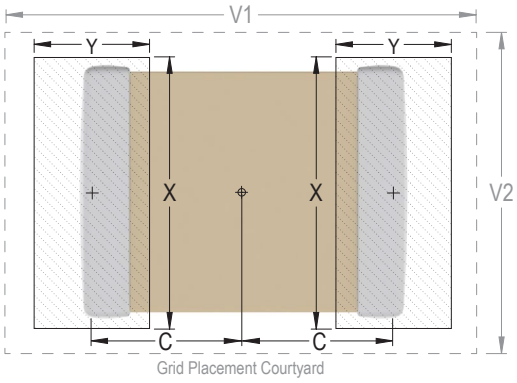
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

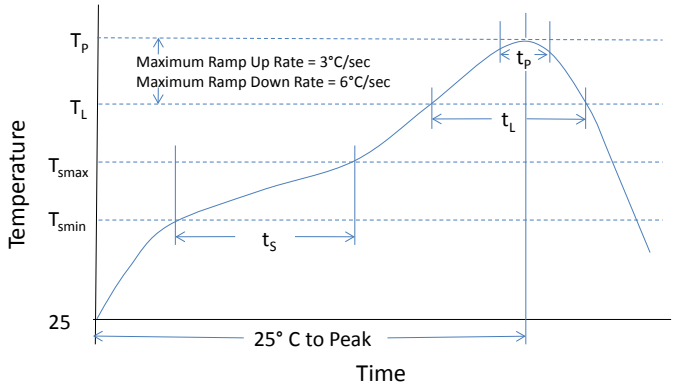
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



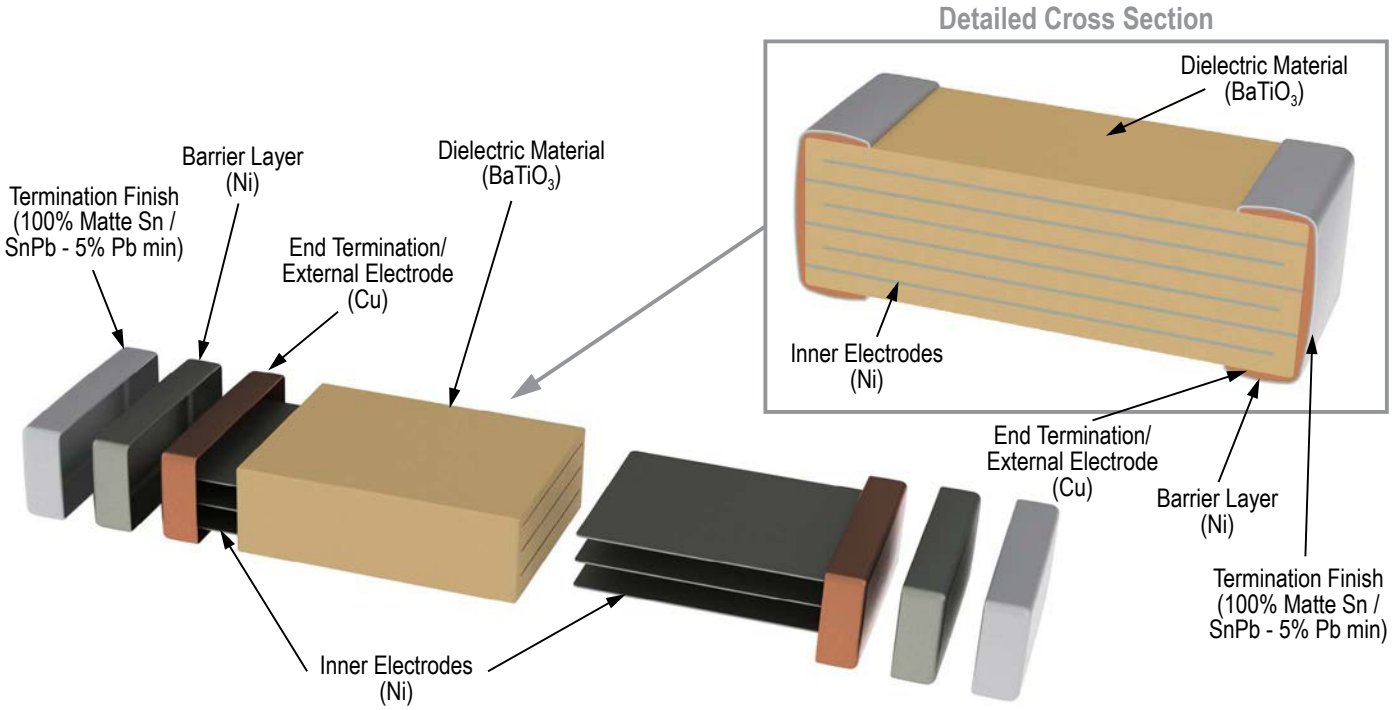
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



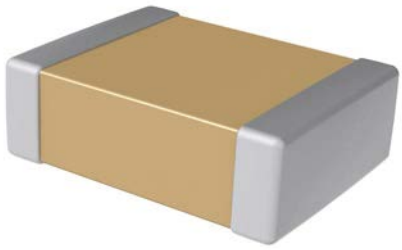
# High Temperature 150°C, Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Ultra-Stable X8R dielectric features a 150°C maximum operating temperature, offering the latest in high temperature dielectric technology and reliability for extreme temperature applications. It offers the same temperature capability as conventional X8R, but without the capacitance loss due to applied DC voltage. Ultra-Stable X8R exhibits no change in capacitance with respect to voltage and boasts a minimal change in capacitance with reference to ambient temperature. It is a suitable replacement for higher capacitance and larger footprint devices that fail to offer capacitance stability. Capacitance change with respect to temperature is limited to ±15% from −55°C to +150°C.

Driven by the demand for a more robust and reliable component, Ultra-Stable X8R dielectric capacitors were developed for critical applications where reliability and capacitance stability at higher operating temperatures are a concern. These capacitors are widely used in automotive circuits as well as general high temperature applications.

In addition to commercial grade, automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1210 | C | 184 | K | 3 | H | A | C | AUTO |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812 | C = Standard | Two significant digits + number of zeros | F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 3 = 25<br>5 = 50<br>1 = 100 | H = Ultra Stable X8R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Flexible termination option is available. Please see FT-CAP product bulletin C1013_X8R_FT-CAP_SMD*

[2] *Additional termination finish options may be available. Contact KEMET for details.*

[2] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 25 V, 50 V, and 100 V
- Capacitance offerings ranging from 100 pF to 0.22 µF
- Available capacitance tolerances of ±1%, ±2%, ±5%, ±10%, and ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Non-polar device, minimizing installation concerns
- Offered in both commercial and automotive grades
- 100% pure matte tin-plated termination finish that allowing for excellent solderability.
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include decoupling, bypass and filtering in extreme environments such as down-hole oil exploration, under-hood automotive, military and aerospace.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

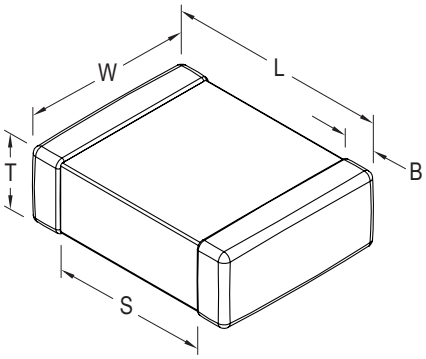
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.177) ±0.30 (0.012) | 3.20 (0.126) ±0.30 (0.012) | | 0.60 (0.024) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit @ 25ºC | 2.5% |
| Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 ±0.2 Vrms if capacitance ≤ 1,000 pF.*

*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance > 1,000 pF*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Ultra-Stable X8R | All | All | 3.0 | 0.3% or ±0.25 pf | 10% of Initial Limit |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | | | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | |
| 100 pF | 101 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 110 pF | 111 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 120 pF | 121 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 130 pF | 131 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 150 pF | 151 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 160 pF | 161 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 180 pF | 181 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 200 pF | 201 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 220 pF | 221 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 240 pF | 241 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 270 pF | 271 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 300 pF | 301 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 330 pF | 331 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 360 pF | 361 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 390 pF | 391 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 430 pF | 431 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 470 pF | 471 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 510 pF | 511 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 560 pF | 561 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 620 pF | 621 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 680 pF | 681 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 750 pF | 751 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 820 pF | 821 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 910 pF | 911 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 1,000 pF | 102 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 1,100 pF | 112 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,200 pF | 122 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,300 pF | 132 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,500 pF | 152 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,600 pF | 162 | F | G | J | K | M | | | | CF | CF | CF | | | | | | | | | | | |
| 1,800 pF | 182 | F | G | J | K | M | | | | CF | CF | CF | | | | | | | | | | | |
| 2,000 pF | 202 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,200 pF | 222 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,400 pF | 242 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,700 pF | 272 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,000 pF | 302 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,300 pF | 332 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,600 pF | 362 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,900 pF | 392 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 4,300 pF | 432 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 4,700 pF | 472 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 5,100 pF | 512 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 5,600 pF | 562 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 6,200 pF | 622 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 6,800 pF | 682 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | EB | EB | EB | | | | | |
| 7,500 pF | 752 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 8,200 pF | 822 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 9,100 pF | 912 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 10,000 pF | 103 | F | G | J | K | M | | | | CF | | | DN | DN | DP | EB | EB | EB | | | | | |
| 12,000 pF | 123 | F | G | J | K | M | | | | | | | DN | DN | DE | EB | EB | EB | FB | FB | FB | | |
| 15,000 pF | 153 | F | G | J | K | M | | | | | | | DN | DP | DG | EB | EB | EB | FB | FB | FB | GB | GB |
| 18,000 pF | 183 | F | G | J | K | M | | | | | | | DN | DP | | EB | EB | EB | FB | FB | FB | GB | GB |
| 22,000 pF | 223 | F | G | J | K | M | | | | | | | DP | DF | | EB | EB | EC | FB | FB | FB | GB | GB |
| 27,000 pF | 273 | F | G | J | K | M | | | | | | | DF | | | EB | EB | EE | FB | FB | FB | GB | GB |
| 33,000 pF | 333 | F | G | J | K | M | | | | | | | DG | | | EB | EB | EE | FB | FB | FB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | | | | | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |

## Table 1 – Capacitance Range/Selection Waterfall (0402 – 1812 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | F G J K M | | | | | | | | | | EC | EE | EH | FB | FB | FE | GB | GB |
| 56,000 pF | 563 | F G J K M | | | | | | | | | | ED | EF | EH | FB | FB | FF | GB | GB |
| 68,000 pF | 683 | F G J K M | | | | | | | | | | EF | EH | | FB | FC | FG | GB | GB |
| 82,000 pF | 823 | F G J K M | | | | | | | | | | EH | EH | | FC | FF | FH | GB | GB |
| 100,000 pF | 104 | F G J K M | | | | | | | | | | EH | | | FE | FG | FM | GB | GD |
| 120,000 pF | 124 | F G J K M | | | | | | | | | | | | | FG | FH | | GB | GH |
| 150,000 pF | 154 | F G J K M | | | | | | | | | | | | | FH | FM | | GD | GN |
| 180,000 pF | 184 | F G J K M | | | | | | | | | | | | | FJ | | | GH | |
| 220,000 pF | 224 | F G J K M | | | | | | | | | | | | | | | | GK | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

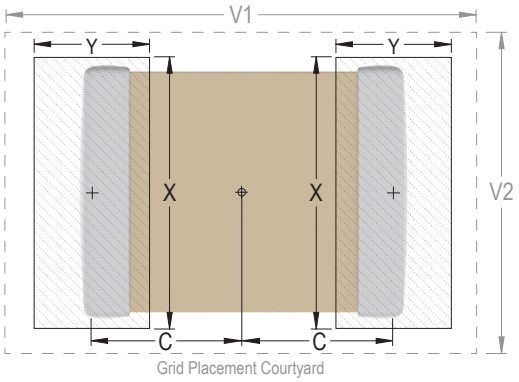
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

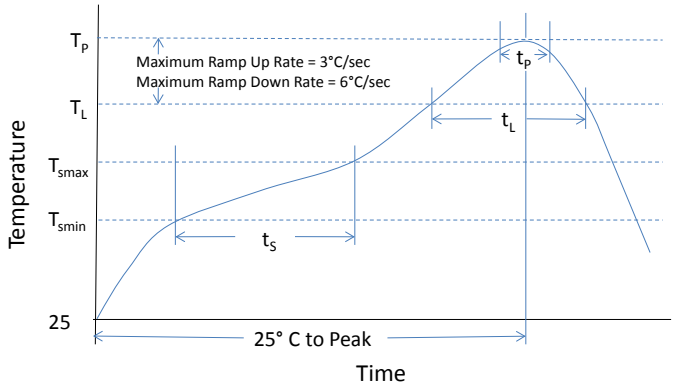
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



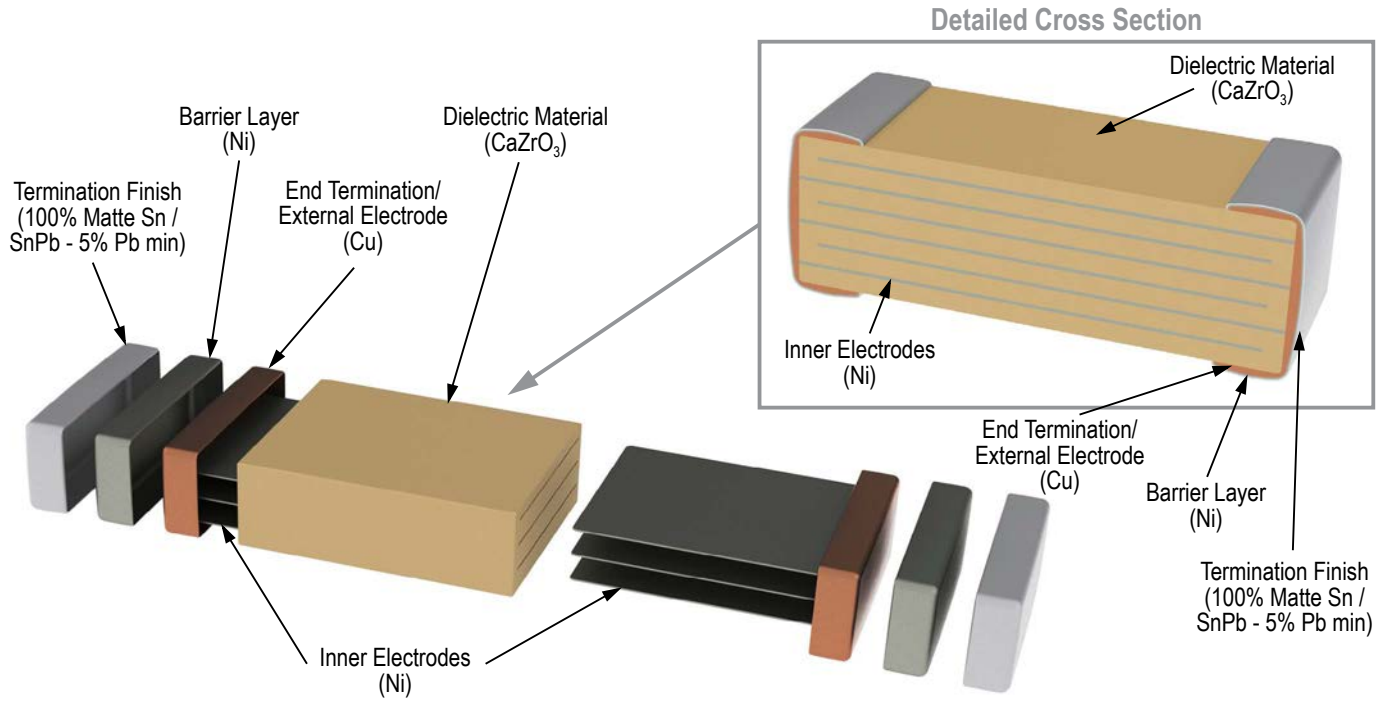
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

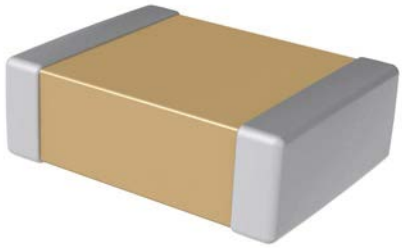
# High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET's X8L dielectric features a 150°C maximum operating temperature and is considered "general purpose high temperature." These components are fixed, ceramic dielectric capacitors suited for high temperature bypass and decoupling applications or frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X8L exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, −40% from 125°C to 150°C.

Driven by the demand for a more robust and reliable component, X8L dielectric capacitors were developed for critical applications where reliability at higher operating temperatures are a concern. These capacitors are widely used in automotive circuits as well as general high temperature applications. Concerned with flex cracks resulting from excessive tensile and shear stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

In addition to commercial grade, automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1210 | X | 106 | K | 8 | N | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210 | C = Standard<br>X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *The flexible termination option is not available on EIA 0402 case size product. "C" must be used in the 6th character position when ordering this case size.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*

[2] *SnPb termination finish option is not available on Automotive Grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, and 1210 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.012 µF to 10 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial & Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request

## Applications

Typical applications include use in extreme environments such as down-hole oil exploration, under-hood automotive, military and aerospace.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

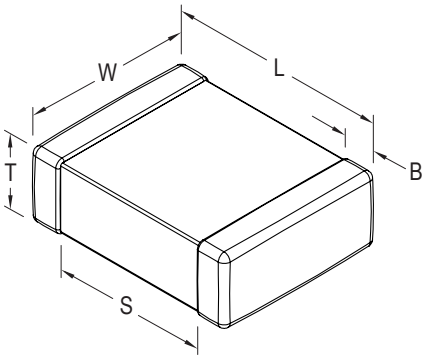
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Standard Termination – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

## Dimensions – Flexible Termination – Millimeters (Inches)

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ±0.17 (0.007) | 0.80 (0.032) ±0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.30 (0.012) | 1.25 (0.049) ±0.30 (0.012) | | 0.50 (0.020) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ±0.40 (0.016) | 1.60 (0.063) ±0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ±0.40 (0.016) | 2.60 (0.102) ±0.30(0.012) | | 0.60 (0.024) ±0.25 (0.010) | | Solder Reflow Only |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Insulation Resistance Limit Table (X8L Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < .012 µF | ≥ .012 µF |
| 0603 | < .047 µF | ≥ .047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 22,000 pF | 223 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 27,000 pF | 273 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 39,000 pF | 393 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | J | K | M | BB | BB | | | CF | CF | CF | CF | CF | | | | | | | | | | | | | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.12 µF | 124 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | J | K | M | | | | | CF | CF | CF | CF | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.18 µF | 184 | J | K | M | | | | | CF | CF | | | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.22 µF | 224 | J | K | M | | | | | CF | CF | | | | DP | DP | DP | DP | DG | | | | | | | | | | |
| 0.27 µF | 274 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.33 µF | 334 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.39 µF | 394 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | | | | | | FD | FD | FD | FD | FD |
| 0.47 µF | 474 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | EG | EG | EG | EG | EG | FD | FD | FD | FD | FD |
| 0.56 µF | 564 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FF | FF | FF | FF | FF |
| 0.68 µF | 684 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FG | FG | FG | FG | FG |
| 0.82 µF | 824 | J | K | M | | | | | | | | | | DG | DG | DG | | | | | | | | FL | FL | FL | FL | FL |
| 1.0 µF | 105 | J | K | M | | | | | | | | | | DG | DG | DG | | | ED | ED | ED | ED | | FM | FM | FM | FM | FM |
| 1.2 µF | 125 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.5 µF | 155 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.8 µF | 185 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.2 µF | 225 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.7 µF | 275 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FH | FH | |
| 3.3 µF | 335 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FM | FM | FM | FM | |
| 3.9 µF | 395 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FK | FK | |
| 4.7 µF | 475 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FS | FS | |
| 5.6 µF | 565 | J | K | M | | | | | | | | | | | | | | | | | | | | FH | FH | FH | | |
| 6.8 µF | 685 | J | K | M | | | | | | | | | | | | | | | | | | | | FM | FM | FM | | |
| 8.2 µF | 825 | J | K | M | | | | | | | | | | | | | | | | | | | | FK | FK | FK | | |
| 10 µF | 106 | J | K | M | | | | | | | | | | | | | | | | | | | | FS | FS | FS | | |
| Cap | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Case Size/Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

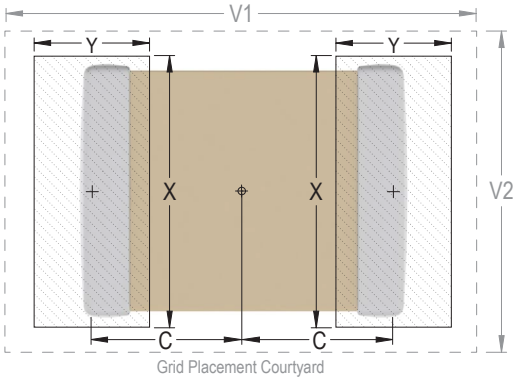
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

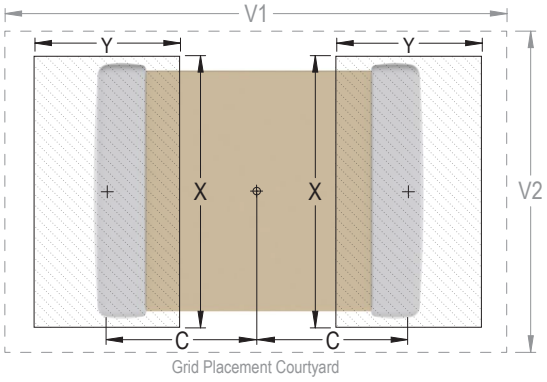


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.65 | 1.90 | 5.90 | 2.90 | 1.50 | 1.45 | 1.80 | 5.00 | 2.30 | 1.40 | 1.25 | 1.70 | 4.30 | 2.00 |
| 1210 | 3225 | 1.60 | 1.65 | 2.80 | 5.90 | 3.80 | 1.50 | 1.45 | 2.70 | 5.00 | 3.20 | 1.40 | 1.25 | 2.60 | 4.30 | 2.90 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

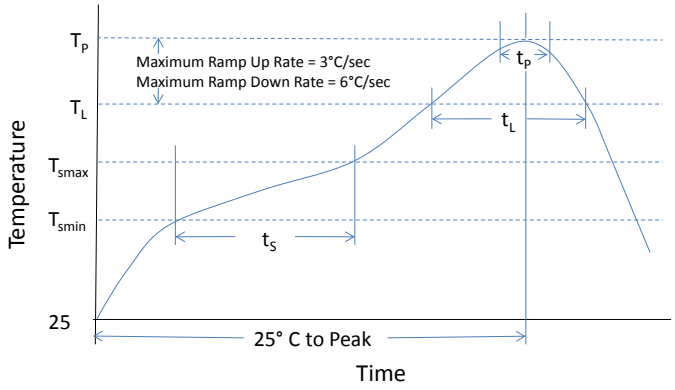
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



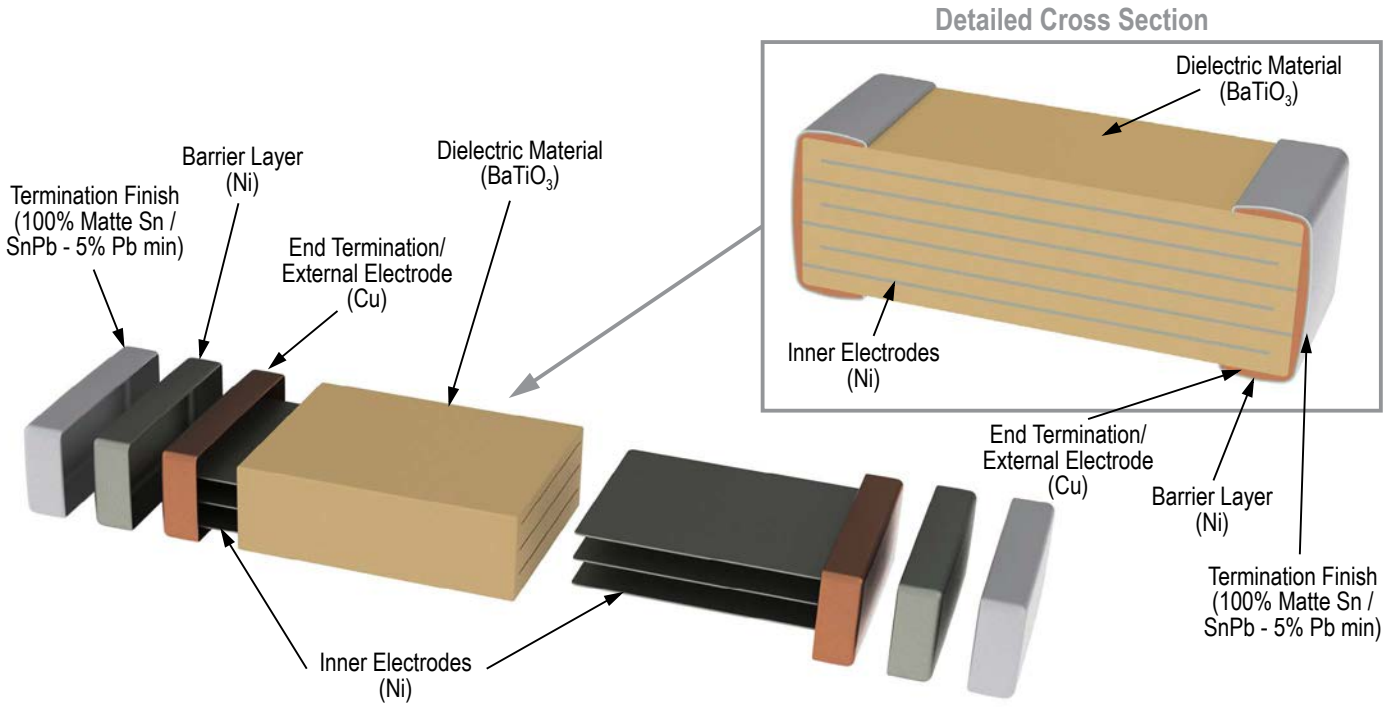
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

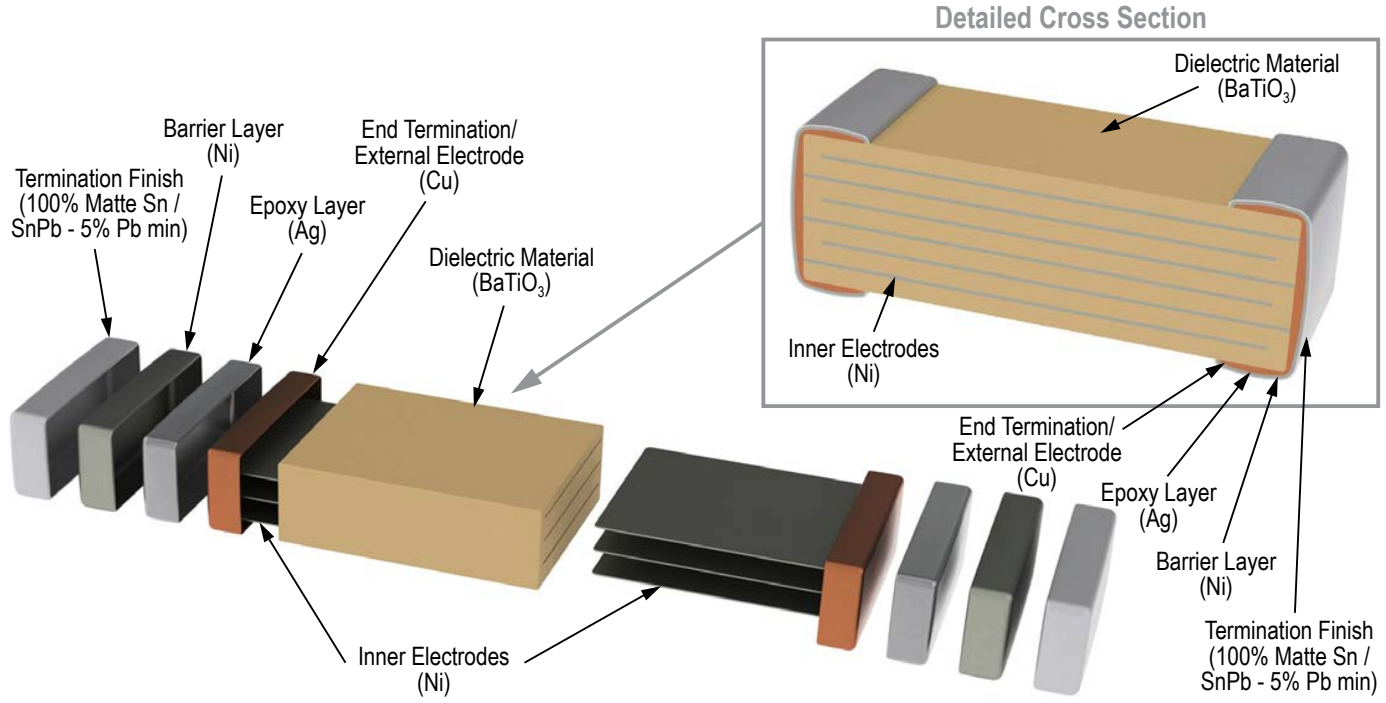
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# Telecom "Tip and Ring," X7R Dielectric, 250 VDC (Commercial Grade)

## Overview

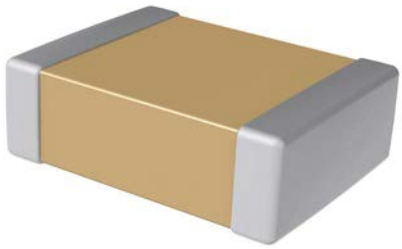
KEMET's 250V DC Tip and Ring MLCCs in X7R dielectric are designed and rated for telecommunication ringer circuits where the capacitor is used to block -48V to -52V DC of line voltage and pass a 16-25 Hz AC signal pulse of 70 Vrms to 90 Vrms. Serving as an excellent replacement for high voltage leaded film devices, these smaller surface mount technology footprints save valuable board space which is critical when creating new designs.

KEMET Tip and Ring capacitors feature a 125°C maximum operating temperature and are considered "temperature stable." The Electronics Industries Alliance (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R dielectric exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

These devices are able to withstand today's higher lead-free reflow processing temperatures and offer superior high frequency filtering characteristics and low ESR.

## Benefits

- −55°C to +125°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, 1812, 1825, 2220, and 2225 case sizes
- DC voltage rating of 250 V
- Capacitance offerings ranging from 1,000 pF to 6.8 µF
- Available capacitance tolerances of ±10% and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish that allows for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request



## Ordering Information

| C | 1825 | C | 105 | K | A | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1812<br>1825<br>2220<br>2225 | C = Standard<br>X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Applications

Typical applications include telecommunication ringing circuits, switch mode power supply snubber circuits, high voltage DC blocking and high voltage coupling. Markets include telephone lines, analog and digital modems, facsimile machines, wireless base stations, cable and digital video recording set-top boxes, satellite dishes, high voltage power supply, DC/DC converters, and Ethernet, POS and ATM hardware.

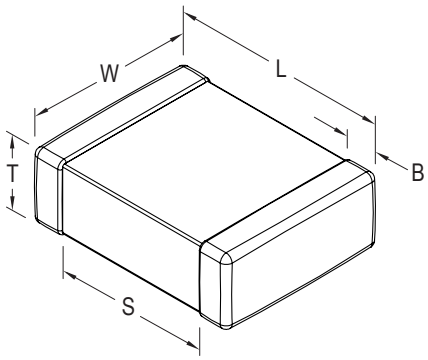
## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35(.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60(.102) ± 0.30(.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0805 – 2225 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | | C0805C | C1206C | C1210C | C1812C | C1825C | C2220C | C2225C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | A | A | A | A | A | A | A |
| | | Rated Voltage (VDC) | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | |
| 180 pF | 181 | J | K | M | DR | | | | | | |
| 220 pF | 221 | J | K | M | DR | | | | | | |
| 270 pF | 271 | J | K | M | DR | | | | | | |
| 330 pF | 331 | J | K | M | DR | | | | | | |
| 390 pF | 391 | J | K | M | DR | | | | | | |
| 470 pF | 471 | J | K | M | DR | | | | | | |
| 560 pF | 561 | J | K | M | DR | | | | | | |
| 680 pF | 681 | J | K | M | DR | | | | | | |
| 820 pF | 821 | J | K | M | DR | | | | | | |
| 1,000 pF | 102 | J | K | M | DR | EQ | | | | | |
| 1,200 pF | 122 | J | K | M | DR | EQ | | | | | |
| 1,500 pF | 152 | J | K | M | DR | EQ | | | | | |
| 1,800 pF | 182 | J | K | M | DR | EQ | | | | | |
| 2,200 pF | 222 | J | K | M | DR | EQ | FN | | | | |
| 2,700 pF | 272 | J | K | M | DR | EQ | FN | | | | |
| 3,300 pF | 332 | J | K | M | DR | EQ | FN | | | | |
| 3,900 pF | 392 | J | K | M | DR | EQ | FN | | | | |
| 4,700 pF | 472 | J | K | M | DR | EQ | FN | | | | |
| 5,600 pF | 562 | J | K | M | DR | EQ | FN | | | | |
| 6,800 pF | 682 | J | K | M | DR | EQ | FN | GB | | | |
| 8,200 pF | 822 | J | K | M | DR | EQ | FN | GB | | | |
| 10,000 pF | 103 | J | K | M | DR | EQ | FN | GB | | | |
| 12,000 pF | 123 | J | K | M | DR | EQ | FN | GB | | | |
| 15,000 pF | 153 | J | K | M | DR | EQ | FN | GB | | | |
| 18,000 pF | 183 | J | K | M | DR | EQ | FN | GB | | | |
| 22,000 pF | 223 | J | K | M | DR | EQ | FN | GB | HB | | |
| 27,000 pF | 273 | J | K | M | | EQ | FN | GB | HB | | |
| 33,000 pF | 333 | J | K | M | | EQ | FN | GB | HB | | |
| 39,000 pF | 393 | J | K | M | | EQ | FN | GB | HB | | |
| 47,000 pF | 473 | J | K | M | | ES | FQ | GB | HB | | KC |
| 56,000 pF | 563 | J | K | M | | ES | FQ | GB | HB | | KC |
| 68,000 pF | 683 | J | K | M | | ES | FQ | GB | HB | | KC |
| 82,000 pF | 823 | J | K | M | | ES | FA | GB | HB | JC | KC |
| 0.10 µF | 104 | J | K | M | | EM | FZ | GB | HB | JC | KC |
| 0.12 µF | 124 | J | K | M | | | FU | GB | HB | JC | KC |
| 0.15 µF | 154 | J | K | M | | | FM | GE | HB | JC | KC |
| 0.18 µF | 184 | J | K | M | | | FK | GG | HB | JC | KC |
| 0.22 µF | 224 | J | K | M | | | FK | GG | HB | JC | KC |
| 0.27 µF | 274 | J | K | M | | | | GG | HB | JC | KC |
| 0.33 µF | 334 | J | K | M | | | | GG | HB | JC | KC |
| 0.39 µF | 394 | J | K | M | | | | GG | HD | JC | KC |
| 0.47 µF | 474 | J | K | M | | | | GJ | HD | JC | KD |
| 0.56 µF | 564 | J | K | M | | | | | HD | JD | KD |
| 0.68 µF | 684 | J | K | M | | | | | HD | JD | KD |
| 0.82 µF | 824 | J | K | M | | | | | HF | JF | KE |
| 1.0 µF | 105 | J | K | M | | | | | HF | JF | KE |
| 1.2 µF | 125 | J | K | M | | | | | | | KE |
| **Capacitance** | **Capacitance Code** | **Rated Voltage (VDC)** | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | **Voltage Code** | | | A | A | A | A | A | A | A |
| | | **Case Size/Series** | | | C0805C | C1206C | C1210C | C1812C | C1825C | C2220C | C2225C |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

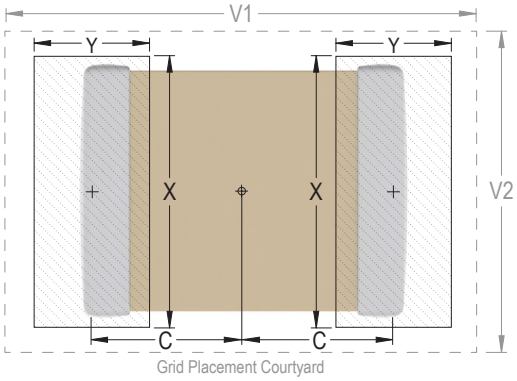
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

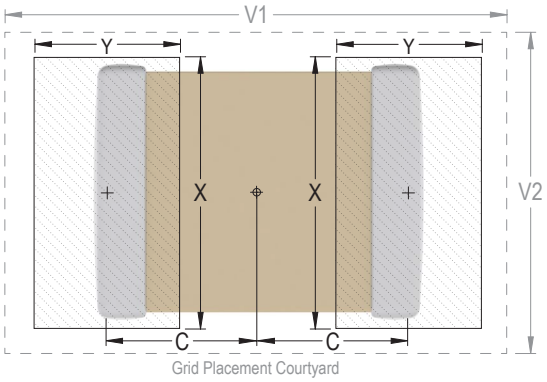


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

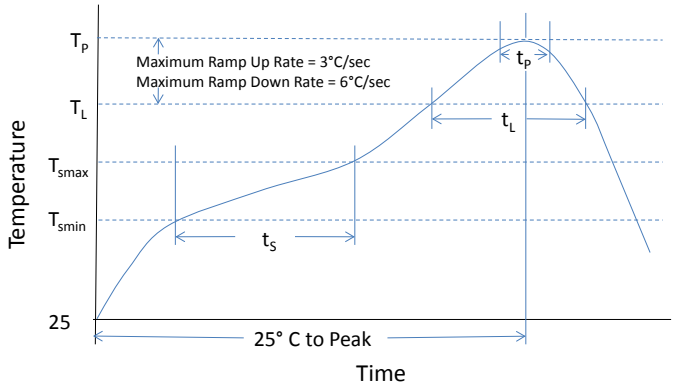
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



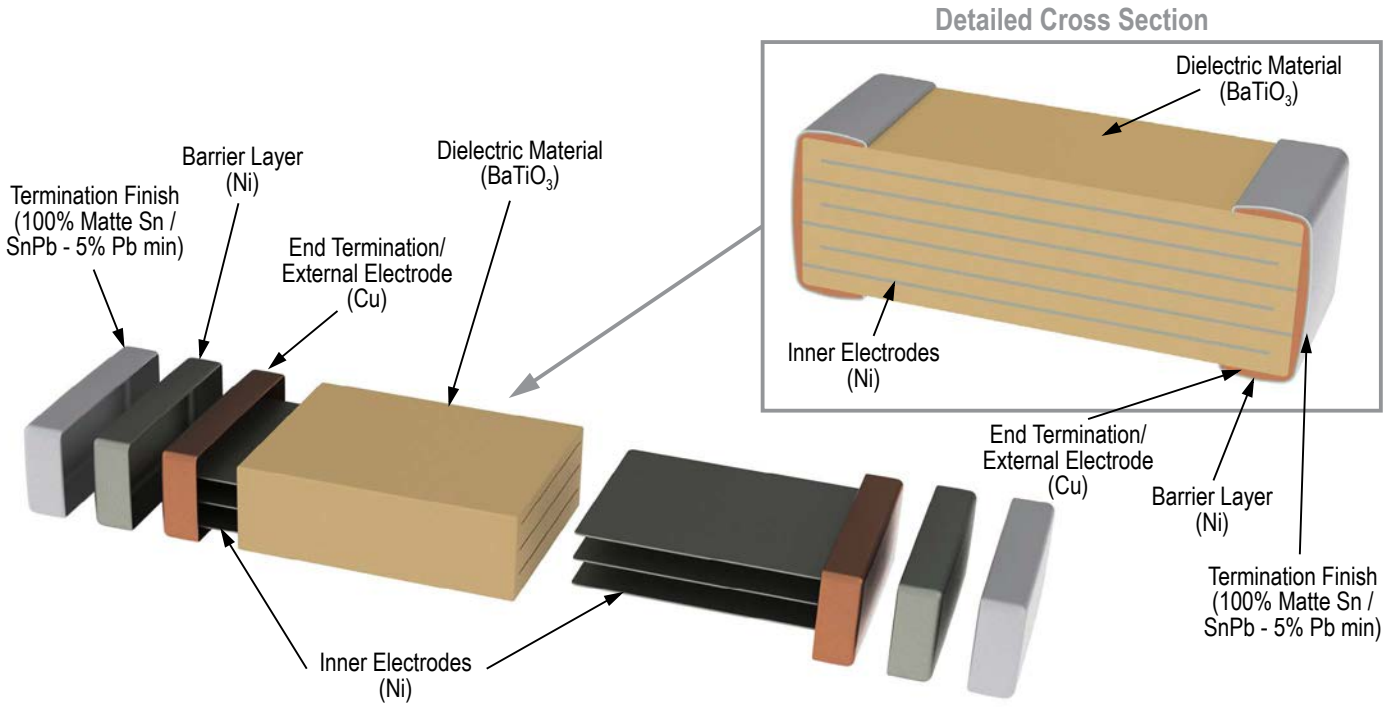
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

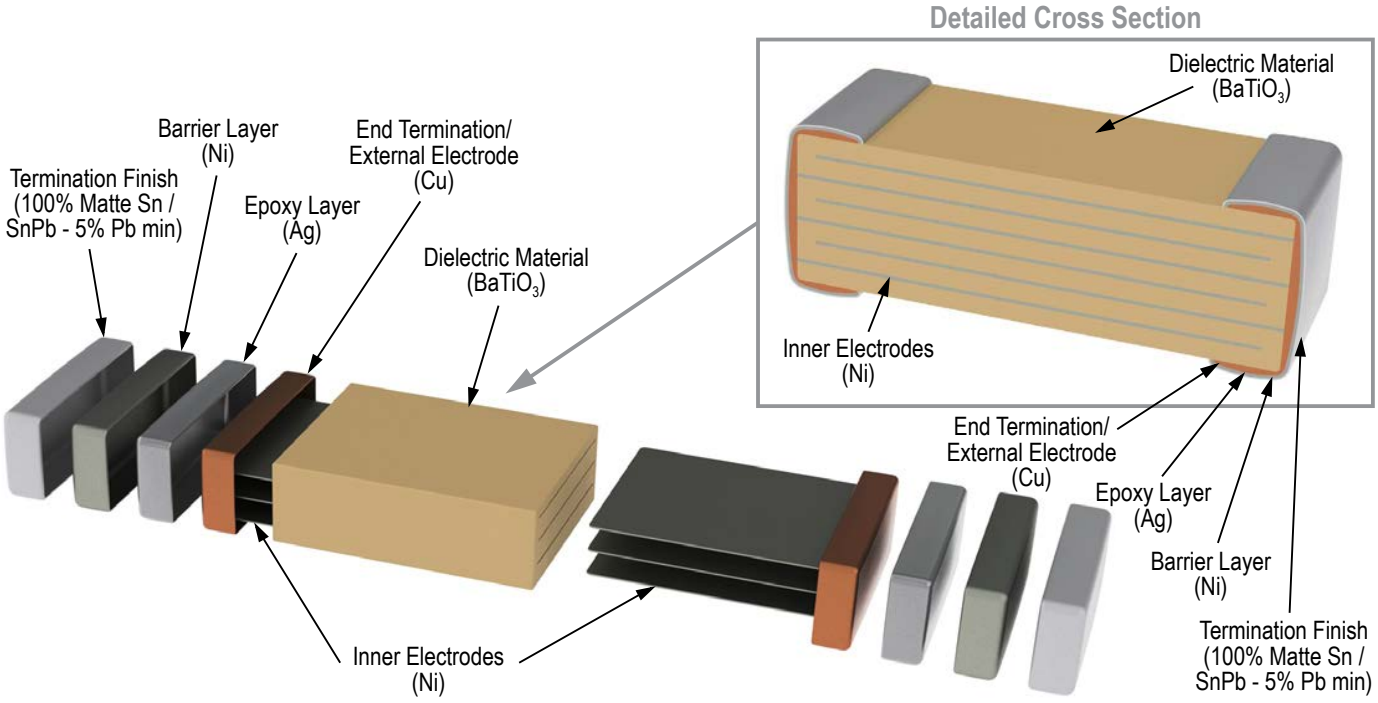
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



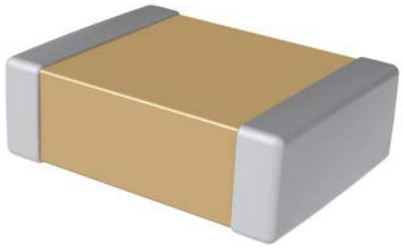
# Open Mode Design (FO-CAP), X7R Dielectric, 16 – 200 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Ceramic Open Mode capacitor in X7R dielectric is designed to significantly minimize the probability of a low IR or short circuit condition when forced to failure in a board stress flex situation, thus reducing the potential for catastrophic failure. The Open Mode capacitor may experience a drop in capacitance; however, a short is unlikely because a crack will not typically propagate across counter electrodes within the device's "active area." Since there will not be any current leakage associated with a typical Open Mode flex crack, there is no localized heating and therefore little chance for a catastrophic and potentially costly failure event.

Driven by the demand for a more robust and reliable component, the Open Mode capacitor was designed for critical applications where higher operating temperatures and mechanical stress are a concern. These capacitors are widely used in automotive circuits as well as power supplies (input and output filters) and general electronic applications.

Concerned with flex cracks resulting from excessive tensile and shear stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. When combined with flexible termination technology these devices offer the ultimate level of protection against a low IR or short circuit condition. Open Mode devices compliment KEMET's Floating Electrode (FE-CAP) and Floating Electrode with Flexible Termination (FF-CAP) product lines by providing a fail-safe design optimized for mid to high range capacitance values. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.



## Ordering Information

| C | 1210 | J | 685 | K | 3 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1812 | F = Open Mode<br>J = Open Mode with Flexible Termination | Two significant digits + number of zeros | K = ±10%<br>M = ±20% | 4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Open Mode/fail open design
- Mid to high capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 16 V, 25 V, 50 V, 100 V, and 200 V
- Capacitance offerings ranging from 1,000 pF to 6.8 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- Commercial and Automotive (AEC–Q200) grades available
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request

## Applications

Typical applications include input side filtering (power plane/bus), high current (battery line) and circuits that cannot be fused to open when short circuits occur due to flex cracks. Markets include automotive applications that are directly connected to the battery and/or involve conversion to a 42 V system and raw power input side filtering in power conversion.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

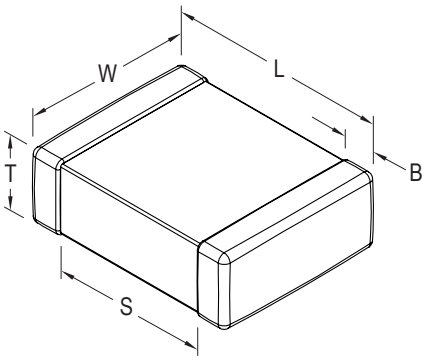
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0805 – 1812 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | C0805F | | | | | C1206F | | | | | C1210F | | | | | C1812F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,200 pF | 122 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,500 pF | 152 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 1,800 pF | 182 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 2,200 pF | 222 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 2,700 pF | 272 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 3,300 pF | 332 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 3,900 pF | 392 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 4,700 pF | 472 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 5,600 pF | 562 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 6,800 pF | 682 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 8,200 pF | 822 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 10,000 pF | 103 | K | M | DP | DP | DP | DP | DP | | | | | | | | | | | | | | |
| 12,000 pF | 123 | K | M | DP | DP | DP | DP | DG | | | | | | | | | | | | | | |
| 15,000 pF | 153 | K | M | DP | DP | DP | DP | DG | | | | | | | | | | | | | | |
| 18,000 pF | 183 | K | M | DP | DP | DP | DP | | EC | EC | EC | EC | EC | | | | | | | | | |
| 22,000 pF | 223 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 27,000 pF | 273 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 33,000 pF | 333 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 39,000 pF | 393 | K | M | DP | DP | DP | DG | | EC | EC | EC | EC | EC | | | | | | | | | |
| 47,000 pF | 473 | K | M | DP | DP | DP | DE | | EC | EC | EC | EC | EG | | | | | | GB | GB | GB | GB |
| 56,000 pF | 563 | K | M | DP | DP | DP | | | EC | EC | EC | EC | EG | | | | | | GB | GB | GB | GB |
| 68,000 pF | 683 | K | M | DP | DP | DG | DG | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FD | GB | GB | GB | GB |
| 82,000 pF | 823 | K | M | DP | DP | DG | | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FD | GB | GB | GB | GB |
| 0.10 µF | 104 | K | M | DG | DG | DG | | | EC | EC | EC | EC | EG | FD | FD | FD | FD | FG | GB | GB | GB | GB |
| 0.12 µF | 124 | K | M | DG | DG | | | | EC | EC | EC | EC | | FD | FD | FD | FD | FG | GB | GB | GB | GB |
| 0.15 µF | 154 | K | M | DG | DG | | | | EC | EC | EC | EG | | FD | FD | FD | FD | FH | GB | GB | GB | GB |
| 0.18 µF | 184 | K | M | DG | DG | | | | EC | EC | EC | EG | | FD | FD | FD | FD | FH | GB | GB | GB | GB |
| 0.22 µF | 224 | K | M | DG | DP | DG | | | EC | EC | EC | ED | | FD | FD | FD | FG | FS | GB | GB | GB | GC |
| 0.27 µF | 274 | K | M | DP | DP | | | | EC | EC | EC | | | FD | FD | FD | FG | | GB | GB | GB | GF |
| 0.33 µF | 334 | K | M | DP | DG | | | | EG | EG | EG | EG | | FD | FD | FD | FH | | GB | GB | GB | GK |
| 0.39 µF | 394 | K | M | DP | DG | | | | EG | EG | | | | FD | FD | FG | FH | | GB | GB | GB | GL |
| 0.47 µF | 474 | K | M | DE | DG | | | | EG | EG | EC | | | FD | FD | FG | FJ | | GB | GB | GC | |
| 0.56 µF | 564 | K | M | | | | | | EG | | | | | FD | FD | FG | FR | | GB | GB | GD | |
| 0.68 µF | 684 | K | M | DG | | | | | EG | | | | | FD | FG | FH | FR | | GD | GD | GF | |
| 0.82 µF | 824 | K | M | | | | | | EG | | | | | FD | FG | FH | FR | | GD | GD | GK | |
| 1.0 µF | 105 | K | M | | | | | | EG | EC | EH | | | FD | FH | FJ | FS | | GN | GN | GM | |
| 1.2 µF | 125 | K | M | | | | | | | | | | | FG | | | | | | | | |
| 1.5 µF | 155 | K | M | | | | | | | | | | | FH | | | | | | | | |
| 1.8 µF | 185 | K | M | | | | | | | | | | | FH | | | | | | | | |
| 2.2 µF | 225 | K | M | | | | | | EC | EH | | | | FJ | FM | FM | | | | | | |
| 2.7 µF | 275 | K | M | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | K | M | | | | | | | | | | | FM | | | | | | | | |
| 3.9 µF | 395 | K | M | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | K | M | | | | | | EH | | | | | FG | FM | | | | GK | GK | | |
| 6.8 µF | 685 | K | M | | | | | | | | | | | FS | FS | | | | | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 16 | 25 | 50 | 100 | 200 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 4 | 3 | 5 | 1 | 2 | 3 | 5 | 1 | 2 |
| | | Case Size/ Series | | C0805F | | | | | C1206F | | | | | C1210F | | | | | C1812F | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FR | 1210 | 2.25 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

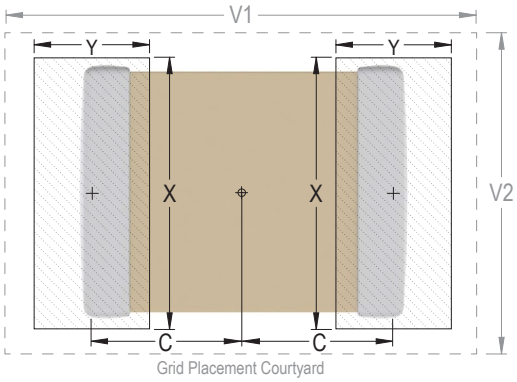
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

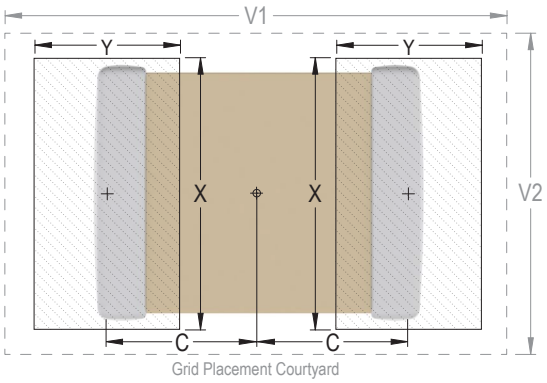


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

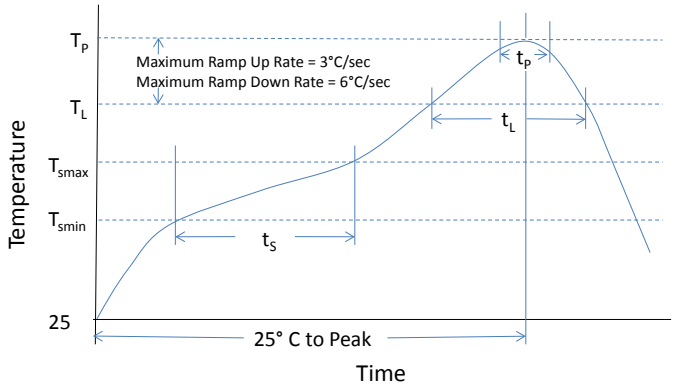
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



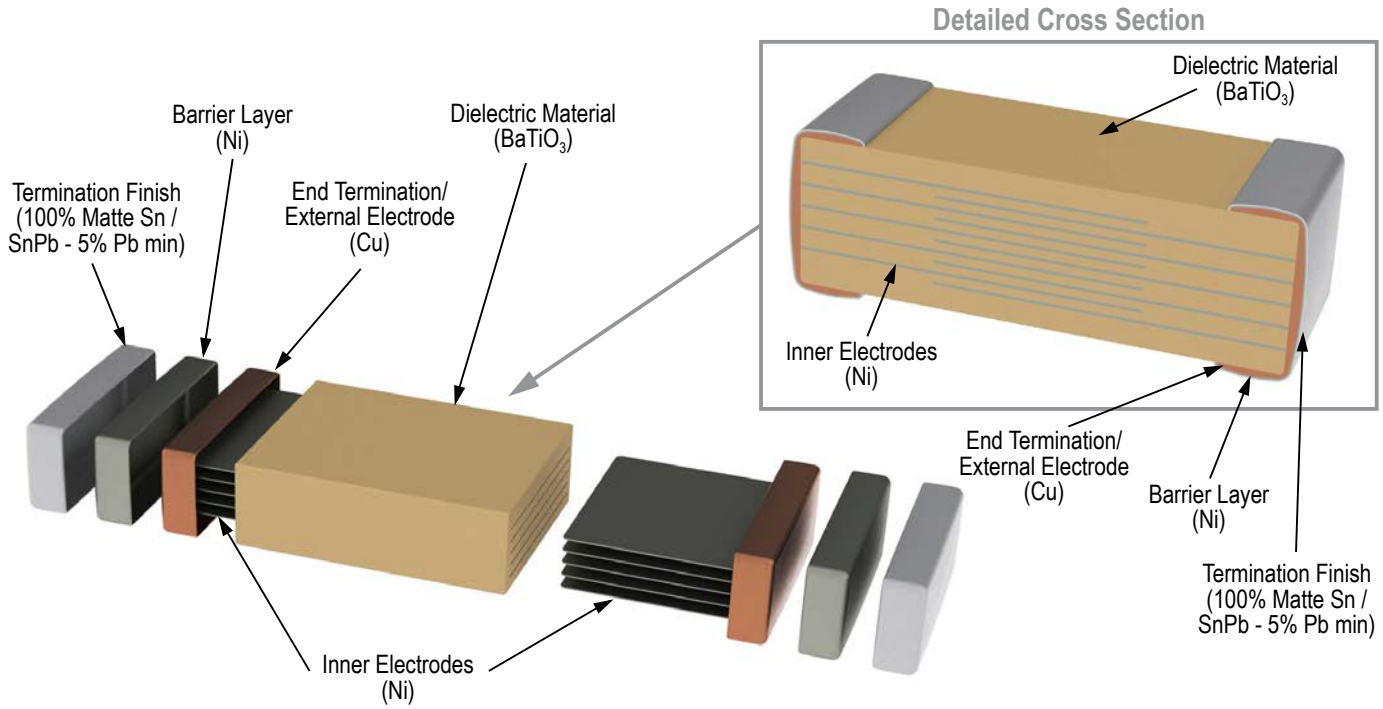
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

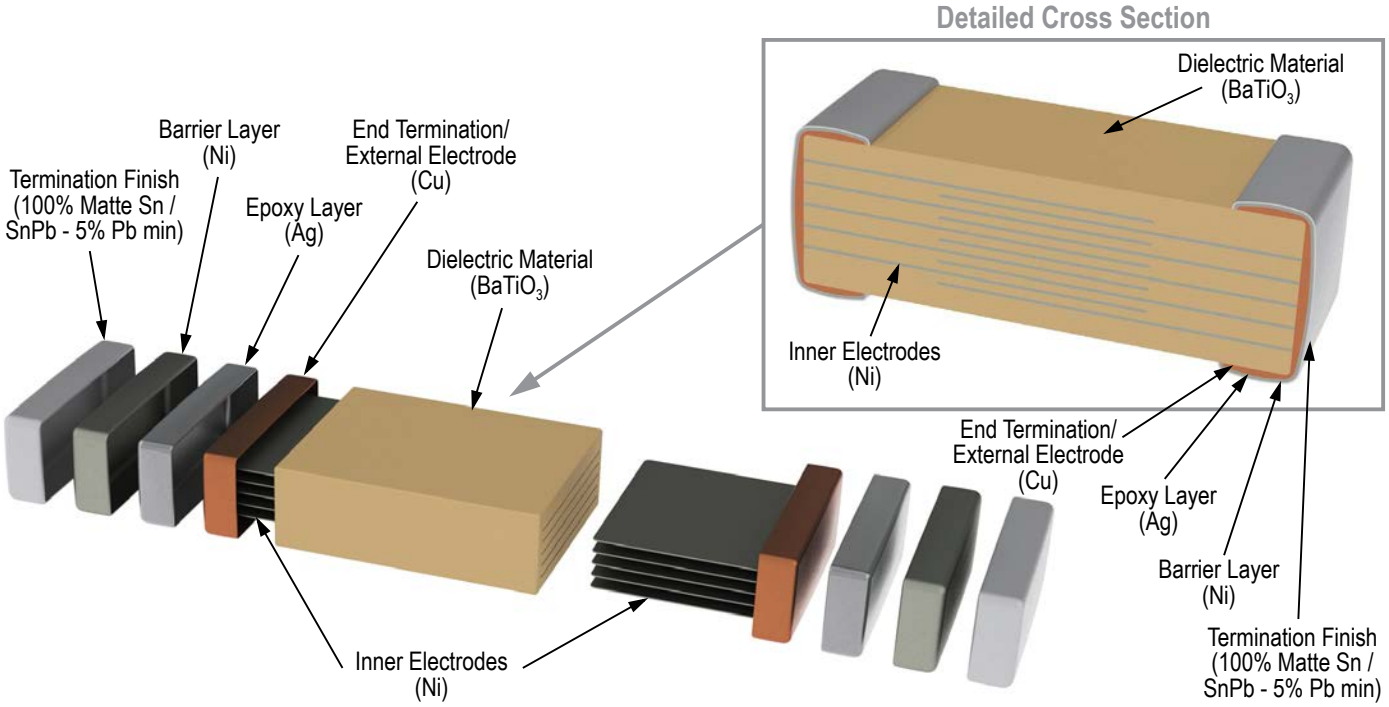
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# Floating Electrode Design (FE-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade)

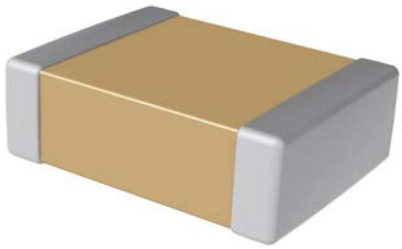
## Overview

KEMET's Floating Electrode (FE-CAP) multilayer ceramic capacitor in X7R dielectric utilizes a cascading internal electrode design configured to form multiple capacitors in series within a single monolithic structure. This unique configuration results in enhanced voltage and ESD performance over standard capacitor designs while allowing for a fail-open condition if mechanically damaged (cracked). If damaged, the device may experience a drop in capacitance but a short is unlikely. The FE-CAP is designed to reduce the likelihood of a low IR or short circuit condition and the chance for a catastrophic and potentially costly failure event.

Driven by the demand for a more robust and reliable component, the FE-CAP was designed for critical applications where higher operating temperatures and mechanical stress are a concern. These capacitors are manufactured in state of the art ISO/TS 16949:2009 certified facilities and are widely used in power supplies (input and output filters) and general electronic applications.

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. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 0805 | S | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812 | S = Floating Electrode | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Floating Electrode/fail open design
- Low to mid capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 150 pF to 0.22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial and Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

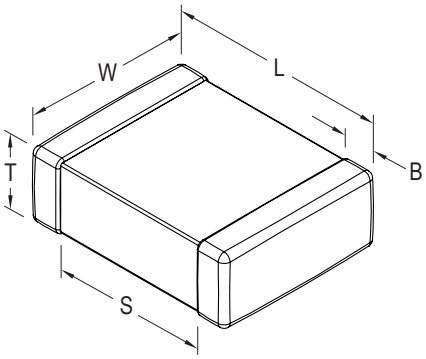
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ± 0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ± 0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (.126) ±0.20 (.008) | 1.60 (0.063) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ±0.20 (.008) | 2.50 (0.098) ± 0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ±0.30 (.012) | 3.20 (0.126) ± 0.30 (0.012) | | 0.60 (0.024) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4 , Performance and Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0402 – 0805 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C0402S | | | | | C0603S | | | | | | | C0805S | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 150 pF | 151 | J | K | M | BB | BB | BB | BB | BB | | | | | | | | | | | | | | | |
| 180 pF | 181 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 220 pF | 221 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 270 pF | 271 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 330 pF | 331 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 390 pF | 391 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 470 pF | 471 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 560 pF | 561 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 680 pF | 681 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 820 pF | 821 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,000 pF | 102 | J | K | M | BB | BB | BB | BB | BB | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,200 pF | 122 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,500 pF | 152 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 1,800 pF | 182 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 2,200 pF | 222 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 2,700 pF | 272 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 3,300 pF | 332 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 3,900 pF | 392 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 4,700 pF | 472 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | DN | DN |
| 5,600 pF | 562 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 6,800 pF | 682 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 8,200 pF | 822 | J | K | M | | | | | | CF | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | DN | DN |
| 10,000 pF | 103 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | DN |
| 12,000 pF | 123 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DN | DN | DN |
| 15,000 pF | 153 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 18,000 pF | 183 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 22,000 pF | 223 | J | K | M | | | | | | CF | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | DP | | |
| 27,000 pF | 273 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 33,000 pF | 333 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 39,000 pF | 393 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 47,000 pF | 473 | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DN | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | | | | | | DP | DP | DP | DP | DP | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | | | | | | DP | DP | DP | DP | DP | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | | | | | | DG | DG | DG | DG | DG | | | |
| 0.10 µF | 104 | J | K | M | | | | | | | | | | | | | DG | DG | DG | DG | DG | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | | | C0402S | | | | | C0603S | | | | | | | C0805S | | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1206 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1206S | | | | | | | | C1210S | | | | | | | | C1812S | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,200 pF | 122 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 2,700 pF | 272 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 3,300 pF | 332 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 3,900 pF | 392 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 4,700 pF | 472 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 5,600 pF | 562 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | | | | | |
| 6,800 pF | 682 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 8,200 pF | 822 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 10,000 pF | 103 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 12,000 pF | 123 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 15,000 pF | 153 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 18,000 pF | 183 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 22,000 pF | 223 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 27,000 pF | 273 | J K M | EB | EB | EB | EB | EB | EB | EB | EB | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 33,000 pF | 333 | J K M | EB | EB | EB | EB | EB | EB | | | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 39,000 pF | 393 | J K M | EB | EB | EB | EB | EB | EC | | | FB | FB | FB | FB | FB | FB | FB | FB | GB | GB | GB | GB | GB |
| 47,000 pF | 473 | J K M | EB | EB | EB | EB | EB | EC | | | FB | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | GB |
| 56,000 pF | 563 | J K M | EB | EB | EB | EB | EB | EB | | | FB | FB | FB | FB | FB | FB | FC | FC | GB | GB | GB | GB | GB |
| 68,000 pF | 683 | J K M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FB | | | GB | GB | GB | GB | GB |
| 82,000 pF | 823 | J K M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FC | | | GB | GB | GB | GB | GB |
| 0.10 µF | 104 | J K M | EB | EB | EB | EB | EB | | | | FB | FB | FB | FB | FB | FC | | | GB | GB | GB | GB | GB |
| 0.12 µF | 124 | J K M | EC | EC | EC | EC | EC | | | | FB | FB | FB | FB | FB | | | | GB | GB | GB | GB | GB |
| 0.15 µF | 154 | J K M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| 0.18 µF | 184 | J K M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| 0.22 µF | 224 | J K M | | | | | | | | | FC | FC | FC | FC | FC | | | | GB | GB | GB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1206S | | | | | | | | C1210S | | | | | | | | C1812S | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

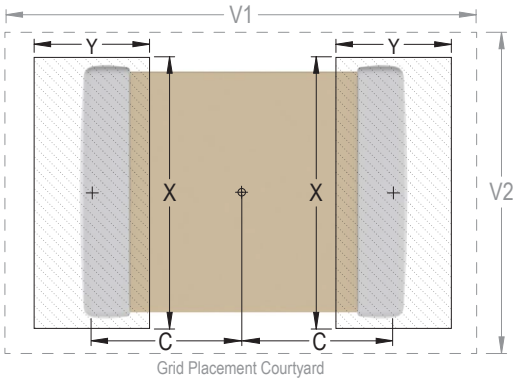
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

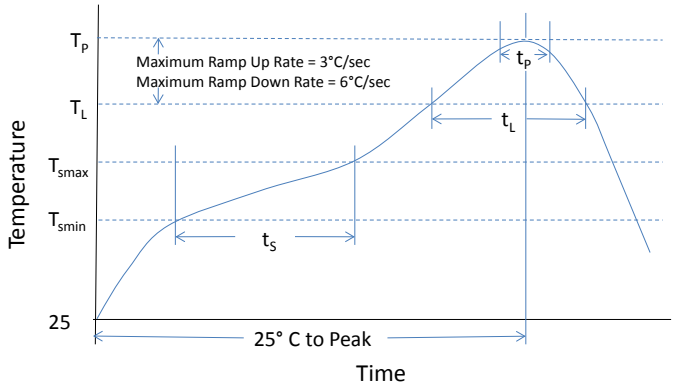
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



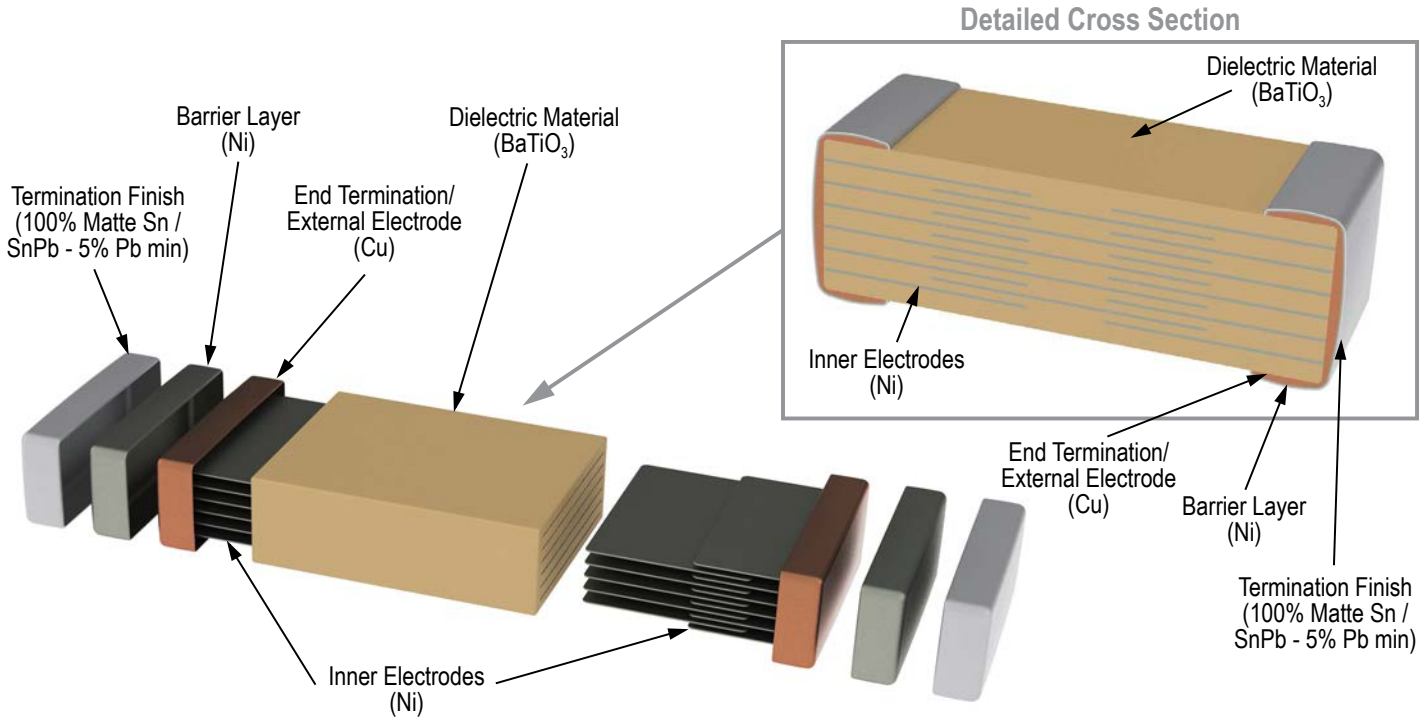
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# Flexible Termination System (FT-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial Grade)

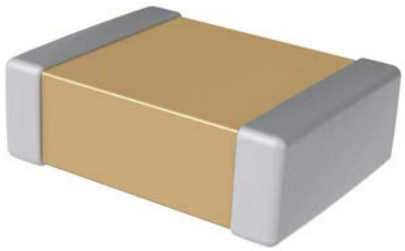
## Overview

KEMET's Flexible Termination (FT-CAP) multilayer ceramic capacitor in X7R dielectric incorporates a unique, flexible termination system that is integrated with KEMET's standard termination materials. A conductive silver epoxy is utilized between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed in order to address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible termination technology inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures.

Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. FT-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Floating Electrode with Flexible Termination (FF-CAP) and KEMET Power Solutions (KPS) product lines by providing a complete portfolio of flex mitigation solutions.

Combined with the stability of an X7R dielectric and designed to accommodate all capacitance requirements, these flex-robust devices are RoHS-compliant, offer up to 5 mm of flex-bend capability and exhibit a predictable change in capacitance with respect to time and voltage. Capacitance change with reference to ambient temperature is limited to ±15% from −55°C to +125°C.

In addition to commercial grade, automotive grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1206 | X | 106 | K | 4 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec)[2] |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

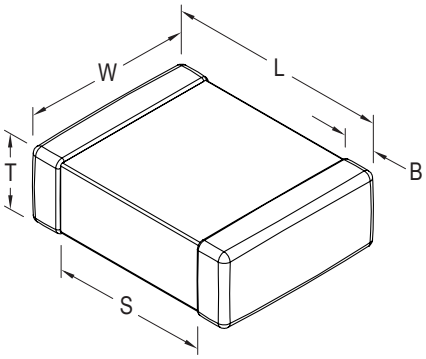
## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- High capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 180 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Automotive (AEC-Q200) grade available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 180 pF | 181 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 220 pF | 221 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 270 pF | 271 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 330 pF | 331 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 390 pF | 391 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 470 pF | 471 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | |
| 560 pF | 561 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 680 pF | 681 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 820 pF | 821 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,200 pF | 122 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,500 pF | 152 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 1,800 pF | 182 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | |
| 2,200 pF | 222 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 2,700 pF | 272 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 3,300 pF | 332 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 3,900 pF | 392 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 4,700 pF | 472 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 5,600 pF | 562 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 6,800 pF | 682 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 8,200 pF | 822 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 10,000 pF | 103 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 12,000 pF | 123 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 15,000 pF | 153 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 18,000 pF | 183 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 22,000 pF | 223 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DR | DR | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 27,000 pF | 273 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 33,000 pF | 333 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 39,000 pF | 393 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DD | DS | | EQ | EQ | EQ | EQ | EQ | ER | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN |
| 47,000 pF | 473 | J K M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DS | DG | | EQ | EQ | EQ | EQ | EQ | ER | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 56,000 pF | 563 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | DG | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 68,000 pF | 683 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FN | FQ | FQ |
| 82,000 pF | 823 | J K M | CJ | CJ | CJ | CJ | CJ | | | DD | DD | DD | DD | DD | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | ES | ES | FN | FN | FN | FN | FN | FQ | FA | FA |
| 0.10 µF | 104 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DS | | | EQ | EQ | EQ | EQ | EQ | EQ | EM | EM | FN | FN | FN | FN | FN | FX | FZ | FZ |
| 0.12 µF | 124 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DD | DG | | | ER | ER | ER | ER | ER | ER | EU | | FN | FN | FN | FN | FN | FX | FU | FU |
| 0.15 µF | 154 | J K M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DD | DG | | | ER | ER | ER | ER | ER | ER | EU | | FQ | FQ | FQ | FQ | FQ | FX | FM | FM |
| 0.18 µF | 184 | J K M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DG | DG | | | ER | ER | ER | ER | ER | ER | | | FQ | FQ | FQ | FQ | FQ | FX | FK | FK |
| 0.22 µF | 224 | J K M | CJ | CJ | CJ | CJ | | | | DR | DR | DR | DR | DG | DG | | | ER | ER | ER | ER | ER | ER | | | FQ | FQ | FQ | FQ | FQ | FX | FK | FK |
| 0.27 µF | 274 | J K M | CJ | CJ | CJ | | | | | DD | DD | DD | DD | DD | | | | EQ | EQ | EQ | EQ | ER | EM | | | FQ | FQ | FQ | FQ | FQ | FX | | |
| 0.33 µF | 334 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DD | | | | EQ | EQ | EQ | EQ | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.39 µF | 394 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DS | | | | EQ | EQ | EQ | EQ | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.47 µF | 474 | J K M | CJ | CJ | CJ | | | | | DG | DG | DG | DG | DS | | | | ER | ER | ER | ER | ER | EU | | | FX | FX | FX | FX | FX | FX | | |
| 0.56 µF | 564 | J K M | | | | | | | | DD | DD | DD | DG | DH | | | | ES | ES | ES | ES | ER | | | | FX | FX | FX | FX | FX | FA | | |
| 0.68 µF | 684 | J K M | | | | | | | | DD | DD | DD | DG | DH | | | | ET | ET | ET | ET | ES | | | | FX | FX | FX | FX | FX | FZ | | |
| 0.82 µF | 824 | J K M | | | | | | | | DD | DD | DD | DG | | | | | EF | EF | EF | EF | ES | | | | FA | FA | FA | FA | FA | FL | | |
| 1.0 µF | 105 | J K M | | | | | | | | DD | DD | DD | DG | | | | | EF | EF | EF | EU | ES | | | | FU | FU | FU | FU | FU | FM | | |
| 1.2 µF | 125 | J K M | | | | | | | | DS | DS | DS | | | | | | ES | ES | ES | EU | EH | | | | FU | FU | FU | FU | FZ | | | |
| 1.5 µF | 155 | J K M | | | | | | | | DG | DG | DG | | | | | | EF | EF | EF | EU | EH | | | | FU | FU | FU | FU | FZ | | | |
| 1.8 µF | 185 | J K M | | | | | | | | DG | DG | DG | | | | | | ES | ES | ES | EF | EH | | | | FU | FU | FU | FU | FZ | | | |
| 2.2 µF | 225 | J K M | | | | | | | | DG | DG | DG | | | | | | ES | ES | ES | EF | EH | | | | FJ | FJ | FJ | FJ | FZ | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | EN | EN | EN | EH | | | | | FE | FE | FE | FZ | FU | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | ES | ES | ES | EH | | | | | FA | FA | FA | FM | FM | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | FZ | FZ | FZ | FZ | FK | | | |
| 4.7 µF | 475 | J K M | | | | | | | | | | | | | | | | EF | EF | EF | EH | | | | | FQ | FQ | FQ | FZ | FS | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FA | FA | FA | FU | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |

## Table 1A – Capacitance Range/Selection Waterfall (0603 – 1210 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 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 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FZ | FZ | FZ | FM | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FU | FU | FU | FK | | | | |
| 10 µF | 106 | J K M | | | | | | | | | | | | | | | | EH | EH | EH | | | | | | FU | FU | FU | FS | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | | | | | | | | | | | | | | | | | | | | | | | | FS | FS | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 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 |
| | | Voltage Code | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | C0603X | | | | | | | C0805X | | | | | | | | C1206X | | | | | | | | C1210X | | | | | | | |

## Table 1B – Capacitance Range/Selection Waterfall (1808 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J K M | LD | LD | LD | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J K M | LD | LD | LD | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 8,200 pF | 822 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 10,000 pF | 103 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 12,000 pF | 123 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 18,000 pF | 183 | J K M | LD | LD | LD | | GB | GB | GB | GB | GB | | | | | | | | | | | | | |
| 22,000 pF | 223 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 27,000 pF | 273 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 33,000 pF | 333 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 39,000 pF | 393 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | | | | |
| 47,000 pF | 473 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 56,000 pF | 563 | J K M | LD | LD | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 68,000 pF | 683 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | | | | | | KC | KC | KC | KC |
| 82,000 pF | 823 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.10 µF | 104 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.12 µF | 124 | J K M | LD | | | | GB | GB | GB | GB | GB | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.15 µF | 154 | J K M | LD | | | | GB | GB | GB | GE | GE | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.18 µF | 184 | J K M | LD | | | | GB | GB | GB | GF | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.22 µF | 224 | J K M | | | | | GB | GB | GB | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KC | KC | KC | KC |
| 0.27 µF | 274 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.33 µF | 334 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HB | HB | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.39 µF | 394 | J K M | | | | | GB | GB | GG | GG | GG | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KC | KC |
| 0.47 µF | 474 | J K M | | | | | GB | GB | GG | GJ | GJ | HB | HB | HD | HD | JC | JC | JC | JC | JC | KB | KC | KD | KD |
| 0.56 µF | 564 | J K M | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JC | JD | JD | KB | KC | KD | KD |
| 0.68 µF | 684 | J K M | | | | | GC | GC | GG | | | HB | HD | HD | HD | JC | JC | JD | JD | JD | KB | KC | KD | KD |
| 0.82 µF | 824 | J K M | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KC | KE | KE |
| 1.0 µF | 105 | J K M | | | | | GE | GE | GG | | | HB | HF | HF | HF | JC | JC | JF | JF | JF | KB | KD | KE | KE |
| 1.2 µF | 125 | J K M | | | | | | | | | | HB | | | | JC | JC | | | | KB | KE | KE | KE |
| Cap | Cap Code | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1808 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Cap Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | |
| 1.5 µF | 155 | J K M | | | | | | | | | | HC | | | | JC | JC | | | | KC | | | |
| 1.8 µF | 185 | J K M | | | | | | | | | | HD | | | | JD | JD | | | | KD | | | |
| 2.2 µF | 225 | J K M | | | | | | | | | | HF | | | | JF | JF | | | | KD | | | |
| 2.7 µF | 275 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 µF | 335 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 3.9 µF | 395 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 4.7 µF | 475 | J K M | | | | | GK | GK | | | | | | | | | | | | | | | | |
| 5.6 µF | 565 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 6.8 µF | 685 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 8.2 µF | 825 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 10 µF | 106 | J K M | | | | | GK | | | | | | | | | JF | JO | | | | | | | |
| 12 µF | 126 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 15 µF | 156 | J K M | | | | | | | | | | | | | | JO | JO | | | | | | | |
| 18 µF | 186 | J K M | | | | | | | | | | | | | | | | | | | | | | |
| 22 µF | 226 | J K M | | | | | | | | | | | | | | JO | | | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 | 50 | 100 | 200 | 250 |
| | | Voltage Code | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A | 5 | 1 | 2 | A |
| | | Case Size/ Series | C1808X | | | | C1812X | | | | | C1825X | | | | C2220X | | | | | C2225X | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DS | 0805 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| EN | 1206 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ET | 1206 | 1.10 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EM | 1206 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FX | 1210 | 0.95 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LD | 1808 | 0.90 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HB | 1825 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HC | 1825 | 1.15 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HD | 1825 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HF | 1825 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JC | 2220 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JD | 2220 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JF | 2220 | 1.50 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JO | 2220 | 2.40 ± 0.15 | 0 | 0 | 500 | 2,000 |
| KB | 2225 | 1.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KC | 2225 | 1.10 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KD | 2225 | 1.30 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

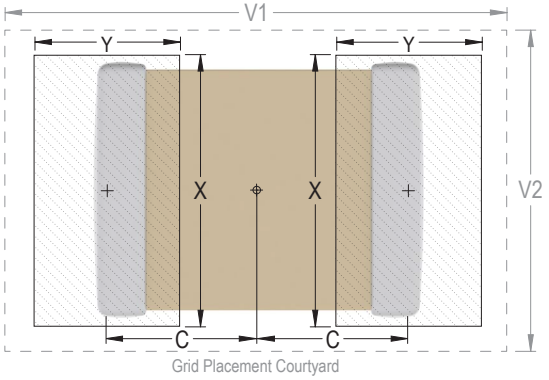
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

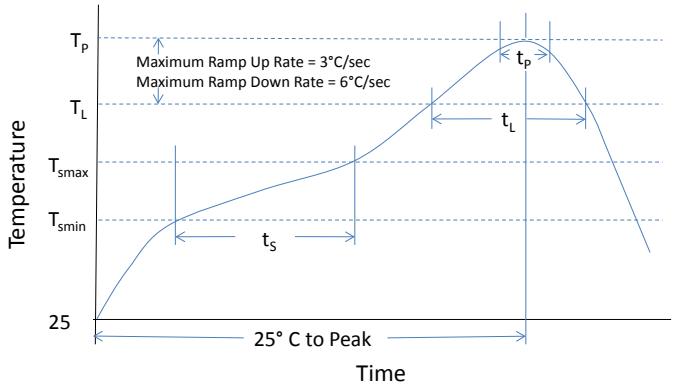
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



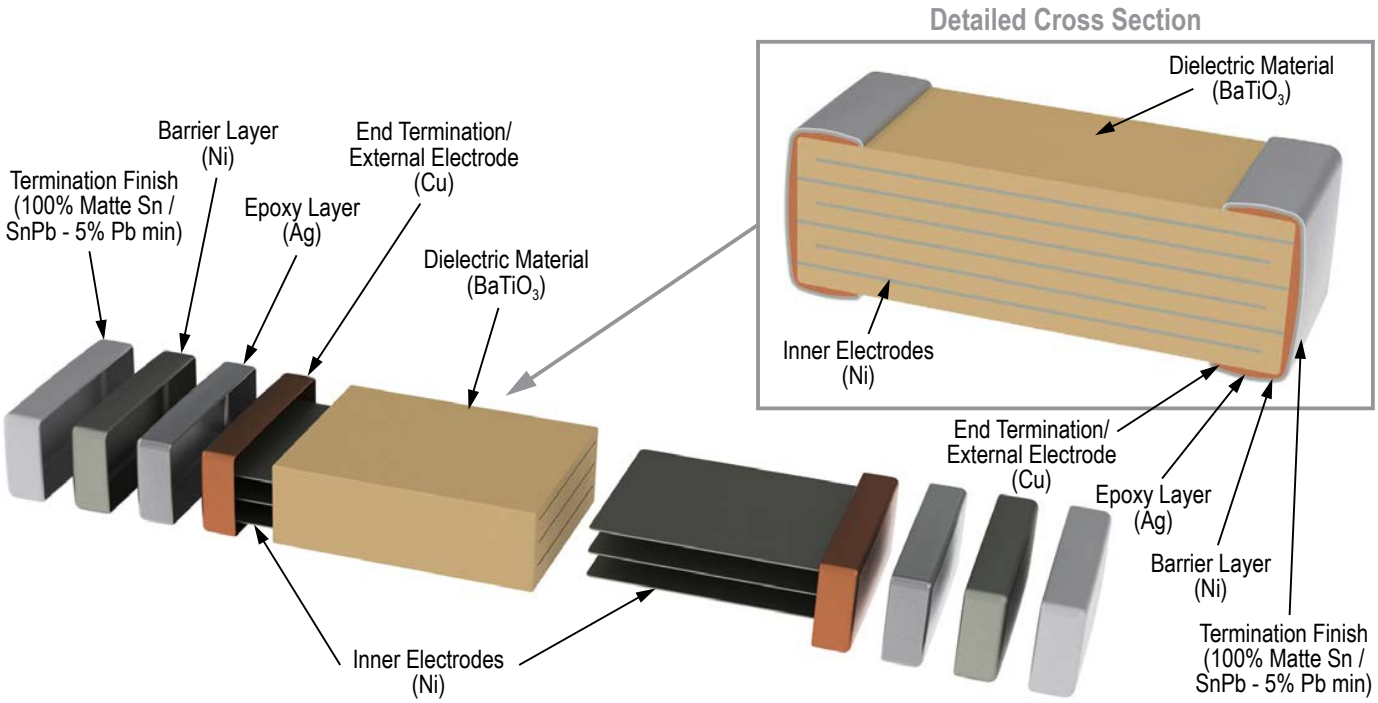
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



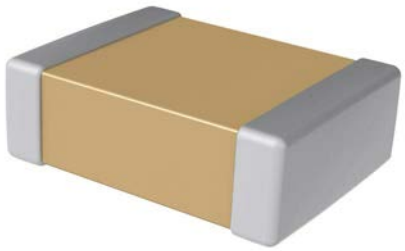
# Floating Electrode Design with Flexible Termination System (FF-CAP), X7R Dielectric, 6.3 – 250 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Floating Electrode with Flexible Termination capacitor (FF-CAP) combines two existing KEMET technologies– Floating Electrode and Flexible Termination. The floating electrode component utilizes a cascading internal electrode design configured to form multiple capacitors in series within a single monolithic structure. This unique configuration results in enhanced voltage and ESD performance over standard capacitor designs while allowing for a fail-open condition if mechanically damaged (cracked). The flexible termination component utilizes a conductive silver epoxy between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. Both technologies address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling.

Although neither technology can eliminate the potential for mechanical damage that may propagate during extreme environmental and/or handling conditions, the combination of these two technologies provide the ultimate level of protection against a low IR or short circuit condition. The FF-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Flexible Termination (FT-CAP) and KEMET Power Solutions (KPS) product lines by providing an ultimate fail-safe design optimized for low to mid range capacitance values. These devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 0805 | Y | 104 | K | 5 | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1812 | Y = Floating Electrode with Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 9 = 6.3<br>8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>A = 250 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*

[1] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Floating Electrode/fail open design
- Low to mid capacitance flex mitigation
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V, and 250 V
- Capacitance offerings ranging from 180 pF to 0.22 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial & Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Examples include raw power input side filtering (power plane/bus), high current applications (automobile battery line) and circuits that cannot be fused to open. Markets include consumer, medical, industrial (power supply), automotive, aerospace and telecom.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

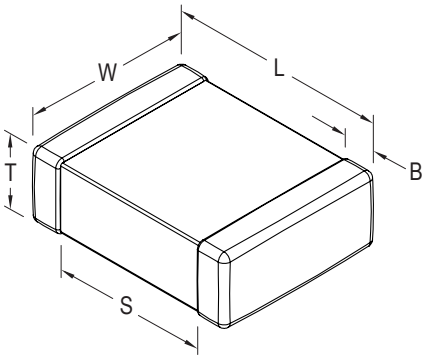
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(6.3V & 10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < 0.012 µF | ≥ 0.012 µF |
| 0603 | < 0.047 µF | ≥ 0.047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 0805 Case Sizes)

| Capacitance | Capacitance Code | Case Size/ Series | | | C0603Y | | | | | | | C0805Y | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | |
| 180 pF | 181 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 220 pF | 221 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 270 pF | 271 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 330 pF | 331 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 390 pF | 391 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 470 pF | 471 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 560 pF | 561 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 680 pF | 681 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 820 pF | 821 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,000 pF | 102 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,200 pF | 122 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,500 pF | 152 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 1,800 pF | 182 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 2,200 pF | 222 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 2,700 pF | 272 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 3,300 pF | 332 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 3,900 pF | 392 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 4,700 pF | 472 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | CJ | DR | DR | DR | DR | DR | DR | DR | DR |
| 5,600 pF | 562 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 6,800 pF | 682 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 8,200 pF | 822 | J | K | M | CJ | CJ | CJ | CJ | CJ | CJ | | DR | DR | DR | DR | DR | DR | DR | DR |
| 10,000 pF | 103 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | DR |
| 12,000 pF | 123 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DR | DR | DR |
| 15,000 pF | 153 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 18,000 pF | 183 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 22,000 pF | 223 | J | K | M | CJ | CJ | CJ | CJ | CJ | | | DR | DR | DR | DR | DR | DD | | |
| 27,000 pF | 273 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 33,000 pF | 333 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 39,000 pF | 393 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 47,000 pF | 473 | J | K | M | | | | | | | | DR | DR | DR | DR | DR | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | DD | DD | DD | DD | DD | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | DD | DD | DD | DD | DD | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | DG | DG | DG | DG | DG | | | |
| 0.10 µF | 104 | J | K | M | | | | | | | | DG | DG | DG | DG | DG | | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A |
| | | Case Size/Series | | | C0603Y | | | | | | | C0805Y | | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall (1206 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C1206Y | | | | | | | | C1210Y | | | | | | | | C1812Y | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,200 pF | 122 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,500 pF | 152 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 1,800 pF | 182 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 2,700 pF | 272 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 3,300 pF | 332 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 3,900 pF | 392 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 4,700 pF | 472 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 5,600 pF | 562 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | | | | | |
| 6,800 pF | 682 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 8,200 pF | 822 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 10,000 pF | 103 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 12,000 pF | 123 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 15,000 pF | 153 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 18,000 pF | 183 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 22,000 pF | 223 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 27,000 pF | 273 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | EQ | EQ | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 33,000 pF | 333 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | | | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 39,000 pF | 393 | J | K | M | EQ | EQ | EQ | EQ | EQ | ER | | | FN | FN | FN | FN | FN | FN | FN | FN | GB | GB | GB | GB | GB |
| 47,000 pF | 473 | J | K | M | EQ | EQ | EQ | EQ | EQ | ER | | | FN | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | GB |
| 56,000 pF | 563 | J | K | M | EQ | EQ | EQ | EQ | EQ | EQ | | | FN | FN | FN | FN | FN | FN | FQ | FQ | GB | GB | GB | GB | GB |
| 68,000 pF | 683 | J | K | M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FN | | | GB | GB | GB | GB | GB |
| 82,000 pF | 823 | J | K | M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FQ | | | GB | GB | GB | GB | GB |
| 0.10 µF | 104 | J | K | M | EQ | EQ | EQ | EQ | EQ | | | | FN | FN | FN | FN | FN | FX | | | GB | GB | GB | GB | GB |
| 0.12 µF | 124 | J | K | M | ER | ER | ER | ER | ER | | | | FN | FN | FN | FN | FN | | | | GB | GB | GB | GB | GB |
| 0.15 µF | 154 | J | K | M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| 0.18 µF | 184 | J | K | M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| 0.22 µF | 224 | J | K | M | | | | | | | | | FQ | FQ | FQ | FQ | FQ | | | | GB | GB | GB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 6.3 | 10 | 16 | 25 | 50 | 100 | 200 | 250 | 25 | 50 | 100 | 200 | 250 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 9 | 8 | 4 | 3 | 5 | 1 | 2 | A | 3 | 5 | 1 | 2 | A |
| | | Case Size/ Series | | | C1206Y | | | | | | | | C1210Y | | | | | | | | C1812Y | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FX | 1210 | 0.95 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

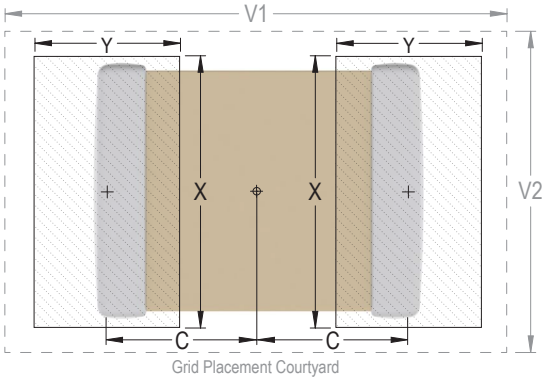
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

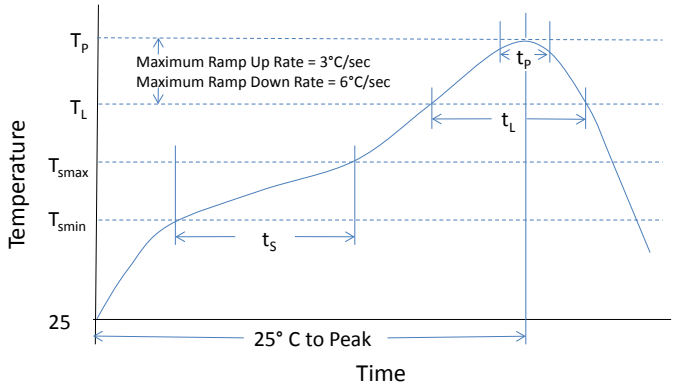
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



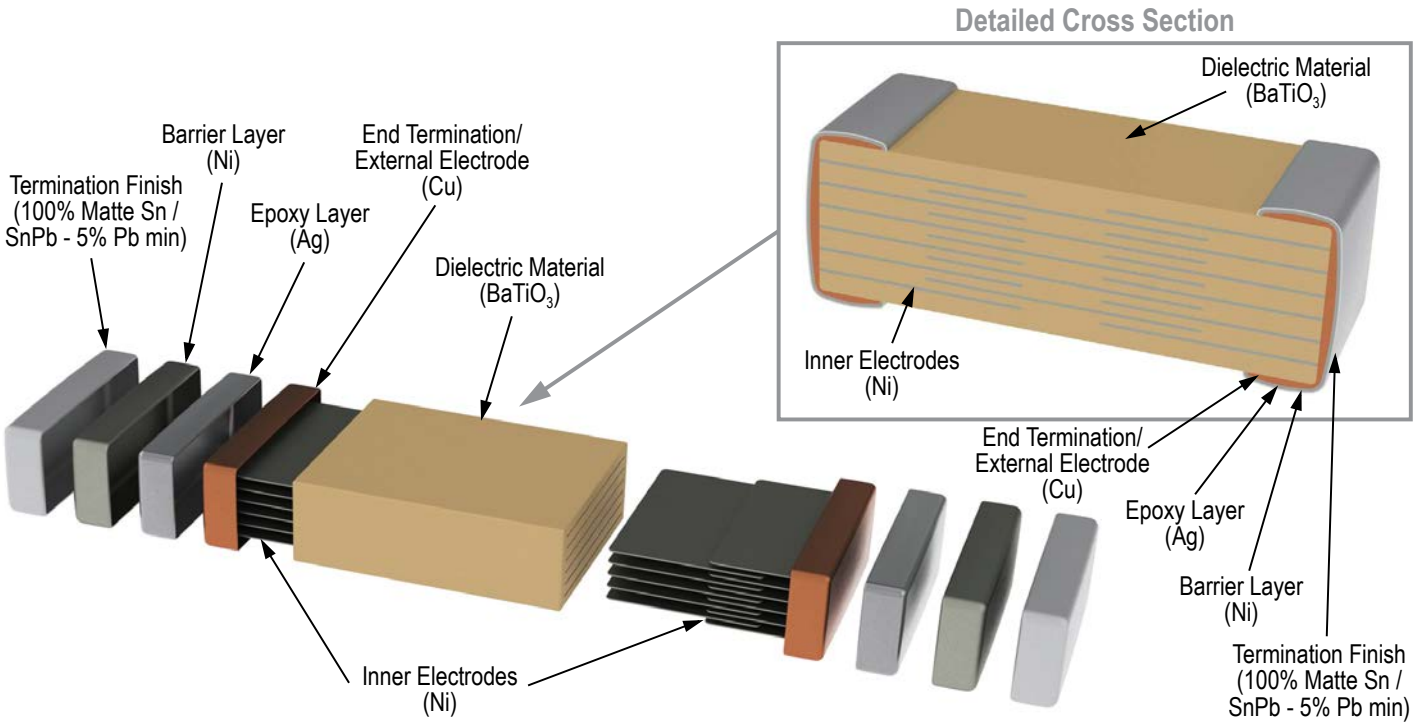
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 Cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300, maximum transfer time – 20 seconds, dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



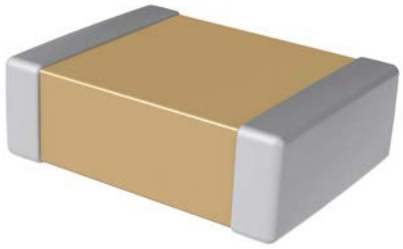
# HV-HT Series, High Voltage, High Temperature 200°C, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade)

## Overview

KEMET's High Voltage-High Temperature (HV-HT) series surface mount C0G Multilayer Ceramic Capacitors (MLCCs) are constructed of a robust and proprietary base metal electrode (BME) dielectric system that offers industry-leading performance at extreme temperatures. These surface mountable devices feature a 200ºC maximum operating temperature and are specifically designed to withstand the demands of harsh industrial environments such as oil exploration and automotive/avionics engine compartment circuitry. They also offer higher and more uniform breakdown voltage performance than competitive products, resulting in increased yields in customer field applications. When dealing with expensive high temperature circuitry and systems, higher yields can quickly result in significant cost savings.

KEMET's HV-HT series MLCCs are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. They exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +200°C. In addition, these capacitors exhibit high insulation resistance with low dissipation factor at elevated temperatures up to 200°C. They also exhibit low ESR at high frequencies and offer superior volumetric efficiency over competitive high temperature precious metal electrode (PME) and base metal electrode (BME) dielectric system devices.

These devices are Lead (Pb)-Free, RoHS and REACH compliant without the need of any exemptions.



## Ordering Information

| C | 2225 | H | 393 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225<br>2824<br>3040<br>3640<br>4540 | H = High Temperature (200°C) | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Gold(Au) termination finish options are not available on 2824, 3040, 3640 and 4540 case sizes.*



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## Packaging C-Spec Ordering Options Table

| Termination Finish Options | Packaging Type/Options | Packaging Ordering Code (C-Spec) |
|---|---|---|
| **Standard Packaging – Unmarked[3]** | | |
| C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Bulk Bag | Blank[1] |
| | Waffle Tray[2] | 7292 |
| | 7" Tape & Reel | TU |
| | 13" Reel | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| | 7" Tape & Reel/2 mm pitch[4] | 7081 |
| | 7" Tape & Reel – 50 pcs | T050 |
| | 7" Tape & Reel – 100 pcs | T100 |
| | 7" Tape & Reel – 250 pcs | T250 |
| | 7" Tape & Reel – 500 pcs | T500 |
| | 7" Tape & Reel – 1,000 pcs | T1K0 |
| **Moisture Sensitive Packaging[5] – Unmarked[3]** | | |
| E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Waffle Tray[2] | 7282 |
| | 7" Tape & Reel | 7130 |
| | 7" Tape & Reel – 50 pcs | Contact KEMET[6] |
| | 7" Tape & Reel – 100 pcs | |
| | 7" Tape & Reel – 250 pcs | |
| | 7" Tape & Reel – 500 pcs | |
| | 7" Tape & Reel – 1,000 pcs | |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] "Bulk Bag" packaging option is not available for Gold (Au) termination finish options and case sizes larger than 2225 (5664 Metric).*

*[2] "Waffle Tray" packaging option is not available for case sizes larger than 2225 (5664 Metric).*

*[3] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*

*3 Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "T1K0" packaging option, 1812 thru 2225 case size devices with chip thickness of ≥ 1.9mm (nominal) may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*

*[4] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[5] Moisture sensitive packaging is required for Gold (Au) termination option "E" (1.97 – 11.8 µin)*

*[6] Additional reeling or packaging options may be available. Contact KEMET for details.*

## Benefits

- Operating temperature range of −55°C to +200°C
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220, 2225, 2824, 3040, 3640 and 4540 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, and 2 KV
- Capacitance offerings ranging from 1 pF to 0.150 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR & ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)
- Gold (Au), Tin/Lead (Sn/Pb) and 100% pure matte Tin (Sn) termination finishes available

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling, DC blocking and voltage multiplier circuits in extreme environments such as down-hole exploration, aerospace engine compartments and geophysical probes. Markets include power supply, HID lighting, industrial equipment/control, automotive, aerospace, and munitions.

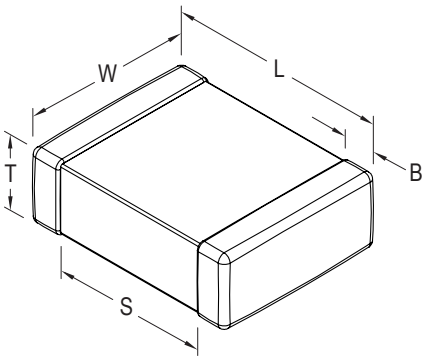
## Qualification/Certification

High temperature (200ºC) Industrial grade products meet or exceed the requirements outlined in Table 4, Performance & Reliability. Qualification packages are available for review and download on our website at www.kemet.com/hightemp

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | "Solder Wave or Solder Reflow" |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2824 | 7260 | 7.10 (.280) ± 0.40 (.016) | 6.10 (.240) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3040 | 7610 | 7.60 (.300) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3640 | 9210 | 9.10 (.358) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 4540 | - | 11.40 (.449) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C (up to +200°C) |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000 V<br>120% of rated voltage for voltage rating of ≥ 1000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 secs @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ± 50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D F G J K M | DG | DG | DG | | | | | | | | | | | LB | LB | LB | LB | LB |
| 10 pF - 47pF* | 100 - 470* | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 51 pF | 510 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 56 pF | 560 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 62 pF | 620 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 68 pF | 680 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 75 pF | 750 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 82 pF | 820 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 91 pF | 910 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 100 pF | 101 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 110 pF | 111 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 120 pF | 121 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 130 pF | 131 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 150 pF | 151 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 160 pF | 161 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 180 pF | 181 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 200 pF | 201 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 220 pF | 221 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 240 pF | 241 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LB | LC |
| 270 pF | 271 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 300 pF | 301 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 330 pF | 331 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 360 pF | 361 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 390 pF | 391 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 430 pF | 431 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 470 pF | 471 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 510 pF | 511 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 560 pF | 561 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 620 pF | 621 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 680 pF | 681 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 750 pF | 751 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 820 pF | 821 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 910 pF | 911 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LA | |
| 1,000 pF | 102 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LB | |
| 1,100 pF | 112 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LB | |
| 1,200 pF | 122 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LC | |
| 1,300 pF | 132 | F G J K M | | | | EF | EG | | | | FM | FS | FS | | | LC | LC | LC | LC | |
| 1,500 pF | 152 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | LC | |
| 1,600 pF | 162 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 2,000 pF | 202 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,200 pF | 222 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,400 pF | 242 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LB | | |
| 2,700 pF | 272 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LC | | |
| 3,000 pF | 302 | F G J K M | | | | | | | | | FS | FL | | | | LA | LA | | | |
| 3,300 pF | 332 | F G J K M | | | | | | | | | FS | FM | | | | LA | LA | | | |
| 3,600 pF | 362 | F G J K M | | | | | | | | | FL | FM | | | | LA | LB | | | |
| 3,900 pF | 392 | F G J K M | | | | | | | | | FL | FY | | | | LA | LB | | | |
| 4,300 pF | 432 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| 4,700 pF | 472 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

## Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | |
| 5,600 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| 8,200 pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 pF - 47pF* | 100 - 470* | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 51 pF | 510 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 56 pF | 560 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 62 pF | 620 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 68 pF | 680 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 75 pF | 750 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 82 pF | 820 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 91 pF | 910 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 100 pF | 101 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 110 pF | 111 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 120 pF | 121 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 130 pF | 131 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 150 pF | 151 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 160 pF | 161 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 180 pF | 181 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 200 pF | 201 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 220 pF | 221 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 240 pF | 241 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 270 pF | 271 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 300 pF | 301 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 330 pF | 331 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 360 pF | 361 | F | G | J | K | M | GK | GK | GK | GK | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 390 pF | 391 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 430 pF | 431 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 470 pF | 471 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KF | KF | KF | KF | KE |
| 510 pF | 511 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 560 pF | 561 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 620 pF | 621 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 680 pF | 681 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE |
| 750 pF | 751 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 820 pF | 821 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 910 pF | 911 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,000 pF | 102 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,100 pF | 112 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,200 pF | 122 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,300 pF | 132 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,500 pF | 152 | F | G | J | K | M | GK | GK | GK | GK | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,600 pF | 162 | F | G | J | K | M | GK | GK | GK | GK | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 1,800 pF | 182 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 2,000 pF | 202 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KE |
| 2,200 pF | 222 | F | G | J | K | M | GK | GK | GK | GO | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KF |
| 2,400 pF | 242 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HJ | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 2,700 pF | 272 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,000 pF | 302 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,300 pF | 332 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KE | KE | KE | KJ |
| 3,600 pF | 362 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 3,900 pF | 392 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HJ | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 4,300 pF | 432 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JK | | KE | KF | KF | KF | |
| 4,700 pF | 472 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JN | | KE | KF | KF | KH | |
| 6,200pF | 622 | F G J K M | GH | GK | | | | HG | HE | HG | | | JK | JE | JE | JN | | KE | KF | KF | KJ | |
| 6,800pF | 682 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | JN | | KE | KF | KF | KJ | |
| 7,500pF | 752 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | | | KF | KE | KF | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | HG | HE | HJ | | | JK | JE | JL | | | KF | KE | KF | | |
| 9,100 pF | 912 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 10,000 pF | 103 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 12,000 pF | 123 | | GO | | | | | HE | HG | | | | JE | JK | JN | | | KE | KE | KH | | |
| 15,000 pF | 153 | | GO | | | | | HE | HJ | | | | JE | JL | | | | KE | KF | KJ | | |
| 18,000 pF | 183 | | | | | | | HG | HK | | | | JE | JL | | | | KE | KH | | | |
| 22,000 pF | 223 | | | | | | | HJ | | | | | JK | JN | | | | KF | KJ | | | |
| 27,000 pF | 273 | | | | | | | HJ | | | | | JL | JN | | | | KF | KJ | | | |
| 33,000 pF | 333 | | | | | | | HK | | | | | JN | | | | | KH | | | | |
| 39,000 pF | 393 | | | | | | | | | | | | | | | | | KJ | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1C – Capacitance Range/Selection Waterfall (2824 – 4540 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 - 2,000 pF | 100 - 202 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,400 pF | 242 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,000 pF | 302 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J | K | M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,600 pF | 362 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J | K | M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,300 pF | 432 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J | K | M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,100 pF | 512 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J | K | M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,200 pF | 622 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J | K | M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 7,500 pF | 752 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J | K | M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 9,100 pF | 912 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J | K | M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J | K | M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J | K | M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J | K | M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J | K | M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J | K | M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J | K | M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J | K | M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J | K | M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J | K | M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J | K | M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J | K | M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.1 µF | 104 | J | K | M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J | K | M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J | K | M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | | Loose Packaging | | Secure Packaging | |
|---|---|---|---|---|---|---|
| | | | Bulk Bag (default) | | 2” x 2” Waffle Pack/Tray[3] | |
| Packaging C-Spec[1] | | | N/A[2] | | 7282 / 7292 | |
| Case Size | | Chip Thickness (mm) | Packaging Quantities (pieces/unit packaging) | | | |
| EIA (in) | Metric (mm) | | Minimum | Maximum | Minimum | Maximum |
| 0402 | 1005 | All | 1 | 50,000 | 1 | 368 |
| 0603 | 1608 | | | | | 368 |
| 0805 | 2012 | | | | | 100 |
| 1206 | 3216 | ≤ 1.25 (nominal) | | | | 126 |
| 1206 | 3216 | > 1.25 (nominal) | | | | 50 |
| 1210 | 3225 | All | | | | 80 |
| 1808 | 4520 | | | 20,000 | | 50 |
| 1812 | 4532 | | | | | 42 |
| 1825 | 4564 | | | | | 20 |
| 2220 | 5650 | | | | | 20 |
| 2225 | 5664 | | | | | 20 |

*[1] The "Packaging C-Spec" is a 4-digit code which identifies the packaging type. When ordering, the proper code must be included in the 15th through 18th character positions of the ordering code. See "Ordering Information" section of this document for further details. Product ordered without a packaging C-Spec will default to our standard " bulk bag" packaging.*

*[2] A packaging C-Spec (see note 1 above) is not required For "bulk bag" packaging (excluding Anti-Static Bulk Bag). The 15th through 18th character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "bulk bag" packaging.*

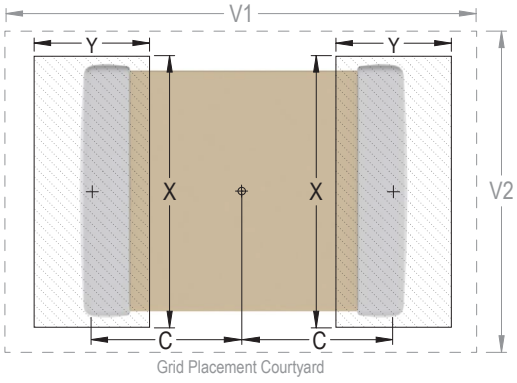
*[3] Also commonly referred to as “Chip Carrier” or “Molded Tray”. All tray packaging options offer static protection.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

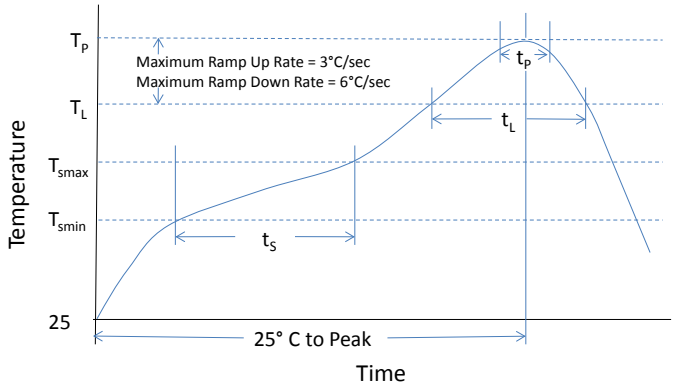
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| Load Humidity | 85°C/85%RH and 200 VDC maximum, 1,000 Hours |
| Low Voltage Humidity | 85°C/85%RH, 1.5V, 1,000 Hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 Cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical – OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes, 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

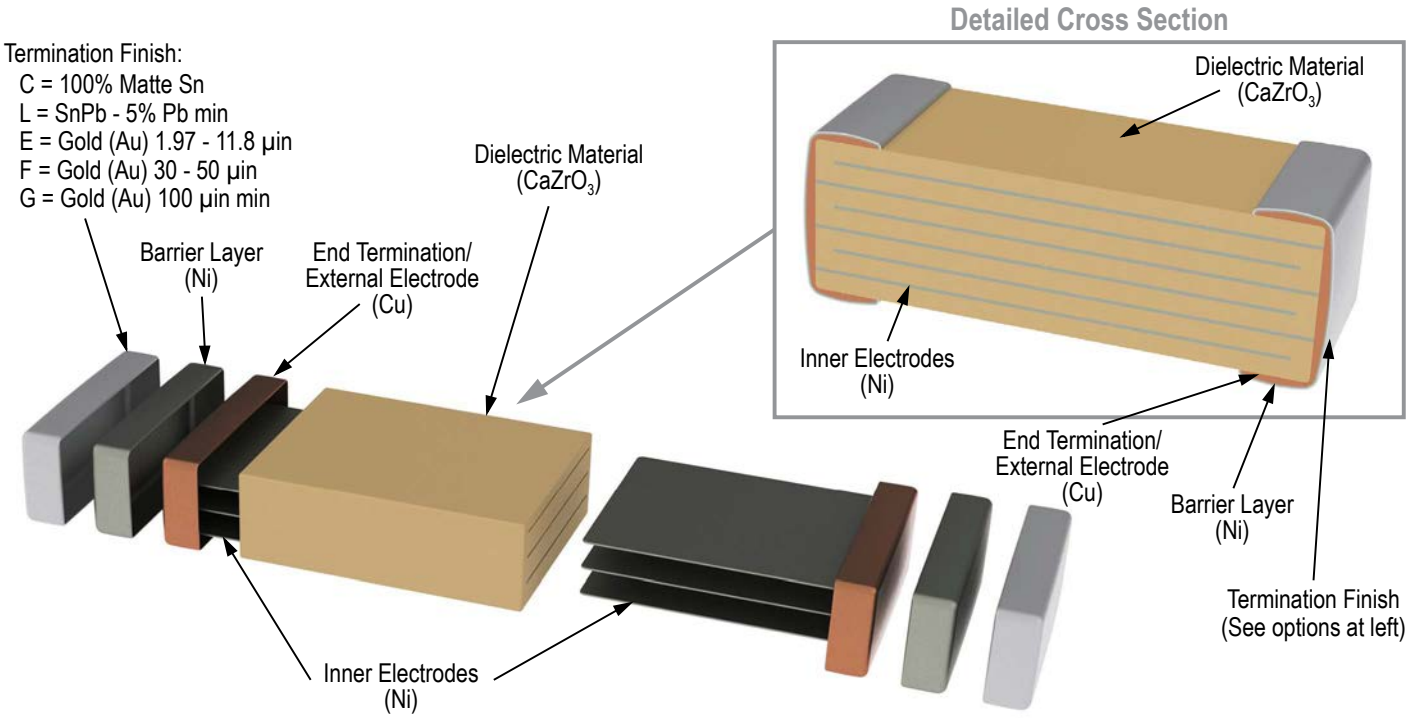
Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40°C and maximum storage humidity not exceed 70% relative humidity. In addition, temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within the time frame outlined in the table below:

| Termination Finish | Termination Finish Ordering Code[1] | Storage Life |
|---|---|---|
| 100% Matte Tin (Sn) | C | 1.5 years upon receipt |
| SnPb (5% Pb min.) | L | 1.5 years upon receipt |
| Gold (Au) 1.97 – 11.8 µin[2] | E | 6 months upon receipt[2] |
| Gold (Au) 30 – 50 µin | F | 1.5 years upon receipt |
| Gold (Au) 100 µin min. | G | 1.5 years upon receipt |

*[1] The fourteenth (14th) character position of the KEMET part number is assigned to identify and/or define the termination finish. For more information, see "Ordering Information" section of this document.*

*[2] Gold plating option "E" devices should remain in its factory sealed moisture sensitive packaging during storage. If the factory sealed packaging is disturbed please store any remaining packaged components in a dry box container to prevent oxidation of the termination finish.*

## Construction (Typical)




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS Series, X7R Dielectric, 10 – 250 VDC (Commercial Grade)

## Overview

KEMET Power Solutions (KPS) Commercial Series stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor/s from the printed circuit board, therefore offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. A two chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCCs devices. Providing up to 10 mm of board flex capability, KPS Series capacitors are environmentally friendly and in compliance with RoHS legislation. Available in X7R dielectric, these devices are capable of Pb-Free reflow profiles and provide lower ESR, ESL and higher ripple current capability when compared to other dielectric solutions.

Combined with the stability of an X7R dielectric, KEMET's KPS Series devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 1210, 1812, and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, and 250 V
- Capacitance offerings ranging from 0.1 µF up to 47 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings
- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible, microphonic noise
- Extremely low ESR and ESL

## Ordering Information

| C | 2220 | C | 106 | M | 5 | R | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 1210<br>1812<br>2220 | C = Standard | Two significant digits + number of zeros | K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>A = 250 | R = X7R | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

[1] *Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

[2] *Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape) / Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape) / Unmarked | 7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits cont'd

- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Tantalum and electrolytic alternative

## Applications

Typical applications include smoothing circuits, DC/DC converters, power supplies (input/output filters), noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Markets include industrial, military, automotive and telecom.

## Qualification/Certification

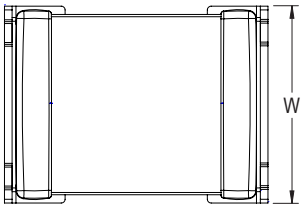
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

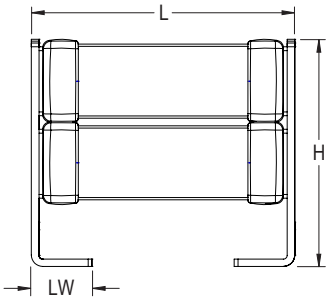
Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)

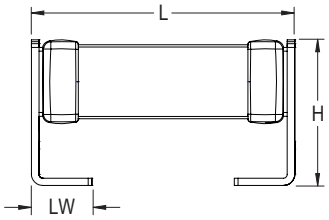
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Number of Chips | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 3.35 (.132) ±0.10 (.004) | 0.80 (.032) ±0.15 (.006) | Solder Reflow Only |
| | 1812 | 4532 | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.50 (.020) | 2.65 (.104) ±0.35 (.014) | 1.10 (.043) ±0.30 (.012) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | |
| Double | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 6.15 (.242) ±0.15 (.006) | 0.80 (.031) ±0.15 (.006) | |
| | 1812 | 4532 | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.10 (.043) ±0.30 (.012) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 5%(10V), 3.5%(16V & 25V) and 2.5%(50V to 250V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(Rated voltage applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 48 or 1,000 hours. Please refer to a part number specific datasheet for referee time details.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*

*120 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

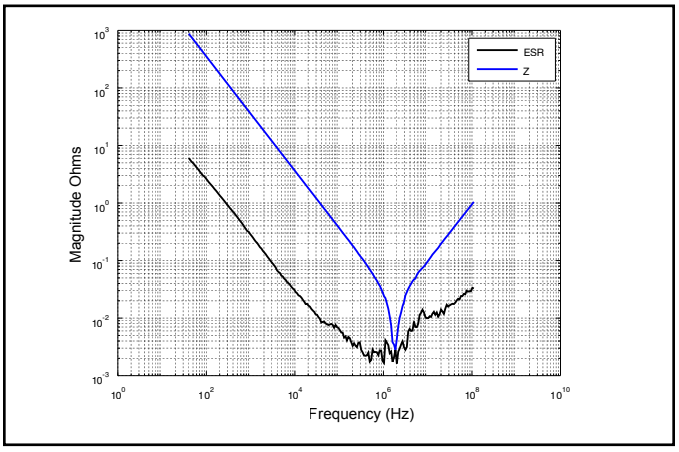
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

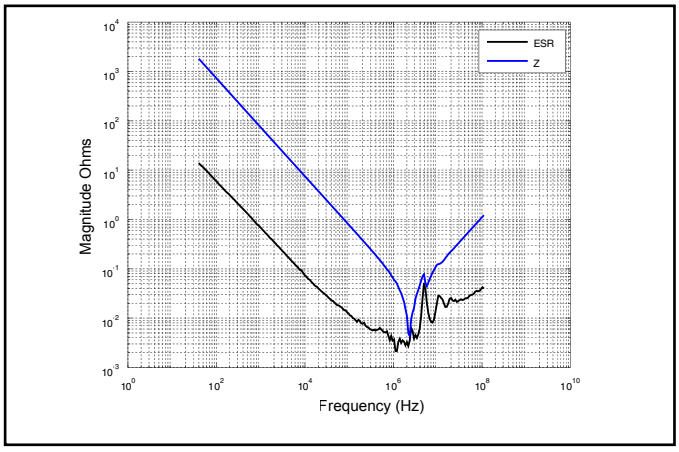
| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 2220 | < 10 µF | ≥ 10 µF |

## Electrical Characteristics

Z and ESR C1210C475M5R1C

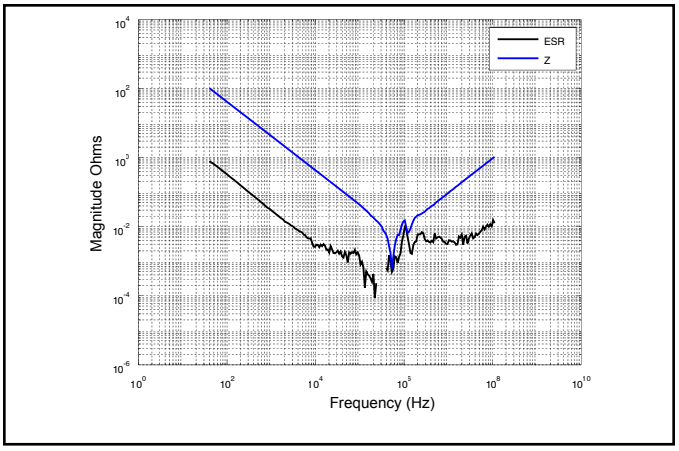



Z and ESR C2220C225MAR2C

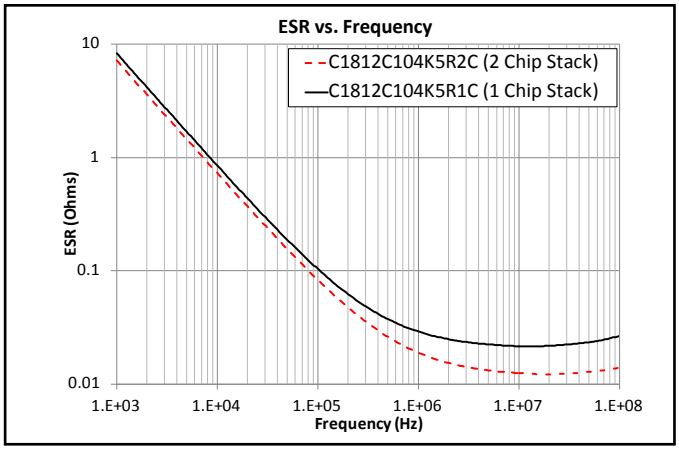


# Electrical Characteristics

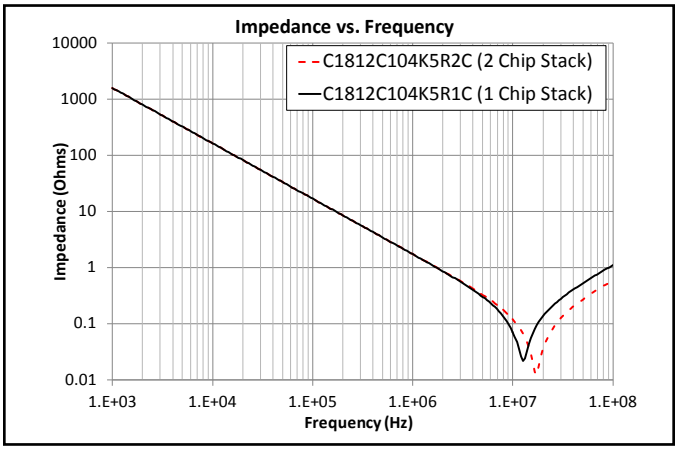
## Z and ESR C2220C476M3R2C



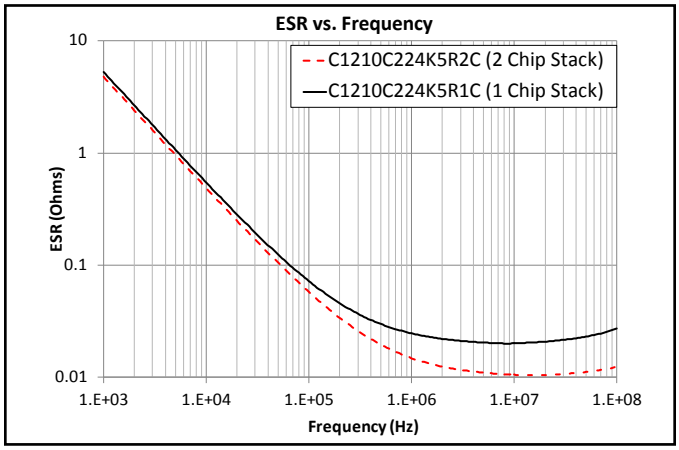

## ESR – 1812, .10 µF, 50 V X7R



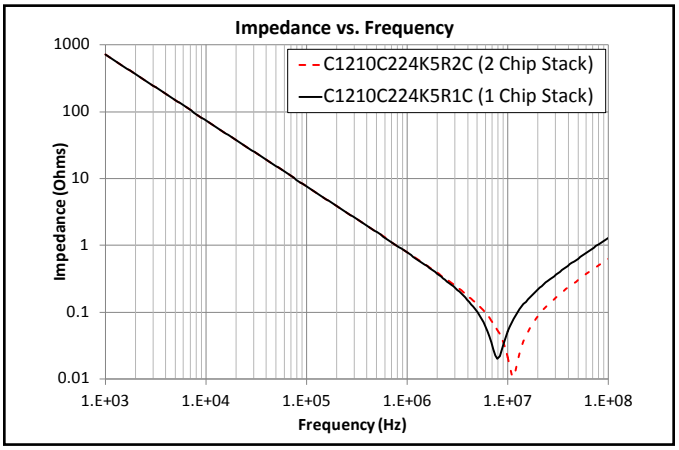

## Impedance – 1812, .10 µF, 50 V X7R




## ESR – 1210, .22 µF, 50 V X7R

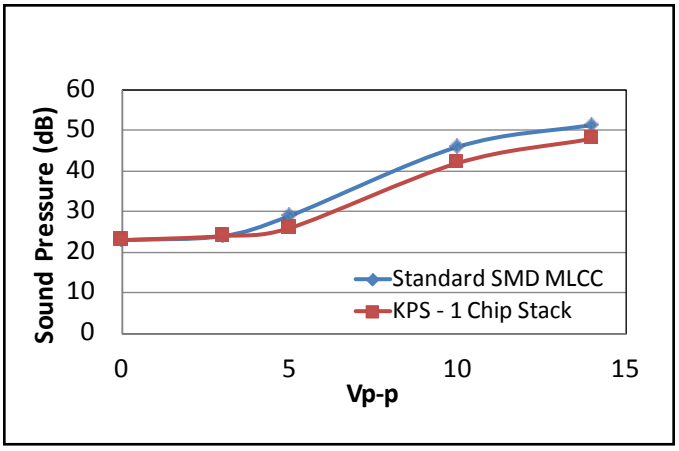



## Impedance – 1210, .22 µF, 50 V X7R

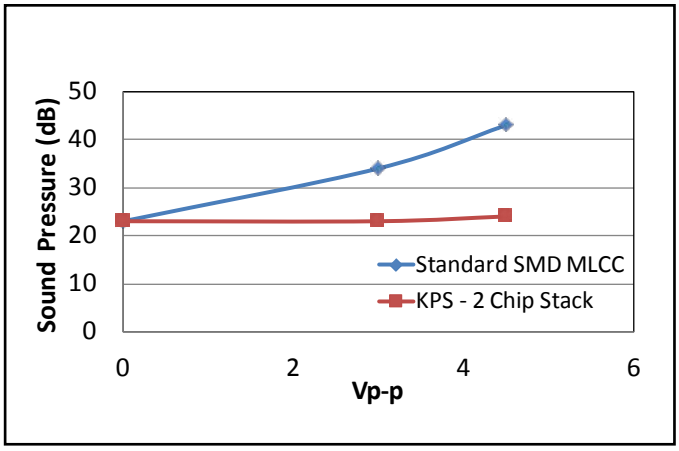


## Electrical Characteristics cont'd

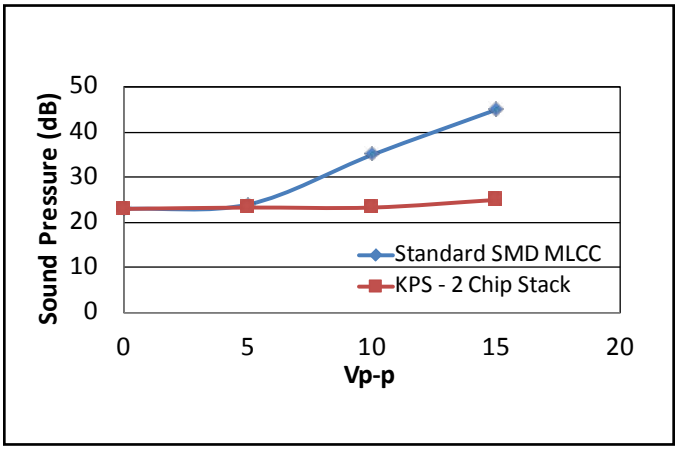
### Microphonics – 1210, 4.7 µF, 50 V, X7R



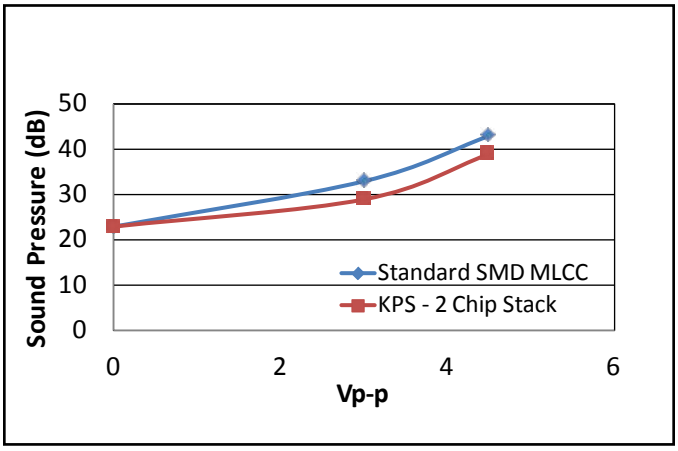

### Microphonics – 2220, 22 µF, 50 V, X7R




### Microphonics – 2220, 47 µF, 25 V, X7R

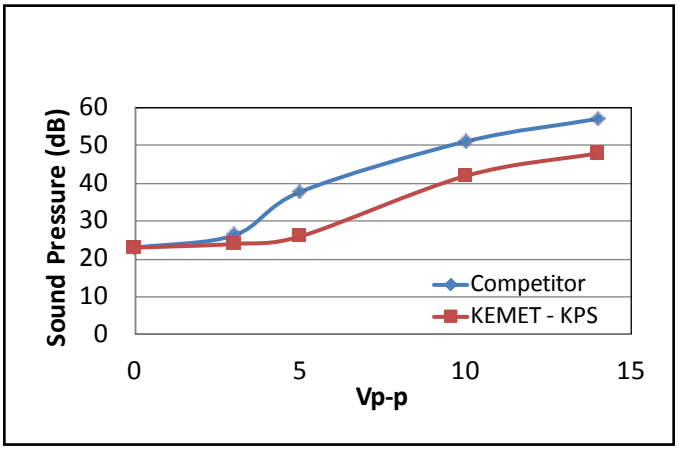



### Microphonics – 1210, 22 µF, 25 V, X7R

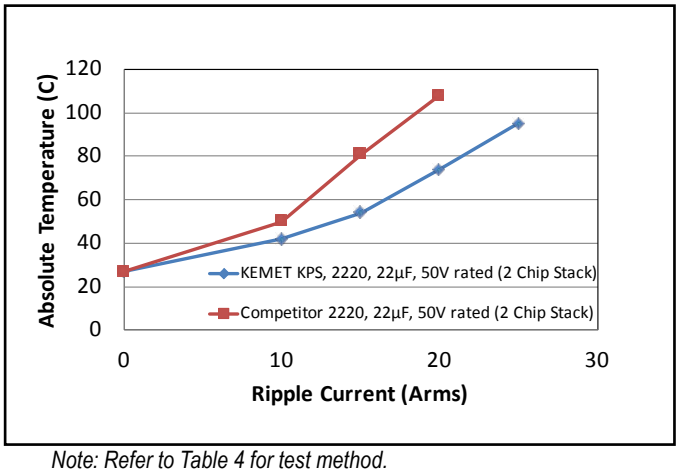



## Competitive Comparision

### Microphonics – 1210, 4.7 µF, 50 V, X7R



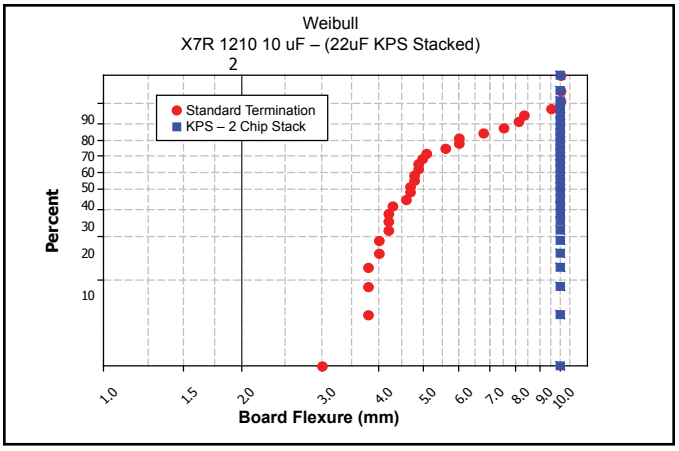

### Ripple Current (Arms) 2220, 22 µF, 50 V



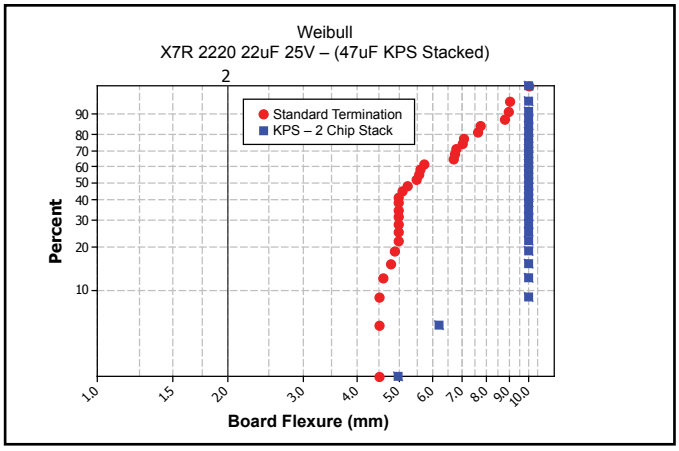

*Note: Refer to Table 4 for test method.*

# Electrical Characteristics cont'd

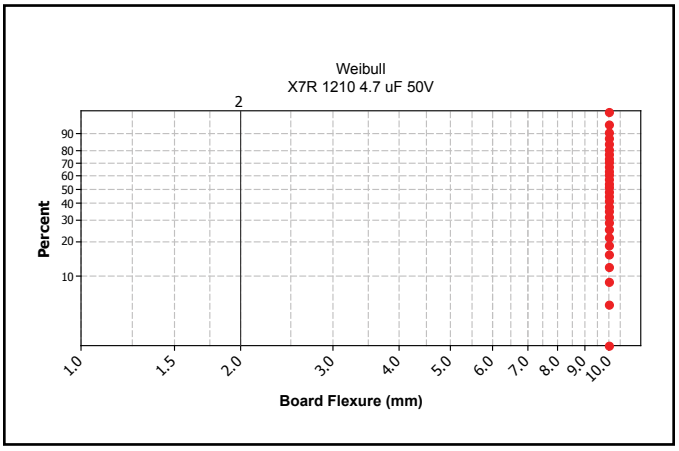
## Board Flex vs. Termination Type



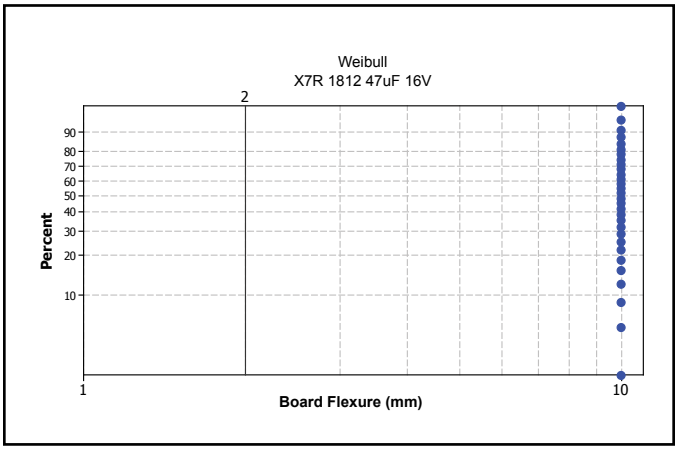

## Board Flex vs. Termination Type




## Board Flexure to 10 mm




## Board Flexure to 10 mm



## Table 1 – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | C1210C | | | | | | C1812C | | | | | C2220C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | 8 | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A |
| | | Rated Voltage (VDC) | | 10 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | |
| **Single Chip Stack** | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | K | M | FV | FV | FV | FV | FV | FV | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 0.22 µF | 224 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 0.47 µF | 474 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | GP | JP | JP | JP | JP | JP |
| 1.0 µF | 105 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | GP | | JP | JP | JP | JP | JP |
| 2.2 µF | 225 | K | M | FV | FV | FV | FV | FV | | GP | GP | GP | | | JP | JP | JP | JP | |
| 3.3 µF | 335 | K | M | FV | FV | FV | FV | | | GP | GP | GP | | | JP | JP | JP | JP | |
| 4.7 µF | 475 | K | M | FV | FV | FV | FV | | | GP | GP | GP | | | JP | JP | JP | | |
| 10 µF | 106 | K | M | FV | FV | FV | | | | GP | GP | | | | JP | JP | JP | | |
| 15 µF | 156 | K | M | FV | | | | | | | | | | | JP | JP | | | |
| 22 µF | 226 | K | M | FV | | | | | | | | | | | JP | JP | | | |
| **Double Chip Stack** | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | | M | FW | FW | FW | FW | FW | FW | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 0.22 µF | 224 | | M | FW | FW | FW | FW | FW | FW | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 0.47 µF | 474 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 1.0 µF | 105 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | GR | JR | JR | JR | JR | JR |
| 2.2 µF | 225 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | | JR | JR | JR | JR | JR |
| 3.3 µF | 335 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | GR | | JR | JR | JR | JR | |
| 4.7 µF | 475 | | M | FW | FW | FW | FW | FW | | GR | GR | GR | | | JR | JR | JR | JR | |
| 10 µF | 106 | | M | FW | FW | FW | FW | | | GR | GR | GR | | | JR | JR | JR | | |
| 22 µF | 226 | | M | FW | FW | FW | | | | GR | GR | | | | JR | JR | JR | | |
| 33 µF | 336 | | M | FW | | | | | | | | | | | JR | JR | | | |
| 47 µF | 476 | | M | FW | | | | | | | | | | | JR | JR | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | 10 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 | 16 | 25 | 50 | 100 | 250 |
| | | Voltage Code | | 8 | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A | 4 | 3 | 5 | 1 | A |
| | | Case Size/Series | | C1210C | | | | | | C1812C | | | | | C2220C | | | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

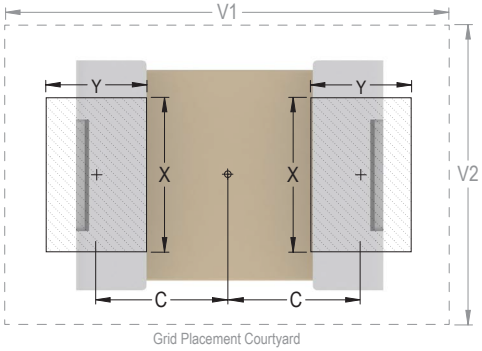
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FV | 1210 | 3.35 ± 0.10 | 0 | 0 | 600 | 2,000 |
| FW | 1210 | 6.15 ± 0.15 | 0 | 0 | 300 | 1,000 |
| GP | 1812 | 2.65 ± 0.35 | 0 | 0 | 500 | 2,000 |
| GR | 1812 | 5.00 ± 0.50 | 0 | 0 | 400 | 1,700 |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |
| Thickness Code | Case Size | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 1812 | 4532 | 2.20 | 1.35 | 2.87 | 6.70 | 4.50 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

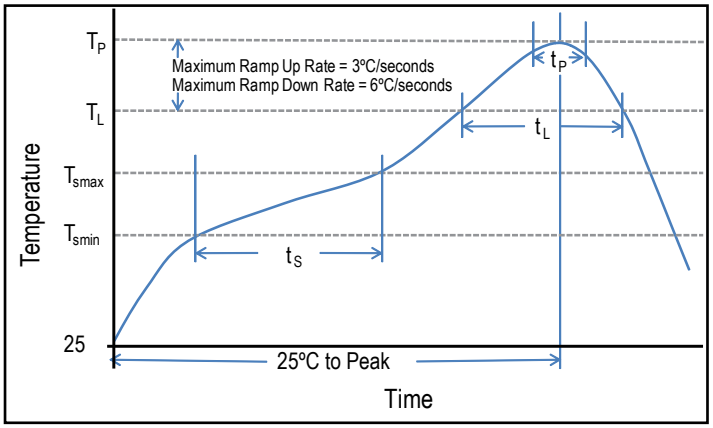
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



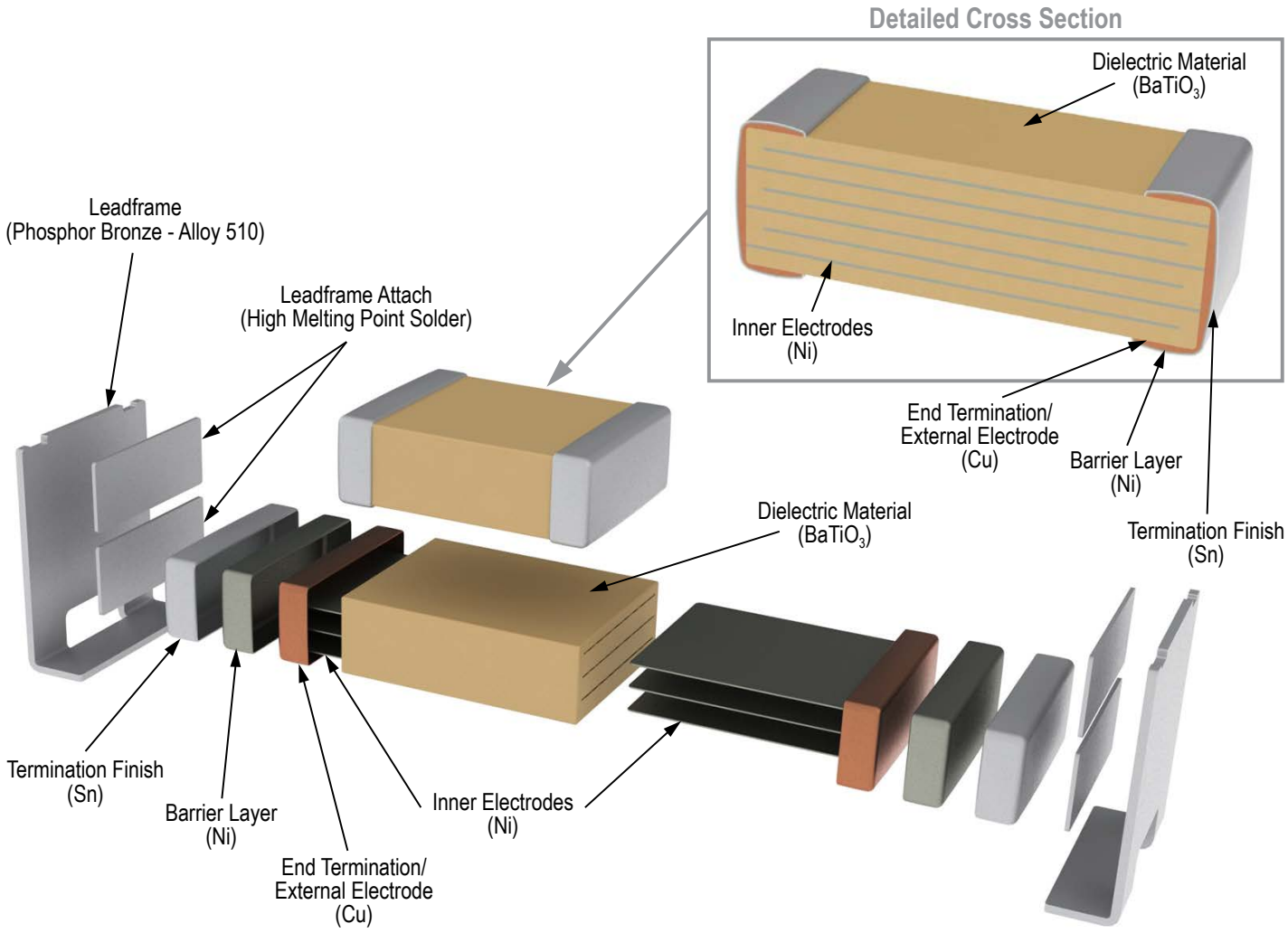
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C with 1.5X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB .031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction (Typical)




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade)

## Overview

KEMET Power Solutions (KPS) High Voltage stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series High Voltage capacitors are environmentally friendly and in compliance with RoHS legislation.

KEMET's KPS Series devices in X7R dielectric exhibit a predictable change in capacitance with respect to time and voltage, and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C. These devices are capable of Pb-Free reflow profiles and provide lower ESR, ESL and higher ripple current capability when compared to other dielectric solutions.

Conventional uses include both snubbers and filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage ceramic capacitors the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors, and test/diagnostic equipment.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 2220 case size
- DC voltage ratings of 500 V and 630 V
- Capacitance offerings ranging from 0.047 µF up to 1.0 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings

## Ordering Information

| C | 2220 | C | 105 | M | C | R | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | C = 500<br>B = 630 | R = X7R | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits cont'd

- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Film alternative

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications.

## Qualification/Certification

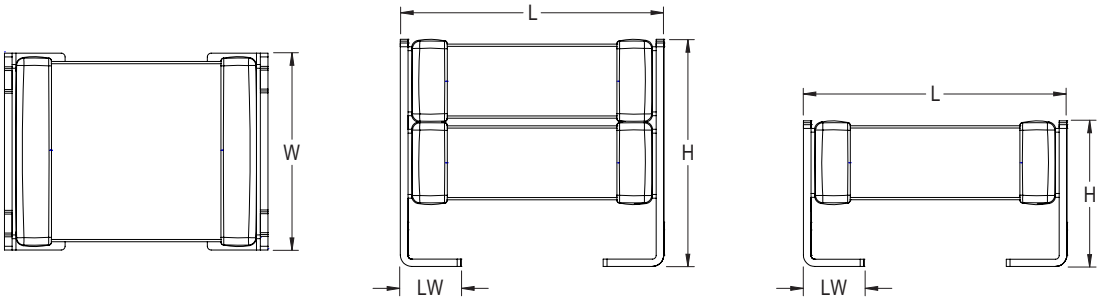
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4 , Performance and Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)

*Single or Double Chip Stack* *Double Chip Stack* *Single Chip Stack*




| Number of Chips | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | Solder Reflow Only |
| Double | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*

*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

## Table 1 – Capacitance Range/Selection Waterfall (2220 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | C2220C | | |
|---|---|---|---|---|---|---|
| | | Voltage Code | | C | B | D |
| | | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | |
| **Single Chip Stack** | | | | | | |
| 0.047 µF | 473 | K | M | JP | JP | |
| 0.10 µF | 104 | K | M | JP | JP | |
| 0.15 µF | 154 | K | M | JP | JP | |
| 0.22 µF | 224 | K | M | JP | JP | |
| 0.33 µF | 334 | K | M | JP | | |
| 0.47 µF | 474 | K | M | JP | | |
| **Double Chip Stack** | | | | | | |
| 0.10 µF | 104 | | M | JR | JR | |
| 0.22 µF | 224 | | M | JR | JR | |
| 0.33 µF | 334 | | M | JR | JR | |
| 0.47 µF | 474 | | M | JR | JR | |
| 0.68 µF | 684 | | M | JR | | |
| 1.0 µF | 105 | | M | JR | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Voltage Code | | C | B | D |
| | | Case Size/Series | | C2220C | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

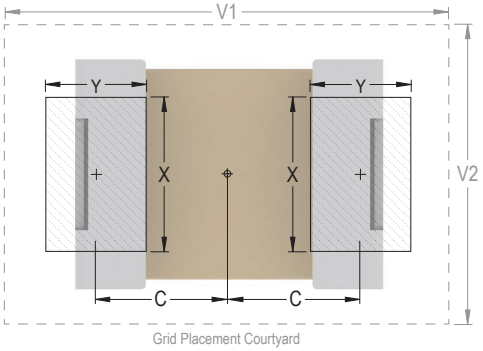
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 1812 | 4532 | 2.20 | 1.35 | 2.87 | 6.70 | 4.50 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

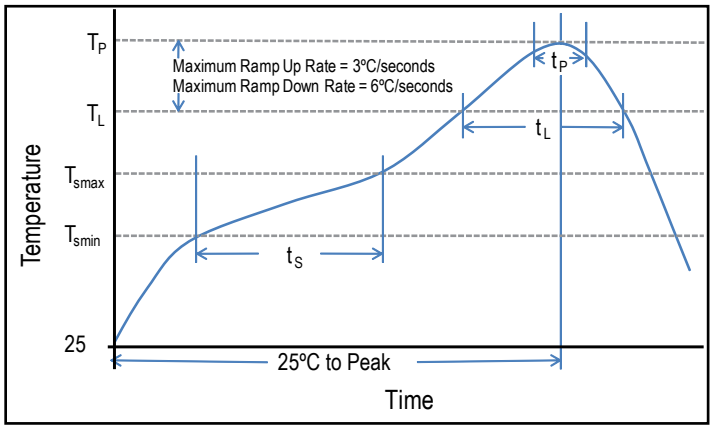
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



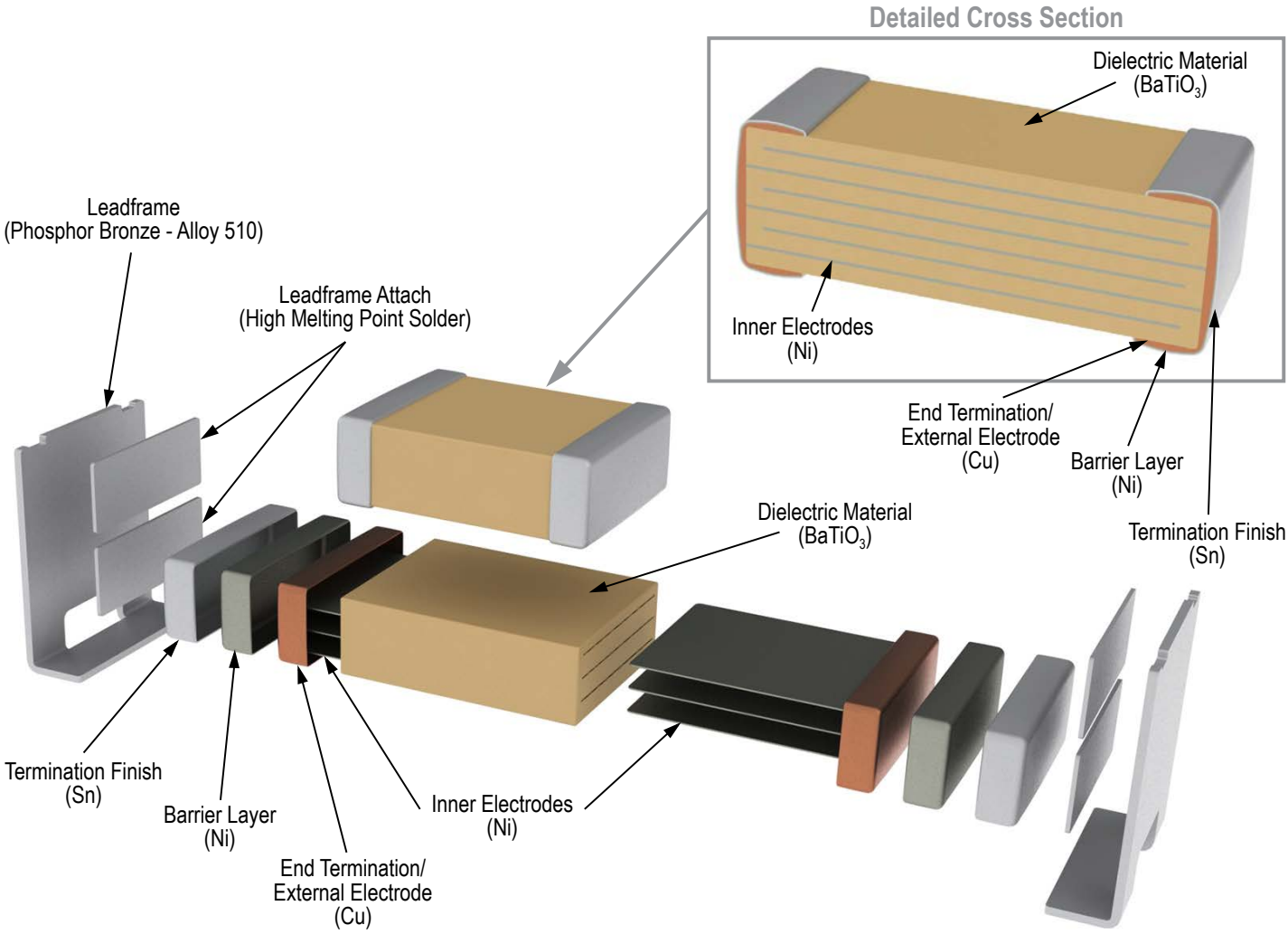
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET Power Solutions High Temperature (KPS HT) stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series capacitors are environmentally friendly and in compliance with RoHS legislation. Combined with X8L dielectric, these devices are capable of reliable operation up to 150°C and are well suited for high temperature filtering, bypass and decoupling applications.

X8L exhibits a predictable change in capacitance with respect to time and voltage, and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C, X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, -40% from 125°C to 150°C.

In addition to Commercial grade, Automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

## Benefits

- −55°C to +150°C operating temperature range
- Reliable and robust termination system
- EIA 1210 and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.47 µF up to 47 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings
- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability

## Ordering Information

| C | 2220 | C | 476 | M | 8 | N | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 1210<br>2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| **Commercial Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |
| **Automotive Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | AUTO |
| 13" Reel (Embossed Plastic Tape)/Unmarked | AUTO7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*
*[2] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

## Benefits

- Reduces audible, microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Tantalum and electrolytic alternative
- Commercial & Automotive (AEC-Q200) grades available

## Applications

Typical applications include smoothing circuits, DC/DC converters, power supplies (input/output filters), noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to extreme environments such as high temperature, high levels of board flexure and/or temperature cycling. Markets include industrial, aerospace, automotive, and telecom.

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

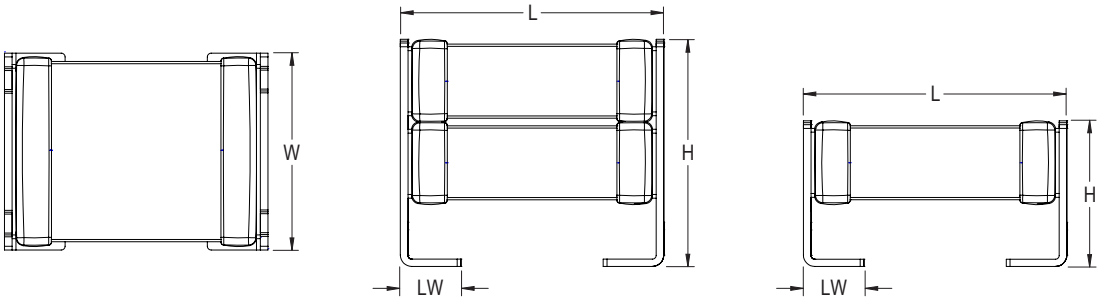
| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)

*Single or Double Chip Stack* *Double Chip Stack* *Single Chip Stack*




| Chip Stack | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 3.35 (.132) ±0.10 (.004) | 0.80 (.032) ±0.15 (.006) | Solder Reflow Only |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | |
| Double | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 6.15 (.242) ±0.15 (.006) | 0.80 (.031) ±0.15 (.006) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Table 1 – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | |
| **Single Chip Stack** | | | | | | | | | | | | | | | | |
| 0.47 µF | 474 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 1.0 µF | 105 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 2.2 µF | 225 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 3.3 µF | 335 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 4.7 µF | 475 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 10 µF | 106 | | K | M | | | | | | | JP | JP | JP | | | |
| 15 µF | 156 | | K | M | | | | | | | JP | | | | | |
| 22 µF | 226 | | K | M | | | | | | | JP | | | | | |
| **Double Chip Stack** | | | | | | | | | | | | | | | | |
| 1.0 µF | 105 | | | M | FW | FW | FW | FW | | | | | | | | |
| 2.2 µF | 225 | | | M | FW | FW | FW | FW | | | | | | | | |
| 3.3 µF | 335 | | | M | FW | FW | FW | | | | | | | | | |
| 4.7 µF | 475 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 10 µF | 106 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 22 µF | 226 | | | M | | | | | | | JR | JR | JR | | | |
| 33 µF | 336 | | | M | | | | | | | JR | | | | | |
| 47 µF | 476 | | | M | | | | | | | JR | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

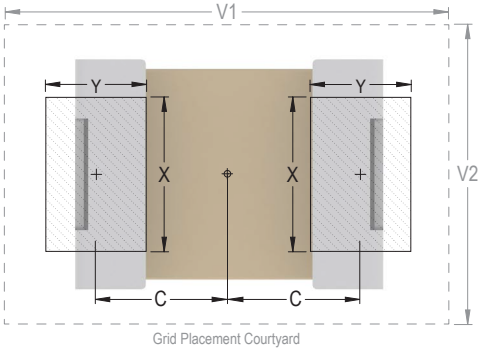
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FV | 1210 | 3.35 ± 0.10 | 0 | 0 | 600 | 2,000 |
| FW | 1210 | 6.15 ± 0.15 | 0 | 0 | 300 | 1,000 |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

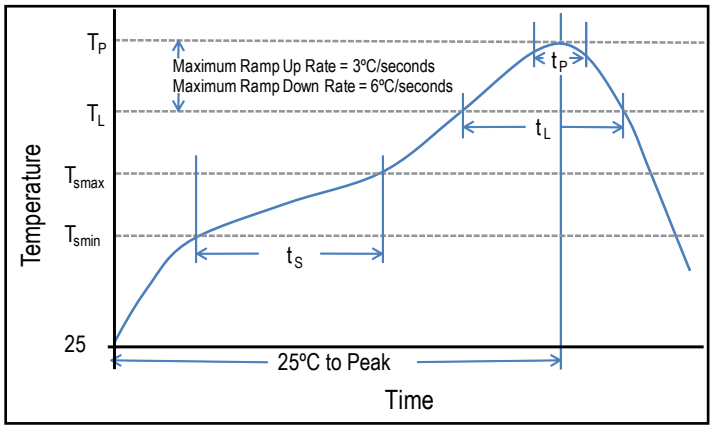
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



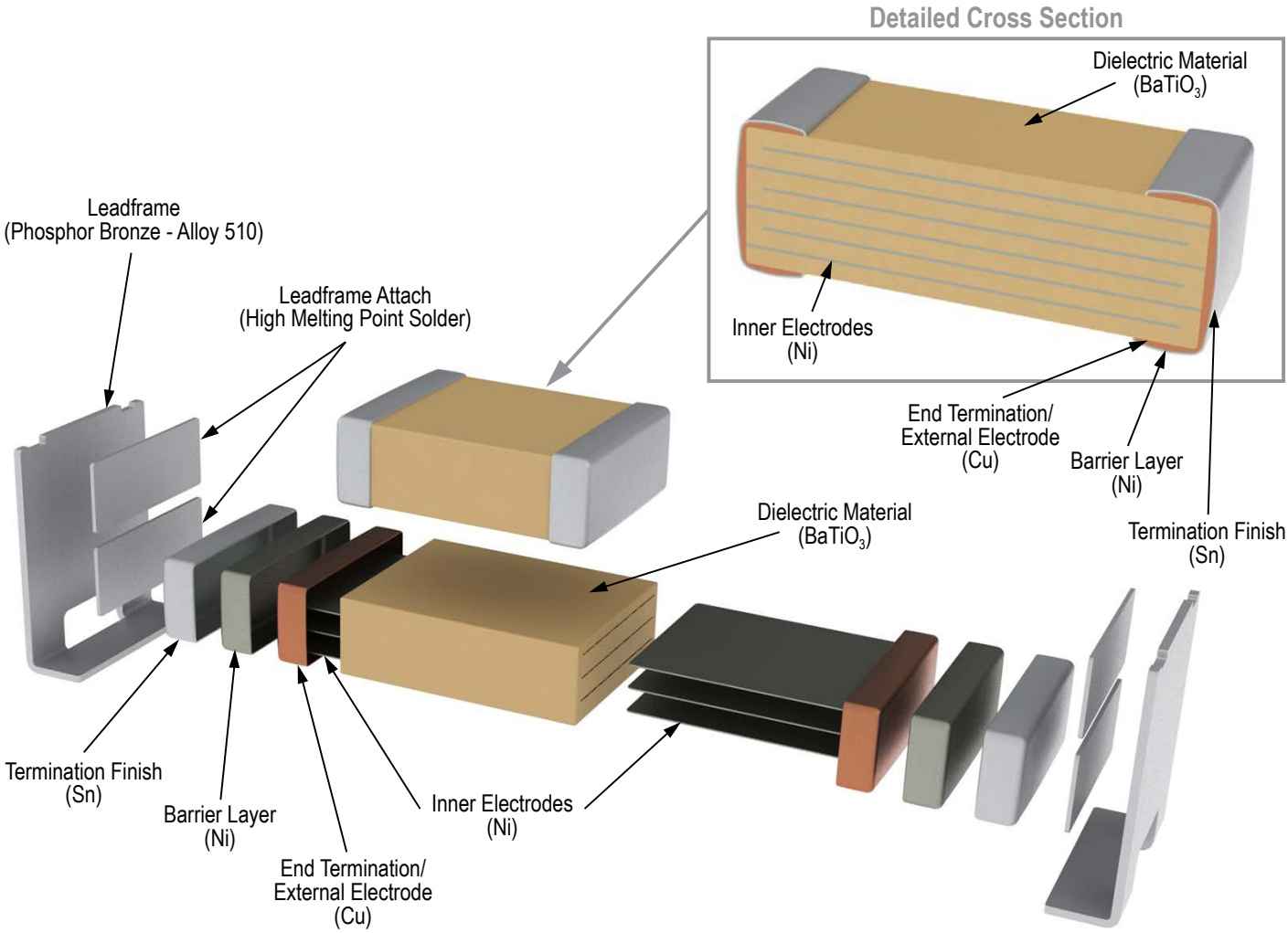
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150°C. Note: Number of cycles required- 300, maximum transfer time- 20 seconds, Dwell time- 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 150°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB .031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS MIL Series, SMPS Stacked Capacitors, MIL–PRF–49470, DSCC 87106, 25 – 1,000 VDC (Commercial, Military, & Space Grades)

## Overview

KEMET Power Solutions (KPS) MIL Series ceramic stacked capacitors are available in commercial, military and space grades and are well suited for standard and high reliability switch mode power supply (SMPS) and pulse energy applications. Qualified under performance specification MIL–PRF–49470, our military and space grade products meet or exceed the requirements outlined by DSCC (Defense Supply Center, Columbus) and are available in both B (standard reliability) & T (high reliability) product levels. MIL–PRF–49470 was developed as part of a cooperative effort between the U.S. Military, NASA and SMPS suppliers to produce a robust replacement to cancelled DSCC Drawing 87106.

The KPS MIL Series is constructed using large chip multilayer ceramic capacitors (MLCCs), horizontally stacked and secured to a lead-frame termination system using a high melting point (HMP) solder alloy. The lead frame isolates the MLCCs from the printed circuit board (PCB) while establishing a parallel circuit configuration. Mechanically isolating the capacitors from the PCB improves mechanical and thermal stress performance, while the parallel circuit configuration allows for bulk capacitance in the same or smaller design footprint.

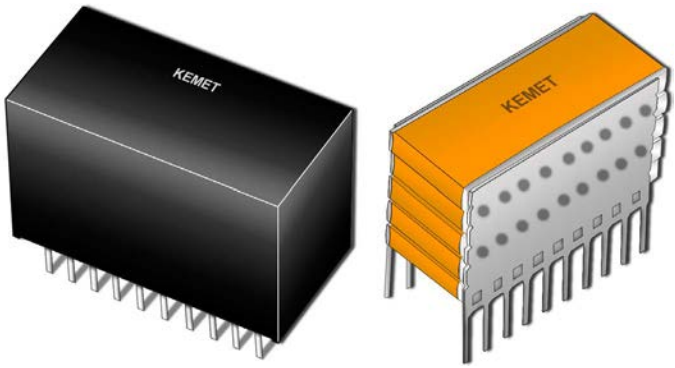
Available in BX, BR, BQ, and X7R dielectrics, these devices are available in encapsulated and unencapsulated styles in both surface mountable and through-hole configurations. Their low Equivalent Series Resistance (ESR) and Equivalent Series Inductance (ESL) make them ideally suited for input and output filtering of power supply as well as snubber applications. The encapsulated styles are primarily used where increased mechanical and environmental protection is required, such as in avionics systems.

## Benefits

- -55°C to +125°C operating temperature range
- High frequency performance
- Bulk capacitance in a reduced footprint
- MIL–PRF–49470 QPL
- Military Case Codes 3, 4 and 5
- Space Grade available (“T” Level)
- DSCC approved (87106)
- Commercial/Industrial Grade available
- Customer specific requirements available
- Low ESR and ESL
- High thermal stability
- High ripple current capability
- Higher reliability than aluminum electrolytic or tantalum
- Available encapsulated or unencapsulated

## Applications

- Military
- Space
- Industrial
- Input and output filtering on power supplies – often found on “capacitor banks“
- Snubber circuits
- Radar filtering (28 V/microwave burst)





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## MIL–PRF–49470 Ordering Information

| M49470 | R | 01 | 474 | K | C | N |
|---|---|---|---|---|---|---|
| Performance Specification Indicating MIL–PRF–49470[1] | Dielectric Classification/ Characteristic[2] | Performance Specification Sheet Number (Indicating MIL–PRF–49470/1)[3] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Lead Configuration[4] |
| M49470 = B level<br>T49470 = T level<br>A "T" prefix is used in place of the "M" for T level product. | Q = BQ<br>R = BR<br>X = BX | 01 = Unencapsulated<br>02 = Encapsulated | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | A = 50<br>B = 100<br>C = 200<br>E = 500 | N = Straight Pin<br>L = Formed "L"<br>M = Formed "L"<br>J = Formed "J"<br>K = Formed "J" |

*[1] Indicates performance and reliability requirements. "B" level represents standard reliability."T" level represents high reliability.*

*[1] Please refer to performance specification sheet MIL–PRF–49470 for details regarding test levels. The latest revision of the specification sheet is available through DSCC.*

*[1, 3] Test level option "T" is not available on encapsulated stacked devices (i.e. MIL–PRF–49470/2).*

*[2] Dielectric classification and characteristic details are outlined in the "Electrical Parameters" section of this document.*

*[4] Lead configuration and dimension details are outlined in the "Dimensions" section of this document.*

## KPS MIL Series, SMPS Stacks Ordering Information

**(Do not use this ordering code if a QPL MIL–SPEC part type is required. Please order using MIL–SPEC ordering code. Details regarding MIL–PRF–49470 QPL ordering information is outlined above.)**

| L1 | R | N | 30 | C | 106 | K | S | 12 | |
|---|---|---|---|---|---|---|---|---|---|
| Product Family[1] | Dielectric Classification/ Characteristic[2] | Lead Configuration[3] | Case Size/ Case Code (CC) | Rated Voltage (VDC) | Capacitance Code (pF) | Capacitance Tolerance | Testing Option[4] | Maximum Height Dimension (in.)[5] | |
| L1 = Unencapsulated<br>L2 = Encapsulated | Q = BQ<br>R = BR<br>X = BX<br>W = X7R | N = Straight<br>L = Formed "L"<br>M = Formed "L"<br>J = Formed "J"<br>K = Formed "J" | 30 = CC 3<br>40 = CC 4<br>50 = CC 5 | 3 = 25<br>5 = 50<br>1 = 100<br>2 = 200<br>C = 500<br>B = 630<br>D = 1,000 | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | B = M49470 "B" Level<br>T = M49470 "T" Level<br>C = DSCC87106<br>S = Commercial<br>X = Non-Standard (Customer Specific Requirements) | Unencapsulated<br>12 = 0.12"<br>24 = 0.24"<br>36 = 0.36"<br>48 = 0.48"<br>65 = 0.65" | Encapsulated<br>27 = 0.27"<br>39 = 0.39"<br>53 = 0.53"<br>66 = 0.66"<br>80 = 0.80" |

*[1, 4] Test level option "T" is not available on encapsulated stacked devices, i.e., MIL–PRF–49470/2. If a QPL MIL–Spec part type is required, please order using the MIL–Spec ordering code.*

*[2] Dielectric classification and characteristic details are outlined in the "Electrical Parameters" section of this document.*

*[3] Lead configuration and dimension details are outlined in the "Dimensions" section of this document. Additional lead configurations may be available. Contact KEMET for details.*

*[4] Indicates performance and reliability requirements. Testing option details are outlined in the "Performance & Reliability" section of this document.*

*[4] Please refer to performance specification sheet MIL–PRF–49470 for additional details regarding test levels. The latest revision of the specification sheet is available through DSCC.*

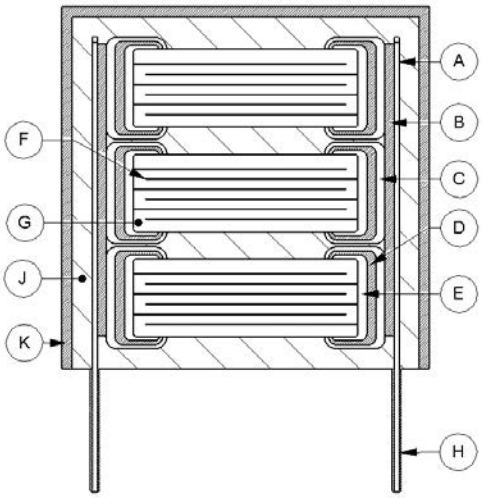
*[4] DSCC Drawing 87106 was cancelled on 01/03/2005. MIL–PRF–49470 capacitors are preferred over DSCC Drawing 87106 capacitors.*

*[5] Maximum height dimensions are provided in product tables 1A, 1B, and 1C of this document*

## Ordering Information Requirements per DSCC Drawing 87106

*DSCC Drawing 87106 was cancelled on 01/03/2005. Customers can continue to order per 87106 requirements using the original DSCC ordering code,i.e., 87106–001. When available, MIL–PRF–49470 devices are preferred over DSCC Drawing 87106. The MIL–PRF–49470 military specification product provides additional quality assurance provisions that are not required by the DSCC drawing. These extra provisions create a more robust replacement.*

## Construction




*Note: Image is exaggerated in order to clearly identify all components of construction*

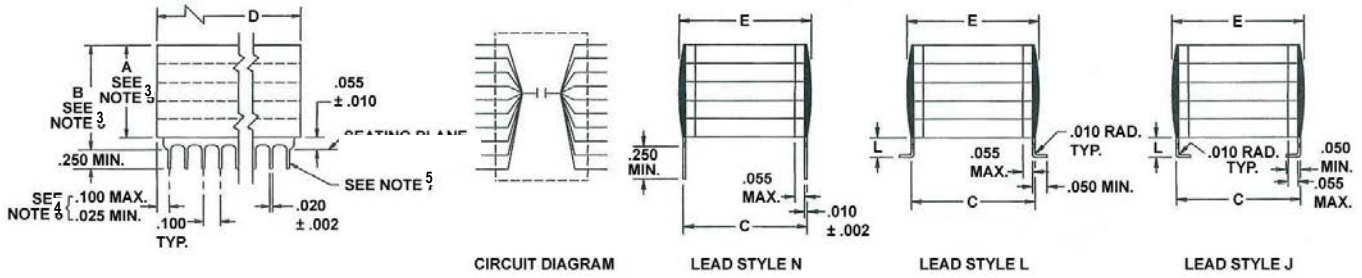
| Reference | Item | Material | |
|---|---|---|---|
| A | Leadframe | Phosphor Bronze – Alloy 510 | |
| B | Leadframe Attach Solder | Sn10, Pb88, Ag2 | |
| C | Termination System[1] | SnPb (4% minimum) | Solderable Silver |
| D | | Ni | |
| E | | Ag | |
| F | Electrode | PdAg | |
| G | Dielectric | $BaTiO_3$ | |
| H | Lead Solder | Sn60, Pb40 | |
| J | Encapsulation[2] | Molding Compound | |
| K | | Diallyl-Phthalate (DAP) | |

[1] *KEMET reserves the right to construct these devices using either of the termination systems outlined.*
[2] *Encapsulated product only, i.e., MIL–PRF–49470/2 and L2 product families.*

## Unencapsulated (M49470/1 & L1) Product Dimensions – Inches (Millimeters)

| Case Code | C Lead Spacing ±0.025 (0.635) | E Length ±0.010 (0.250) | D Width Minimum | D Width Maximum | A Height Maximum | Seating Plane[1] ±0.010 (0.250) | Number of Leads per Side | Mounting Technique |
|---|---|---|---|---|---|---|---|---|
| 3 | 0.450 (11.43) | 0.500 (12.70) | 0.950 (24.13) | 1.075 (27.30) | Refer to tables 1A & 1C for specific maximum A dimension | 0.055 (1.40) | 10 | Solder reflow only |
| 4 | 0.400 (10.16) | 0.440 (11.18) | 0.350 (8.89) | 0.425 (10.80) | | | 4 | |
| 5 | 0.250 (6.35) | 0.300 (7.62) | 0.224 (5.69) | 0.275 (6.98) | | | 3 | |

[1] *Only applies to lead style "N" (straight).*




*1. Unless otherwise specified, tolerances are ±0.010" (0.25 mm).*

*2. Metric equivalents for C, D and E dimensions are provided for general information only.*

*3. For maximum B dimension, add 0.065" (1.65 mm) to the appropriate A dimension. For all lead styles, the number of chips is determined by the capacitance and voltage rating.*

*4. For case code 5, dimensions shall be 0.100" (2.54 mm) maximum and 0.012" (0.30 mm) minimum.*

*5. Lead alignment within pin rows shall be within ±0.005" (0.13 mm).*

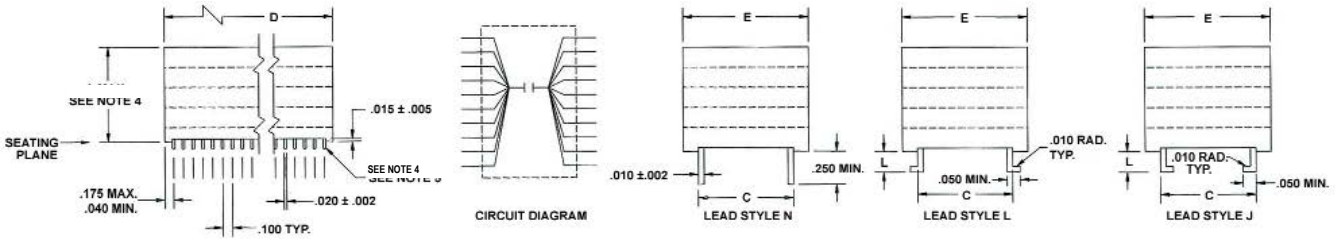
## Unencapsulated & Encapsulated Lead Configurations – Inches (Millimeters)

| Lead Style Symbol | Lead Style | L Lead Length |
|---|---|---|
| N | (N) Straight | 0.250 Minimum (6.35) |
| L | (L) Formed | 0.070 ± 0.010 (1.78 ±0.25) |
| M | | 0.045 ± 0.010 (1.14 ±0.25) |
| J | (J) Formed | 0.070 ± 0.010 (1.78 ±0.25) |
| K | | 0.045 ± 0.010 (1.14 ±0.25) |

*Additional lead configurations may be available. Contact KEMET for details.*

## Encapsulated (M49470/2 & L2) Product Dimensions – Inches (Millimeters)

| Case Code | C Lead Spacing ±0.025 (0.635) | E Length Maximum | D Width ±0.635 (±0.025) | A Height | Number of Leads per Side | Mounting Technique |
|---|---|---|---|---|---|---|
| 3 | 0.450 (11.43) | 0.580 (14.73) | 1.155 (29.34) | Refer to table 1B for specific maximum A dimension | 10 | Solder reflow only |
| 4 | 0.400 (10.16) | 0.485 (12.32) | 0.485 (12.32) | | 4 | |
| 5 | 0.250 (6.35) | 0.355 (9.02) | 0.355 (9.02) | | 3 | |




*1. Dimensions are in inches.*
*2. Metric equivalents are given for general information only.*
*3. Unless otherwise specified, tolerances are ±0.010" (0.25 mm).*
*4. Lead alignment within pin rows shall be within ±0.005" (0.13 mm).*

## Unencapsulated & Encapsulated Lead Configurations – Inches (Millimeters)

| Lead Style Symbol | Lead Style | L Lead Length |
|---|---|---|
| N | (N) Straight | 0.250 Minimum (6.35) |
| L | (L) Formed | 0.070 ± 0.010 (1.78 ±0.25) |
| M | | 0.045 ± 0.010 (1.14 ±0.25) |
| J | (J) Formed | 0.070 ± 0.010 (1.78 ±0.25) |
| K | | 0.045 ± 0.010 (1.14 ±0.25) |

*Additional lead configurations may be available. Contact KEMET for details.*

## Qualification Inspection Per MIL–PRF–49470

| Inspection | Test Method Paragraph |
|---|---|
| **Group I** | |
| Thermal shock and voltage conditioning | 4.8.5 |
| **Group II** | |
| Visual and mechanical Inspection | 4.8.4 |
| **Group III** | |
| Low temperature storage | 4.8.23 |
| Barometric pressure | 4.8.9 |
| Terminal strength | 4.8.10 |
| **Group IV** | |
| Voltage-temperature limits | 4.8.13.1 |
| Vibration, high frequency | 4.8.14 |
| Immersion | 4.8.15 |
| **Group V** | |
| Shock, specified pulse | 4.8.16 |
| Resistance to soldering heat | 4.8.17 |
| Moisture resistance | 4.8.18 |
| **Group VI** | |
| DPA (T level only) | 4.8.19 |
| **Group VII** | |
| Humidity, steady state, low voltage (T level only) | 4.8.21 |
| **Group VIII** | |
| Life | 4.8.22 |

## Environmental Compliance

These devices do not meet RoHS criteria

## Electrical Parameters/Performance Characteristics: BQ Dielectric

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Capacitance Change with Reference to +25°C and 100% Rated VDC Applied | +15%, -50% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 1% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated DC voltage for voltage rating < 500 V<br>150% of rated DC voltage for voltage rating of 500 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit at 25ºC | 2.5% |
| Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads (minimum) or 100 GΩ |
| Insulation Resistance (IR) Limit at 125°C | 100 megohm microfarads (minimum) or 10 GΩ |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±100 Hz at 1.0 Vrms ±0.2 Vrms (open circuit voltage).*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Electrical Parameters/Performance Characteristics: BR Dielectric

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Capacitance Change with Reference to +25°C and 100% Rated VDC Applied | +15%, -40% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 1% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated DC voltage for voltage rating < 500 V<br>150% of rated DC voltage for voltage rating of 500 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit at 25ºC | 2.5% |
| Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads (minimum) or 100 GΩ |
| Insulation Resistance (IR) Limit at 125°C | 100 megohm microfarads (minimum) or 10 GΩ |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±100 Hz at 1.0 Vrms ±0.2 Vrms (open circuit voltage).*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Electrical Parameters/Performance Characteristics: BX Dielectric

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Capacitance Change with Reference to +25°C and 100% Rated VDC Applied | +15%, -25% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 1% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated DC voltage for voltage rating < 500 V<br>150% of rated DC voltage for voltage rating of 500 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit at 25ºC | 2.5% |
| Insulation Resistance (IR) Limit at 25°C | 1000 megohm microfarads (minimum) or 100 GΩ |
| Insulation Resistance (IR) Limit at 125°C | 100 megohm microfarads (minimum) or 10 GΩ |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±100 Hz at 1.0 Vrms ±0.2 Vrms (open circuit voltage).*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Electrical Parameters/Performance Characteristics: X7R Dielectric

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit at 25ºC | 3.5% (25 V) and 2.5% (50 V to 200 V) |
| Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds at 25°C) |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF.*
*20 Hz ±10 Hz and 0.5 ±0.1 Vrms if capacitance > 10 µF.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Table 1A – MIL–PRF–49470/1, Product Selection 50 – 200 VDC

| MIL–PRF–49470/1 Unencapsulated, Horizontally Stacked | | | | | | |
|---|---|---|---|---|---|---|
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |
| **50 VDC – BX Dielectric** | | | | | | |
| (1)49470X01105(2)A(3) | 1 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K | L1X(3)505105(2)(4)12 |
| (1)49470X01125(2)A(3) | 1.2 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K | L1X(3)505125(2)(4)12 |
| (1)49470X01155(2)A(3) | 1.5 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)505155(2)(4)24 |
| (1)49470X01185(2)A(3) | 1.8 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)505185(2)(4)24 |
| (1)49470X01225(2)A(3) | 2.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)505225(2)(4)24 |
| (1)49470X01275(2)A(3) | 2.7 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)505275(2)(4)36 |
| (1)49470X01335(2)A(3) | 3.3 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)505335(2)(4)36 |
| (1)49470X01475(2)A(3) | 3.9 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)505475(2)(4)48 |
| (1)49470X01395(2)A(3) | 3.9 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)505395(2)(4)48 |
| (1)49470X01565(2)A(3) | 5.6 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)505565(2)(4)65 |
| (1)49470X01685(2)A(3) | 6.8 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)405685(2)(4)36 |
| (1)49470X01825(2)A(3) | 8.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)405825(2)(4)36 |
| (1)49470X01106(2)A(3) | 10 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)405106(2)(4)48 |
| (1)49470X01126(2)A(3) | 12 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)405126(2)(4)48 |
| (1)49470X01156(2)A(3) | 15 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)405156(2)(4)65 |
| (1)49470X01186(2)A(3) | 18 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)305186(2)(4)24 |
| (1)49470X01226(2)A(3) | 22 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)305226(2)(4)36 |
| (1)49470X01276(2)A(3) | 27 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)305276(2)(4)36 |
| (1)49470X01336(2)A(3) | 33 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)305336(2)(4)36 |
| (1)49470X01396(2)A(3) | 39 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)305396(2)(4)48 |
| (1)49470X01476(2)A(3) | 47 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)305476(2)(4)65 |
| **100 VDC – BX Dielectric** | | | | | | |
| (1)49470X01684(2)B(3) | 0.68 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K | L1X(3)501684(2)(4)12 |
| (1)49470X01824(2)B(3) | 0.82 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)501824(2)(4)24 |
| (1)49470X01105(2)B(3) | 1 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)501105(2)(4)24 |
| (1)49470X01125(2)B(3) | 1.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)501125(2)(4)24 |
| (1)49470X01155(2)B(3) | 1.5 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)501155(2)(4)36 |
| (1)49470X01185(2)B(3) | 1.8 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)501185(2)(4)36 |
| (1)49470X01225(2)B(3) | 2.2 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)501225(2)(4)48 |
| (1)49470X01275(2)B(3) | 2.7 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)501275(2)(4)48 |
| (1)49470X01335(2)B(3) | 3.3 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)501335(2)(4)65 |
| (1)49470X01395(2)B(3) | 3.9 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)401395(2)(4)36 |
| (1)49470X01475(2)B(3) | 4.7 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)401475(2)(4)36 |
| (1)49470X01565(2)B(3) | 5.6 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)401565(2)(4)48 |
| (1)49470X01685(2)B(3) | 6.8 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)401685(2)(4)48 |
| (1)49470X01825(2)B(3) | 8.2 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)401825(2)(4)65 |
| (1)49470X01106(2)B(3) | 10 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)301106(2)(4)24 |
| (1)49470X01126(2)B(3) | 12 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1X(3)301126(2)(4)24 |
| (1)49470X01156(2)B(3) | 15 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)301156(2)(4)36 |
| (1)49470X01186(2)B(3) | 18 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1X(3)301186(2)(4)36 |
| (1)49470X01226(2)B(3) | 22 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K | L1X(3)301226(2)(4)48 |
| (1)49470X01276(2)B(3) | 27 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K | L1X(3)301276(2)(4)65 |
| **200 VDC – BR Dielectric** | | | | | | |
| (1)49470R01474(2)C(3) | 0.47 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1R(3)502474(2)(4)24 |
| (1)49470R01564(2)C(3) | 0.56 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1R(3)502564(2)(4)24 |
| (1)49470R01684(2)C(3) | 0.68 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)502684(2)(4)36 |
| (1)49470R01824(2)C(3) | 0.82 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)502824(2)(4)36 |
| (1)49470R01105(2)C(3) | 1 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1R(3)502105(2)(4)48 |
| **MIL–PRF–49470 P/N [1]** | **Capacitance (µF)** | **Case Code** | **Height A inch (mm)** | **Capacitance Tolerance** | **Lead Configuration** | **KEMET P/N [1]** |

*[1] Complete P/N requires additional characters in the numbered positions provided in order to indicate product level (B level or T level), capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Test level character "M" for B level, or "T" for T level (MIL–PRF–49470/1 part number only).*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Lead style character " N", "L", "M", "J" or "K".*

*(4) Test level character "B" for B level, or "T" for T level (KEMET part number only).*

## Table 1A – MIL–PRF–49470 /1, Product Selection 200 – 500 VDC cont'd

| MIL–PRF–49470/1 Unencapsulated, Horizontally Stacked | | | | | | |
|---|---|---|---|---|---|---|
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |
| (1)49470R01125(2)C(3) | 1.2 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1R(3)502125(2)(4)48 |
| (1)49470R01155(2)C(3) | 1.5 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K | L1R(3)502155(2)(4)65 |
| (1)49470R01185(2)C(3) | 1.8 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)402185(2)(4)36 |
| (1)49470R01225(2)C(3) | 2.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)402225(2)(4)36 |
| (1)49470R01275(2)C(3) | 2.7 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1R(3)402275(2)(4)48 |
| (1)49470R01335(2)C(3) | 3.3 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1R(3)402335(2)(4)48 |
| (1)49470R01395(2)C(3) | 3.9 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K | L1R(3)402395(2)(4)65 |
| (1)49470R01475(2)C(3) | 4.7 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1R(3)302475(2)(4)24 |
| (1)49470R01565(2)C(3) | 5.6 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1R(3)302565(2)(4)24 |
| (1)49470R01685(2)C(3) | 6.8 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)302685(2)(4)36 |
| (1)49470R01825(2)C(3) | 8.2 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1R(3)302825(2)(4)36 |
| (1)49470R01106(2)C(3) | 10 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K | L1R(3)302106(2)(4)48 |
| (1)49470R01126(2)C(3) | 12 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K | L1R(3)302126(2)(4)65 |
| **500 VDC – BQ Dielectric** | | | | | | |
| (1)49470Q01154(2)E(3) | 0.15 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K | L1Q(3)50C154(2)(4)12 |
| (1)49470Q01184(2)E(3) | 0.18 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1Q(3)50C184(2)(4)24 |
| (1)49470Q01224(2)E(3) | 0.22 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1Q(3)50C224(2)(4)24 |
| (1)49470Q01274(2)E(3) | 0.27 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K | L1Q(3)50C274(2)(4)24 |
| (1)49470Q01334(2)E(3) | 0.33 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)50C334(2)(4)36 |
| (1)49470Q01394(2)E(3) | 0.39 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)50C394(2)(4)36 |
| (1)49470Q01474(2)E(3) | 0.47 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)50C474(2)(4)36 |
| (1)49470Q01564(2)E(3) | 0.56 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K | L1Q(3)50C564(2)(4)48 |
| (1)49470Q01684(2)E(3) | 0.68 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K | L1Q(3)50C684(2)(4)65 |
| (1)49470Q01824(2)E(3) | 0.82 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)40C824(2)(4)36 |
| (1)49470Q01105(2)E(3) | 1 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)40C105(2)(4)36 |
| (1)49470Q01125(2)E(3) | 1.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)40C125(2)(4)36 |
| (1)49470Q01155(2)E(3) | 1.5 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K | L1Q(3)40C155(2)(4)48 |
| (1)49470Q01185(2)E(3) | 1.8 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K | L1Q(3)40C185(2)(4)65 |
| (1)49470Q01225(2)E(3) | 2.2 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K | L1Q(3)30C225(2)(4)24 |
| (1)49470Q01275(2)E(3) | 2.7 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)30C275(2)(4)36 |
| (1)49470Q01335(2)E(3) | 3.3 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)30C335(2)(4)36 |
| (1)49470Q01395(2)E(3) | 3.9 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K | L1Q(3)30C395(2)(4)36 |
| (1)49470Q01475(2)E(3) | 4.7 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K | L1Q(3)30C475(2)(4)48 |
| (1)49470Q01565(2)E(3) | 5.6 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K | L1Q(3)30C565(2)(4)65 |
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |

*[1] Complete P/N requires additional characters in the numbered positions provided in order to indicate product level (B level or T level), capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Test level character "M" for B level, or "T" for T level (MIL-PRF-49470/1 part number only).*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Lead style character " N", "L", "M", "J" or "K".*

*(4) Test level character "B" for B level, or "T" for T level (KEMET part number only).*

# Table 1B – MIL–PRF–49470/2, Product Selection 50 – 200 VDC

| MIL–PRF–49470/2 Encapsulated, Horizontally Stacked | | | | | | |
|---|---|---|---|---|---|---|
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |
| **50 VDC – BX Dielectric** | | | | | | |
| M49470X02125(1)A(2) | 1.2 | 5 | 0.270 (6.86) | K, M | N, L, M, J, K | L2X(2)505125(1)B27 |
| M49470X02155(1)A(2) | 1.5 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)505155(1)B39 |
| M49470X02185(1)A(2) | 1.8 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)505185(1)B39 |
| M49470X02225(1)A(2) | 2.2 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)505225(1)B39 |
| M49470X02275(1)A(2) | 2.7 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)505275(1)B53 |
| M49470X02335(1)A(2) | 3.3 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)505335(1)B53 |
| M49470X02475(1)A(2) | 3.9 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)505475(1)B66 |
| M49470X02395(1)A(2) | 4.7 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)505395(1)B66 |
| M49470X02565(1)A(2) | 5.6 | 5 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)505565(1)B80 |
| M49470X02685(1)A(2) | 6.8 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)405685(1)B53 |
| M49470X02825(1)A(2) | 8.2 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)405825(1)B53 |
| M49470X02106(1)A(2) | 10 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)405106(1)B66 |
| M49470X02126(1)A(2) | 12 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)405126(1)B66 |
| M49470X02156(1)A(2) | 15 | 4 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)405156(1)B80 |
| M49470X02186(1)A(2) | 18 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)305186(1)B39 |
| M49470X02226(1)A(2) | 22 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)305226(1)B53 |
| M49470X02276(1)A(2) | 27 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)305276(1)B53 |
| M49470X02336(1)A(2) | 33 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)305336(1)B53 |
| M49470X02396(1)A(2) | 39 | 3 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)305396(1)B66 |
| M49470X02476(1)A(2) | 47 | 3 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)305476(1)B80 |
| **100 VDC – BX Dielectric** | | | | | | |
| M49470X02684(1)B(2) | 0.68 | 5 | 0.270 (6.86) | K, M | N, L, M, J, K | L2X(2)501684(1)B27 |
| M49470X02824(1)B(2) | 0.82 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)501824(1)B39 |
| M49470X02105(1)B(2) | 1 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)501105(1)B39 |
| M49470X02125(1)B(2) | 1.2 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)501125(1)B39 |
| M49470X02155(1)B(2) | 1.5 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)501155(1)B53 |
| M49470X02185(1)B(2) | 1.8 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)501185(1)B53 |
| M49470X02225(1)B(2) | 2.2 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)501225(1)B66 |
| M49470X02275(1)B(2) | 2.7 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)501275(1)B66 |
| M49470X02335(1)B(2) | 3.3 | 5 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)501335(1)B80 |
| M49470X02395(1)B(2) | 3.9 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)401395(1)B53 |
| M49470X02475(1)B(2) | 4.7 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)401475(1)B53 |
| M49470X02565(1)B(2) | 5.6 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)401565(1)B66 |
| M49470X02685(1)B(2) | 6.8 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)401685(1)B66 |
| M49470X02825(1)B(2) | 8.2 | 4 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)401825(1)B80 |
| M49470X02106(1)B(2) | 10 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)301106(1)B39 |
| M49470X02126(1)B(2) | 12 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2X(2)301126(1)B39 |
| M49470X02156(1)B(2) | 15 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)301156(1)B53 |
| M49470X02186(1)B(2) | 18 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2X(2)301186(1)B53 |
| M49470X02226(1)B(2) | 22 | 3 | 0.660 (16.76) | K, M | N, L, M, J, K | L2X(2)301226(1)B66 |
| M49470X02276(1)B(2) | 27 | 3 | 0.800 (20.32) | K, M | N, L, M, J, K | L2X(2)301276(1)B80 |
| **200 VDC – BR Dielectric** | | | | | | |
| M49470R02474(1)C(2) | 0.47 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2R(2)502474(1)B39 |
| M49470R02564(1)C(2) | 0.56 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2R(2)502564(1)B39 |
| M49470R02684(1)C(2) | 0.68 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)502684(1)B53 |
| M49470R02824(1)C(2) | 0.82 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)502824(1)B53 |
| M49470R02105(1)C(2) | 1 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2R(2)502105(1)B66 |
| M49470R02125(1)C(2) | 1.2 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2R(2)502125(1)B66 |
| M49470R02155(1)C(2) | 1.5 | 5 | 0.800 (20.32) | K, M | N, L, M, J, K | L2R(2)502155(1)B80 |
| M49470R02185(1)C(2) | 1.8 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)402185(1)B53 |
| M49470R02225(1)C(2) | 2.2 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)402225(1)B53 |
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |

*[1] Complete P/N requires additional characters in the numbered positions provided in order to indicate capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Capacitance tolerance character " K" or " M".*

*(2) Lead style character " N", "L", "M", "J" or "K".*

## Table 1B – MIL–PRF–49470 /2, Product Selection 200 – 500 VDC cont'd

| MIL–PRF–49470/2 Encapsulated, Horizontally Stacked | | | | | | |
|---|---|---|---|---|---|---|
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |
| M49470R02275(1)C(2) | 2.7 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2R(2)402275(1)B66 |
| M49470R02335(1)C(2) | 3.3 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2R(2)402335(1)B66 |
| M49470R02395(1)C(2) | 3.9 | 4 | 0.800 (20.32) | K, M | N, L, M, J, K | L2R(2)402395(1)B80 |
| M49470R02475(1)C(2) | 4.7 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2R(2)302475(1)B39 |
| M49470R02565(1)C(2) | 5.6 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2R(2)302565(1)B39 |
| M49470R02685(1)C(2) | 6.8 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)302685(1)B53 |
| M49470R02825(1)C(2) | 8.2 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2R(2)302825(1)B53 |
| M49470R02106(1)C(2) | 10 | 3 | 0.660 (16.76) | K, M | N, L, M, J, K | L2R(2)302106(1)B66 |
| M49470R02126(1)C(2) | 12 | 3 | 0.800 (20.32) | K, M | N, L, M, J, K | L2R(2)302126(1)B80 |
| **500 VDC – BQ Dielectric** | | | | | | |
| M49470Q02154(1)E(2) | 0.15 | 5 | 0.270 (6.86) | K, M | N, L, M, J, K | L2Q(2)50C154(1)B27 |
| M49470Q02184(1)E(2) | 0.18 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2Q(2)50C184(1)B39 |
| M49470Q02224(1)E(2) | 0.22 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2Q(2)50C224(1)B39 |
| M49470Q02274(1)E(2) | 0.27 | 5 | 0.390 (9.91) | K, M | N, L, M, J, K | L2Q(2)50C274(1)B39 |
| M49470Q02334(1)E(2) | 0.33 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)50C334(1)B53 |
| M49470Q02394(1)E(2) | 0.39 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)50C394(1)B53 |
| M49470Q02474(1)E(2) | 0.47 | 5 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)50C474(1)B53 |
| M49470Q02564(1)E(2) | 0.56 | 5 | 0.660 (16.76) | K, M | N, L, M, J, K | L2Q(2)50C564(1)B66 |
| M49470Q02684(1)E(2) | 0.68 | 5 | 0.800 (20.32) | K, M | N, L, M, J, K | L2Q(2)50C684(1)B80 |
| M49470Q02824(1)E(2) | 0.82 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)40C824(1)B53 |
| M49470Q02105(1)E(2) | 1 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)40C105(1)B53 |
| M49470Q02125(1)E(2) | 1.2 | 4 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)40C125(1)B53 |
| M49470Q02155(1)E(2) | 1.5 | 4 | 0.660 (16.76) | K, M | N, L, M, J, K | L2Q(2)40C155(1)B66 |
| M49470Q02185(1)E(2) | 1.8 | 4 | 0.800 (20.32) | K, M | N, L, M, J, K | L2Q(2)40C185(1)B80 |
| M49470Q02225(1)E(2) | 2.2 | 3 | 0.390 (9.91) | K, M | N, L, M, J, K | L2Q(2)30C225(1)B39 |
| M49470Q02275(1)E(2) | 2.7 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)30C275(1)B53 |
| M49470Q02335(1)E(2) | 3.3 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)30C335(1)B53 |
| M49470Q02395(1)E(2) | 3.9 | 3 | 0.530 (13.46) | K, M | N, L, M, J, K | L2Q(2)30C395(1)B53 |
| M49470Q02475(1)E(2) | 4.7 | 3 | 0.660 (16.76) | K, M | N, L, M, J, K | L2Q(2)30C475(1)B66 |
| M49470Q02565(1)E(2) | 5.6 | 3 | 0.800 (20.32) | K, M | N, L, M, J, K | L2Q(2)30C565(1)B80 |
| M49470Q02565(1)E(2) | 5.6 | 3 | 0.800 (20.32) | K, M | N, L, M, J, K | L2Q(2)30C565(1)B65 |
| MIL–PRF–49470 P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration | KEMET P/N [1] |

*[1] Complete P/N requires additional characters in the numbered positions provided in order to indicate capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Capacitance tolerance character " K" or " M".*

*(2) Lead style character " N", "L", "M", "J" or "K".*

## Table 1C – Product Selection 25 VDC

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| 25 VDC – BX Dielectric | | | | | |
| L1X(1)503824(2)(3)12 | 0.82 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503105(2)(3)12 | 1 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503125(2)(3)12 | 1.2 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503155(2)(3)12 | 1.5 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503185(2)(3)24 | 1.8 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403225(2)(3)12 | 2.2 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503225(2)(3)24 | 2.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)503255(2)(3)24 | 2.5 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403275(2)(3)12 | 2.7 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503275(2)(3)24 | 2.7 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403335(2)(3)12 | 3.3 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503335(2)(3)36 | 3.3 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)403395(2)(3)12 | 3.9 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503395(2)(3)36 | 3.9 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)403475(2)(3)12 | 4.7 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)503475(2)(3)36 | 4.7 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)403565(2)(3)24 | 5.6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)503565(2)(3)48 | 5.6 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)403605(2)(3)24 | 6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)503605(2)(3)48 | 6 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303685(2)(3)12 | 6.8 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)403685(2)(3)24 | 6.8 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)503685(2)(3)65 | 6.8 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)403755(2)(3)24 | 7.5 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)503755(2)(3)65 | 7.5 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)303825(2)(3)12 | 8.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)403825(2)(3)24 | 8.2 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)303106(2)(3)12 | 10 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)403106(2)(3)24 | 10 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)303116(2)(3)12 | 11 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)303126(2)(3)12 | 12 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)403126(2)(3)36 | 12 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303156(2)(3)12 | 15 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)403156(2)(3)36 | 15 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303166(2)(3)24 | 16 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403166(2)(3)48 | 16 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303186(2)(3)24 | 18 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403186(2)(3)48 | 18 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303206(2)(3)24 | 20 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403206(2)(3)48 | 20 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303226(2)(3)24 | 22 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)403226(2)(3)65 | 22 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)403246(2)(3)65 | 24 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)303276(2)(3)24 | 27 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)303306(2)(3)24 | 30 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)303306(2)(3)36 | 30 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303336(2)(3)36 | 33 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303396(2)(3)36 | 39 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303456(2)(3)36 | 45 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)303506(2)(3)48 | 50 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303546(2)(3)48 | 54 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)303606(2)(3)48 | 60 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

# Table 1C – Commercial/Non-Standard – Product Selection 25 – 50 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1X(1)303666(2)(3)65 | 66 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)303726(2)(3)65 | 72 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)303756(2)(3)65 | 75 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **50 VDC – BX Dielectric** | | | | | |
| L1X(1)505824(2)(3)12 | 0.82 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505105(2)(3)12 | 1 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505125(2)(3)12 | 1.2 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505155(2)(3)12 | 1.5 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505185(2)(3)24 | 1.8 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405225(2)(3)12 | 2.2 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505225(2)(3)24 | 2.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505255(2)(3)24 | 2.5 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405275(2)(3)12 | 2.7 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505275(2)(3)24 | 2.7 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505275(2)(3)36 | 2.7 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)405335(2)(3)12 | 3.3 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505335(2)(3)36 | 3.3 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)405395(2)(3)12 | 3.9 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505395(2)(3)36 | 3.9 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)405475(2)(3)12 | 4.7 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)505475(2)(3)36 | 4.7 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)405565(2)(3)24 | 5.6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505565(2)(3)48 | 5.6 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)405605(2)(3)24 | 6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505605(2)(3)48 | 6 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305685(2)(3)12 | 6.8 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)405685(2)(3)24 | 6.8 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505685(2)(3)65 | 6.8 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)405755(2)(3)24 | 7.5 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)505755(2)(3)65 | 7.5 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)305825(2)(3)12 | 8.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)405825(2)(3)24 | 8.2 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)305106(2)(3)12 | 10 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)405106(2)(3)24 | 10 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)305116(2)(3)12 | 11 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)305126(2)(3)12 | 12 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)405126(2)(3)36 | 12 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)305156(2)(3)12 | 15 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1X(1)405156(2)(3)36 | 15 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)305166(2)(3)24 | 16 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405166(2)(3)48 | 16 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305186(2)(3)24 | 18 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405186(2)(3)48 | 18 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305206(2)(3)24 | 20 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405206(2)(3)48 | 20 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305226(2)(3)24 | 22 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)405226(2)(3)65 | 22 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)405246(2)(3)65 | 24 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)305276(2)(3)24 | 27 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)305306(2)(3)24 | 30 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1X(1)305336(2)(3)36 | 33 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)305396(2)(3)36 | 39 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1X(1)305456(2)(3)36 | 45 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

# Table 1C – Commercial/Non-Standard – Product Selection 50 – 100 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1X(1)305506(2)(3)48 | 50 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305546(2)(3)48 | 54 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305606(2)(3)48 | 60 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1X(1)305666(2)(3)65 | 66 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)305726(2)(3)65 | 72 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1X(1)305756(2)(3)65 | 75 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **100 VDC – BR Dielectric** | | | | | |
| L1R(1)501564(2)(3)12 | 0.56 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501684(2)(3)12 | 0.68 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501754(2)(3)12 | 0.75 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501824(2)(3)12 | 0.82 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501105(2)(3)12 | 1 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501125(2)(3)12 | 1.2 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401155(2)(3)12 | 1.5 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501155(2)(3)24 | 1.5 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401185(2)(3)12 | 1.8 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501185(2)(3)24 | 1.8 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401225(2)(3)12 | 2.2 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501225(2)(3)24 | 2.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)501255(2)(3)24 | 2.5 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401275(2)(3)12 | 2.7 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501275(2)(3)36 | 2.7 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)401335(2)(3)12 | 3.3 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501335(2)(3)36 | 3.3 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)401395(2)(3)12 | 3.9 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)501395(2)(3)48 | 3.9 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)401475(2)(3)24 | 4.7 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)501475(2)(3)48 | 4.7 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)301565(2)(3)12 | 5.6 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401565(2)(3)24 | 5.6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)501565(2)(3)65 | 5.6 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1R(1)301605(2)(3)12 | 6 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401605(2)(3)24 | 6 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)501605(2)(3)65 | 6 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1R(1)301685(2)(3)12 | 6.8 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401685(2)(3)24 | 6.8 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401755(2)(3)24 | 7.5 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)301825(2)(3)12 | 8.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401825(2)(3)36 | 8.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)301106(2)(3)12 | 10 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)401106(2)(3)36 | 10 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)301116(2)(3)12 | 11 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1R(1)301126(2)(3)24 | 12 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401126(2)(3)48 | 12 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)301156(2)(3)24 | 15 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401156(2)(3)48 | 15 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)301166(2)(3)24 | 16 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401166(2)(3)65 | 16 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1R(1)301186(2)(3)24 | 18 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)401186(2)(3)65 | 18 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1R(1)301206(2)(3)24 | 20 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1R(1)301226(2)(3)36 | 22 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)301276(2)(3)36 | 27 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

## Table 1C – Commercial/Non-Standard – Product Selection 100 – 200 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1R(1)301306(2)(3)36 | 30 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1R(1)301336(2)(3)48 | 33 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)301396(2)(3)48 | 39 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1R(1)301456(2)(3)65 | 45 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1R(1)301506(2)(3)65 | 50 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **200 VDC – BQ Dielectric** | | | | | |
| L1Q(1)502334(2)(3)12 | 0.33 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502394(2)(3)12 | 0.39 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502474(2)(3)12 | 0.47 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502564(2)(3)12 | 0.56 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502684(2)(3)12 | 0.68 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502754(2)(3)12 | 0.75 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402824(2)(3)12 | 0.82 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502824(2)(3)24 | 0.82 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402105(2)(3)12 | 1 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502105(2)(3)24 | 1 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402125(2)(3)12 | 1.2 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502125(2)(3)24 | 1.2 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402155(2)(3)12 | 1.5 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502155(2)(3)36 | 1.5 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)402185(2)(3)12 | 1.8 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502185(2)(3)36 | 1.8 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)402225(2)(3)24 | 2.2 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)502225(2)(3)48 | 2.2 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302245(2)(3)12 | 2.4 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)502255(2)(3)48 | 2.5 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302275(2)(3)12 | 2.7 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402275(2)(3)24 | 2.7 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)502275(2)(3)48 | 2.7 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302335(2)(3)12 | 3.3 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402335(2)(3)24 | 3.3 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)502335(2)(3)65 | 3.3 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1Q(1)302365(2)(3)12 | 3.6 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)302395(2)(3)12 | 3.9 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402395(2)(3)24 | 3.9 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)302475(2)(3)12 | 4.7 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402475(2)(3)36 | 4.7 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302565(2)(3)12 | 5.6 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402565(2)(3)36 | 5.6 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302605(2)(3)12 | 6 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1Q(1)402605(2)(3)36 | 6 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302685(2)(3)24 | 6.8 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402685(2)(3)48 | 6.8 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)402755(2)(3)48 | 7.5 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302825(2)(3)24 | 8.2 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402825(2)(3)65 | 8.2 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1Q(1)302106(2)(3)24 | 10 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)402106(2)(3)65 | 10 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1Q(1)302116(2)(3)24 | 11 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1Q(1)302126(2)(3)36 | 12 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302156(2)(3)36 | 15 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302166(2)(3)36 | 16 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1Q(1)302186(2)(3)48 | 18 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

## Table 1C – Commercial/Non-Standard – Product Selection 200 – 630 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1Q(1)302206(2)(3)48 | 20 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302226(2)(3)48 | 22 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1Q(1)302276(2)(3)65 | 27 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **500 VDC – X7R Dielectric** | | | | | |
| L1W(1)50C124(2)(3)12 | 0.12 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C154(2)(3)12 | 0.15 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C184(2)(3)12 | 0.18 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C224(2)(3)12 | 0.22 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C274(2)(3)12 | 0.27 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C334(2)(3)24 | 0.33 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40C394(2)(3)12 | 0.39 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C394(2)(3)24 | 0.39 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40C474(2)(3)12 | 0.47 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C474(2)(3)24 | 0.47 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50C564(2)(3)24 | 0.56 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40C684(2)(3)12 | 0.68 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C684(2)(3)36 | 0.68 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)50C754(2)(3)36 | 0.75 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)40C824(2)(3)12 | 0.82 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50C824(2)(3)36 | 0.82 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30C105(2)(3)12 | 1 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40C105(2)(3)24 | 1 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50C105(2)(3)48 | 1 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30C125(2)(3)12 | 1.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40C125(2)(3)24 | 1.2 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50C125(2)(3)65 | 1.2 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30C155(2)(3)12 | 1.5 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40C155(2)(3)24 | 1.5 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50C155(2)(3)65 | 1.5 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)40C185(2)(3)36 | 1.8 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30C225(2)(3)12 | 2.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40C225(2)(3)36 | 2.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30C245(2)(3)12 | 2.4 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)30C275(2)(3)12 | 2.7 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40C275(2)(3)48 | 2.7 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30C335(2)(3)24 | 3.3 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40C335(2)(3)48 | 3.3 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30C365(2)(3)24 | 3.6 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30C395(2)(3)24 | 3.9 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40C395(2)(3)65 | 3.9 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30C475(2)(3)24 | 4.7 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30C565(2)(3)24 | 5.6 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30C605(2)(3)24 | 6 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30C685(2)(3)36 | 6.8 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30C825(2)(3)36 | 8.2 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30C106(2)(3)48 | 10 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30C116(2)(3)65 | 11 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30C126(2)(3)65 | 12 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **630 VDC – X7R Dielectric** | | | | | |
| L1W(1)50B683(2)(3)12 | 0.068 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B104(2)(3)12 | 0.1 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B104(2)(3)12 | 0.1 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

## Table 1C – Commercial/Non-Standard – Product Selection 630 – 1,000 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1W(1)50B124(2)(3)12 | 0.12 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B154(2)(3)12 | 0.15 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B184(2)(3)24 | 0.18 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30B224(2)(3)12 | 0.22 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B224(2)(3)12 | 0.22 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B224(2)(3)24 | 0.22 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50B274(2)(3)24 | 0.27 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30B334(2)(3)12 | 0.33 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B334(2)(3)36 | 0.33 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)40B394(2)(3)12 | 0.39 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50B394(2)(3)36 | 0.39 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B474(2)(3)12 | 0.47 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B474(2)(3)24 | 0.47 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50B474(2)(3)36 | 0.47 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)50B564(2)(3)48 | 0.56 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30B684(2)(3)12 | 0.68 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B684(2)(3)24 | 0.68 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50B684(2)(3)65 | 0.68 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)50B754(2)(3)65 | 0.75 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)40B824(2)(3)24 | 0.82 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30B105(2)(3)12 | 1 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B105(2)(3)36 | 1 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B125(2)(3)12 | 1.2 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B125(2)(3)36 | 1.2 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B155(2)(3)12 | 1.5 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40B155(2)(3)48 | 1.5 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)40B185(2)(3)48 | 1.8 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30B225(2)(3)24 | 2.2 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40B225(2)(3)65 | 2.2 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30B245(2)(3)24 | 2.4 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30B275(2)(3)24 | 2.7 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30B335(2)(3)36 | 3.3 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B365(2)(3)36 | 3.6 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B395(2)(3)36 | 3.9 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B475(2)(3)36 | 4.7 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30B565(2)(3)48 | 5.6 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30B605(2)(3)65 | 6 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30B685(2)(3)65 | 6.8 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| **1,000 VDC – X7R Dielectric** | | | | | |
| L1W(1)50D473(2)(3)12 | 0.047 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50D683(2)(3)12 | 0.068 | 5 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)30D104(2)(3)12 | 0.1 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40D104(2)(3)12 | 0.1 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50D104(2)(3)24 | 0.1 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50D124(2)(3)24 | 0.12 | 5 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50D154(2)(3)36 | 0.15 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)50D184(2)(3)36 | 0.18 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30D224(2)(3)12 | 0.22 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40D224(2)(3)12 | 0.22 | 4 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50D224(2)(3)36 | 0.22 | 5 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)50D274(2)(3)48 | 0.27 | 5 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30D334(2)(3)12 | 0.33 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)50D334(2)(3)65 | 0.33 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

## Table 1C – Commercial/Non-Standard – Product Selection 1,000 VDC cont'd

| Commercial/Non-Standard – Customer Specific Unencapsulated, Horizontally Stacked | | | | | |
|---|---|---|---|---|---|
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |
| L1W(1)40D394(2)(3)24 | 0.39 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)50D394(2)(3)65 | 0.39 | 5 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30D474(2)(3)12 | 0.47 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40D474(2)(3)24 | 0.47 | 4 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30D684(2)(3)12 | 0.68 | 3 | 0.120 (3.05) | K, M | N, L, M, J, K |
| L1W(1)40D684(2)(3)36 | 0.68 | 4 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)40D824(2)(3)48 | 0.82 | 4 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30D105(2)(3)24 | 1 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)40D105(2)(3)65 | 1 | 4 | 0.650 (16.51) | K, M | N, L, M, J, K |
| L1W(1)30D125(2)(3)24 | 1.2 | 3 | 0.240 (6.10) | K, M | N, L, M, J, K |
| L1W(1)30D155(2)(3)36 | 1.5 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30D225(2)(3)36 | 2.2 | 3 | 0.360 (9.14) | K, M | N, L, M, J, K |
| L1W(1)30D245(2)(3)48 | 2.4 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30D275(2)(3)48 | 2.7 | 3 | 0.480 (12.19) | K, M | N, L, M, J, K |
| L1W(1)30D335(2)(3)65 | 3.3 | 3 | 0.650 (16.51) | K, M | N, L, M, J, K |
| KEMET P/N [1] | Capacitance (µF) | Case Code | Height A inch (mm) | Capacitance Tolerance | Lead Configuration |

*[1] Complete part number requires additional characters in the numbered positions provided in order to indicate testing option, capacitance tolerance and lead configuration. For each numbered position, available options are as follows:*

*(1) Lead style character " N", "L", "M", "J" or "K".*

*(2) Capacitance tolerance character " K" or " M".*

*(3) Testing option character "S" for Commercial, or "X" for non-standard (customer specific).*

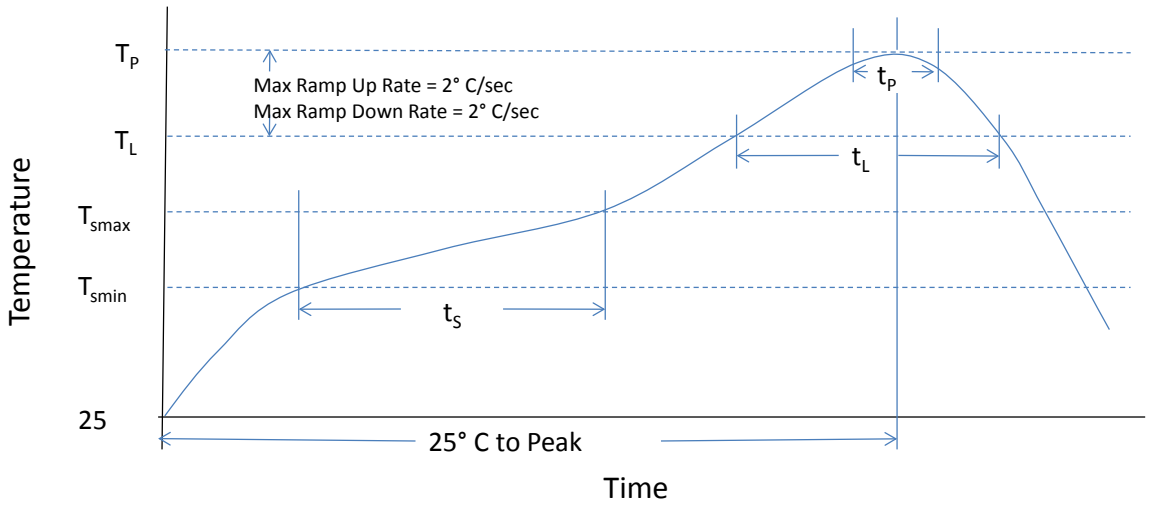
## Soldering Process

The capacitors and assemblies outlined in this specification sheet are susceptible to thermal shock damage due to their large ceramic mass. Temperature profiles used should provide adequate temperature rise and cool-down time to prevent damage from thermal shock. In general, KEMET recommends against hand soldering for these types of large ceramic devices.

Recommended Soldering Technique:

- Solder reflow only

Recommended Reflow Soldering Profile:




| Profile Feature | Sn-Pb Assembly |
|---|---|
| **Preheat/Soak** | |
| Temperature Minimum ($T_{Smin}$) | 100°C |
| Temperature Maximum ($T_{Smax}$) | 150°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60-90 seconds |
| Ramp-up rate ($T_L$ to $T_P$) | 2°C/seconds |
| Liquidous temperature ($T_L$) | 183°C |
| Time above liquidous ($t_L$) | 95 seconds |
| Peak Temperature ($T_P$) | 240°C |
| Time within 5°C of maximum peak temperature ($t_P$) | 5 seconds |
| Ramp-down rate ($T_P$ to $T_L$) | 2°C/seconds |
| Time 25° C to peak temperature | 3.5 minutes |

*Note 1: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow*

*Preheating and Reflow Profile Notes:*
*Due to differences in the coefficient of thermal expansion for the different materials of construction, it is critical to monitor and control the heating and cooling rates during the soldering process. During the reflow soldering process, the maximum recommended heating and cooling rate (dT/dt) is 4°C/second. To ensure optimal component reliability, KEMET's recommended heating and cooling rate is 2°C/second. After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.*

## Table 4 – Performance & Reliability: Test Methods and Conditions

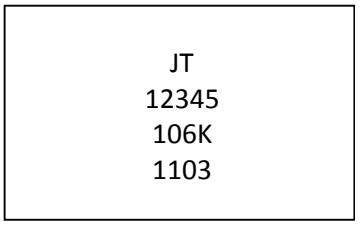
| Inspection | Test Method | Test Level Option | | | | |
|---|---|---|---|---|---|---|
| | | MIL–PRF–49470 B Level (B) | MIL–PRF–49470 T Level (T) | DSSC Drawing 87106 (C)[1] | Commercial (S) | Non-Standard (X)[2] |
| **In-Process Inspection** | | | | | | |
| Ultrasonic Scanning (C-SAM) | Meet EIA–469 Criteria | Not required | Yes (per lot) | Not required | Not required | Optional per Source Controlled Drawing (SCD) |
| DPA Analysis | EIA–469 | | | | | |
| In-Process Visual Inspection | MIL–PRF–49470 Method 4.8.3 | | | | | |
| **Group A Requirements** | | | | | | |
| Thermal Shock | MIL–STD–202 Method 107 | Yes (5 cycles) | Yes (20 cycles) | Yes (5 cycles) | Not required | Optional per Source Controlled Drawing (SCD) |
| Voltage Conditioning<br>≤ 200 V<br>500 V | MIL–PRF–49470 Method 4.8.5.2<br>200%$V_R$ at125°C<br>120%$V_R$ at125°C | Yes (96 hours minimum) | Yes (168 hours minimum) | Yes (96 hours minimum) | | |
| Visual and Mechanical Inspection | MIL–PRF–49470 Method 4.8.4 | Yes (per lot) | Yes (per lot) | Yes (per lot) | | Yes (per lot) |
| Solderability | MIL–STD–202 Method 208 | Yes (per Inspection lot) | | Yes (per inspection lot) | | Optional per Source Controlled Drawing (SCD) |
| DPA Analysis | EIA–469 | Not required | | Not required | | |
| **Group B Requirements** | | | | | | |
| Voltage–Temperature Limits (TCVC) | MIL–PRF–49470 Method 4.8.13.2 | Yes (periodic) | Yes (per lot) | Yes (periodic) | Not required | Optional per Source Controlled Drawing (SCD) |
| Resistance to Solvents | MIL–STD–202 Method 215 | | | | | |
| Terminal Strength | MIL–STD–202 Method 211 | | | | | |
| Resistance to Soldering Heat | MIL–STD–202 Method 210 | | | | | |
| Moisture Resistance | MIL–STD–202 Method 106 | | | | | |
| Marking Legibility | MIL–PRF–49470 Method 4.8.4.1 | | | | | |
| Low Voltage Humidity Testing | MIL–STD–202 Method 103 | Not required | | Not required | | |
| Life Test<br>≤ 200 V<br>500 V | MIL–STD–202 Method 108<br>200%$V_R$ at125°C<br>120%$V_R$ at125°C | Yes (periodic) | | Yes (periodic) | | |
| Thermal Shock | MIL–STD–202 Method 107 | Not required | | Not required | | |
| **KEMET Requirements** | | | | | | |
| Visual and Mechanical Inspection (100%) | KEMET Standard | Yes | Yes | Yes | Yes | Yes |
| Voltage Conditioning | | | | | | |

[1] *As per discretionary statement outlined in cancelled DSCC Drawing 87106, KEMET will not perform Group B inspections on a per lot basis. KEMET 87106 orders may include a standard certificate of compliance stating compliance to the 87106 requirements, specifically conformance to Group B inspections. Please contact KEMET for additional details*

[2] *Non-standard test level option is designated to satisfy customer specific testing requirements that may deviate from those stated in a Mil-Spec or DSCC drawing.*

## Product Marking

Capacitors shall be marked with KEMET's name, trademark or (CAGE) code, date, capacitance and capacitance tolerance codes. The date code shall consist of the year and week. For example, the third week of 2011 would be 1103 using a 4-digit date code or 103 using a 3-digit date code. At the option of the manufacturer, the date code may be placed on a separate line. Full marking shall be included on the package.




*Case code 4 or 5 example*

**MIL–PRF–49470**

Capacitor marking will include "JAN" or "J."
Case codes 4 and 5 shall be marked with the following sequence of information:
J brand (1 digit), product level designator (“B” or “T”)
Manufacturer's identification (1 to 5 digits)
Capacitance code (3 digits) and capacitance tolerance (1 digit)
Date code (3 or 4 digits)
Case code 3 shall either be fully marked or partially marked like case code 4 or 5 parts at the option of KEMET.

**DSCC 87106**

Marking shall be in accordance with MIL–STD–1285, except the parts shall be marked with the part number as specified in paragraph 1.2 of DSCC Drawing 87106 with the manufacturer's name or code and date code minimum. Case sizes 4 and 5 shall be marked with coded capacitance and tolerance minimum. Full marking shall be included on the package.

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Packaging

**Shipping Container Packaging Quantities**

| Case Code | Small Box Quantity[1] (7.5” x 7.5”) | Large Box Quantity[1] (13.0” x 13.0” ) |
|---|---|---|
| 3 | 28 | 104 |
| 4 | 36 | 144 |
| 5 | 64 | 225 |

*[1] Minimum order value applies. Contact KEMET for details.*

# Application Notes

### Notice of KEMET MIL–PRF–49470 Qualified Products Listing (QPL) Status.

*KEMET is qualified to supply MIL–PRF–49470/1 unencapsulated X7R Case Codes 3, 4, & 5 ceramic SMPS capacitors in DC voltage ratings of 50 V, 100 V, 200 V, and 500 V. This qualification includes both "B" and "T" test levels.*

*KEMET is also qualified to supply MIL–PRF–49470/2 encapsulated X7R Case Codes 3, 4, & 5 ceramic SMPS capacitors in DC voltage ratings of 50 V, 100 V, 200 V, and 500 V. This qualification includes "B" level testing only.*

### Notice of Cancellation: DSCC Drawing 87106 was cancelled on January 3rd 2005. MIL–PRF–49470 parts are preferred and direct replacements.

*MIL–PRF–49470 capacitors are preferred over DSCC 87106 capacitors. The MIL–PRF–49470 specification was developed as part of a cooperative effort between the U.S. Military, NASA and the switch mode power supply capacitor manufacturers to produce a robust direct replacement for the DSCC drawing. The military specification product provides additional quality assurance provisions that are NOT required by the DSCC drawing. Two product levels are offered in MIL–PRF–49470: the standard "B" level and the high reliability "T" level. Some of the benefits of the MIL–PRF–49470 product over the 87106 product include the following: Formal qualification process (QPL established), MIL–STD–790 compliance, DSCC audits, routine qualification maintenance testing, i.e., life testing, group A percent defective allowed (PDA) specified, and prohibiting the mixing of chips from different production lots within a single SMPS capacitor stack lot.*

*MIL–PRF–49470 "T" Level product is recommended for all high reliability applications. MIL–PRF–49470 "T" level product requires the following in-process inspections and additional group A and B screening inspections that are not part of the normal "B" level flow: In-process screening that includes non-destructive internal examination (chip level) and destructive physical analysis (chip level), group A destructive physical analysis (finished stack level), group B lot specific humidity, steady-state, low voltage (lot sample test), and group B lot specific thermal shock and life test (lot sample test).*

*For additional information regarding KEMET MIL–PRF–49470 QPL status or cancellation of DSCC Drawing 87106, please visit the DSCC website at: www.dscc.dla.mil.*

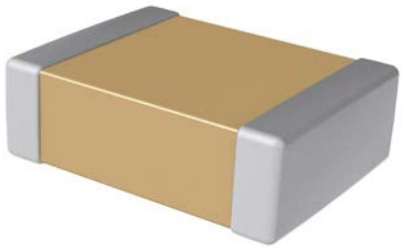
# High Temperature 150°C, Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade)

## Overview

KEMET's Ultra-Stable X8R dielectric features a 150°C maximum operating temperature, offering the latest in high temperature dielectric technology and reliability for extreme temperature applications. It offers the same temperature capability as conventional X8R, but without the capacitance loss due to applied DC voltage. Ultra-Stable X8R exhibits no change in capacitance with respect to voltage and boasts a minimal change in capacitance with reference to ambient temperature. It is a suitable replacement for higher capacitance and larger footprint devices that fail to offer capacitance stability. Capacitance change with respect to temperature is limited to ±15% from −55°C to +150°C.

Driven by the demand for a more robust and reliable component, Ultra-Stable X8R dielectric capacitors were developed for critical applications where reliability and capacitance stability at higher operating temperatures are a concern. These capacitors are widely used in automotive circuits as well as general high temperature applications.

In addition to commercial grade, automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1210 | C | 184 | K | 3 | H | A | C | AUTO |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812 | C = Standard | Two significant digits + number of zeros | F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 3 = 25<br>5 = 50<br>1 = 100 | H = Ultra Stable X8R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Flexible termination option is available. Please see FT-CAP product bulletin C1013_X8R_FT-CAP_SMD*

[2] *Additional termination finish options may be available. Contact KEMET for details.*

[2] *SnPb termination finish option is not available on automotive grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 25 V, 50 V, and 100 V
- Capacitance offerings ranging from 100 pF to 0.22 µF
- Available capacitance tolerances of ±1%, ±2%, ±5%, ±10%, and ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Non-polar device, minimizing installation concerns
- Offered in both commercial and automotive grades
- 100% pure matte tin-plated termination finish that allowing for excellent solderability.
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include decoupling, bypass and filtering in extreme environments such as down-hole oil exploration, under-hood automotive, military and aerospace.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

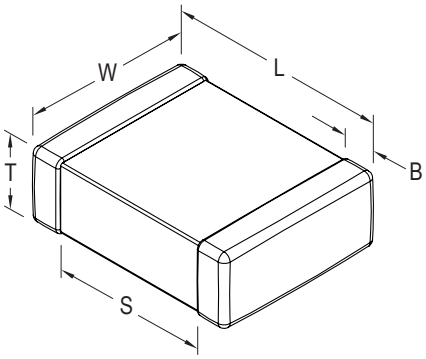
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.177) ±0.30 (0.012) | 3.20 (0.126) ±0.30 (0.012) | | 0.60 (0.024) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit @ 25ºC | 2.5% |
| Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 ±0.2 Vrms if capacitance ≤ 1,000 pF.*

*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance > 1,000 pF*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Ultra-Stable X8R | All | All | 3.0 | 0.3% or ±0.25 pf | 10% of Initial Limit |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | | | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | |
| 100 pF | 101 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 110 pF | 111 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 120 pF | 121 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 130 pF | 131 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 150 pF | 151 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 160 pF | 161 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 180 pF | 181 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 200 pF | 201 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 220 pF | 221 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 240 pF | 241 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 270 pF | 271 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 300 pF | 301 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 330 pF | 331 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 360 pF | 361 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 390 pF | 391 | F | G | J | K | M | BB | BB | BB | | | | | | | | | | | | | | |
| 430 pF | 431 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 470 pF | 471 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 510 pF | 511 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 560 pF | 561 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 620 pF | 621 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 680 pF | 681 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 750 pF | 751 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 820 pF | 821 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 910 pF | 911 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 1,000 pF | 102 | F | G | J | K | M | BB | BB | BB | CF | CF | CF | | | | | | | | | | | |
| 1,100 pF | 112 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,200 pF | 122 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,300 pF | 132 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,500 pF | 152 | F | G | J | K | M | BB | BB | | CF | CF | CF | | | | | | | | | | | |
| 1,600 pF | 162 | F | G | J | K | M | | | | CF | CF | CF | | | | | | | | | | | |
| 1,800 pF | 182 | F | G | J | K | M | | | | CF | CF | CF | | | | | | | | | | | |
| 2,000 pF | 202 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,200 pF | 222 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,400 pF | 242 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 2,700 pF | 272 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,000 pF | 302 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,300 pF | 332 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,600 pF | 362 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 3,900 pF | 392 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 4,300 pF | 432 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 4,700 pF | 472 | F | G | J | K | M | | | | CF | CF | CF | DN | DN | DN | | | | | | | | |
| 5,100 pF | 512 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 5,600 pF | 562 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 6,200 pF | 622 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | | | | | | | | |
| 6,800 pF | 682 | F | G | J | K | M | | | | CF | CF | | DN | DN | DN | EB | EB | EB | | | | | |
| 7,500 pF | 752 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 8,200 pF | 822 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 9,100 pF | 912 | F | G | J | K | M | | | | CF | | | DN | DN | DN | EB | EB | EB | | | | | |
| 10,000 pF | 103 | F | G | J | K | M | | | | CF | | | DN | DN | DP | EB | EB | EB | | | | | |
| 12,000 pF | 123 | F | G | J | K | M | | | | | | | DN | DN | DE | EB | EB | EB | FB | FB | FB | | |
| 15,000 pF | 153 | F | G | J | K | M | | | | | | | DN | DP | DG | EB | EB | EB | FB | FB | FB | GB | GB |
| 18,000 pF | 183 | F | G | J | K | M | | | | | | | DN | DP | | EB | EB | EB | FB | FB | FB | GB | GB |
| 22,000 pF | 223 | F | G | J | K | M | | | | | | | DP | DF | | EB | EB | EC | FB | FB | FB | GB | GB |
| 27,000 pF | 273 | F | G | J | K | M | | | | | | | DF | | | EB | EB | EE | FB | FB | FB | GB | GB |
| 33,000 pF | 333 | F | G | J | K | M | | | | | | | DG | | | EB | EB | EE | FB | FB | FB | GB | GB |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | | | | | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |

## Table 1 – Capacitance Range/Selection Waterfall (0402 – 1812 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | F G J K M | | | | | | | | | | EC | EE | EH | FB | FB | FE | GB | GB |
| 56,000 pF | 563 | F G J K M | | | | | | | | | | ED | EF | EH | FB | FB | FF | GB | GB |
| 68,000 pF | 683 | F G J K M | | | | | | | | | | EF | EH | | FB | FC | FG | GB | GB |
| 82,000 pF | 823 | F G J K M | | | | | | | | | | EH | EH | | FC | FF | FH | GB | GB |
| 100,000 pF | 104 | F G J K M | | | | | | | | | | EH | | | FE | FG | FM | GB | GD |
| 120,000 pF | 124 | F G J K M | | | | | | | | | | | | | FG | FH | | GB | GH |
| 150,000 pF | 154 | F G J K M | | | | | | | | | | | | | FH | FM | | GD | GN |
| 180,000 pF | 184 | F G J K M | | | | | | | | | | | | | FJ | | | GH | |
| 220,000 pF | 224 | F G J K M | | | | | | | | | | | | | | | | GK | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | C0402C | | | C0603C | | | C0805C | | | C1206C | | | C1210C | | | C1812C | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| Thickness Code | Case Size[1] | Thickness ± Range (mm) | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | | Paper Quantity[1] | | Plastic Quantity | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

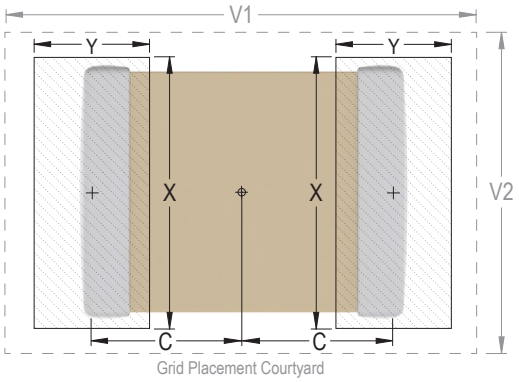
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

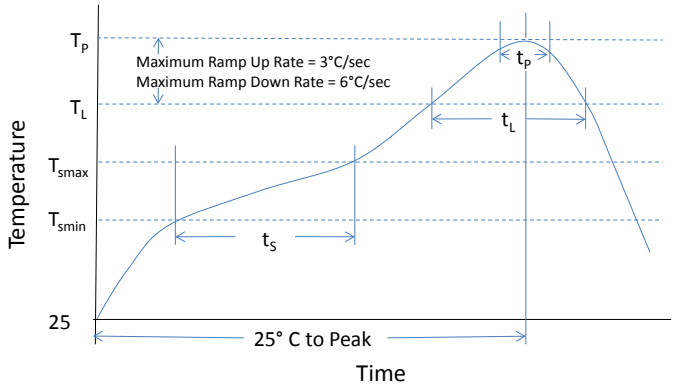
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



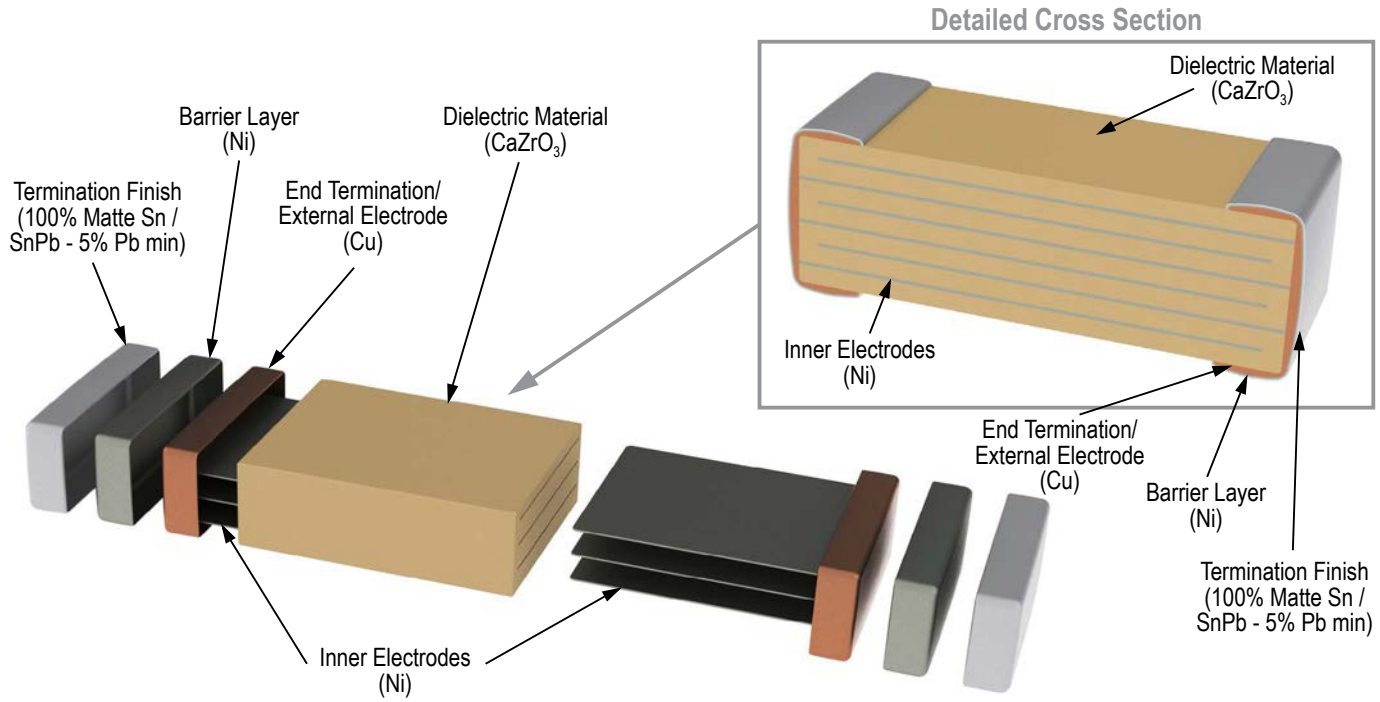
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

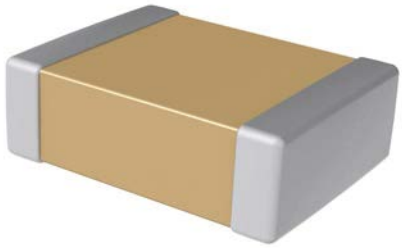
# High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET's X8L dielectric features a 150°C maximum operating temperature and is considered "general purpose high temperature." These components are fixed, ceramic dielectric capacitors suited for high temperature bypass and decoupling applications or frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X8L exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, −40% from 125°C to 150°C.

Driven by the demand for a more robust and reliable component, X8L dielectric capacitors were developed for critical applications where reliability at higher operating temperatures are a concern. These capacitors are widely used in automotive circuits as well as general high temperature applications. Concerned with flex cracks resulting from excessive tensile and shear stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

In addition to commercial grade, automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC–Q200 qualification requirements.



## Ordering Information

| C | 1210 | X | 106 | K | 8 | N | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210 | C = Standard<br>X = Flexible Termination | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *The flexible termination option is not available on EIA 0402 case size product. "C" must be used in the 6th character position when ordering this case size.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*

[2] *SnPb termination finish option is not available on Automotive Grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, and 1210 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.012 µF to 10 µF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Commercial & Automotive (AEC–Q200) grades available
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb termination finish option available upon request (5% Pb minimum)
- Flexible termination option available upon request

## Applications

Typical applications include use in extreme environments such as down-hole oil exploration, under-hood automotive, military and aerospace.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

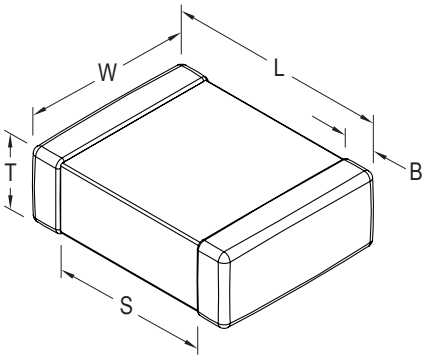
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Standard Termination – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ±0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ±0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ±0.25 (0.010) | | Solder Reflow Only |

## Dimensions – Flexible Termination – Millimeters (Inches)

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ±0.17 (0.007) | 0.80 (0.032) ±0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.30 (0.012) | 1.25 (0.049) ±0.30 (0.012) | | 0.50 (0.020) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ±0.40 (0.016) | 1.60 (0.063) ±0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ±0.40 (0.016) | 2.60 (0.102) ±0.30(0.012) | | 0.60 (0.024) ±0.25 (0.010) | | Solder Reflow Only |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Insulation Resistance Limit Table (X8L Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 500 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0201 | N/A | ALL |
| 0402 | < .012 µF | ≥ .012 µF |
| 0603 | < .047 µF | ≥ .047 µF |
| 0805 | < 0.15 µF | ≥ 0.15 µF |
| 1206 | < 0.47 µF | ≥ 0.47 µF |
| 1210 | < 0.39 µF | ≥ 0.39 µF |
| 1808 | ALL | N/A |
| 1812 | < 2.2 µF | ≥ 2.2 µF |
| 1825 | ALL | N/A |
| 2220 | < 10 µF | ≥ 10 µF |
| 2225 | ALL | N/A |

# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1210 Case Sizes)

| Cap | Cap Code | Case Size/ Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 22,000 pF | 223 | J | K | M | BB | BB | BB | BB | | | | | | | | | | | | | | | | | | | | |
| 27,000 pF | 273 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 33,000 pF | 333 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 39,000 pF | 393 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | | | | | |
| 47,000 pF | 473 | J | K | M | BB | BB | | | CF | CF | CF | CF | CF | | | | | | | | | | | | | | | |
| 56,000 pF | 563 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 68,000 pF | 683 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 82,000 pF | 823 | J | K | M | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.10 µF | 104 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.12 µF | 124 | J | K | M | | | | | CF | CF | CF | CF | | | | | | | | | | | | | | | | |
| 0.15 µF | 154 | J | K | M | | | | | CF | CF | CF | CF | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.18 µF | 184 | J | K | M | | | | | CF | CF | | | | DG | DG | DG | DG | DG | | | | | | | | | | |
| 0.22 µF | 224 | J | K | M | | | | | CF | CF | | | | DP | DP | DP | DP | DG | | | | | | | | | | |
| 0.27 µF | 274 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.33 µF | 334 | J | K | M | | | | | | | | | | DP | DP | DP | DP | | | | | | | | | | | |
| 0.39 µF | 394 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | | | | | | FD | FD | FD | FD | FD |
| 0.47 µF | 474 | J | K | M | | | | | | | | | | DE | DE | DE | DE | | EG | EG | EG | EG | EG | FD | FD | FD | FD | FD |
| 0.56 µF | 564 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FF | FF | FF | FF | FF |
| 0.68 µF | 684 | J | K | M | | | | | | | | | | DG | DG | DH | DH | | | | | | | FG | FG | FG | FG | FG |
| 0.82 µF | 824 | J | K | M | | | | | | | | | | DG | DG | DG | | | | | | | | FL | FL | FL | FL | FL |
| 1.0 µF | 105 | J | K | M | | | | | | | | | | DG | DG | DG | | | ED | ED | ED | ED | | FM | FM | FM | FM | FM |
| 1.2 µF | 125 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.5 µF | 155 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | EH | | FG | FG | FG | FG | |
| 1.8 µF | 185 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.2 µF | 225 | J | K | M | | | | | | | | | | | | | | | EF | EF | EH | EH | | FG | FG | FG | FG | |
| 2.7 µF | 275 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FH | FH | |
| 3.3 µF | 335 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FM | FM | FM | FM | |
| 3.9 µF | 395 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FK | FK | |
| 4.7 µF | 475 | J | K | M | | | | | | | | | | | | | | | EH | EH | EH | | | FG | FG | FS | FS | |
| 5.6 µF | 565 | J | K | M | | | | | | | | | | | | | | | | | | | | FH | FH | FH | | |
| 6.8 µF | 685 | J | K | M | | | | | | | | | | | | | | | | | | | | FM | FM | FM | | |
| 8.2 µF | 825 | J | K | M | | | | | | | | | | | | | | | | | | | | FK | FK | FK | | |
| 10 µF | 106 | J | K | M | | | | | | | | | | | | | | | | | | | | FS | FS | FS | | |
| Cap | Cap Code | Rated Voltage (VDC) | | | 6.3 | 10 | 16 | 25 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 | 6.3 | 10 | 16 | 25 | 50 |
| | | Voltage Code | | | 9 | 8 | 4 | 3 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 | 9 | 8 | 4 | 3 | 5 |
| | | Case Size/Series | | | C0402C | | | | C0603C | | | | | C0805C | | | | | C1206C | | | | | C1210C | | | | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| DH | 0805 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FD | 1210 | 0.95 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

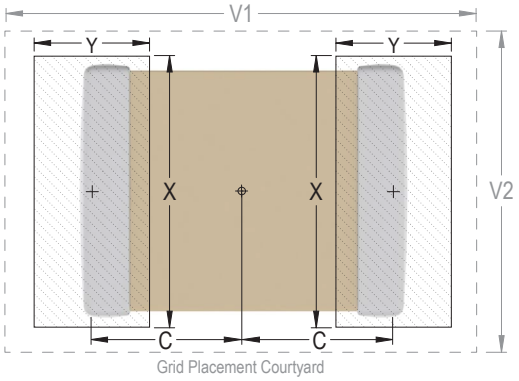
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

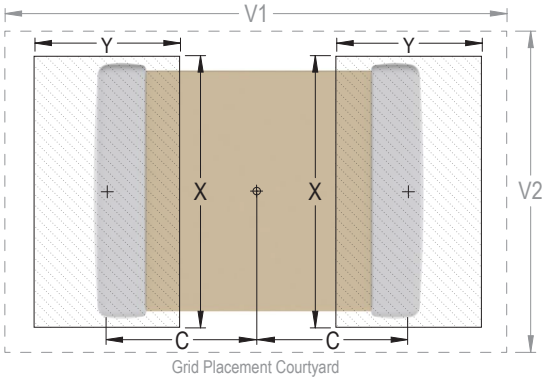


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.65 | 1.90 | 5.90 | 2.90 | 1.50 | 1.45 | 1.80 | 5.00 | 2.30 | 1.40 | 1.25 | 1.70 | 4.30 | 2.00 |
| 1210 | 3225 | 1.60 | 1.65 | 2.80 | 5.90 | 3.80 | 1.50 | 1.45 | 2.70 | 5.00 | 3.20 | 1.40 | 1.25 | 2.60 | 4.30 | 2.90 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

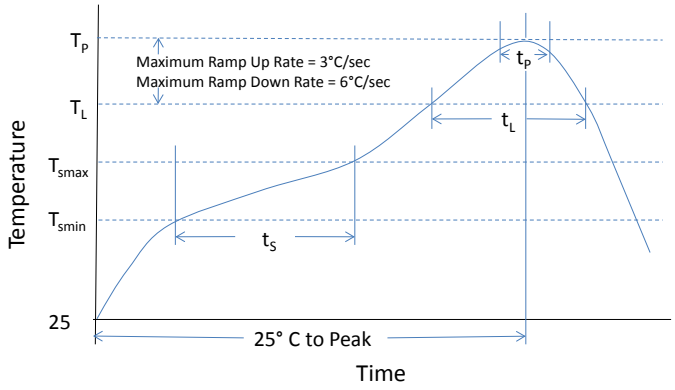
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



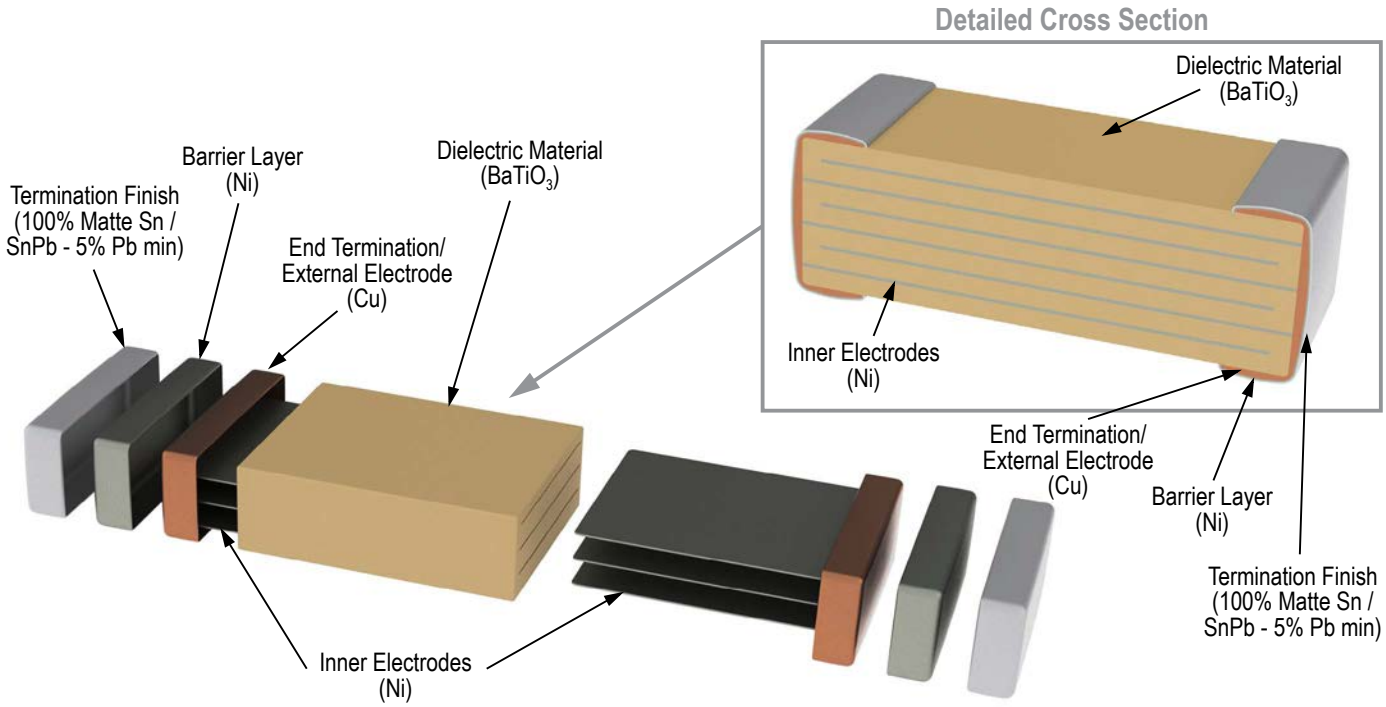
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

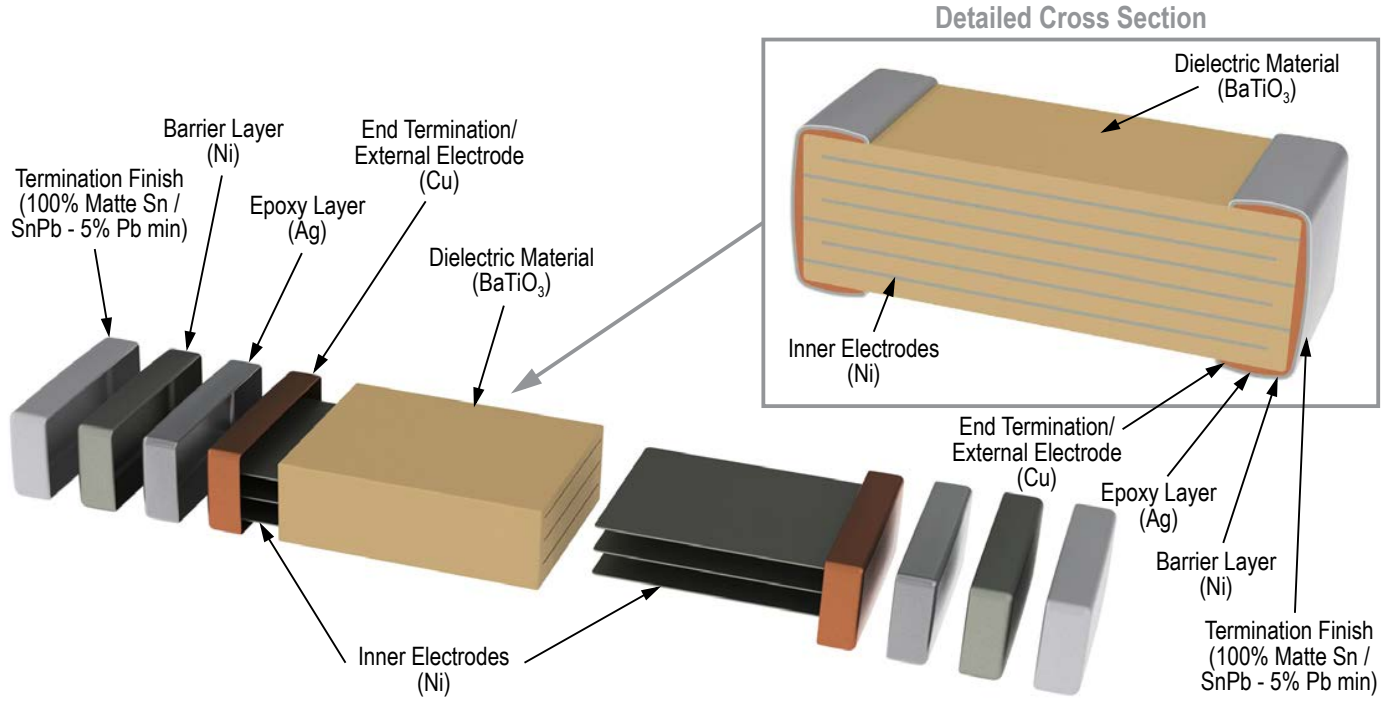
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination



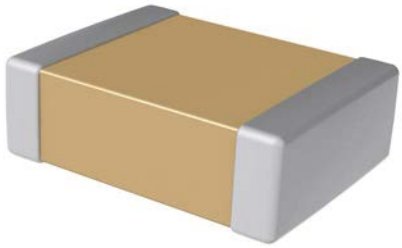

## Construction – Flexible Termination



# High Temperature 175ºC, X7R Dielectric, 16 – 200 VDC (Industrial Grade)

## Overview

KEMET's High Temperature X7R Dielectric capacitors are formulated and designed for extreme temperature applications. Constructed of a robust and proprietary base metal electrode (BME) dielectric system, these devices are capable of reliable operation in temperatures up to 175°C. Providing an attractive combination of performance and robustness in general high temperature applications, High Temperature X7R dielectric capacitors are well suited for high temperature bypass and decoupling applications or frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. They exhibit a predictable change in capacitance with respect to time, voltage and temperature up to 175°C.



## Ordering Information

| C | 1210 | R | 225 | K | 3 | R | A | C | T050 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size[1] (L" x W") | Specification/ Series[1] | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish | Packaging/Grade (C-Spec)[2] |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812 | G = 175°C with standard termination<br>R = 175°C w/ Flexible Termination | First two digits represent significant figures. Third digit specifies number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | 4 = 16<br>3 = 25<br>5 = 50<br>1 = 100<br>2 = 200 | R = X7R | A = N/A | C = 100% Matte Sn | Blank = Bulk<br>7292 = Waffle Pack/Tray<br>TU = 7" Reel - Unmarked (full reel quantity)<br>T050 = 50 pieces/7" Reel - Unmarked<br>T100 = 100 pieces/7" Reel - Unmarked<br>T250 = 250 pieces/7" Reel - Unmarked<br>T500 = 500 pieces/7" Reel - Unmarked<br>T1K0 = 1,000 pieces/Reel - Unmarked |

[1] *Flexible termination option is only available in 0603 (1608 metric) and larger case sizes.*

[2] *Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "T1K0" packaging option, 1812 case size devices with chip thickness of ≥ 1.9 mm (nominal) may be shipped on multiple 7" reels or a single 13" reel. The term "Unmarked" pertains to laser marking of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Additional reeling or packaging options may be available. Contact KEMET for details.*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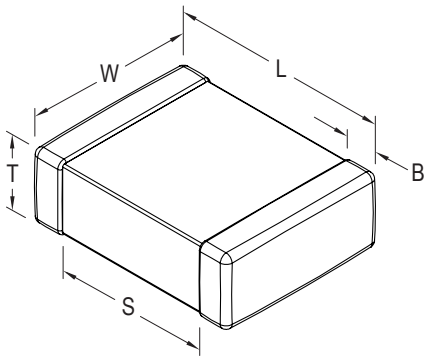
## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (0.040) ±0.05 (0.002) | 0.50 (0.020) ±0.05 (0.002) | See Table 2 for Thickness | 0.30 (0.012) ± 0.10 (0.004) | 0.30 (0.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (0.063) ±0.15 (0.006) | 0.80 (0.032) ±0.15 (0.006) | | 0.35 (0.014) ± 0.15 (0.006) | 0.70 (0.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.20 (0.008) | 1.25 (0.049) ±0.20 (0.008) | | 0.50 (0.02) ± 0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.20 (0.126) ±0.20 (0.008) | 1.60 (0.063) ±0.20 (0.008) | | 0.50 (0.02) ± 0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.20 (0.126) ±0.20 (0.008) | 2.50 (0.098) ±0.20 (0.008) | | 0.50 (0.02) ± 0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.177) ±0.30 (0.012) | 3.20 (0.126) ±0.30 (0.012) | | 0.60 (0.024) ± 0.35 (0.014) | | Solder Reflow Only |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ±0.17 (0.007) | 0.80 (0.032) ±0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ±0.30 (0.012) | 1.25 (0.049) ±0.30 (0.012) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ±0.40 (0.016) | 1.60 (0.063) ±0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ±0.40 (0.016) | 2.60 (0.102) ±0.30 (0.012) | | 0.60 (0.024) ±0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.178) ±0.40 (0.016) | 3.20 (0.126) ±0.30 (0.012) | | 0.70 (0.028) ±0.35 (0.014) | | Solder Reflow Only |

## Overview cont'd

Concerned with flex cracks resulting from excessive stresses produced during board flexure and thermal cycling? These devices are available with KEMET's Flexible termination technology which inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

KEMET's High Temperature X7R surface mount MLCCs are manufactured in state of the art ISO/TS 16949:2009 certified facilities and are proven to function reliably in harsh, high temperature and high humidity, down-hole environments.

## Benefits

- Operating temperature range of −55°C to +175°C
- Voltage derating not required
- Lead (Pb)-Free, RoHS and REACH compliant
- Base metal electrode (BME) dielectric system
- EIA 0402, 0603, 0805, 1206, 1210 and 1812 case sizes
- DC voltage ratings of 16 V, 25 V, 50 V, 100 V & 200 V
- Capacitance offerings ranging from 2.7 nF to 3.3 µF
- Available capacitance tolerances of ±5%, ±10% & ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- Flexible termination option available upon request

## Applications

Typical applications include decoupling, bypass, filtering and transient voltage suppression in extreme environments such as down-hole exploration, aerospace engine compartments and geophysical probes.

## Application Notes

X7R dielectric is not recommended for AC line filtering or pulse applications.

Voltage derating of these capacitors is not required for application temperatures up to 175°C.

## Qualification/Certification

High temperature Industrial grade products meet or exceed the requirements outlined Table 4, Performance & Reliability. Qualification packages are available upon request.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +175°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to +125°C) beyond 125°C see "Capacitance vs. Temperature Performance" plot - Reference Only |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | <3.0% |
| Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit at 25°C | See Dissipation Factor Limit Table |
| Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ± 5 secs at 25°C) |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance ≤ 10 µF*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Dissipation Factor Limit Table

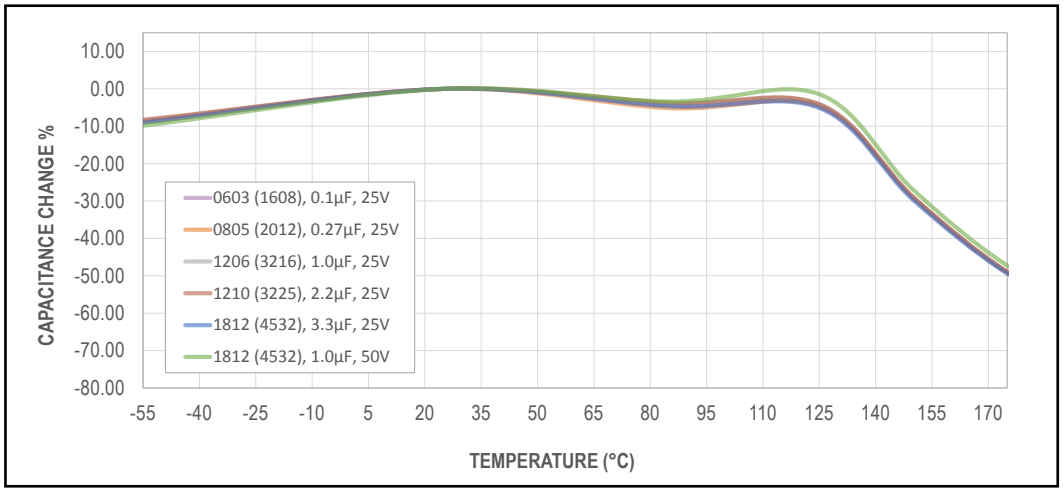
| Rated DC Voltage | Dissipation Factor |
|---|---|
| 16/25 | 3.5% |
| >25 | 2.5% |

## Post Environmental Limits

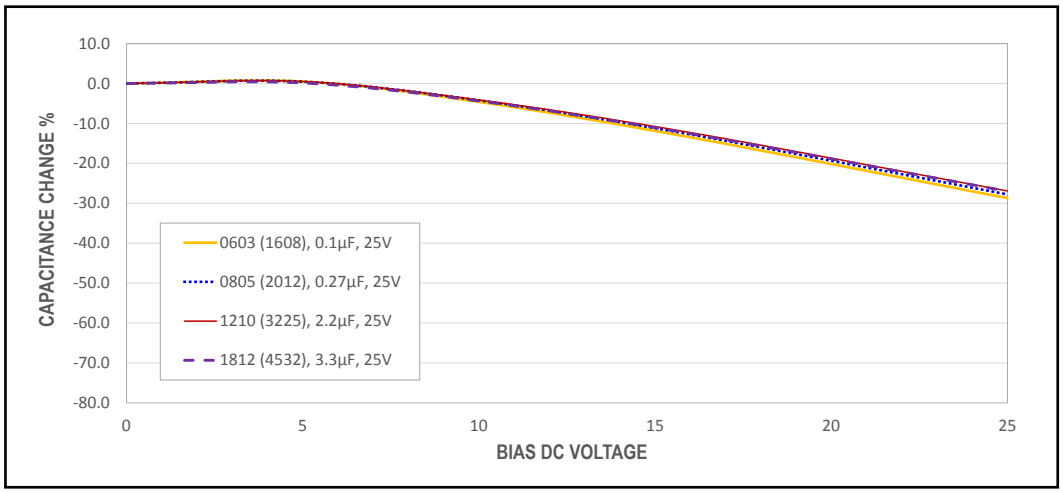
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | 16/25 | All | 5.0 | ± 20% | 10% of Initial Limit |
| | >25 | | 3.0 | | |

# Electrical Characteristics

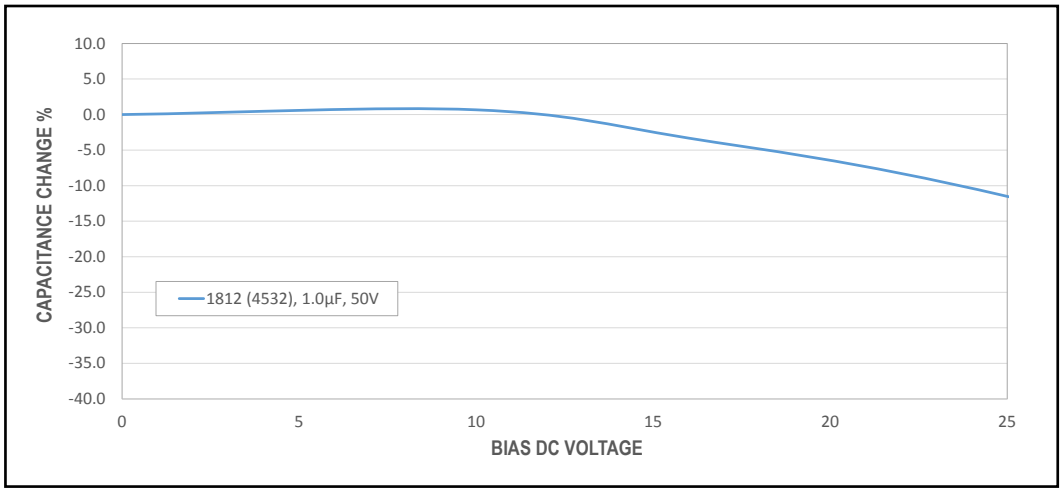
## Capacitance vs. Temperature Performance (−55°C to +175°C)




## Capacitance vs. Bias Voltage Performance (25 VDC Rated )




## Capacitance vs. Bias Voltage Performance (1812 Case Size, 1.0 µF, 50 VDC Rated)



# Table 1 – Capacitance Range/Selection Waterfall (0402 – 1812 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C0402G | | | | C0603G/R | | | C0805G/R | | | C1206G/R | | | C1210G/R | | | C1812G/R | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 4 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | | 16 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 2700 pF | 272 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 3300 pF | 332 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 3900 pF | 392 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 4700 pF | 472 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 5600 pF | 562 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 6800 pF | 682 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 8200 pF | 822 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 10000 pF | 103 | J | K | M | BB | BB | BB | | | | | | | | | | | | | | | | | |
| 12000 pF | 123 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | |
| 15000 pF | 153 | J | K | M | BB | BB | | | | | | | | | | | | | | | | | | |
| 18000 pF | 183 | J | K | M | BB | BB | | | CF | CF | | | | | | | | | | | | | | |
| 22000 pF | 223 | J | K | M | BB | BB | | | CF | CF | | | | | | | | | | | | | | |
| 27000 pF | 273 | J | K | M | | | | | CF | CF | | | | | | | | | | | | | | |
| 33000 pF | 333 | J | K | M | | | | | CF | CF | | | | | | | | | | | | | | |
| 39000 pF | 393 | J | K | M | | | | | CF | CF | | | | | | | | | | | | | | |
| 47000 pF | 473 | J | K | M | BB | | | | CF | CF | | DN | DN | | | | | | | | | | | |
| 56000 pF | 563 | J | K | M | | | | | CF | CF | | DN | DN | | | | | | | | GN | GN | GN | GN |
| 68000 pF | 683 | J | K | M | | | | | CF | CF | | DN | DN | | | | | | | | | | | |
| 82000 pF | 823 | J | K | M | | | | | CF | CF | | DN | DN | | | | | | | | | | | |
| 0.1 µF | 104 | J | K | M | | | | | CF | CF | | DN | DN | | ED | ED | | | | | GM | GM | GM | GM |
| 0.12 µF | 124 | J | K | M | | | | | CF | | | DP | DP | | ED | ED | | | | | | | | |
| 0.15 µF | 154 | J | K | M | | | | | CF | | | DP | DP | | ED | ED | | | | | | | | |
| 0.18 µF | 184 | J | K | M | | | | | | | | DF | DF | | ED | ED | | FE | FE | | | | | |
| 0.22 µF | 224 | J | K | M | | | | | | | | DG | DG | | EP | EP | | FE | FE | | GB | GB | | |
| 0.27 µF | 274 | J | K | M | | | | | | | | DG | DG | | EP | EP | | FF | FF | | GB | GB | | |
| 0.33 µF | 334 | J | K | M | | | | | | | | DP | | | EJ | EJ | | FF | FF | | GB | GB | | |
| 0.39 µF | 394 | J | K | M | | | | | | | | DP | | | EJ | EJ | | FG | FG | | GB | GB | | |
| 0.47 µF | 474 | J | K | M | | | | | | | | DG | | | EJ | EJ | | FG | FG | | GB | GB | | |
| 0.56 µF | 564 | J | K | M | | | | | | | | DG | | | EP | | | FH | FH | | GB | GB | | |
| 0.68 µF | 684 | J | K | M | | | | | | | | DG | | | EJ | | | FM | FM | | GC | GC | | |
| 0.82 µF | 824 | J | K | M | | | | | | | | | | | EJ | | | FK | FK | | GE | GE | | |
| 1 µF | 105 | J | K | M | | | | | | | | | | | EJ | | | FK | FK | | GH | GH | | |
| 1.2 µF | 125 | J | K | M | | | | | | | | | | | | | | FH | | | GJ | GJ | | |
| 1.5 µF | 155 | J | K | M | | | | | | | | | | | | | | FM | | | GL | GL | | |
| 1.8 µF | 185 | J | K | M | | | | | | | | | | | | | | FK | | | GE | | | |
| 2.2 µF | 225 | J | K | M | | | | | | | | | | | | | | FK | | | GG | | | |
| 2.7 µF | 275 | J | K | M | | | | | | | | | | | | | | | | | GJ | | | |
| 3.3 µF | 335 | J | K | M | | | | | | | | | | | | | | | | | GL | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 16 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | | 4 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 2 |
| | | Case Size/ Series | | | C0402G | | | | C0603G/R | | | C0805G/R | | | C1206G/R | | | C1210G/R | | | C1812G/R | | | |

## Table 2 – Chip Thickness/Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07* | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10* | 4,000 | 15,000 | 0 | 0 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EP | 1206 | 1.20 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

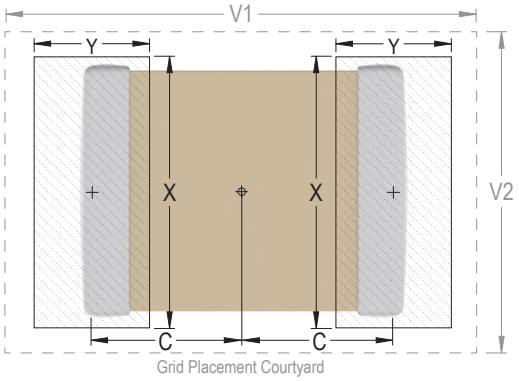
*Package quantity based on finished chip thickness specifications.*

## Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

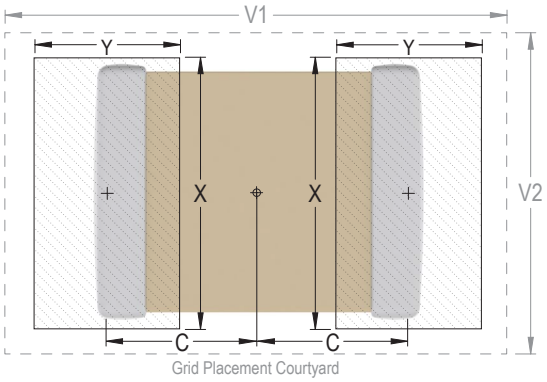


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

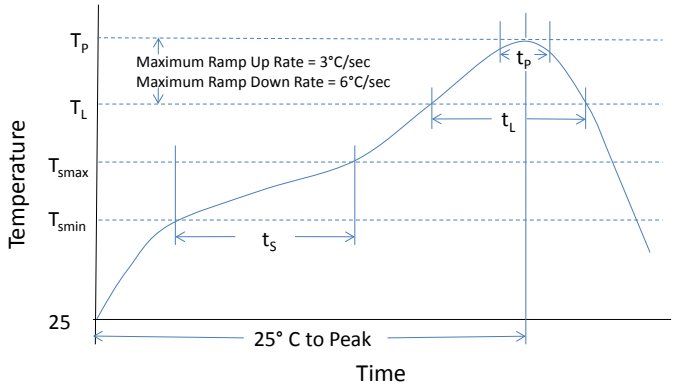
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish |
|---|---|
| | 100% Matte Sn |
| **Preheat/Soak** | |
| Temperature Minimum ($T_{Smin}$) | 150°C |
| Temperature Maximum ($T_{Smax}$) | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum |
| Time 25°C to Peak Temperature | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



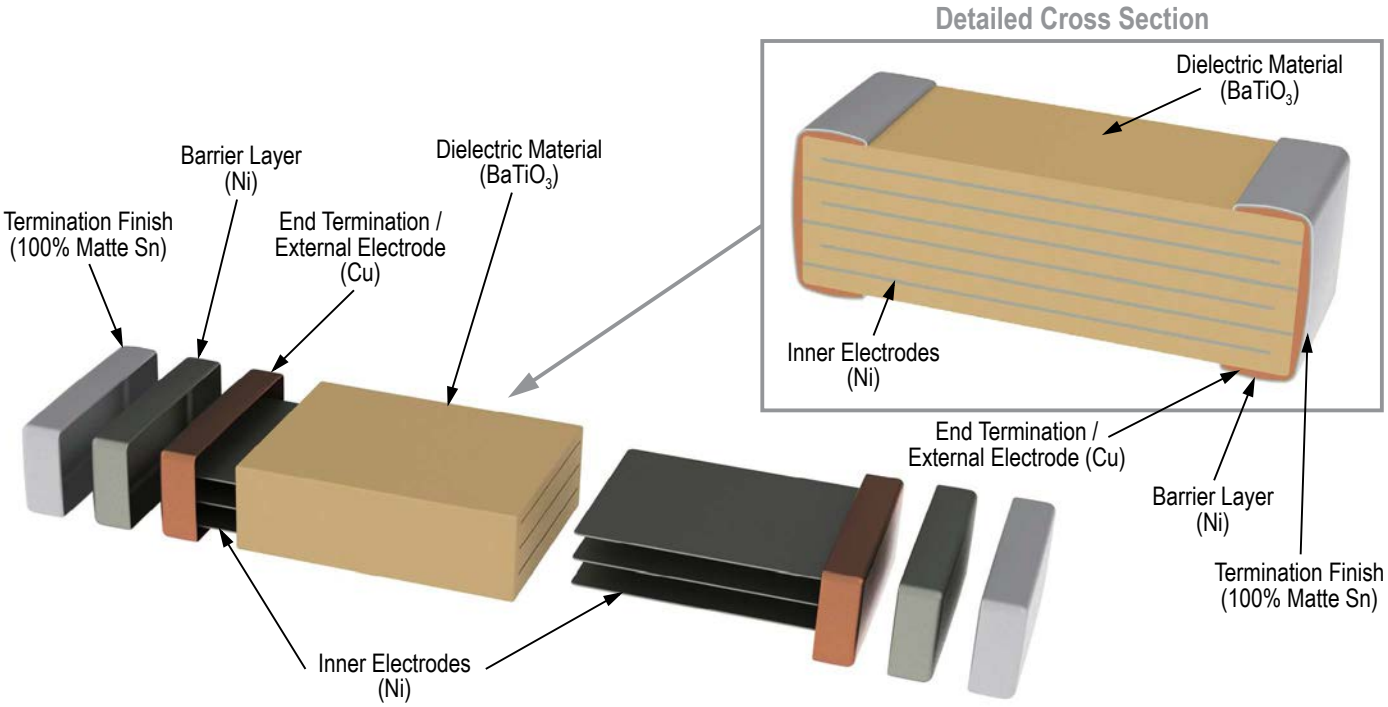
## Table 4 – Performance & Reliability: Test Methods and Conditions

<table>
<tr><th>Stress</th><th>Reference</th><th>Test or Inspection Method</th></tr>
<tr><td>Terminal Strength</td><td>JIS–C–6429</td><td>Appendix 1, Note:
<table>
<tr><th>Package Size (L" x W")</th><th>Force</th><th>Duration</th></tr>
<tr><td>0402</td><td>5 N (0.51 kg)</td><td rowspan="3">60 seconds</td></tr>
<tr><td>0603</td><td>10 N (1.02 kg)</td></tr>
<tr><td>≥ 0805</td><td>18 N (1.83 kg)</td></tr>
</table></td></tr>
<tr><td>Board Flex</td><td>JIS–C–6429</td><td>Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum).</td></tr>
<tr><td rowspan="4">Solderability</td><td rowspan="4">J–STD–002</td><td>Magnification 50 X. Conditions:</td></tr>
<tr><td>a) Method B, 4 hours at 155°C, dry heat at 235°C</td></tr>
<tr><td>b) Method B at 215°C category 3</td></tr>
<tr><td>c) Method D, category 3 at 260°C</td></tr>
<tr><td>Temperature Cycling</td><td>KEMET defined</td><td>50 cycles (−55°C to +220°C). Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td rowspan="2">Biased Humidity</td><td rowspan="2">MIL–STD–202 Method 103</td><td>Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion.</td></tr>
<tr><td>Moisture Resistance</td><td>MIL–STD–202 Method 106</td><td>t = 24 hours/cycle. Steps 7a and 7b not required. Unpowered. Measurement at 24 hours +/- 2 hours after test conclusion.</td></tr>
<tr><td>High Temperature Life</td><td>MIL–STD–202 Method 108 /EIA–198</td><td>1,000 hours at 175°C with 2 X rated voltage applied.</td></tr>
<tr><td>Storage Life</td><td>KEMET defined</td><td>200°C, 0 VDC for 1,000 hours.</td></tr>
<tr><td>Vibration</td><td>MIL–STD–202 Method 204</td><td>5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz</td></tr>
<tr><td>Mechanical Shock</td><td>MIL–STD–202 Method 213</td><td>Figure 1 of Method 213, Condition F.</td></tr>
<tr><td>Resistance to Solvents</td><td>MIL–STD–202 Method 215</td><td>Add aqueous wash chemical, OKEM Clean or equivalent.</td></tr>
</table>

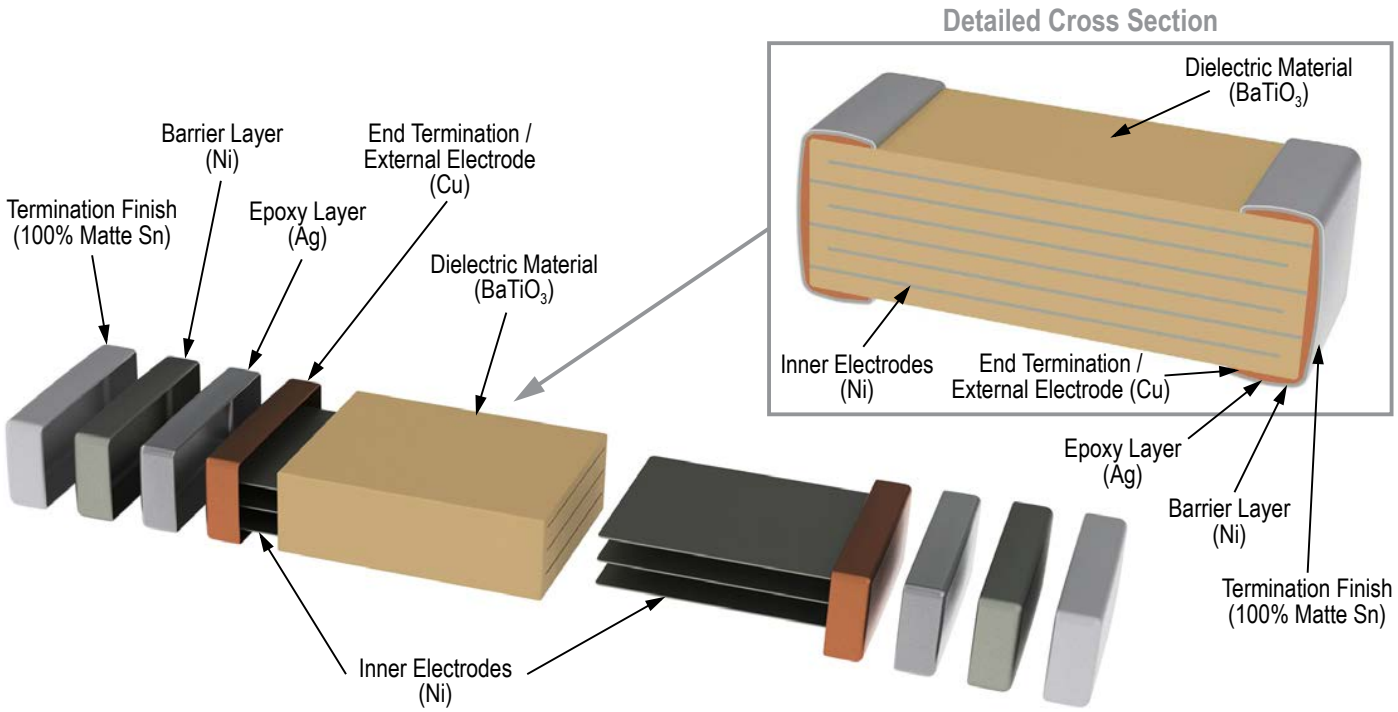
## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



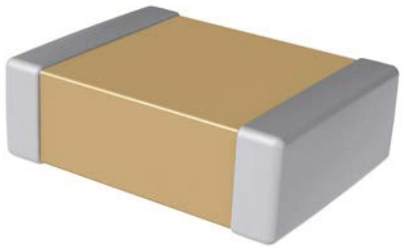
# High Temperature 200°C, C0G Dielectric, 10 – 200 VDC (Industrial Grade)

## Overview

KEMET's High Temperature surface mount C0G Multilayer Ceramic Capacitors (MLCCs) are constructed of a robust and proprietary C0G/NP0 base metal electrode (BME) dielectric system that offers industry-leading performance at extreme temperatures up to 200°C. These devices are specifically designed to withstand the demands of harsh industrial environments such as down-hole oil exploration and automotive/avionics engine compartment circuitry.

KEMET's High Temperature C0G capacitors are temperature compensating and are well suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. They exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ± 30ppm/ºC from −55°C to +200°C. In addition, these capacitors exhibit high insulation resistance with low dissipation factor at elevated temperatures up to 200°C. They also exhibit low ESR at high frequencies and offer greater volumetric efficiency over competitive high temperature precious metal electrode (PME) and BME ceramic capacitor devices.

These devices are Lead (Pb)-Free, RoHS and REACH compliant without the need of any exemptions.



## Ordering Information

| C | 1210 | H | 124 | J | 5 | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Voltage | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0402<br>0603<br>0805<br>1206<br>1210<br>1812<br>2220 | H = High Temperature (200°C) | Two significant digits + number of zeros.<br>Use 9 for 1.0 – 9.9 pF<br>Use 8 for 0.5 – .99 pF<br>e.g., 2.2 pF = 229<br>e.g., 0.5 pF = 508 | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 8 = 10 V<br>4 = 16 V<br>3 = 25 V<br>5 = 50 V<br>1 = 100 V<br>2 = 200 V | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum)<br>E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin minimum | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

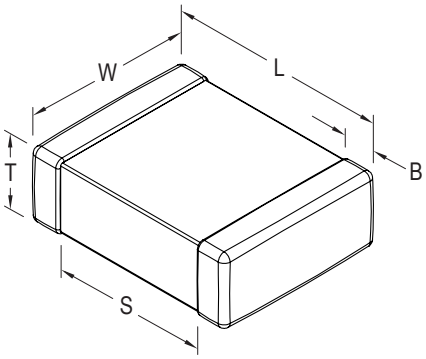
| Termination Finish Options | Packaging Type/Options | Packaging Ordering Code (C-Spec) |
|---|---|---|
| **Standard Packaging – Unmarked[3]** | | |
| C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin minimum | Bulk Bag | Blank[1] |
| | Waffle Tray[2] | 7292 |
| | 7" Tape & Reel | TU |
| | 13" Reel | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| | 7" Tape & Reel/2 mm pitch[4] | 7081 |
| | 7" Tape & Reel – 50 pieces | T050 |
| | 7" Tape & Reel – 100 pieces | T100 |
| | 7" Tape & Reel – 250 pieces | T250 |
| | 7" Tape & Reel – 500 pieces | T500 |
| | 7" Tape & Reel – 1,000 pieces | T1K0 |
| **Moisture Sensitive Packaging[5] – Unmarked[3]** | | |
| E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin minimum | Waffle Tray[2] | 7282 |
| | 7" Tape & Reel | 7130 |
| | 7" Tape & Reel – 50 pieces | Contact KEMET[6] |
| | 7" Tape & Reel – 100 pieces | |
| | 7" Tape & Reel – 250 pieces | |
| | 7" Tape & Reel – 500 pieces | |
| | 7" Tape & Reel – 1,000 pieces | |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*
*[1] "Bulk Bag" packaging option is not available for Gold (Au) termination finish options and case sizes larger than 2225 (5664 Metric).*
*[2] "Waffle Tray" packaging option is not available for case sizes larger than 2225 (5664 Metric).*
*[3] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*
*[3] Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "T1K0" packaging option, 1812 thru 2225 case size devices with chip thickness of ≥ 1.9 mm (nominal) may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*
*[4] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*
*[5] Moisture sensitive packaging is required for Gold (Au) termination option "E" (1.97 – 11.8 µin)*
*[6] Additional reeling or packaging options may be available. Contact KEMET for details.*

## Benefits

- −55°C to +200°C operating temperature range
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0402, 0603, 0805, 1206, 1210, 1812, and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, 50 V, 100 V, and 200 V
- Capacitance offerings ranging from 0.5 pF up to 470 nF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10% or ±20%
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies and into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +200°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- Gold (Au), Tin/Lead (Sn/Pb) and 100% pure matte Tin (Sn) termination finishes available

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0402 | 1005 | 1.00 (.040) ±0.05 (.002) | 0.50 (.020) ±0.05 (.002) | See Table 2 for Thickness | 0.30 (.012) ±0.10 (.004) | 0.30 (.012) | Solder Reflow Only |
| 0603 | 1608 | 1.60 (.063) ±0.15 (.006) | 0.80 (.032) ±0.15 (.006) | | 0.35 (.014) ±0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ±0.20 (.008) | 1.25 (.049) ±0.20 (.008) | | 0.50 (0.02) ±0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ±0.20 (.008) | 1.60 (.063) ±0.20 (.008) | | 0.50 (0.02) ±0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ±0.20 (.008) | 2.50 (.098) ±0.20 (.008) | | 0.50 (0.02) ±0.25 (.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (.177) ±0.30 (.012) | 3.20 (.126) ±0.30 (.012) | | 0.60 (.024) ±0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ±0.40 (.016) | 5.00 (.197) ±0.40 (.016) | | 0.60 (.024) ±0.35 (.014) | | |

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, decoupling, bypass, filtering, transient voltage suppression, blocking and energy storage for use in extreme environments such as down-hole exploration, aerospace engine compartments and geophysical probes.

## Qualification/Certification

High temperature (200ºC) Industrial grade products meet or exceed the requirements outlined in Table 4, Performance & Reliability. Qualification packages are available for review and download on our website at www.kemet.com/hightemp

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C (up to 200°C) |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

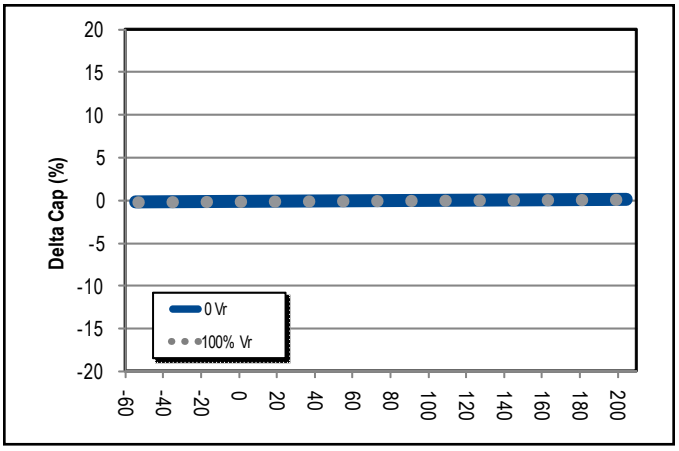
*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 ±0.2 Vrms if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

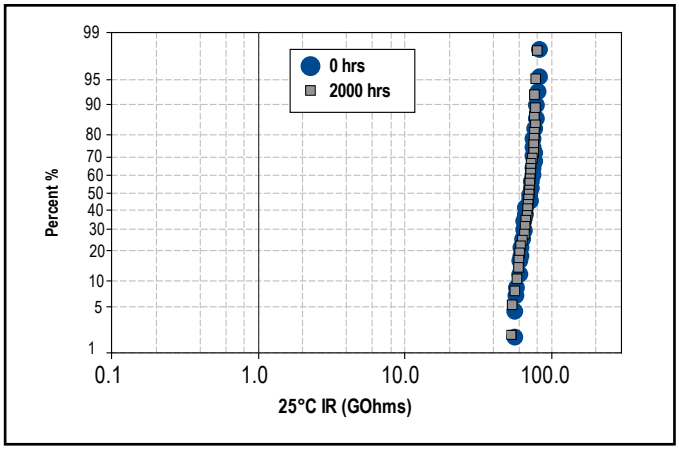
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Electrical Characteristics

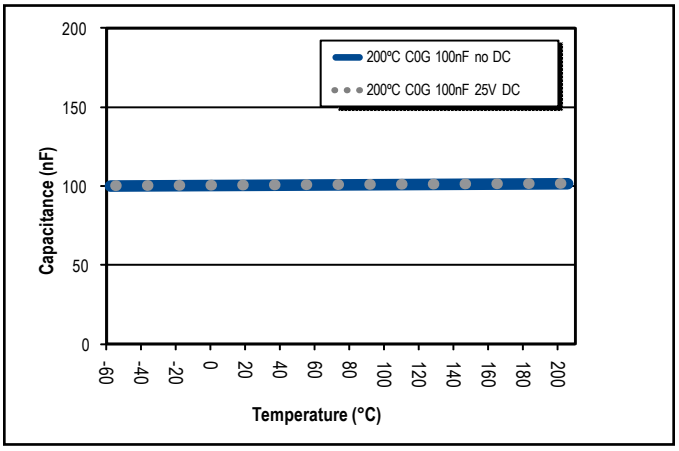
## Delta Cap vs. Temperature (Typical)



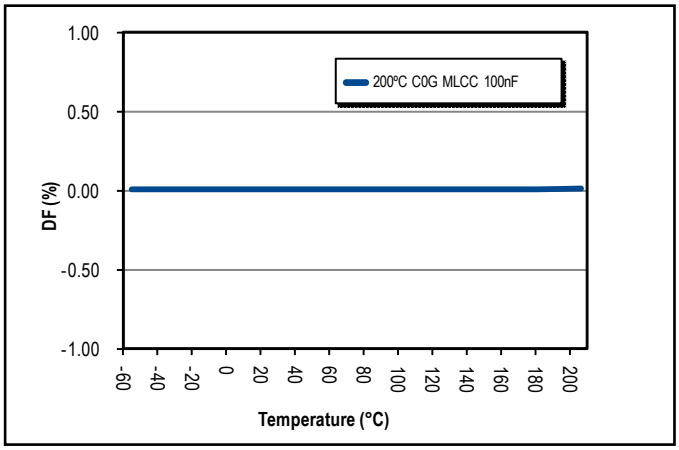

## C1210H104J1GAC - Life Test IR Distribution (Lognormal)



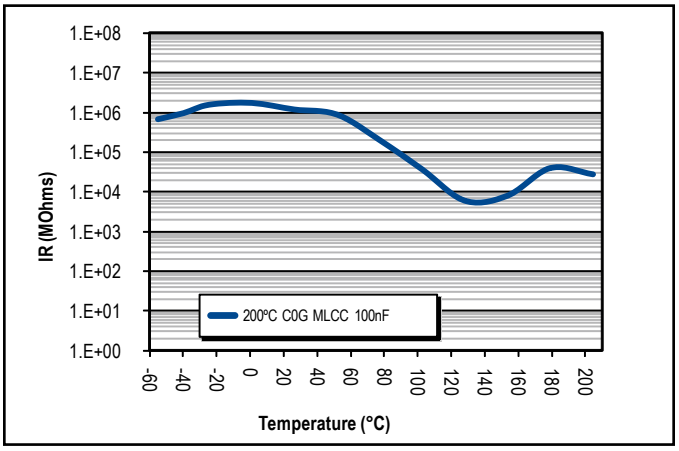

## Capacitance vs. Temperature with 25 V DC Bias (Rated Voltage)



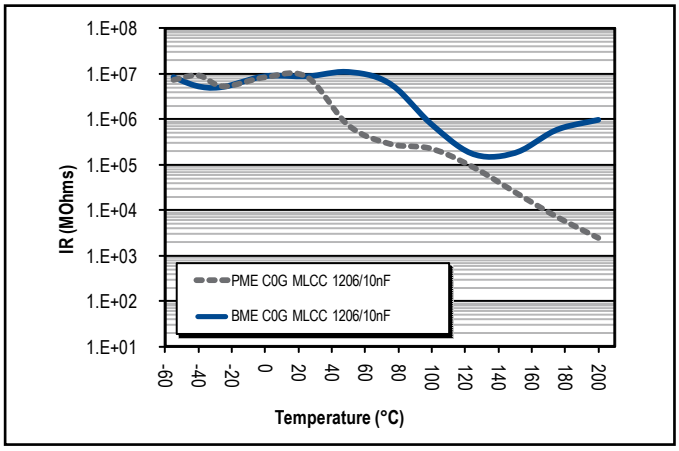

## DF vs. Temperature without DC Bias.




## IR vs. Temperature with 25 V DC Bias (Rated Voltage)




## BME vs. PME/IR vs. Temperature with 25 V DC Bias (Rated Voltage)



# Table 1A – Capacitance Range/Selection Waterfall (0402 – 1206 Case Sizes)

| Capacitance | Cap Code | Case Size / Series | | | | | | | | C0402H | | | | | | C0603H | | | | | | C0805H | | | | | | C1206H | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | | | | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | |
| 0.5 & 0.75 pF | 508 & 758 | B | C | D | | | | | | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | | | | | | |
| 1.0 - 9.0 pF* | 109 - 919* | B | C | D | | | | | | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 10 - 91 pF* | 100 - 910* | | | | F | G | J | K | M | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 100 - 180 pF* | 101 - 181* | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | CF | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 200 - 430 pF* | 201 - 431* | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 470 pF | 471 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DP | EB | EB | EB | EB | EB | EB |
| 510 pF | 511 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 560 pF | 561 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 620 pF | 621 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 680 pF | 681 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 750 pF | 751 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 820 pF | 821 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | DN | EB | EB | EB | EB | EB | EB |
| 910 pF | 911 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EB |
| 1,000 pF | 102 | | | | F | G | J | K | M | BB | BB | BB | BB | BB | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DP | DP | EB | EB | EB | EB | EB | EE |
| 1,100 pF | 112 | | | | F | G | J | K | M | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB |
| 1,200 pF | 122 | | | | F | G | J | K | M | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | EB |
| 1,300 pF | 132 | | | | F | G | J | K | M | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DP | | EB | EB | EB | EB | EC | EC |
| 1,500 pF | 152 | | | | F | G | J | K | M | BB | BB | BB | BB | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DP | | EB | EB | EB | EB | ED | EC |
| 1,600 pF | 162 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DP | | EB | EB | EB | EB | ED | ED |
| 1,800 pF | 182 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DP | | EB | EB | EB | EB | ED | ED |
| 2,000 pF | 202 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | ED | ED |
| 2,200 pF | 222 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EE | EE |
| 2,400 pF | 242 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EC | EC |
| 2,700 pF | 272 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EC | EC |
| 3,000 pF | 302 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DN | | EC | EC | EC | EC | EC | |
| 3,300 pF | 332 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DN | | EC | EC | EC | EC | EE | |
| 3,600 pF | 362 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DP | DP | DP | DP | DN | | EC | EC | EC | EC | EE | |
| 3,900 pF | 392 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DE | DE | DE | DE | DN | | EC | EC | EC | EC | EF | |
| 4,300 pF | 432 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DE | DE | DE | DE | DN | | EC | EC | EC | EC | EC | |
| 4,700 pF | 472 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | CF | | DE | DE | DE | DE | DN | | EC | EC | EC | EC | EC | |
| 5,100 pF | 512 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | | | DE | DE | DE | DE | DN | | ED | ED | ED | ED | ED | |
| 5,600 pF | 562 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | | ED | ED | ED | ED | ED | |
| 6,200 pF | 622 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | |
| 6,800 pF | 682 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | CF | | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | |
| 7,500 pF | 752 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | | | | DN | DN | DN | DN | DN | | EB | EB | EB | EB | EB | |
| 8,200 pF | 822 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | | | | DN | DN | DN | DN | DN | | EC | EC | EC | EC | EB | |
| 9,100 pF | 912 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | | | | DN | DN | DN | DN | DN | | EC | EC | EC | EC | EB | |
| 10,000 pF | 103 | | | | F | G | J | K | M | | | | | | | CF | CF | CF | | | | DN | DN | DN | DN | DP | | ED | ED | ED | ED | EB | |
| 12,000 pF | 123 | | | | F | G | J | K | M | | | | | | | | | | | | | DN | DN | DN | DN | DE | | EB | EB | EB | EB | EB | |
| 15,000 pF | 153 | | | | F | G | J | K | M | | | | | | | | | | | | | DN | DN | DN | DP | DG | | EB | EB | EB | EB | EB | |
| 18,000 pF | 183 | | | | F | G | J | K | M | | | | | | | | | | | | | DN | DN | DN | DP | | | EB | EB | EB | EB | EB | |
| 22,000 pF | 223 | | | | F | G | J | K | M | | | | | | | | | | | | | DP | DP | DP | DF | | | EB | EB | EB | EB | EC | |
| 27,000 pF | 273 | | | | F | G | J | K | M | | | | | | | | | | | | | DF | DF | DF | | | | EB | EB | EB | EB | EE | |
| 33,000 pF | 333 | | | | F | G | J | K | M | | | | | | | | | | | | | DG | DG | DG | | | | EB | EB | EB | EB | EE | |
| 39,000 pF | 393 | | | | F | G | J | K | M | | | | | | | | | | | | | DG | DG | DG | | | | EC | EC | EC | EE | EH | |
| 47,000 pF | 473 | | | | F | G | J | K | M | | | | | | | | | | | | | DG | DG | DG | | | | EC | EC | EC | EE | EH | |
| 56,000 pF | 563 | | | | F | G | J | K | M | | | | | | | | | | | | | | | | | | | ED | ED | ED | EF | | |
| 68,000 pF | 683 | | | | F | G | J | K | M | | | | | | | | | | | | | | | | | | | EF | EF | EF | EH | | |
| 82,000 pF | 823 | | | | F | G | J | K | M | | | | | | | | | | | | | | | | | | | EH | EH | EH | EH | | |
| 0.10 µF | 104 | | | | F | G | J | K | M | | | | | | | | | | | | | | | | | | | EH | EH | EH | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | | | | 10 | 16 | 25 | 50 | 100 | | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Voltage Code | | | | | | | | 8 | 4 | 3 | 5 | 1 | | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Case Size / Series | | | | | | | | C0402H | | | | | | C0603H | | | | | | C0805H | | | | | | C1206H | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts..*

# Table 1B – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size / Series | C1210H | | | | | | C1812H | | | | | | C2220H | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes<br>See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 0.5 & 0.75 pF | 508 & 758 | B C D | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 10 - 91 pF* | 100 - 910* | F G J K M | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 100 - 910 pF* | 101 - 911* | F G J K M | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 1,000 pF | 102 | F G J K M | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | FB | FB | FB | FB | FB | FB | | | | | | | | | | | | |
| 1,300 pF | 132 | F G J K M | FB | FB | FB | FB | FB | FC | | | | | | | | | | | | |
| 1,500 pF | 152 | F G J K M | FB | FB | FB | FB | FB | FE | | | | | | | | | | | | |
| 1,600 pF | 162 | F G J K M | FB | FB | FB | FB | FB | FE | | | | | | | | | | | | |
| 1,800 pF | 182 | F G J K M | FB | FB | FB | FB | FB | FE | | | | | | | | | | | | |
| 2,000 pF | 202 | F G J K M | FB | FB | FB | FB | FC | FE | | | | | | | | | | | | |
| 2,200 pF | 222 | F G J K M | FB | FB | FB | FB | FC | FG | | | | | | | | | | | | |
| 2,400 pF | 242 | F G J K M | FB | FB | FB | FB | FC | FC | | | | | | | | | | | | |
| 2,700 pF | 272 | F G J K M | FB | FB | FB | FB | FC | FC | | | | | | | | | | | | |
| 3,000 pF | 302 | F G J K M | FB | FB | FB | FB | FC | FF | | | | | | | | | | | | |
| 3,300 pF | 332 | F G J K M | FB | FB | FB | FB | FF | FF | | | | | | | | | | | | |
| 3,600 pF | 362 | F G J K M | FB | FB | FB | FB | FF | FF | | | | | | | | | | | | |
| 3,900 pF | 392 | F G J K M | FB | FB | FB | FB | FF | FF | | | | | | | | | | | | |
| 4,300 pF | 432 | F G J K M | FB | FB | FB | FB | FF | FF | | | | | | | | | | | | |
| 4,700 pF | 472 | F G J K M | FF | FF | FF | FF | FG | FG | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | FB | FB | FB | FB | FG | FG | | | | | | | | | | | | |
| 5,600 pF | 562 | F G J K M | FB | FB | FB | FB | FG | FG | | | | | | | | | | | | |
| 6,200 pF | 622 | F G J K M | FB | FB | FB | FB | FG | | | | | | | | | | | | | |
| 6,800 pF | 682 | F G J K M | FB | FB | FB | FB | FG | | | | | | | | | | | | | |
| 7,500 pF | 752 | F G J K M | FC | FC | FC | FC | FC | | | | | | | | | | | | | |
| 8,200 pF | 822 | F G J K M | FC | FC | FC | FC | FC | | | | | | | | | | | | | |
| 9,100 pF | 912 | F G J K M | FE | FE | FE | FE | FE | | | | | | | | | | | | | |
| 10,000 pF | 103 | F G J K M | FF | FF | FF | FF | FF | | | | | | | | | | | | | |
| 12,000 pF | 123 | F G J K M | FG | FG | FG | FG | FB | | | | | | | | | | | | | |
| 15,000 pF | 153 | F G J K M | FG | FG | FG | FG | FB | | GB | GB | GB | GB | GB | | | | | | | |
| 18,000 pF | 183 | F G J K M | FB | FB | FB | FB | FB | | GB | GB | GB | GB | GB | | | | | | | |
| 22,000 pF | 223 | F G J K M | FB | FB | FB | FB | FB | | GB | GB | GB | GB | GB | | | | | | | |
| 27,000 pF | 273 | F G J K M | FB | FB | FB | FB | FB | | GB | GB | GB | GB | GB | | | | | | | |
| 33,000 pF | 333 | F G J K M | FB | FB | FB | FB | FB | | GB | GB | GB | GB | GB | | | | | | | |
| 39,000 pF | 393 | F G J K M | FB | FB | FB | FB | FE | | GB | GB | GB | GB | GB | | | | | | | |
| 47,000 pF | 473 | F G J K M | FB | FB | FB | FB | FE | | GB | GB | GB | GB | GB | | | | | | | |
| 56,000 pF | 563 | F G J K M | FB | FB | FB | FB | FF | | GB | GB | GB | GB | GB | | | | | | | |
| 68,000 pF | 683 | F G J K M | FB | FB | FB | FC | FG | | GB | GB | GB | GB | GB | | | | | | | |
| 82,000 pF | 823 | F G J K M | FC | FC | FC | FF | FH | | GB | GB | GB | GB | GB | | | | | | | |
| 0.10 µF | 104 | F G J K M | FE | FE | FE | FG | FM | | GB | GB | GB | GB | GD | | | | | | | |
| 0.12 µF | 124 | F G J K M | FG | FG | FG | FH | | | GB | GB | GB | GB | GH | | | | | | | |
| 0.15 µF | 154 | F G J K M | FH | FH | FH | FM | | | GD | GD | GD | GD | GN | | | | | | | |
| 0.18 µF | 184 | F G J K M | | | | | | | GH | GH | GH | GH | | | | | | | | |
| 0.22 µF | 224 | F G J K M | | | | | | | GK | GK | GK | GK | | | | | | | | |
| 0.47 µF | 474 | F G J K M | | | | | | | | | | | | | JJ | JJ | JJ | JJ | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 | 10 | 16 | 25 | 50 | 100 | 200 |
| | | Voltage Code | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 | 8 | 4 | 3 | 5 | 1 | 2 |
| | | Case Size / Series | C1210H | | | | | | C1812H | | | | | | C2220H | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts..*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| BB | 0402 | 0.50 ± 0.05 | 10,000 | 50,000 | 0 | 0 |
| CF | 0603 | 0.80 ± 0.07 | 4,000 | 15,000 | 0 | 0 |
| DN | 0805 | 0.78 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DP | 0805 | 0.90 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DE | 0805 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4,000 | 10,000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EE | 1206 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FB | 1210 | 0.78 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FC | 1210 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FF | 1210 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JJ | 2220 | 2.20 ± 0.15 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | | Loose Packaging | | Secure Packaging | |
|---|---|---|---|---|---|---|
| | | | Bulk Bag (default) | | 2” x 2” Waffle Pack/Tray[3] | |
| Packaging C-Spec[1] | | | N/A[2] | | 7282 / 7292 | |
| Case Size | | Chip Thickness (mm) | Packaging Quantities (pieces/unit packaging) | | | |
| EIA (in) | Metric (mm) | | Minimum | Maximum | Minimum | Maximum |
| 0402 | 1005 | All | 1 | 50,000 | 1 | 368 |
| 0603 | 1608 | | | | | 368 |
| 0805 | 2012 | | | | | 100 |
| 1206 | 3216 | ≤ 1.25 (nominal) | | | | 126 |
| 1206 | 3216 | > 1.25 (nominal) | | | | 50 |
| 1210 | 3225 | All | | | | 80 |
| 1808 | 4520 | | | 20,000 | | 50 |
| 1812 | 4532 | | | | | 42 |
| 1825 | 4564 | | | | | 20 |
| 2220 | 5650 | | | | | 20 |
| 2225 | 5664 | | | | | 20 |

*[1] The "Packaging C-Spec" is a 4-digit code which identifies the packaging type. When ordering, the proper code must be included in the 15th through 18th character positions of the ordering code. See "Ordering Information" section of this document for further details. Product ordered without a packaging C-Spec will default to our standard " bulk bag" packaging.*

*[2] A packaging C-Spec (see note 1 above) is not required For "bulk bag" packaging (excluding Anti-Static Bulk Bag). The 15th through 18th character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "bulk bag" packaging.*

*[3] Also commonly referred to as “Chip Carrier” or “Molded Tray”. All tray packaging options offer static protection.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |

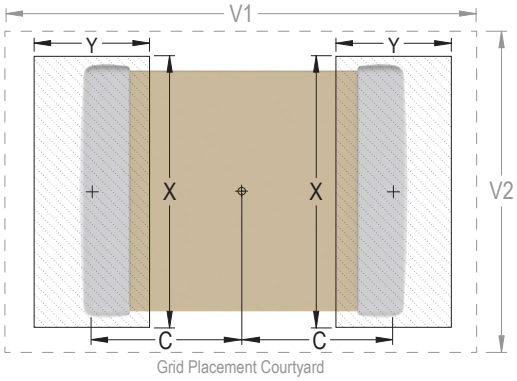
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

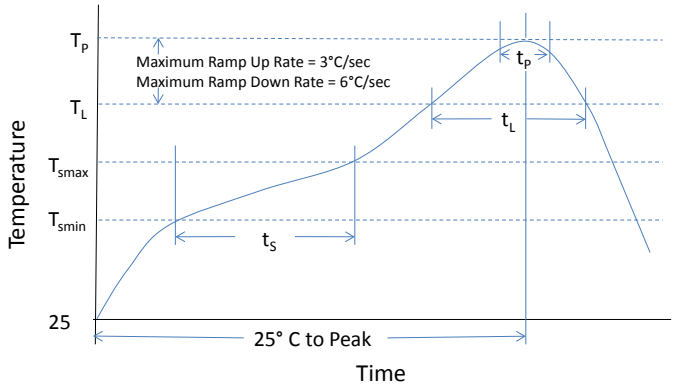
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| High Temperature Life | 200°C rated voltage 1,000 hours |
| Load Humidity | 85°C /85%RH rated voltage 1,000 hours |
| Low Voltage Humidity | 85°C /85%RH, 1.5 V, 1,000 hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical, OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

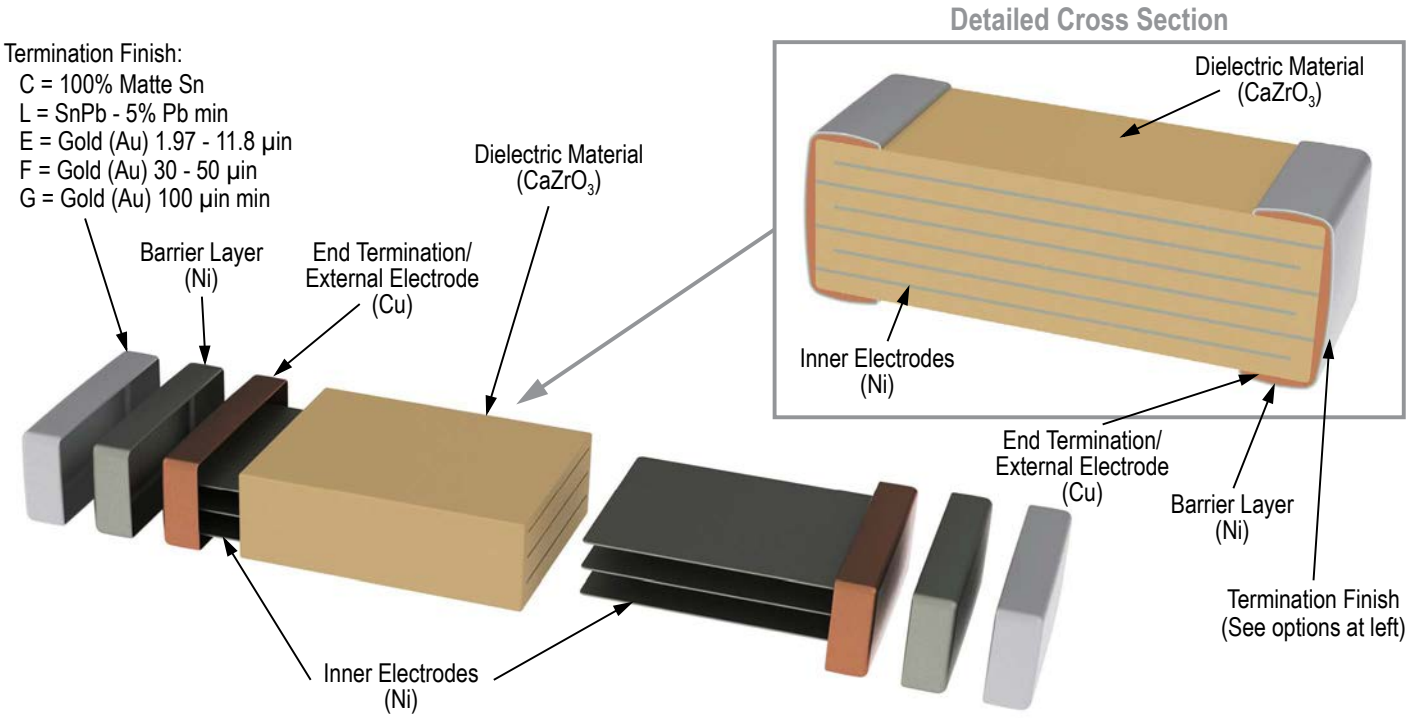
Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40°C and maximum storage humidity not exceed 70% relative humidity. In addition, temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within the time frame outlined in the table below:

| Termination Finish | Termination Finish Ordering Code[1] | Storage Life |
|---|---|---|
| 100% Matte Tin (Sn) | C | 1.5 years upon receipt |
| SnPb (5% Pb min.) | L | 1.5 years upon receipt |
| Gold (Au) 1.97 – 11.8 µin[2] | E | 6 months upon receipt[2] |
| Gold (Au) 30 – 50 µin | F | 1.5 years upon receipt |
| Gold (Au) 100 µin min. | G | 1.5 years upon receipt |

*[1] The fourteenth (14th) character position of the KEMET part number is assigned to identify and/or define the termination finish. For more information, see "Ordering Information" section of this document.*

*[2] Gold plating option "E" devices should remain in its factory sealed moisture sensitive packaging during storage. If the factory sealed packaging is disturbed please store any remaining packaged components in a dry box container to prevent oxidation of the termination finish.*

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

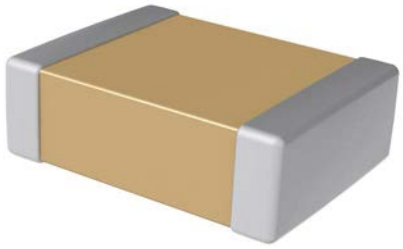
# HV-HT Series, High Voltage, High Temperature 200°C, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade)

## Overview

KEMET's High Voltage-High Temperature (HV-HT) series surface mount C0G Multilayer Ceramic Capacitors (MLCCs) are constructed of a robust and proprietary base metal electrode (BME) dielectric system that offers industry-leading performance at extreme temperatures. These surface mountable devices feature a 200ºC maximum operating temperature and are specifically designed to withstand the demands of harsh industrial environments such as oil exploration and automotive/avionics engine compartment circuitry. They also offer higher and more uniform breakdown voltage performance than competitive products, resulting in increased yields in customer field applications. When dealing with expensive high temperature circuitry and systems, higher yields can quickly result in significant cost savings.

KEMET's HV-HT series MLCCs are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. They exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +200°C. In addition, these capacitors exhibit high insulation resistance with low dissipation factor at elevated temperatures up to 200°C. They also exhibit low ESR at high frequencies and offer superior volumetric efficiency over competitive high temperature precious metal electrode (PME) and base metal electrode (BME) dielectric system devices.

These devices are Lead (Pb)-Free, RoHS and REACH compliant without the need of any exemptions.



## Ordering Information

| C | 2225 | H | 393 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225<br>2824<br>3040<br>3640<br>4540 | H = High Temperature (200°C) | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Gold(Au) termination finish options are not available on 2824, 3040, 3640 and 4540 case sizes.*



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## Packaging C-Spec Ordering Options Table

| Termination Finish Options | Packaging Type/Options | Packaging Ordering Code (C-Spec) |
|---|---|---|
| **Standard Packaging – Unmarked[3]** | | |
| C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Bulk Bag | Blank[1] |
| | Waffle Tray[2] | 7292 |
| | 7" Tape & Reel | TU |
| | 13" Reel | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| | 7" Tape & Reel/2 mm pitch[4] | 7081 |
| | 7" Tape & Reel – 50 pcs | T050 |
| | 7" Tape & Reel – 100 pcs | T100 |
| | 7" Tape & Reel – 250 pcs | T250 |
| | 7" Tape & Reel – 500 pcs | T500 |
| | 7" Tape & Reel – 1,000 pcs | T1K0 |
| **Moisture Sensitive Packaging[5] – Unmarked[3]** | | |
| E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Waffle Tray[2] | 7282 |
| | 7" Tape & Reel | 7130 |
| | 7" Tape & Reel – 50 pcs | Contact KEMET[6] |
| | 7" Tape & Reel – 100 pcs | |
| | 7" Tape & Reel – 250 pcs | |
| | 7" Tape & Reel – 500 pcs | |
| | 7" Tape & Reel – 1,000 pcs | |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] "Bulk Bag" packaging option is not available for Gold (Au) termination finish options and case sizes larger than 2225 (5664 Metric).*

*[2] "Waffle Tray" packaging option is not available for case sizes larger than 2225 (5664 Metric).*

*[3] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*

*3 Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "T1K0" packaging option, 1812 thru 2225 case size devices with chip thickness of ≥ 1.9mm (nominal) may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*

*[4] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[5] Moisture sensitive packaging is required for Gold (Au) termination option "E" (1.97 – 11.8 µin)*

*[6] Additional reeling or packaging options may be available. Contact KEMET for details.*

## Benefits

- Operating temperature range of −55°C to +200°C
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220, 2225, 2824, 3040, 3640 and 4540 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, and 2 KV
- Capacitance offerings ranging from 1 pF to 0.150 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR & ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)
- Gold (Au), Tin/Lead (Sn/Pb) and 100% pure matte Tin (Sn) termination finishes available

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling, DC blocking and voltage multiplier circuits in extreme environments such as down-hole exploration, aerospace engine compartments and geophysical probes. Markets include power supply, HID lighting, industrial equipment/control, automotive, aerospace, and munitions.

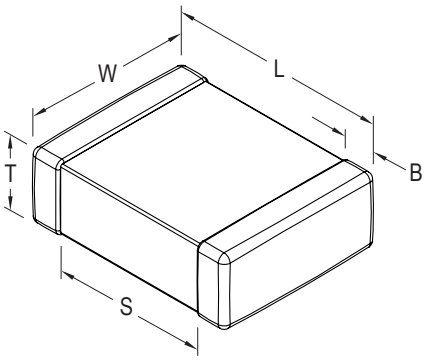
## Qualification/Certification

High temperature (200ºC) Industrial grade products meet or exceed the requirements outlined in Table 4, Performance & Reliability. Qualification packages are available for review and download on our website at www.kemet.com/hightemp

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | "Solder Wave or Solder Reflow" |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2824 | 7260 | 7.10 (.280) ± 0.40 (.016) | 6.10 (.240) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3040 | 7610 | 7.60 (.300) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3640 | 9210 | 9.10 (.358) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 4540 | - | 11.40 (.449) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C (up to +200°C) |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000 V<br>120% of rated voltage for voltage rating of ≥ 1000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 secs @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ± 50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D F G J K M | DG | DG | DG | | | | | | | | | | | LB | LB | LB | LB | LB |
| 10 pF - 47pF* | 100 - 470* | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 51 pF | 510 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 56 pF | 560 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 62 pF | 620 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 68 pF | 680 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 75 pF | 750 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 82 pF | 820 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 91 pF | 910 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 100 pF | 101 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 110 pF | 111 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 120 pF | 121 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 130 pF | 131 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 150 pF | 151 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 160 pF | 161 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 180 pF | 181 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 200 pF | 201 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 220 pF | 221 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 240 pF | 241 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LB | LC |
| 270 pF | 271 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 300 pF | 301 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 330 pF | 331 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 360 pF | 361 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 390 pF | 391 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 430 pF | 431 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 470 pF | 471 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 510 pF | 511 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 560 pF | 561 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 620 pF | 621 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 680 pF | 681 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 750 pF | 751 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 820 pF | 821 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 910 pF | 911 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LA | |
| 1,000 pF | 102 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LB | |
| 1,100 pF | 112 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LB | |
| 1,200 pF | 122 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LC | |
| 1,300 pF | 132 | F G J K M | | | | EF | EG | | | | FM | FS | FS | | | LC | LC | LC | LC | |
| 1,500 pF | 152 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | LC | |
| 1,600 pF | 162 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 2,000 pF | 202 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,200 pF | 222 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,400 pF | 242 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LB | | |
| 2,700 pF | 272 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LC | | |
| 3,000 pF | 302 | F G J K M | | | | | | | | | FS | FL | | | | LA | LA | | | |
| 3,300 pF | 332 | F G J K M | | | | | | | | | FS | FM | | | | LA | LA | | | |
| 3,600 pF | 362 | F G J K M | | | | | | | | | FL | FM | | | | LA | LB | | | |
| 3,900 pF | 392 | F G J K M | | | | | | | | | FL | FY | | | | LA | LB | | | |
| 4,300 pF | 432 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| 4,700 pF | 472 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

## Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | |
| 5,600 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| 8,200 pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 pF - 47pF* | 100 - 470* | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 51 pF | 510 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 56 pF | 560 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 62 pF | 620 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 68 pF | 680 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 75 pF | 750 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 82 pF | 820 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 91 pF | 910 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 100 pF | 101 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 110 pF | 111 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 120 pF | 121 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 130 pF | 131 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 150 pF | 151 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 160 pF | 161 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 180 pF | 181 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 200 pF | 201 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 220 pF | 221 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 240 pF | 241 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 270 pF | 271 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 300 pF | 301 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 330 pF | 331 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 360 pF | 361 | F | G | J | K | M | GK | GK | GK | GK | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 390 pF | 391 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 430 pF | 431 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 470 pF | 471 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KF | KF | KF | KF | KE |
| 510 pF | 511 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 560 pF | 561 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 620 pF | 621 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 680 pF | 681 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE |
| 750 pF | 751 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 820 pF | 821 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 910 pF | 911 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,000 pF | 102 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,100 pF | 112 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,200 pF | 122 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,300 pF | 132 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,500 pF | 152 | F | G | J | K | M | GK | GK | GK | GK | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,600 pF | 162 | F | G | J | K | M | GK | GK | GK | GK | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 1,800 pF | 182 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 2,000 pF | 202 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KE |
| 2,200 pF | 222 | F | G | J | K | M | GK | GK | GK | GO | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KF |
| 2,400 pF | 242 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HJ | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 2,700 pF | 272 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,000 pF | 302 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,300 pF | 332 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KE | KE | KE | KJ |
| 3,600 pF | 362 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 3,900 pF | 392 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HJ | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 4,300 pF | 432 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JK | | KE | KF | KF | KF | |
| 4,700 pF | 472 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JN | | KE | KF | KF | KH | |
| 6,200pF | 622 | F G J K M | GH | GK | | | | HG | HE | HG | | | JK | JE | JE | JN | | KE | KF | KF | KJ | |
| 6,800pF | 682 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | JN | | KE | KF | KF | KJ | |
| 7,500pF | 752 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | | | KF | KE | KF | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | HG | HE | HJ | | | JK | JE | JL | | | KF | KE | KF | | |
| 9,100 pF | 912 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 10,000 pF | 103 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 12,000 pF | 123 | | GO | | | | | HE | HG | | | | JE | JK | JN | | | KE | KE | KH | | |
| 15,000 pF | 153 | | GO | | | | | HE | HJ | | | | JE | JL | | | | KE | KF | KJ | | |
| 18,000 pF | 183 | | | | | | | HG | HK | | | | JE | JL | | | | KE | KH | | | |
| 22,000 pF | 223 | | | | | | | HJ | | | | | JK | JN | | | | KF | KJ | | | |
| 27,000 pF | 273 | | | | | | | HJ | | | | | JL | JN | | | | KF | KJ | | | |
| 33,000 pF | 333 | | | | | | | HK | | | | | JN | | | | | KH | | | | |
| 39,000 pF | 393 | | | | | | | | | | | | | | | | | KJ | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1C – Capacitance Range/Selection Waterfall (2824 – 4540 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 - 2,000 pF | 100 - 202 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,400 pF | 242 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,000 pF | 302 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J | K | M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,600 pF | 362 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J | K | M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,300 pF | 432 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J | K | M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,100 pF | 512 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J | K | M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,200 pF | 622 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J | K | M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 7,500 pF | 752 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J | K | M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 9,100 pF | 912 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J | K | M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J | K | M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J | K | M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J | K | M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J | K | M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J | K | M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J | K | M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J | K | M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J | K | M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J | K | M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J | K | M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J | K | M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.1 µF | 104 | J | K | M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J | K | M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J | K | M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | | Loose Packaging | | Secure Packaging | |
|---|---|---|---|---|---|---|
| | | | Bulk Bag (default) | | 2” x 2” Waffle Pack/Tray[3] | |
| Packaging C-Spec[1] | | | N/A[2] | | 7282 / 7292 | |
| Case Size | | Chip Thickness (mm) | Packaging Quantities (pieces/unit packaging) | | | |
| EIA (in) | Metric (mm) | | Minimum | Maximum | Minimum | Maximum |
| 0402 | 1005 | All | 1 | 50,000 | 1 | 368 |
| 0603 | 1608 | | | | | 368 |
| 0805 | 2012 | | | | | 100 |
| 1206 | 3216 | ≤ 1.25 (nominal) | | | | 126 |
| 1206 | 3216 | > 1.25 (nominal) | | | | 50 |
| 1210 | 3225 | All | | | | 80 |
| 1808 | 4520 | | | 20,000 | | 50 |
| 1812 | 4532 | | | | | 42 |
| 1825 | 4564 | | | | | 20 |
| 2220 | 5650 | | | | | 20 |
| 2225 | 5664 | | | | | 20 |

*[1] The "Packaging C-Spec" is a 4-digit code which identifies the packaging type. When ordering, the proper code must be included in the 15th through 18th character positions of the ordering code. See "Ordering Information" section of this document for further details. Product ordered without a packaging C-Spec will default to our standard " bulk bag" packaging.*

*[2] A packaging C-Spec (see note 1 above) is not required For "bulk bag" packaging (excluding Anti-Static Bulk Bag). The 15th through 18th character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "bulk bag" packaging.*

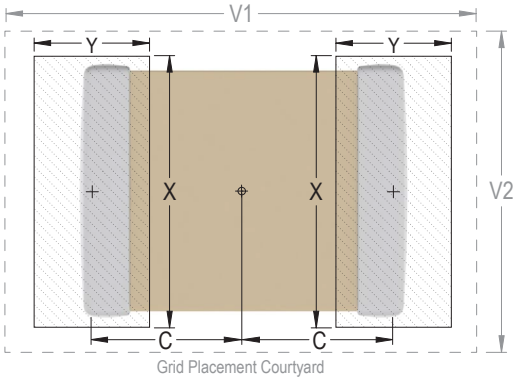
*[3] Also commonly referred to as “Chip Carrier” or “Molded Tray”. All tray packaging options offer static protection.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

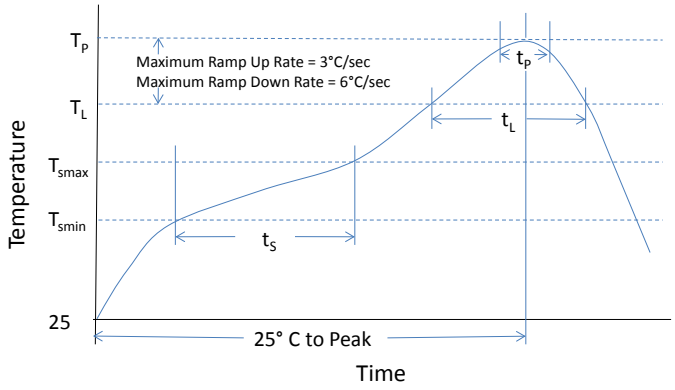
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| Load Humidity | 85°C/85%RH and 200 VDC maximum, 1,000 Hours |
| Low Voltage Humidity | 85°C/85%RH, 1.5V, 1,000 Hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 Cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical – OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes, 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

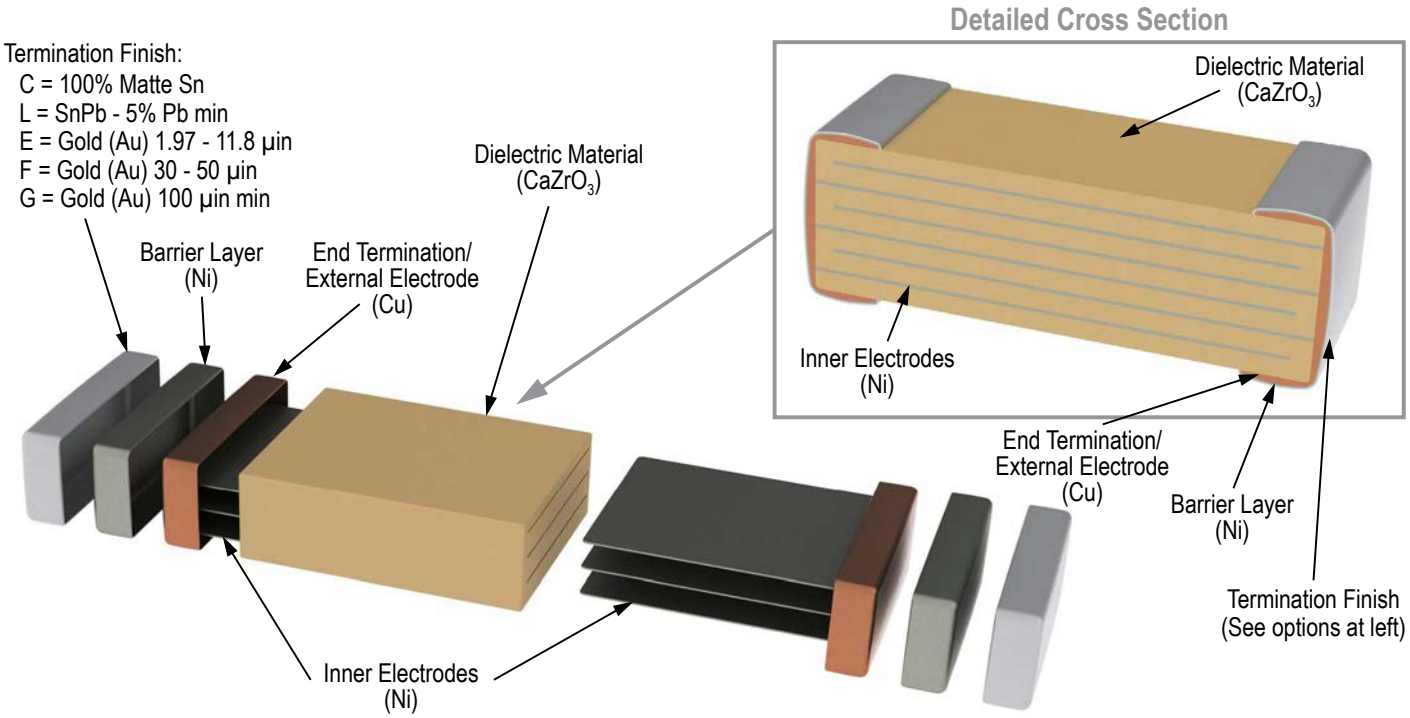
Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40°C and maximum storage humidity not exceed 70% relative humidity. In addition, temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within the time frame outlined in the table below:

| Termination Finish | Termination Finish Ordering Code[1] | Storage Life |
|---|---|---|
| 100% Matte Tin (Sn) | C | 1.5 years upon receipt |
| SnPb (5% Pb min.) | L | 1.5 years upon receipt |
| Gold (Au) 1.97 – 11.8 µin[2] | E | 6 months upon receipt[2] |
| Gold (Au) 30 – 50 µin | F | 1.5 years upon receipt |
| Gold (Au) 100 µin min. | G | 1.5 years upon receipt |

*[1] The fourteenth (14th) character position of the KEMET part number is assigned to identify and/or define the termination finish. For more information, see "Ordering Information" section of this document.*

*[2] Gold plating option "E" devices should remain in its factory sealed moisture sensitive packaging during storage. If the factory sealed packaging is disturbed please store any remaining packaged components in a dry box container to prevent oxidation of the termination finish.*

## Construction (Typical)




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Flexible Termination System (FT-CAP), Ultra-Stable X8R Dielectric, 25 – 100 VDC (Commercial & Automotive Grade)

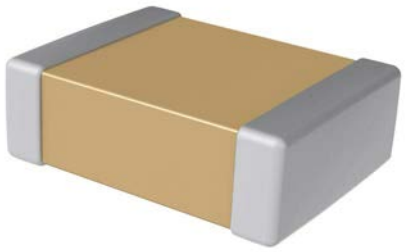
## Overview

KEMET's Flexible Termination (FT-CAP) Multilayer Ceramic Capacitor in Ultra-Stable X8R dielectric incorporates a unique, flexible termination system that is integrated with KEMET's standard termination materials. A conductive silver epoxy is utilized between the base metal and nickel barrier layers of KEMET's standard termination system in order to establish pliability while maintaining terminal strength, solderability and electrical performance. This technology was developed in order to address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible termination technology inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures.

Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems. FT-CAP complements KEMET's Open Mode, Floating Electrode (FE-CAP), Floating Electrode with Flexible Termination (FF-CAP), and KEMET Power Solutions (KPS) product lines by providing a complete portfolio of flex mitigation solutions.

Combined with the stability of KEMET's Ultra-Stable high temperature dielectric technology, these flex-robust devices are RoHS Compliant, offer up to 5 mm of flex-bend capability and feature a 150°C maximum operating temperature. Ultra-Stable X8R dielectric offers the same temperature capability as conventional X8R but without the capacitance loss due to applied DC voltage. These devices exhibit no change in capacitance with respect to voltage and boast a minimal change in capacitance with reference to ambient temperature. They are also suitable replacements for higher capacitance and larger footprint devices that fail to offer capacitance stability. Capacitance change with respect to temperature is limited to ±15% from −55°C to +150°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1206 | X | 104 | J | 3 | H | A | C | AUTO |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Reated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1812 | X = Flexible Termination | Two significant digits + number of zeros. | F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | 3 = 25<br>5 = 50<br>1 = 100 | H = Ultra-Stable X8R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*

*[1] SnPb termination finish option is not available on Automotive Grade product.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade[1]** | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade[3]** | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- −55°C to +150°C operating temperature range
- Superior flex performance (up to 5 mm)
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, and 1812 case sizes
- DC voltage ratings of 25 V, 50 V, and 100 V
- Capacitance offerings ranging from 430 pF to 0.22 µF
- Available capacitance tolerances of ±1%, ±2%, ±5%, ±10%, and ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Non-polar device, minimizing installation concerns
- Commercial & Automotive (AEC–Q200) Grades available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include decoupling, bypass, filtering and transient voltage suppression in critical and safety relevant circuits without (integrated) current limitation including those subject to high levels of board flexure or temperature cycling.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

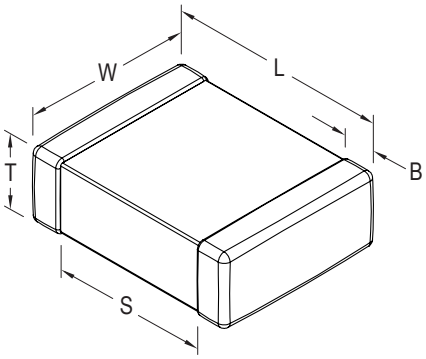
- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (0.063) ± 0.17 (0.007) | 0.80 (0.032) ± 0.15 (0.006) | See Table 2 for Thickness | 0.45 (0.018) ±0.15 (0.006) | 0.58 (0.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (0.079) ± 0.30 (0.012) | 1.25 (0.049) ± 0.30 (0.012) | | 0.50 (0.02) ±0.25 (0.010) | 0.75 (0.030) | |
| 1206 | 3216 | 3.30 (0.130) ± 0.40 (0.016) | 1.60 (0.063) ± 0.35 (0.013) | | 0.60 (0.024) ±0.25 (0.010) | N/A | |
| 1210 | 3225 | 3.30 (0.130) ± 0.40 (0.016) | 2.60 (0.102) ± 0.30 (0.012) | | 0.60 (0.024) ± 0.25 (0.010) | | Solder Reflow Only |
| 1812 | 4532 | 4.50 (0.178) ± 0.40 (0.016) | 3.20 (0.126) ± 0.30 (0.012) | | 0.70 (0.028) ±0.35 (0.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 ±0.2 Vrms if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 ±0.2 Vrms if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| Ultra-Stable X8R | All | All | 3.0 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | | | | C0603X | | | C0805X | | | C1206X | | | C1210X | | | C1812X | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | |
| 430 pF | 431 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 470 pF | 471 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 510 pF | 511 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 560 pF | 561 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 620 pF | 621 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 680 pF | 681 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 750 pF | 751 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 820 pF | 821 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 910 pF | 911 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,000 pF | 102 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,100 pF | 112 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,200 pF | 122 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,300 pF | 132 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,500 pF | 152 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,600 pF | 162 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 1,800 pF | 182 | F | G | J | K | M | CJ | CJ | CJ | | | | | | | | | | | |
| 2,000 pF | 202 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,200 pF | 222 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,400 pF | 242 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 2,700 pF | 272 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,000 pF | 302 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,300 pF | 332 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,600 pF | 362 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 3,900 pF | 392 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 4,300 pF | 432 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 4,700 pF | 472 | F | G | J | K | M | CJ | CJ | CJ | DR | DR | DR | | | | | | | | |
| 5,100 pF | 512 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 5,600 pF | 562 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 6,200 pF | 622 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | | | | | | | | |
| 6,800 pF | 682 | F | G | J | K | M | CJ | CJ | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 7,500 pF | 752 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 8,200 pF | 822 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 9,100 pF | 912 | F | G | J | K | M | CJ | | | DR | DR | DR | EQ | EQ | EQ | | | | | |
| 10,000 pF | 103 | F | G | J | K | M | CJ | | | DR | DR | DD | EQ | EQ | EQ | | | | | |
| 12,000 pF | 123 | F | G | J | K | M | | | | DR | DR | DS | EQ | EQ | EQ | FN | FN | FN | | |
| 15,000 pF | 153 | F | G | J | K | M | | | | DR | DD | DG | EQ | EQ | EQ | FN | FN | FN | GB | GB |
| 18,000 pF | 183 | F | G | J | K | M | | | | DR | DD | | EQ | EQ | EQ | FN | FN | FN | GB | GB |
| 22,000 pF | 223 | F | G | J | K | M | | | | DD | DF | | EQ | EQ | ER | FN | FN | FN | GB | GB |
| 27,000 pF | 273 | F | G | J | K | M | | | | DF | | | EQ | EQ | ET | FN | FN | FN | GB | GB |
| 33,000 pF | 333 | F | G | J | K | M | | | | DG | | | EQ | EQ | ET | FN | FN | FN | GB | GB |
| 47,000 pF | 473 | F | G | J | K | M | | | | | | | ER | ET | EH | FN | FN | FE | GB | GB |
| 56,000 pF | 563 | F | G | J | K | M | | | | | | | ES | EF | EH | FN | FN | FA | GB | GB |
| 68,000 pF | 683 | F | G | J | K | M | | | | | | | EF | EH | | FN | FQ | FZ | GB | GB |
| 82,000 pF | 823 | F | G | J | K | M | | | | | | | EH | EH | | FQ | FA | FU | GB | GB |
| 100,000 pF | 104 | F | G | J | K | M | | | | | | | EH | | | FE | FZ | FM | GB | GD |
| 120,000 pF | 124 | F | G | J | K | M | | | | | | | | | | FZ | FU | | GB | GH |
| 150,000 pF | 154 | F | G | J | K | M | | | | | | | | | | FU | FM | | GD | GN |
| 180,000 pF | 184 | F | G | J | K | M | | | | | | | | | | FJ | | | GH | |
| 220,000 pF | 224 | F | G | J | K | M | | | | | | | | | | | | | GK | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | | | | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 25 | 50 | 100 | 50 | 100 |
| | | Voltage Code | | | | | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 3 | 5 | 1 | 5 | 1 |
| | | Case Size/Series | | | | | C0603X | | | C0805X | | | C1206X | | | C1210X | | | C1812X | |

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CJ | 0603 | 0.80 ± 0.15 | 4,000 | 15,000 | 0 | 0 |
| DR | 0805 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| DD | 0805 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| DS | 0805 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| DF | 0805 | 1.10 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4,000 | 10,000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| ET | 1206 | 1.10 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EH | 1206 | 1.60 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FN | 1210 | 0.78 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FQ | 1210 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FA | 1210 | 1.10 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FJ | 1210 | 1.85 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GD | 1812 | 1.25 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

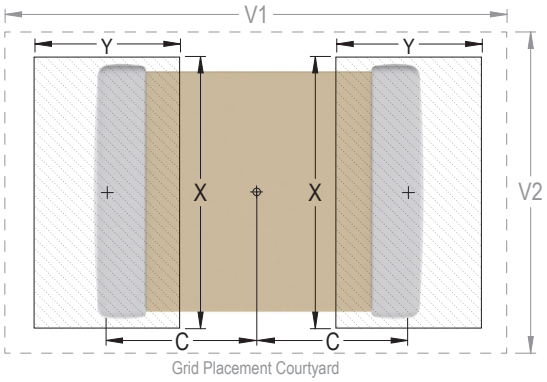
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351 (mm)

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805, and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0402 | 1005 | 0.50 | 0.72 | 0.72 | 2.20 | 1.20 | 0.45 | 0.62 | 0.62 | 1.90 | 1.00 | 0.40 | 0.52 | 0.52 | 1.60 | 0.80 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1210[1] | 3225 | 1.50 | 1.60 | 2.90 | 5.60 | 3.90 | 1.40 | 1.40 | 2.80 | 4.70 | 3.30 | 1.30 | 1.20 | 2.70 | 4.00 | 3.00 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |

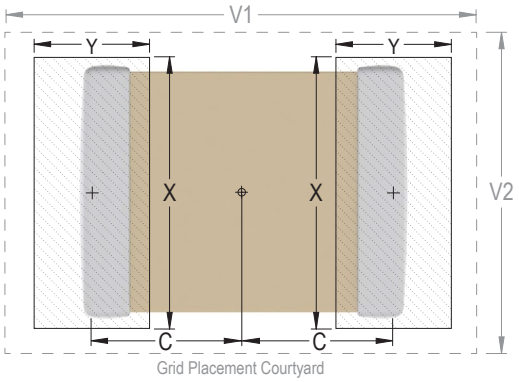
[1] *Only for capacitance values ≥ 22 µF*

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*

***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*

***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

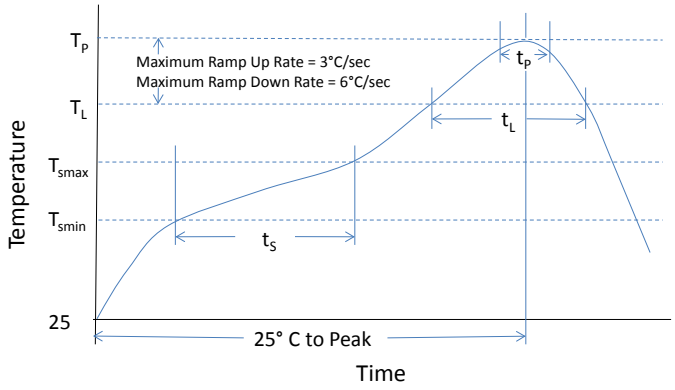
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



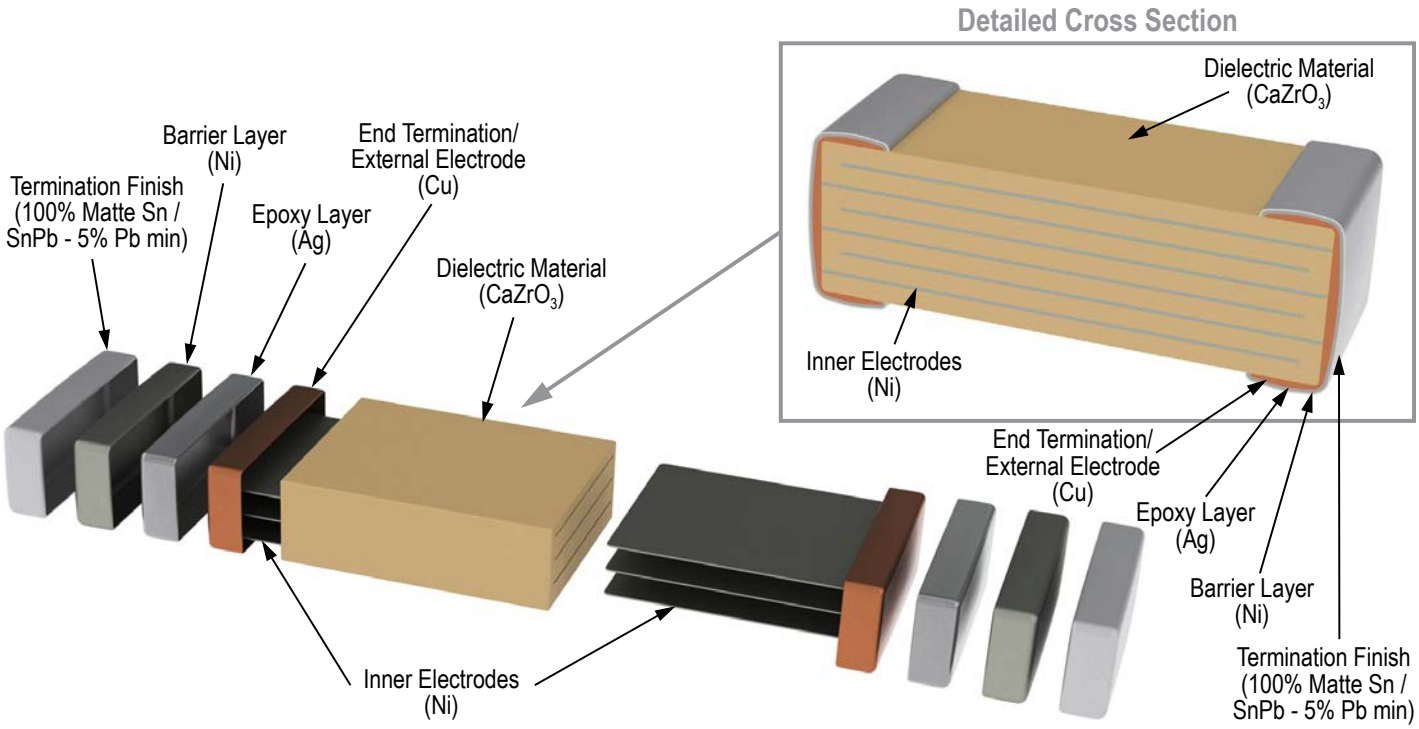
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85%RH and rated voltage. Add 100K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours. +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA–198 | 1,000 hours at 150°C with 2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS HT Series, High Temperature 150°C, X8L Dielectric, 10 – 50 VDC (Commercial & Automotive Grade)

## Overview

KEMET Power Solutions High Temperature (KPS HT) stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series capacitors are environmentally friendly and in compliance with RoHS legislation. Combined with X8L dielectric, these devices are capable of reliable operation up to 150°C and are well suited for high temperature filtering, bypass and decoupling applications.

X8L exhibits a predictable change in capacitance with respect to time and voltage, and boasts a minimal change in capacitance with reference to ambient temperature up to 125°C. Beyond 125°C, X8L displays a wider variation in capacitance. Capacitance change is limited to ±15% from −55°C to +125°C and +15, -40% from 125°C to 150°C.

In addition to Commercial grade, Automotive grade devices are available and meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

## Benefits

- −55°C to +150°C operating temperature range
- Reliable and robust termination system
- EIA 1210 and 2220 case sizes
- DC voltage ratings of 10 V, 16 V, 25 V, and 50 V
- Capacitance offerings ranging from 0.47 µF up to 47 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings
- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability

## Ordering Information

| C | 2220 | C | 476 | M | 8 | N | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 1210<br>2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | 8 = 10<br>4 = 16<br>3 = 25<br>5 = 50 | N = X8L | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| **Commercial Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |
| **Automotive Grade** | |
| 7" Reel (Embossed Plastic Tape)/Unmarked | AUTO |
| 13" Reel (Embossed Plastic Tape)/Unmarked | AUTO7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

## Benefits

- Reduces audible, microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Tantalum and electrolytic alternative
- Commercial & Automotive (AEC-Q200) grades available

## Applications

Typical applications include smoothing circuits, DC/DC converters, power supplies (input/output filters), noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to extreme environments such as high temperature, high levels of board flexure and/or temperature cycling. Markets include industrial, aerospace, automotive, and telecom.

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

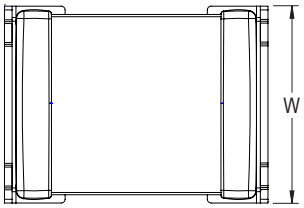
| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

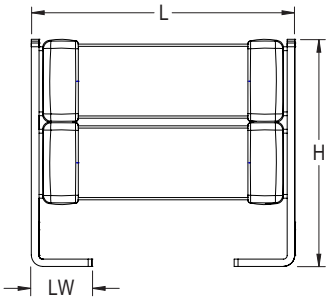
● Part Number specific PPAP available
○ Product family PPAP only

## Dimensions – Millimeters (Inches)

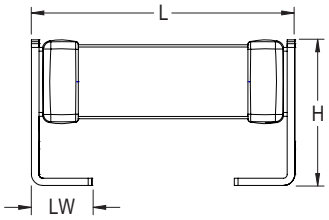
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Chip Stack | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 3.35 (.132) ±0.10 (.004) | 0.80 (.032) ±0.15 (.006) | Solder Reflow Only |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | |
| Double | 1210 | 3225 | 3.50 (.138) ±0.30 (.012) | 2.60 (.102) ±0.30 (.012) | 6.15 (.242) ±0.15 (.006) | 0.80 (.031) ±0.15 (.006) | |
| | 2220 | 5650 | 6.00 (.236) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +150°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% (−55°C to 125°C), +15, -40% (125°C to 150°C) |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 250% of rated voltage<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 3.5% ( ≤ 16V) and 2.5% ( ≥ 25V) |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 500 megohm microfarads or 10 GΩ<br>(Rated voltage applied for 120 ±5 seconds @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X8L | ≥ 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | ≤ 16 | | 5.0 | | |

## Table 1 – Capacitance Range/Selection Waterfall (1210 – 2220 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | |
| **Single Chip Stack** | | | | | | | | | | | | | | | | |
| 0.47 µF | 474 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 1.0 µF | 105 | | K | M | FV | FV | FV | FV | | | | | | | | |
| 2.2 µF | 225 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 3.3 µF | 335 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 4.7 µF | 475 | | K | M | FV | FV | FV | | | | JP | JP | JP | | | |
| 10 µF | 106 | | K | M | | | | | | | JP | JP | JP | | | |
| 15 µF | 156 | | K | M | | | | | | | JP | | | | | |
| 22 µF | 226 | | K | M | | | | | | | JP | | | | | |
| **Double Chip Stack** | | | | | | | | | | | | | | | | |
| 1.0 µF | 105 | | | M | FW | FW | FW | FW | | | | | | | | |
| 2.2 µF | 225 | | | M | FW | FW | FW | FW | | | | | | | | |
| 3.3 µF | 335 | | | M | FW | FW | FW | | | | | | | | | |
| 4.7 µF | 475 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 10 µF | 106 | | | M | FW | FW | FW | | | | JR | JR | JR | | | |
| 22 µF | 226 | | | M | | | | | | | JR | JR | JR | | | |
| 33 µF | 336 | | | M | | | | | | | JR | | | | | |
| 47 µF | 476 | | | M | | | | | | | JR | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 10 | 16 | 25 | 50 | 100 | 250 | 10 | 16 | 25 | 50 | 100 | 250 |
| | | Voltage Code | | | 8 | 4 | 3 | 5 | 1 | A | 8 | 4 | 3 | 5 | 1 | A |
| | | Case Size/Series | | | C1210C | | | | | | C2220C | | | | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

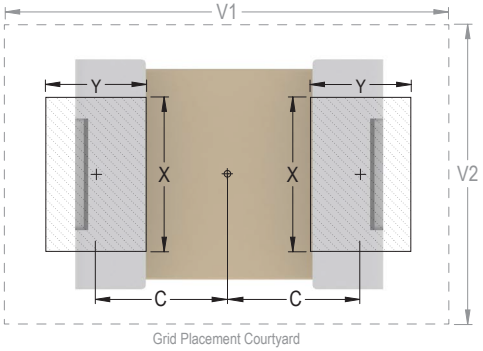
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| FV | 1210 | 3.35 ± 0.10 | 0 | 0 | 600 | 2,000 |
| FW | 1210 | 6.15 ± 0.15 | 0 | 0 | 300 | 1,000 |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

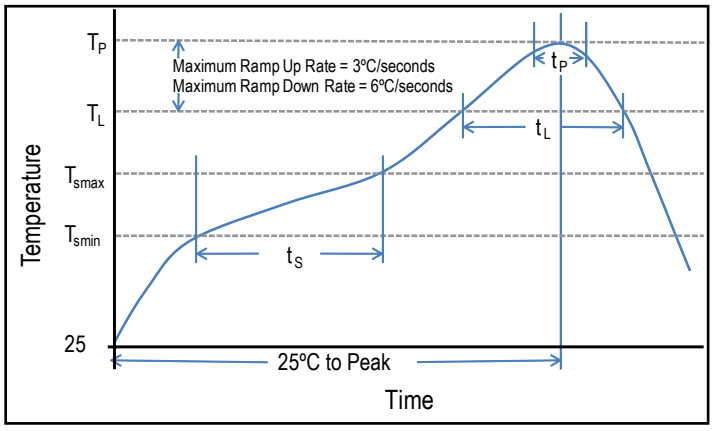
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



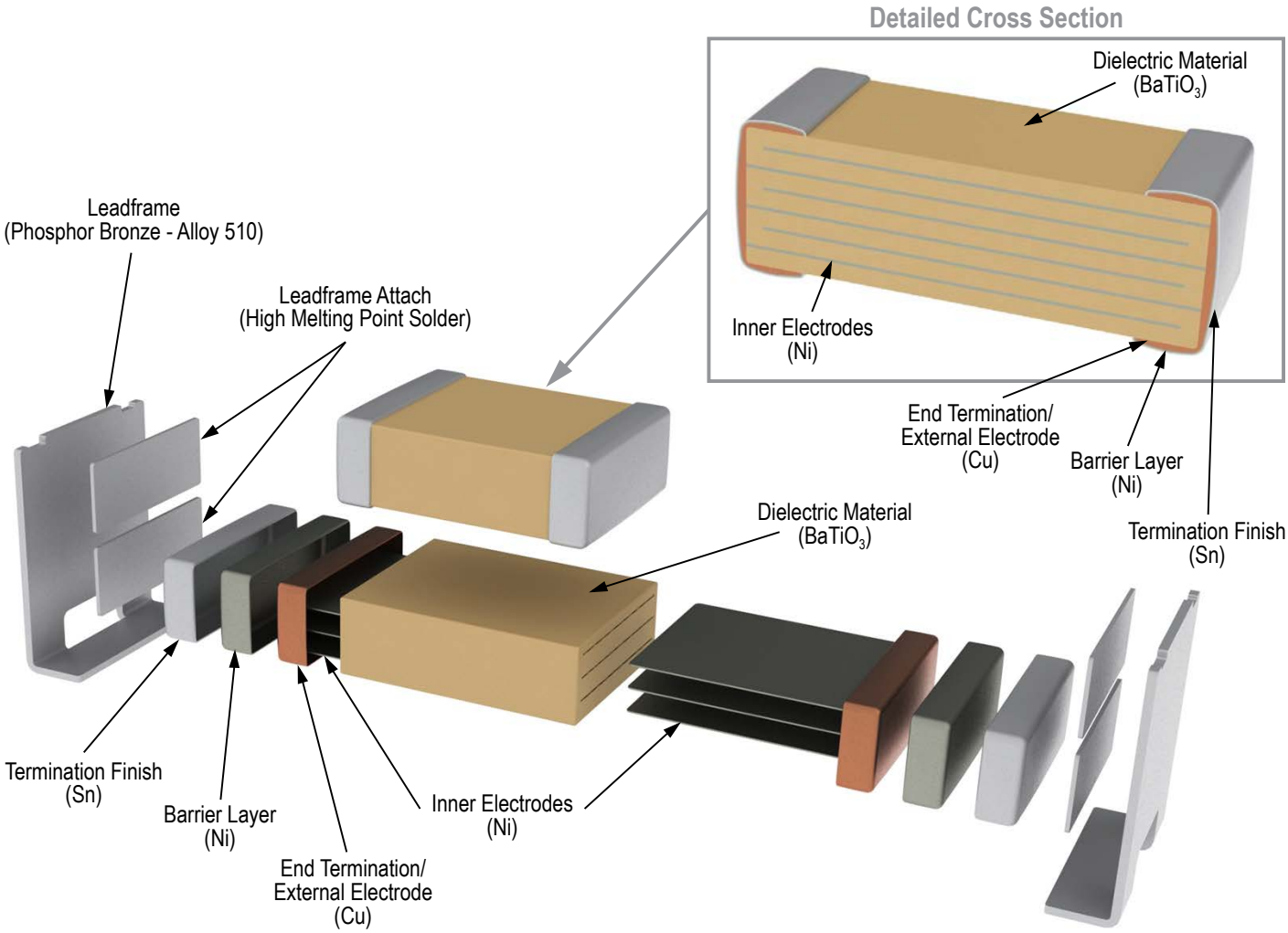
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +150°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and rated voltage. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+150°C. Note: Number of cycles required- 300, maximum transfer time- 20 seconds, Dwell time- 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 150°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB .031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Pulse Discharge, High Voltage, High Temperature 200°C C0G Dielectric, 1,000 VDC – 3,500 VDC (Industrial Grade)

## Overview

KEMET's Industrial Grade Pulse Discharge Series surface mount capacitors in C0G Dielectric deliver reliable high voltage and high temperature performance required for operation in harsh environments, specifically discharge circuitry. Constructed of a robust and proprietary base metal electrode (BME) dielectric system, these devices offer industry-leading performance relative to capacitance and case size. KEMET Pulse Discharge capacitors average greater than 30% higher breakdown voltage than competitive precious metal electrode (PME) devices with similar capacitance & voltage ratings.

Designed for down-hole oil exploration and perforation, these devices feature a 200°C maximum operating temperature. The Electronics Industries Alliance (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. Pulse Discharge series capacitors in C0G dielectric exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. These devices retain high insulation resistance with low dissipation factor at elevated temperatures up 200°C.

KEMET's Pulse Discharge surface mount MLCCs are manufactured in state-of-the-art ISO/TS 16949:2009 certified facilities and are proven to function reliably in harsh, high temperature and high humidity, down-hole environments.

## Ordering Information

| C | 2824 | H | 393 | K | U | G | W | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Dielectric Withstanding Voltage (VDC)[1] | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec)[3] |
| | 2824<br>3040<br>3640<br>4540 | H = High Temp (200°C) | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | D = 1,000<br>U = 1,250<br>G = 2,000<br>H = 3,000<br>V = 3,500 | G = C0G | W = Pulse Discharge | C = 100% Matte Sn<br>L = SnPb (5% Pb min.) | See "Packaging C-Spec Ordering Options Table" below |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor. See waterfall table for working voltage.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*

*[3] Additional reeling or packaging options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type/Options[1] | Packaging Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape)/Unmarked | TU |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7210 |
| Reel (Embossed Plastic Tape)/Unmarked - 50 pieces | T050 |
| Reel (Embossed Plastic Tape)/Unmarked - 100 pieces | T100 |
| Reel (Embossed Plastic Tape)/Unmarked - 250 pieces | T250 |
| Reel (Embossed Plastic Tape)/Unmarked - 500 pieces | T500 |
| Reel (Embossed Plastic Tape)/Unmarked - 1,000 pieces | T1K0 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*

*[2] Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "Txxx" packaging ordering codes (C-Specs) outlined above, product may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*

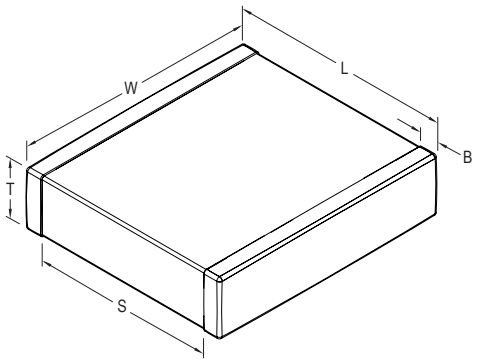
## Benefits

- Operating temperature range of −55°C to +200°C
- Lead (Pb)-Free, RoHS and REACH compliant
- Base metal technology
- Higher UVBD capability than competitive dielectric technologies
- Capacitance offerings ranging from 2.2 nF up to 150 nF
- Available capacitance tolerances of ±5%, ±10% or ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +200°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability

## Applications

Typical applications include high temperature discharge circuits for munitions and down-hole oil exploration/perforation.

## Dimensions – Millimeters (Inches)




| Size Code | L Length | W Width | T Thickness Maximum | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|
| 2824 | 7.10 ± 0.40 (0.280 ± 0.016) | 6.10 ± 0.40 (0.240 ± 0.016) | See Table 2 | 1.27 ± 0.40 (0.050 ± 0.016) | N/A | Solder Reflow Only |
| 3040 | 7.60 ± 0.40 (0.300 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |
| 3640 | 9.10 ± 0.40 (0.358 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |
| 4540 | 11.40 ± 0.40 (0.449 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |

## Qualification/Certification

Industrial grade pulse discharge products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

## Environmental Compliance

Lead (Pb)-free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | See product selection table (product waterfall) for available ratings |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 seconds @ 25°C) |

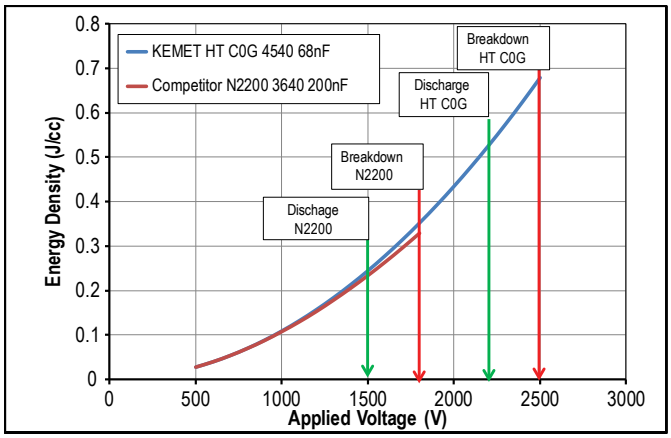
*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ± 50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

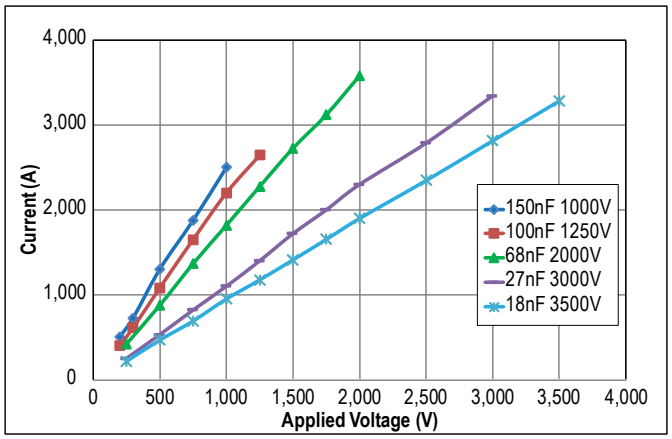
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

## Electrical Characteristics

### Energy Density vs. Applied Voltage




### Discharge Current vs. Applied Voltage



# Table 1 – Pulse Discharge Series, Capacitance Range Waterfall

| Capacitance | Cap Code | Case Size/ Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V |
| | | Dielectric Withstanding Voltage (DWV) | | | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 |
| | | Working Voltage | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,000 pF | 202 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J | K | M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,900 pF | 392 | J | K | M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,700 pF | 472 | J | K | M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,600 pF | 562 | J | K | M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,800 pF | 682 | J | K | M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 8,200 pF | 822 | J | K | M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 10,000 pF | 103 | J | K | M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J | K | M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J | K | M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J | K | M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J | K | M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J | K | M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J | K | M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J | K | M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J | K | M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J | K | M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J | K | M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J | K | M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.10 µF | 104 | J | K | M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J | K | M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J | K | M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Working Voltage | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Dielectric Withstanding Voltage (DWV) | | | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 |
| | | Voltage Code | | | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V |
| | | Case Size/Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |

*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

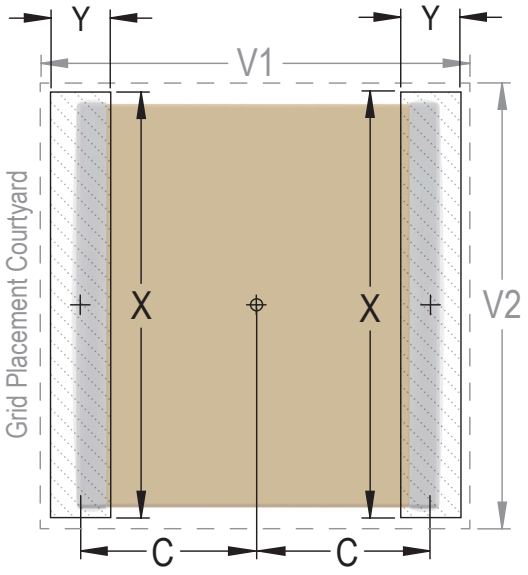
*Package quantity based on finished chip thickness specifications.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| Size Code (In.) | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Provides a wider process window for reflow solder processes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations, the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for a 3640 case size.*



# Soldering Process

### Recommended Soldering Technique:

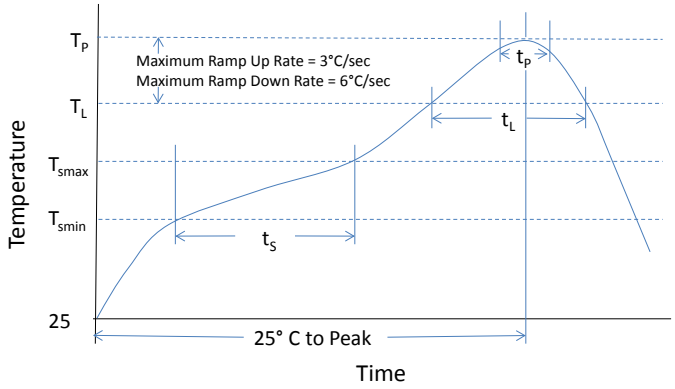
- Solder reflow only

### Recommended Reflow Soldering Profile:

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



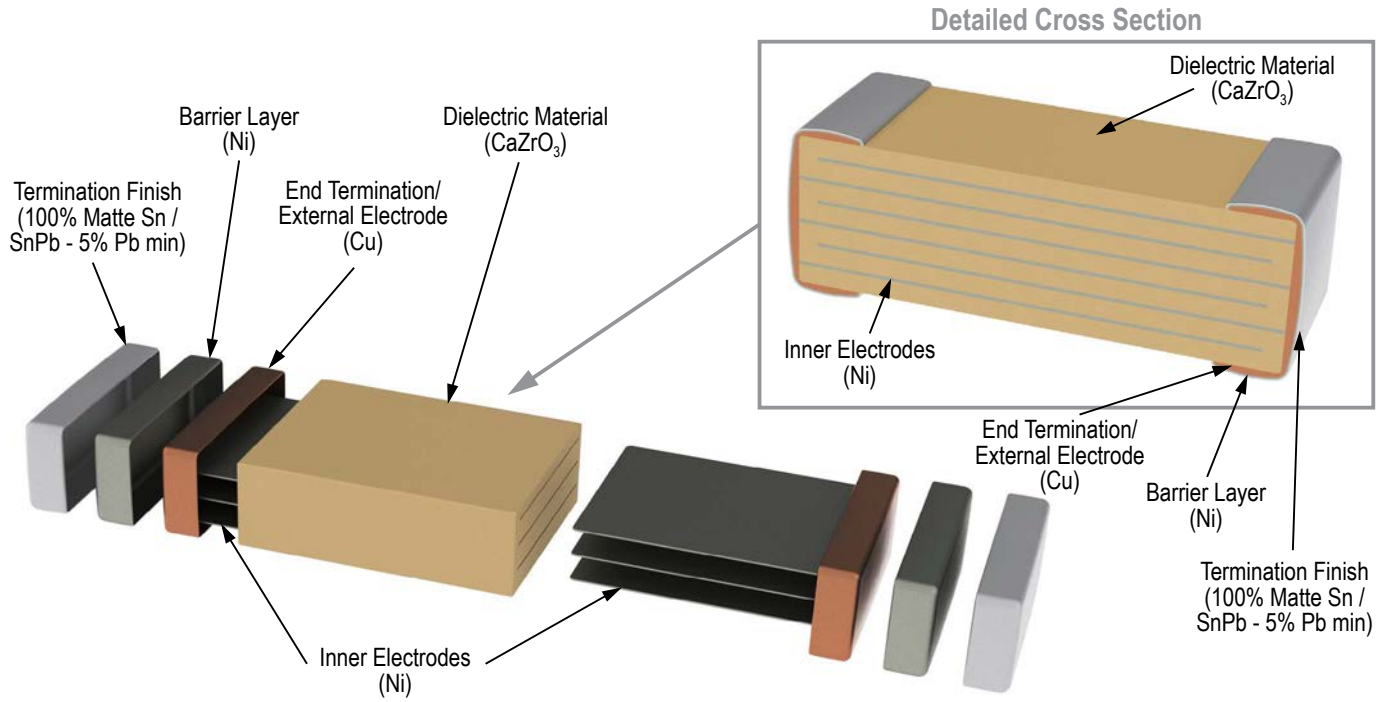
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| Load Humidity | 85°C/85%RH and 200 VDC maximum, 1,000 Hours |
| Low Voltage Humidity | 85°C/85%RH, 1.5V, 1,000 Hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 Cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical – OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes, 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

## Packaging

Please contact KEMET for details regarding available packaging options.

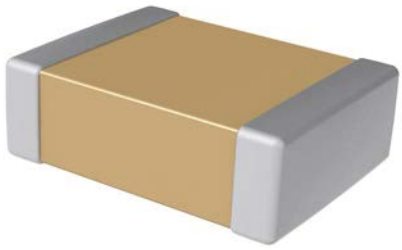
# High Voltage C0G Dielectric, 500 – 3,000 VDC (Commercial Grade)

## Overview

KEMET's High Voltage surface mount MLCCs in C0G dielectric feature a 125°C maximum operating temperature and are considered "stable." The Electronics Industries Alliance (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. C0G exhibits no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +125°C.

These devices exhibit low ESR at high frequencies and find conventional use as snubbers or filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage MLCC's the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive(hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1210 | C | 332 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/ Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225<br>2824<br>3040<br>3640<br>4540 | C = Standard | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb min.) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

[2] *Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] "Bulk Bag" packaging option is not available for case sizes larger than 2225 (5664 Metric).*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

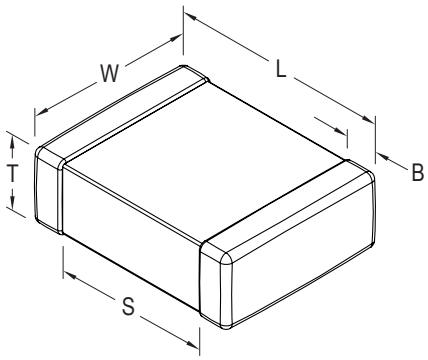
## Benefits

- Operating temperature range of −55°C to +125°C
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220, 2225, 2824, 3040, 3640 and 4540 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV, and 3 KV
- Capacitance offerings ranging from 1 pF to 0.150 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies & into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- Automotive (AEC-Q200) grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | "Solder Wave or Solder Reflow" |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2824 | 7260 | 7.10 (.280) ± 0.40 (.016) | 6.10 (.240) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3040 | 7610 | 7.60 (.300) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3640 | 9210 | 9.10 (.358) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 4540 | - | 11.40 (.449) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1,000 V<br>120% of rated voltage for voltage rating of ≥ 1,000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit at 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 seconds at 25°C) |

*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-μF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D | DG | DG | DG | | | | | | | | | | | LB | LB | LB | LB | LB | LB | |
| 10 pF - 47pF* | 100 - 470* | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 11 pF | 110 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 12 pF | 120 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 13 pF | 130 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 15 pF | 150 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 16 pF | 160 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 18 pF | 180 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 20 pF | 200 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 22 pF | 220 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 24 pF | 240 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 27 pF | 270 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 30 pF | 300 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 33 pF | 330 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 36 pF | 360 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 39 pF | 390 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 43 pF | 430 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 47 pF | 470 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 51 pF | 510 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 56 pF | 560 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 62 pF | 620 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 68 pF | 680 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 75 pF | 750 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 82 pF | 820 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 91 pF | 910 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | |
| 100 pF | 101 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | |
| 110 pF | 111 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | |
| 120 pF | 121 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB | LC | |
| 130 pF | 131 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB | LC | |
| 150 pF | 151 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB | LC | |
| 160 pF | 161 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | |
| 180 pF | 181 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | |
| 200 pF | 201 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | |
| 220 pF | 221 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | |
| 240 pF | 241 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LB | LC | LC | |
| 270 pF | 271 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC | LC | |
| 300 pF | 301 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC | LC | |
| 330 pF | 331 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC | LC | |
| 360 pF | 361 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA | LC | |
| 390 pF | 391 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA | LC | |
| 430 pF | 431 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 470 pF | 471 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 510 pF | 511 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 560 pF | 561 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 620 pF | 621 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC | | |
| 680 pF | 681 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LB | LB | LB | LA | LC | | |
| 750 pF | 751 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | | | |
| 820 pF | 821 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | | | |
| 910 pF | 911 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LA | | | |
| 1,000 pF | 102 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LB | | | |
| 1,100 pF | 112 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LB | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LC | | | |
| 1,300 pF | 132 | F G J K M | | | | EF | EG | | | | FM | FS | FS | | | LC | LC | LC | LC | | | |
| 1,500 pF | 152 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | LC | | | |
| 1,600 pF | 162 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 2,000 pF | 202 | F G J K M | | | | EG | EB | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,200 pF | 222 | F G J K M | | | | EG | EB | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,400 pF | 242 | F G J K M | | | | EG | EB | | | | FS | FL | FS | | | LC | LA | LB | | | | |
| 2,700 pF | 272 | F G J K M | | | | EG | EB | | | | FS | FL | FS | | | LC | LA | LC | | | | |
| 3,000 pF | 302 | F G J K M | | | | EB | EB | | | | FS | FL | | | | LA | LA | | | | | |
| 3,300 pF | 332 | F G J K M | | | | EB | EB | | | | FS | FM | | | | LA | LA | | | | | |
| 3,600 pF | 362 | F G J K M | | | | EC | EC | | | | FL | FM | | | | LA | LB | | | | | |
| 3,900 pF | 392 | F G J K M | | | | EC | EC | | | | FL | FY | | | | LA | LB | | | | | |
| 4,300 pF | 432 | F G J K M | | | | ED | ED | | | | FM | FY | | | | LA | LC | | | | | |
| 4,700 pF | 472 | F G J K M | | | | ED | ED | | | | FM | FY | | | | LA | LC | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | | | |
| 5,600 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| 8,200 pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1812C | | | | | | | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF - 47pF* | 100 - 470* | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 11 pF | 110 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 12 pF | 120 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 13 pF | 130 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 15 pF | 150 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 16 pF | 160 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 18 pF | 180 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 20 pF | 200 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 22 pF | 220 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 24 pF | 240 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 27 pF | 270 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 30 pF | 300 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 33 pF | 330 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 36 pF | 360 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 39 pF | 390 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 43 pF | 430 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 47 pF | 470 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 51 pF | 510 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 56 pF | 560 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 62 pF | 620 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 68 pF | 680 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 75 pF | 750 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 82 pF | 820 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 91 pF | 910 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 100 pF | 101 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 110 pF | 111 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 120 pF | 121 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 130 pF | 131 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 150 pF | 151 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 160 pF | 161 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 180 pF | 181 | F G J K M | GK | GK | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 200 pF | 201 | F G J K M | GH | GH | GH | GH | GH | GK | GM | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 220 pF | 221 | F G J K M | GH | GH | GH | GH | GH | GK | GM | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 240 pF | 241 | F G J K M | GH | GH | GH | GH | GH | GK | GM | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 270 pF | 271 | F G J K M | GH | GH | GH | GH | GH | GK | GM | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 300 pF | 301 | F G J K M | GH | GH | GH | GH | GH | GK | GM | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 330 pF | 331 | F G J K M | GH | GH | GH | GH | GH | GK | GO | HE | HE | HE | HE | HE | HE | HG | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 360 pF | 361 | F G J K M | GK | GK | GK | GK | GH | GK | GO | HE | HE | HE | HE | HE | HE | HG | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 390 pF | 391 | F G J K M | GK | GK | GK | GK | GK | GK | GO | HE | HE | HE | HE | HE | HE | HG | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 430 pF | 431 | F G J K M | GK | GK | GK | GK | GK | GK | | HE | HE | HE | HE | HE | HE | HJ | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KE | KF |
| 470 pF | 471 | F G J K M | GK | GK | GK | GK | GK | GK | | HE | HE | HE | HE | HE | HE | HJ | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 510 pF | 511 | F G J K M | GH | GH | GH | GK | GH | GM | | HE | HE | HE | HE | HE | HE | HJ | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 560 pF | 561 | F G J K M | GH | GH | GH | GK | GH | GM | | HE | HE | HE | HE | HG | HE | HJ | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KE | KF |
| 620 pF | 621 | F G J K M | GH | GH | GH | GK | GH | GM | | HE | HE | HE | HE | HG | HE | HK | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 680 pF | 681 | F G J K M | GH | GH | GH | GK | GH | GO | | HE | HE | HE | HE | HG | HG | HK | JE | JE | JE | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 750 pF | 751 | F G J K M | GH | GH | GH | GK | GK | | | HE | HE | HE | HG | HG | HG | | JE | JE | JE | JK | JK | JK | JL | KE | KE | KE | KF | KE | KF | KH |
| 820 pF | 821 | F G J K M | GH | GH | GH | GK | GK | | | HE | HE | HE | HG | HG | HG | | JE | JE | JE | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 910 pF | 911 | F G J K M | GH | GH | GH | GH | GM | | | HE | HE | HE | HG | HG | HG | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812C | | | | | | | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C1812C | | | | | | | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | F G J K M | GH | GH | GH | GH | GM | | | HE | HE | HE | HG | HG | HG | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 1,100 pF | 112 | F G J K M | GH | GK | GK | GH | GO | | | HE | HE | HE | HG | HG | HJ | | JE | JK | JK | JK | JK | JK | | KE | KE | KE | KF | KF | KF | |
| 1,200 pF | 122 | F G J K M | GH | GK | GK | GH | GO | | | HE | HE | HE | HG | HG | HJ | | JE | JK | JK | JK | JK | JL | | KE | KE | KE | KF | KF | KF | |
| 1,300 pF | 132 | F G J K M | GH | GK | GK | GH | GO | | | HE | HE | HE | HG | HE | HJ | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,500 pF | 152 | F G J K M | GK | GK | GK | GK | GO | | | HE | HE | HE | HG | HE | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,600 pF | 162 | F G J K M | GK | GK | GK | GK | | | | HE | HG | HG | HG | HG | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KE | KH | |
| 1,800 pF | 182 | F G J K M | GK | GK | GK | GM | | | | HE | HG | HG | HG | HG | | | JE | JK | JK | JK | JE | JN | | KE | KE | KE | KF | KE | KH | |
| 2,000 pF | 202 | F G J K M | GK | GK | GK | GM | | | | HE | HG | HG | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KE | KJ | |
| 2,200 pF | 222 | F G J K M | GK | GK | GK | GO | | | | HE | HG | HG | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KF | KJ | |
| 2,400 pF | 242 | F G J K M | GK | GH | GK | GO | | | | HE | HG | HG | HE | HJ | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 2,700 pF | 272 | F G J K M | GK | GH | GK | GO | | | | HE | HG | HG | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,000 pF | 302 | F G J K M | GK | GH | GK | | | | | HG | HG | HG | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,300 pF | 332 | F G J K M | GK | GH | GK | | | | | HG | HG | HG | HG | | | | JK | JK | JK | JK | JN | | | KE | KE | KE | KE | KJ | | |
| 3,600 pF | 362 | F G J K M | GK | GH | GM | | | | | HG | HG | HG | HG | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 3,900 pF | 392 | F G J K M | GK | GH | GM | | | | | HG | HG | HG | HJ | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 4,300 pF | 432 | F G J K M | GH | GH | GO | | | | | HG | HG | HG | HJ | | | | JK | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 4,700 pF | 472 | F G J K M | GH | GH | GO | | | | | HG | HG | HG | HJ | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | | | HG | HE | HG | HK | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | | | HG | HE | HG | HK | | | | JK | JK | JK | JN | | | | KE | KF | KF | KH | | | |
| 6,200pF | 622 | F G J K M | GH | GK | | | | | | HG | HE | HG | | | | | JK | JE | JE | JN | | | | KE | KF | KF | KJ | | | |
| 6,800pF | 682 | F G J K M | GH | GM | | | | | | HG | HE | HJ | | | | | JK | JE | JK | JN | | | | KE | KF | KF | KJ | | | |
| 7,500pF | 752 | F G J K M | GH | GM | | | | | | HG | HE | HJ | | | | | JK | JE | JK | | | | | KF | KE | KF | | | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | | | HG | HE | HJ | | | | | JK | JE | JL | | | | | KF | KE | KF | | | | |
| 9,100 pF | 912 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 10,000 pF | 103 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 12,000 pF | 123 | F G J K M | GO | | | | | | | HE | HG | | | | | | JE | JK | JN | | | | | KE | KE | KH | | | | |
| 15,000 pF | 153 | F G J K M | GO | | | | | | | HE | HJ | | | | | | JE | JL | | | | | | KE | KF | KJ | | | | |
| 18,000 pF | 183 | F G J K M | | | | | | | | HG | HK | | | | | | JE | JL | | | | | | KE | KH | | | | | |
| 22,000 pF | 223 | F G J K M | | | | | | | | HJ | | | | | | | JK | JN | | | | | | KF | KJ | | | | | |
| 27,000 pF | 273 | F G J K M | | | | | | | | HJ | | | | | | | JL | JN | | | | | | KF | KJ | | | | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | HK | | | | | | | JN | | | | | | | KH | | | | | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | | | | | | | | KJ | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812C | | | | | | | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1C – Capacitance Range/Selection Waterfall (2824 – 4540 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C2824C | | | | | C3040C | | | | | C3640C | | | | | C4540C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 - 2,000 pF | 100 - 202 | J K M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,400 pF | 242 | J K M | | | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J K M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,000 pF | 302 | J K M | | | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J K M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,600 pF | 362 | J K M | | | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J K M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,300 pF | 432 | J K M | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J K M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,100 pF | 512 | J K M | | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J K M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,200 pF | 622 | J K M | | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J K M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 7,500 pF | 752 | J K M | | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J K M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 9,100 pF | 912 | J K M | | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J K M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J K M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J K M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J K M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J K M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J K M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J K M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J K M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J K M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J K M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J K M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J K M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.1 µF | 104 | J K M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C2824C | | | | | C3040C | | | | | C3640C | | | | | C4540C | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EB | 1206 | 0.78 ± 0.10 | 4000 | 10000 | 4,000 | 10,000 |
| EC | 1206 | 0.90 ± 0.10 | 0 | 0 | 4,000 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

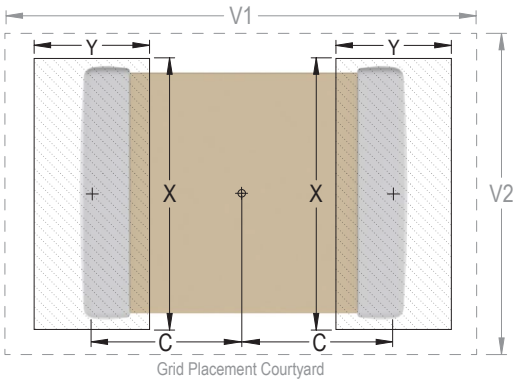
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



# Soldering Process

**Recommended Soldering Technique:**

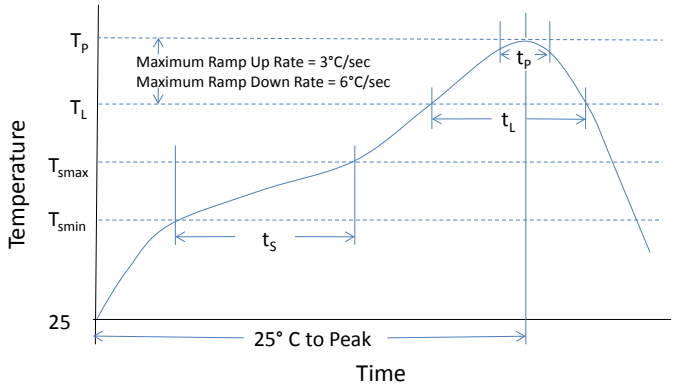
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



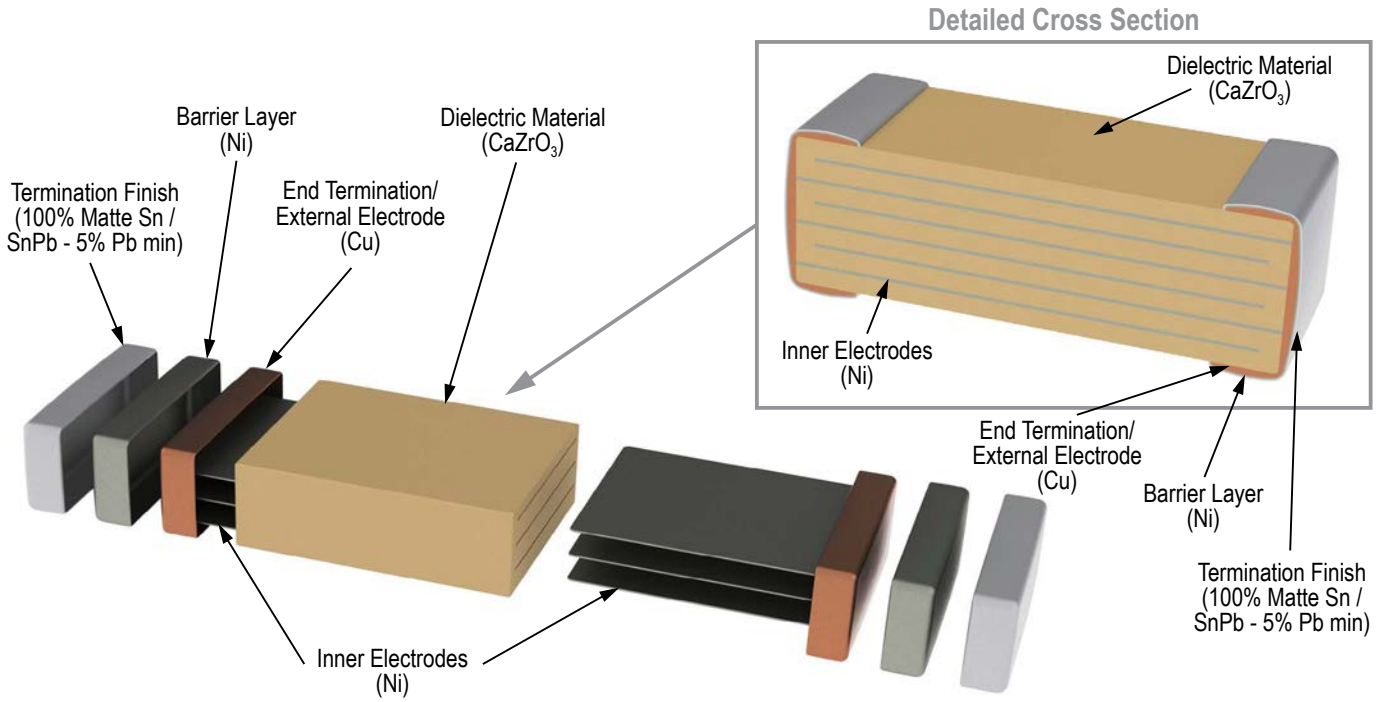
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

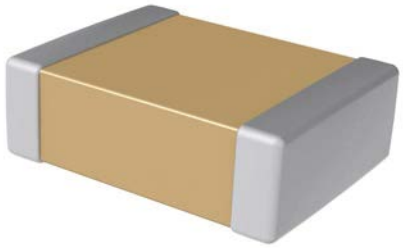
# High Voltage X7R Dielectric, 500 – 3,000 VDC (Commercial Grade)

## Overview

KEMET's High Voltage surface mount MLCCs in X7R Dielectric feature a 125°C maximum operating temperature and are considered "temperature stable." The Electronics Industries Alliance (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors suited for bypass and decoupling applications or for frequency discriminating circuits where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

Available in a variety of case sizes and industry leading CV values (capacitance/voltage), these devices exhibit low leakage current and low ESR at high frequencies. Conventional uses include both snubbers and filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage MLCC's the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1210 | C | 154 | K | C | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | C = Standard | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

[1] *Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Benefits

- −55°C to +125°C operating temperature range
- Industry-leading CV values
- Exceptional performance at high frequencies
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV, and 3 KV
- Capacitance offerings ranging from 10 pF to 560 nF
- Available capacitance tolerances of ±5%, ±10%, and ±20%
- Low ESR and ESL
- Non-polar device, minimizing installation concerns
- Automotive (AEC–Q200) Grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

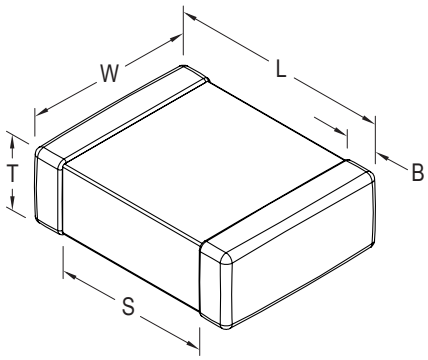
## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications. These capacitors and/or the assembled circuit board containing these capacitors may require a protective surface coating to prevent external surface arcing.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0603 | N/A | All |
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603C | | | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | | C1812C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | 100 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 11 pF | 110 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 12 pF | 120 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 13 pF | 130 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 15 pF | 150 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 16 pF | 160 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 18 pF | 180 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 20 pF | 200 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 22 pF | 220 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 24 pF | 240 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 27 pF | 270 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 30 pF | 300 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 33 pF | 330 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 36 pF | 360 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 39 pF | 390 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 43 pF | 430 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 47 pF | 470 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 51 pF | 510 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 56 pF | 560 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 62 pF | 620 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 68 pF | 680 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 75 pF | 750 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 82 pF | 820 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 91 pF | 910 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 100 pF | 101 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 110 pF | 111 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 120 pF | 121 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LA | LA | LA | LA | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 130 pF | 131 | J K M | | | | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 150 pF | 151 | J K M | | | | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 180 pF | 181 | J K M | | | | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 220 pF | 221 | J K M | | | | DG | DG | DG | ED | ED | ED | EF | EF | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC | LC | LB | GH | GH | GH | GH | GH | GK | GK |
| 270 pF | 271 | J K M | | | | DG | DG | DG | ED | ED | ED | EF | EF | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 330 pF | 331 | J K M | | | | DG | DG | DG | ED | ED | EF | EF | EF | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 390 pF | 391 | J K M | | | | DG | DG | DG | ED | ED | EF | EF | EF | FG | FG | FG | FK | FS | LA | LA | LA | LB | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 470 pF | 471 | J K M | | | | DG | DG | DG | ED | ED | EF | EF | EF | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 560 pF | 561 | J K M | | | | DG | DG | DG | ED | ED | EF | EF | EF | FG | FM | FM | FS | FL | LA | LB | LB | LC | LB | LB | LC | GH | GH | GH | GK | GH | GK | GK |
| 680 pF | 681 | J K M | | | | DG | DG | DG | ED | ED | EF | EF | EF | FG | FM | FM | FS | FL | LB | LB | LB | LA | LB | LC | LC | GH | GH | GH | GK | GH | GK | GK |
| 820 pF | 821 | J K M | | | | DG | DG | DG | ED | ED | ED | EF | EF | FG | FM | FM | FL | FL | LB | LB | LB | LA | LB | LC | LC | GH | GH | GH | GK | GH | GK | GK |
| 1,000 pF | 102 | J K M | CG | CG | CG | DG | DG | DG | ED | ED | ED | EF | EF | FM | FM | FM | FL | FL | LB | LB | LB | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 1,200 pF | 122 | J K M | CG | CG | | DG | DG | DG | ED | ED | ED | EG | EG | FM | FK | FK | FL | FM | LC | LC | LC | LB | LC | LA | | GH | GK | GK | GH | GH | GK | GK |
| 1,500 pF | 152 | J K M | CG | CG | | DG | DG | DG | ED | ED | ED | EG | EG | FK | FS | FS | FL | FM | LC | LC | LC | LB | LC | LB | | GK | GK | GK | GH | GH | GK | |
| 1,800 pF | 182 | J K M | CG | | | DG | DG | DG | ED | ED | ED | EG | EG | FK | FS | FS | FL | FM | LC | LC | LC | LB | LC | LC | | GK | GK | GK | GH | GH | GK | |
| 2,200 pF | 222 | J K M | CG | | | DG | DG | DG | ED | ED | ED | EG | EG | FK | FL | FL | FL | FM | LC | LA | LA | LB | LC | LC | | GK | GK | GK | GH | GH | GK | |
| 2,700 pF | 272 | J K M | CG | | | DG | DG | DG | ED | ED | ED | EG | | FS | FL | FL | FL | FM | LC | LA | LA | LB | LC | | | GK | GH | GH | GH | GK | GM | |
| 3,300 pF | 332 | J K M | CG | | | DG | DG | DG | ED | ED | ED | EG | | FS | FL | FL | FL | FM | LA | LA | LA | LB | LA | | | GK | GH | GH | GH | GK | GM | |
| 3,900 pF | 392 | J K M | CG | | | DG | DG | DG | ED | ED | ED | EG | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LB | | | GK | GH | GH | GH | GK | GO | |
| 4,700 pF | 472 | J K M | | | | DG | DG | DG | ED | ED | ED | EG | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LC | | | GH | GH | GH | GH | GH | GO | |
| 5,600 pF | 562 | J K M | | | | DG | DG | DG | ED | EF | EF | EF | | FL | FL | FL | FM | FK | LA | LB | LB | LC | | | | GH | GH | GH | GK | GK | | |
| 6,800 pF | 682 | J K M | | | | DG | DG | | EF | EF | EF | EF | | FL | FL | FL | FM | FS | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 8,200 pF | 822 | J K M | | | | DG | DG | | EF | EG | EG | EF | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 10,000 pF | 103 | J K M | | | | DG | DG | | EF | EG | EG | EG | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GO | | |
| 12,000 pF | 123 | J K M | | | | DG | DG | | EG | EJ | EJ | | | FL | FL | FL | FK | | LA | LC | LC | LB | | | | GH | GK | GK | GK | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603C | | | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | | C1812C | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

## Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0603C | | | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | | C1812C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | | | | DG | | | EG | EJ | EJ | | | FL | FL | FL | FL | | LA | LC | LC | LC | | | | GH | GK | GK | GH | | | |
| 18,000 pF | 183 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FL | FL | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 22,000 pF | 223 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FM | FM | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 27,000 pF | 273 | J K M | | | | | | | EJ | EJ | | | | FM | FK | FK | FK | | LA | LA | LA | | | | | GH | GB | GB | GO | | | |
| 33,000 pF | 333 | J K M | | | | | | | EJ | EJ | | | | FM | FG | FH | FS | | LC | LA | LA | | | | | GH | GB | GB | GO | | | |
| 39,000 pF | 393 | J K M | | | | | | | EJ | | | | | FK | FG | FH | FS | | LC | LA | LA | | | | | GH | GB | GB | | | | |
| 47,000 pF | 473 | J K M | | | | | | | EJ | | | | | FK | FH | FK | | | LC | LA | LB | | | | | GH | GB | GC | | | | |
| 56,000 pF | 563 | J K M | | | | | | | EJ | | | | | FG | FH | FK | | | LC | LA | LB | | | | | GH | GB | GE | | | | |
| 62,000 pF | 623 | J K M | | | | | | | EJ | | | | | FG | FK | FS | | | LA | LA | LC | | | | | GK | GB | GE | | | | |
| 68,000 pF | 683 | J K M | | | | | | | EJ | | | | | FG | FK | FS | | | LA | LA | LC | | | | | GE | GE | GE | | | | |
| 82,000 pF | 823 | J K M | | | | | | | | | | | | FH | FK | | | | LA | LC | | | | | | GB | GE | GK | | | | |
| 0.10 µF | 104 | J K M | | | | | | | | | | | | FK | FS | | | | LA | LC | | | | | | GB | GH | GJ | | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | | | FK | | | | | LA | | | | | | | GE | GK | | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | | | FK | | | | | LB | | | | | | | GE | GN | | | | | |
| 0.18 µF | 184 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GF | | | | | | |
| 0.22 µF | 224 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GJ | | | | | | |
| 0.27 µF | 274 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GL | | | | | | |
| 0.33 µF | 334 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GS | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603C | | | C0805C | | | C1206C | | | | | C1210C | | | | | C1808C | | | | | | | C1812C | | | | | | |

## Table 1B – Capacitance Range/Selection Waterfall (1825–2225 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 100 pF | 101 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 110 pF | 111 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 120 pF | 121 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 130 pF | 131 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 150 pF | 151 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 180 pF | 181 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 220 pF | 221 | J K M | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 270 pF | 271 | J K M | HE | HE | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 330 pF | 331 | J K M | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 390 pF | 391 | J K M | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 470 pF | 471 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 560 pF | 561 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 680 pF | 681 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JE | JE | JK | JK | JK | JK | KF | KF | KF | KF | KE | KF | KF |
| 820 pF | 821 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JE | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE | KF | KF |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 1B – Capacitance Range/Selection Waterfall (1825 – 2225 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/ Series | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| | | J K M | | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JK | JK | JK | JK | JK | JK | KE | KE | KE | KF | KE | KF | KF |
| 1,200 pF | 122 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JK | JK | JK | JK | JK | JK | KE | KE | KE | KF | KF | KF | KF |
| 1,500 pF | 152 | J K M | HG | HG | HG | HG | HG | HG | HG | JE | JK | JK | JK | JK | JK | JK | KE | KE | KE | KF | KF | KF | KF |
| 1,800 pF | 182 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | JK | JK | KE | KE | KE | KF | KF | KF | KF |
| 2,200 pF | 222 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JK | JK | JE | JE | JK | JK | KF | KE | KE | KF | KF | KF | KF |
| 2,700 pF | 272 | J K M | HE | HE | HE | HE | HE | HG | | JK | JK | JK | JE | JE | JK | JK | KE | KE | KE | KE | KE | KF | KE |
| 3,300 pF | 332 | J K M | HE | HE | HE | HE | HE | HG | | JK | JK | JK | JE | JE | JK | JE | KE | KE | KE | KE | KE | KF | KE |
| 3,900 pF | 392 | J K M | HE | HE | HE | HE | HE | HG | | JK | JK | JK | JE | JE | JK | JE | KE | KF | KF | KE | KE | KF | KE |
| 4,700 pF | 472 | J K M | HE | HE | HE | HE | HE | HG | | JK | JK | JK | JE | JK | JE | JE | KE | KF | KF | KE | KE | KF | KE |
| 5,600 pF | 562 | J K M | HE | HE | HE | HE | HE | HG | | JK | JK | JK | JE | JK | JE | JE | KE | KF | KF | KE | KE | KF | KE |
| 6,800 pF | 682 | J K M | HE | HE | HE | HE | HE | HJ | | JK | JE | JE | JE | JK | JE | JE | KE | KF | KF | KE | KF | KE | KE |
| 8,200 pF | 822 | J K M | HE | HE | HE | HE | HE | HJ | | JK | JE | JE | JE | JK | JK | JK | KF | KE | KE | KE | KF | KF | KF |
| 10,000 pF | 103 | J K M | HE | HE | HE | HE | HJ | HK | | JE | JE | JE | JE | JL | JL | JL | KF | KE | KE | KE | KF | KH | KH |
| 12,000 pF | 123 | J K M | HE | HE | HE | HG | HJ | | | JE | JK | JK | JK | JL | JL | JL | KE | KE | KE | KE | KF | KH | KH |
| 15,000 pF | 153 | J K M | HE | HE | HE | HG | HK | | | JE | JK | JK | JK | JL | JN | JN | KE | KE | KE | KE | KF | KJ | KJ |
| 18,000 pF | 183 | J K M | HE | HE | HE | HG | | | | JE | JK | JK | JK | JN | | | KE | KE | KE | KE | KH | | |
| 22,000 pF | 223 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 27,000 pF | 273 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | KJ | | |
| 33,000 pF | 333 | J K M | HE | HG | HG | HE | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 39,000 pF | 393 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JE | | | | KE | KF | KF | KF | | | |
| 47,000 pF | 473 | J K M | HE | HG | HG | HJ | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 56,000 pF | 563 | J K M | HE | HG | HG | HJ | | | | JE | JE | JE | JL | | | | KE | KF | KF | KF | | | |
| 62,000 pF | 623 | J K M | HG | HG | HG | HK | | | | JE | JE | JE | JL | | | | KE | KF | KF | KH | | | |
| 68,000 pF | 683 | J K M | HG | HJ | HJ | HK | | | | JE | JK | JK | JL | | | | KE | KF | KF | KJ | | | |
| 82,000 pF | 823 | J K M | HG | HJ | HJ | | | | | JE | JL | JL | JN | | | | KE | KF | KF | KJ | | | |
| 0.10 µF | 104 | J K M | HG | HK | HK | | | | | JE | JN | JN | | | | | KE | KH | KH | KJ | | | |
| 0.12 µF | 124 | J K M | HG | HE | | | | | | JE | JN | JN | | | | | KE | KH | KH | | | | |
| 0.15 µF | 154 | J K M | HG | HE | | | | | | JK | JE | | | | | | KF | KJ | KJ | | | | |
| 0.18 µF | 184 | J K M | HG | HG | | | | | | JK | JE | | | | | | KF | KE | | | | | |
| 0.22 µF | 224 | J K M | HG | HJ | | | | | | JK | JK | | | | | | KF | KF | | | | | |
| 0.27 µF | 274 | J K M | HJ | HJ | | | | | | JK | JL | | | | | | KF | KH | | | | | |
| 0.33 µF | 334 | J K M | HJ | | | | | | | JL | JN | | | | | | KF | KH | | | | | |
| 0.39 µF | 394 | J K M | HK | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.47 µF | 474 | J K M | | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | | | KJ | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C1825C | | | | | | | C2220C | | | | | | | C2225C | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FH | 1210 | 1.55 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LE | 1808 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GS | 1812 | 2.10 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

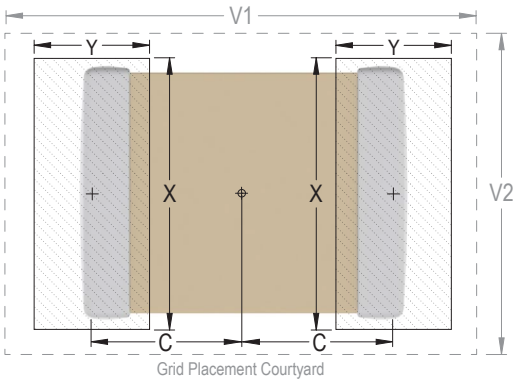
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 1.50 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

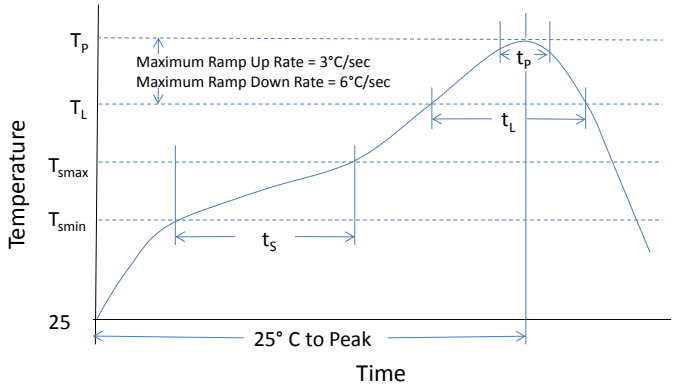
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



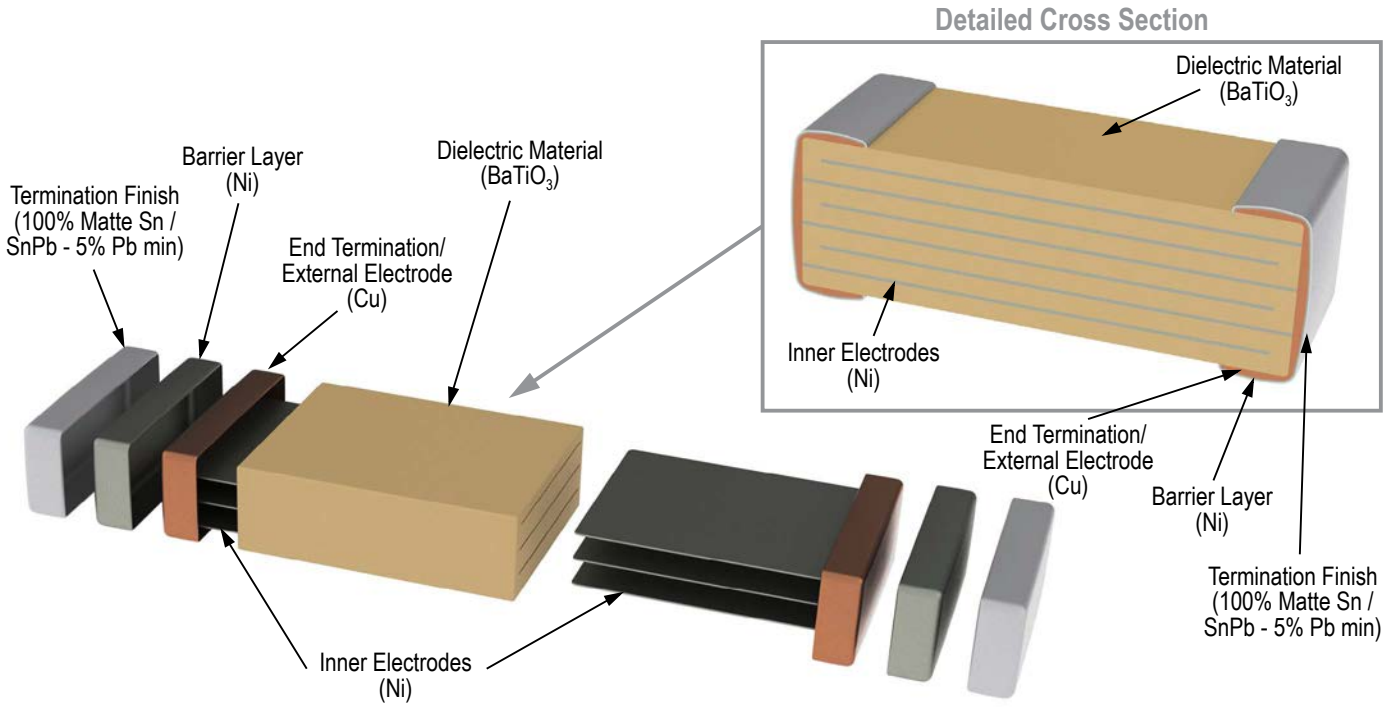
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# High Voltage with Flexible Termination System (HV FT-CAP) X7R Dielectric, 500 – 3,000 VDC (Commercial Grade)

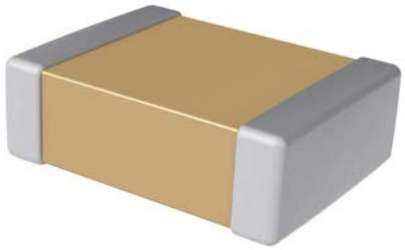
## Overview

KEMET's High Voltage with Flexible Termination (HV FT-CAP) surface mount MLCCs in X7R dielectric address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Featuring several of the highest CV (capacitance/voltage) values available in the industry, these devices utilize a pliable and conductive silver epoxy between the base metal and nickel barrier layers of the termination system. The addition of this epoxy layer inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

The HV FT-CAP offers low leakage current, exhibits low ESR at high frequencies and finds conventional use as snubbers or filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made them a preferred choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive(hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

Combined with the stability of an X7R dielectric and designed to accommodate all capacitance requirements, these flex-robust devices are RoHS-compliant, offer up to 5 mm of flex-bend capability and exhibits a predictable change in capacitance with respect to time and voltage. Capacitance change with reference to ambient temperature is limited to ±15% from −55°C to +125°C.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 1210 | X | 154 | K | C | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/Grade (C-Spec) |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X = Flexible Termination | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Benefits

- −55°C to +125°C operating temperature range
- Industry-leading CV values
- Superior flex performance (up to 5 mm)
- Exceptional performance at high frequencies
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220, and 2225 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV, and 3 KV
- Capacitance offerings ranging from 10 pF to 560 nF
- Available capacitance tolerances of ±5%, ±10% or ±20%
- Low ESR and ESL
- Non-polar device, minimizing installation concerns
- Automotive (AEC–Q200) Grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

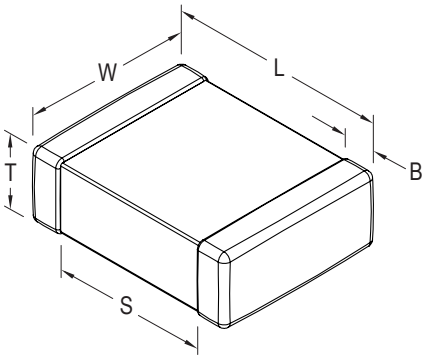
## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications. These capacitors and/or the assembled circuit board containing these capacitors may require a protective surface coating to prevent external surface arcing.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (%) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table (X7R Dielectric)

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0603 | N/A | All |
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | 100 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 11 pF | 110 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 12 pF | 120 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 13 pF | 130 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 15 pF | 150 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 16 pF | 160 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 18 pF | 180 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 20 pF | 200 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 22 pF | 220 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 24 pF | 240 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 27 pF | 270 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 30 pF | 300 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 33 pF | 330 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 36 pF | 360 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 39 pF | 390 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 43 pF | 430 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 47 pF | 470 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 51 pF | 510 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 56 pF | 560 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 62 pF | 620 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 68 pF | 680 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 75 pF | 750 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 82 pF | 820 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 91 pF | 910 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 100 pF | 101 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 110 pF | 111 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB | GK | GK | GK | GK | GK | GK | GK |
| 120 pF | 121 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LA | LA | LA | LA | LB | LC | LB | GG | GG | GG | GG | GG | GG | GK |
| 130 pF | 131 | J K M | | | | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 150 pF | 151 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 180 pF | 181 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 220 pF | 221 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FZ | FZ | FZ | FM | FM | LB | LB | LB | LB | LB | LB | LB | GK | GK | GK | GK | GK | GK | GK |
| 270 pF | 271 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FZ | FZ | FZ | FK | FK | LC | LC | LC | LC | LC | LC | LC | GK | GK | GK | GK | GK | GK | GK |
| 330 pF | 331 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FZ | FZ | FK | FK | LC | LC | LC | LC | LC | LC | LC | GK | GK | GK | GK | GK | GK | GK |
| 390 pF | 391 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FZ | FZ | FK | FS | LB | LB | LB | LB | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 470 pF | 471 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FZ | FM | FM | FS | FS | LB | LB | LB | LB | LB | LB | LC | GK | GK | GK | GK | GK | GK | GK |
| 560 pF | 561 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FL | FL | FL | FL | FL | LB | LB | LB | LB | LB | LB | LC | GH | GH | GH | GH | GH | GK | GK |
| 680 pF | 681 | J K M | | | | DG | DG | DG | ES | ES | EF | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 820 pF | 821 | J K M | | | | DG | DG | DG | ES | ES | ES | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 1,000 pF | 102 | J K M | CG | CG | CG | DG | DG | DG | ES | ES | ES | EF | EF | FL | FL | FL | FL | FL | LA | LA | LA | LA | LB | LC | LC | GH | GH | GH | GH | GH | GK | GK |
| 1,200 pF | 122 | J K M | CG | CG | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LA | | GH | GH | GH | GH | GH | GK | GK |
| 1,500 pF | 152 | J K M | CG | CG | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LB | | GH | GH | GH | GH | GH | GK | |
| 1,800 pF | 182 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LB | LB | LB | LB | LC | LC | | GH | GH | GH | GH | GH | GK | |
| 2,200 pF | 222 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | EU | FL | FL | FL | FL | FM | LA | LA | LA | LB | LC | LC | | GH | GH | GH | GH | GH | GK | |
| 2,700 pF | 272 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FM | LA | LA | LA | LB | LC | | | GH | GH | GH | GH | GK | GM | |
| 3,300 pF | 332 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FM | LA | LA | LA | LB | LA | | | GH | GH | GH | GH | GK | GM | |
| 3,900 pF | 392 | J K M | CG | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LB | | | GH | GH | GH | GH | GK | GO | |
| 4,700 pF | 472 | J K M | | | | DG | DG | DG | ES | ES | ES | EU | | FL | FL | FL | FL | FK | LA | LA | LA | LB | LC | | | GH | GH | GH | GH | GH | GO | |
| 5,600 pF | 562 | J K M | | | | DG | DG | DG | ES | EF | EF | EF | | FL | FL | FL | FM | FK | LA | LB | LB | LC | | | | GH | GH | GH | GK | GK | | |
| 6,800 pF | 682 | J K M | | | | DG | DG | | EF | EF | EF | EF | | FL | FL | FL | FM | FS | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 8,200 pF | 822 | J K M | | | | DG | DG | | EF | EU | EU | EF | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GM | | |
| 10,000 pF | 103 | J K M | | | | DG | DG | | EF | EU | EU | EU | | FL | FL | FL | FK | | LA | LB | LB | LC | | | | GH | GH | GH | GK | GO | | |
| 12,000 pF | 123 | J K M | | | | DG | DG | | EU | EJ | EJ | | | FL | FL | FL | FK | | LA | LC | LC | LB | | | | GH | GK | GK | GK | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 1A – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes) cont'd

| Cap | Cap Code | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes - See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | | | | DG | | | EU | EJ | EJ | | | FL | FL | FL | FL | | LA | LC | LC | LC | | | | GH | GK | GK | GH | | | |
| 18,000 pF | 183 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FL | FL | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 22,000 pF | 223 | J K M | | | | DG | | | EJ | EJ | EJ | | | FL | FM | FM | FM | | LA | LE | LE | | | | | GH | GK | GK | GM | | | |
| 27,000 pF | 273 | J K M | | | | | | | EJ | EJ | | | | FM | FK | FK | FK | | LA | LA | LA | | | | | GH | GB | GB | GO | | | |
| 33,000 pF | 333 | J K M | | | | | | | EJ | EJ | | | | FM | FZ | FU | FS | | LC | LA | LA | | | | | GH | GB | GB | GO | | | |
| 39,000 pF | 393 | J K M | | | | | | | EJ | | | | | FK | FZ | FU | FS | | LC | LA | LA | | | | | GH | GB | GB | | | | |
| 47,000 pF | 473 | J K M | | | | | | | EJ | | | | | FK | FU | FK | | | LC | LA | LB | | | | | GH | GB | GC | | | | |
| 56,000 pF | 563 | J K M | | | | | | | EJ | | | | | FZ | FU | FK | | | LC | LA | LB | | | | | GH | GB | GE | | | | |
| 62,000 pF | 623 | J K M | | | | | | | EJ | | | | | FZ | FK | FS | | | LA | LA | LC | | | | | GK | GB | GE | | | | |
| 68,000 pF | 683 | J K M | | | | | | | EJ | | | | | FZ | FK | FS | | | LA | LA | LC | | | | | GE | GE | GE | | | | |
| 82,000 pF | 823 | J K M | | | | | | | | | | | | FU | FK | | | | LA | LC | | | | | | GB | GE | GK | | | | |
| 0.10 µF | 104 | J K M | | | | | | | | | | | | FK | FS | | | | LA | LC | | | | | | GB | GH | GJ | | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | | | FK | | | | | LA | | | | | | | GE | GK | | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | | | FK | | | | | LB | | | | | | | GE | GN | | | | | |
| 0.18 µF | 184 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GF | | | | | | |
| 0.22 µF | 224 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GJ | | | | | | |
| 0.27 µF | 274 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GL | | | | | | |
| 0.33 µF | 334 | J K M | | | | | | | | | | | | | | | | | | | | | | | | GS | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C0603X | | | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | | C1812X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 1B – Capacitance Range/Selection Waterfall (1825 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | |
| 470 pF | 471 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | | | | | | | |
| 560 pF | 561 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | | | | | | | |
| 680 pF | 681 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 820 pF | 821 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,000 pF | 102 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,200 pF | 122 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,500 pF | 152 | J K M | HG | HG | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 1,800 pF | 182 | J K M | HE | HE | HE | HE | HE | HG | HG | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 2,200 pF | 222 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 2,700 pF | 272 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KF | KE |
| 3,300 pF | 332 | J K M | HE | HE | HE | HE | HE | HG | HG | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KF | KE |
| 3,900 pF | 392 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KF | KE |
| 4,700 pF | 472 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KE | KF | KE |
| 5,600 pF | 562 | J K M | HE | HE | HE | HE | HE | HG | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KE | KF | KE |
| 6,800 pF | 682 | J K M | HE | HE | HE | HE | HE | HJ | | JE | JE | JE | JE | JK | JE | JE | KE | KE | KE | KE | KF | KE | KE |
| 8,200 pF | 822 | J K M | HE | HE | HE | HE | HE | HJ | | JE | JE | JE | JE | JK | JK | JK | KE | KE | KE | KE | KF | KF | KF |
| 10,000 pF | 103 | J K M | HE | HE | HE | HE | HJ | HK | | JE | JE | JE | JE | JL | JL | JL | KE | KE | KE | KE | KF | KH | KH |
| 12,000 pF | 123 | J K M | HE | HE | HE | HG | HJ | | | JE | JK | JK | JK | JL | JL | JL | KE | KE | KE | KE | KF | KH | KH |
| 15,000 pF | 153 | J K M | HE | HE | HE | HG | HK | | | JE | JK | JK | JK | JN | JN | JN | KE | KE | KE | KE | KF | KJ | KJ |
| 18,000 pF | 183 | J K M | HE | HE | HE | HG | | | | JE | JK | JK | JK | JN | | | KE | KE | KE | KE | KH | | |
| 22,000 pF | 223 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 27,000 pF | 273 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | KJ | | |
| 33,000 pF | 333 | J K M | HE | HG | HG | HE | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 39,000 pF | 393 | J K M | HE | HG | HG | HG | | | | JE | JK | JK | JE | | | | KE | KF | KF | KF | | | |
| 47,000 pF | 473 | J K M | HE | HG | HG | HJ | | | | JE | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 56,000 pF | 563 | J K M | HE | HG | HG | HJ | | | | JE | JE | JE | JL | | | | KE | KF | KF | KF | | | |
| 62,000 pF | 623 | J K M | HG | HG | HG | HK | | | | JE | JE | JE | JL | | | | KF | KF | KF | KH | | | |
| 68,000 pF | 683 | J K M | HG | HJ | HJ | HK | | | | JE | JK | JK | JL | | | | KE | KF | KF | KJ | | | |
| 82,000 pF | 823 | J K M | HG | HJ | HJ | | | | | JE | JL | JL | JN | | | | KE | KF | KF | KJ | | | |
| 0.10 µF | 104 | J K M | HG | HK | HK | | | | | JE | JN | JN | | | | | KE | KH | KH | KJ | | | |
| 0.12 µF | 124 | J K M | HG | HE | | | | | | JE | JN | JN | | | | | KE | KH | KH | | | | |
| 0.15 µF | 154 | J K M | HG | HE | | | | | | JK | JE | | | | | | KF | KJ | KJ | | | | |
| 0.18 µF | 184 | J K M | HG | HG | | | | | | JK | JE | | | | | | KF | KE | | | | | |
| 0.22 µF | 224 | J K M | HG | HJ | | | | | | JK | JK | | | | | | KF | KF | | | | | |
| 0.27 µF | 274 | J K M | HJ | HJ | | | | | | JK | JL | | | | | | KF | KH | | | | | |
| 0.33 µF | 334 | J K M | HJ | | | | | | | JL | JN | | | | | | KF | KH | | | | | |
| 0.39 µF | 394 | J K M | HK | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.47 µF | 474 | J K M | | | | | | | | JN | | | | | | | KH | KJ | | | | | |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | | | KJ | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/ Series | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LE | 1808 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GG | 1812 | 1.55 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GS | 1812 | 2.10 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*
*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

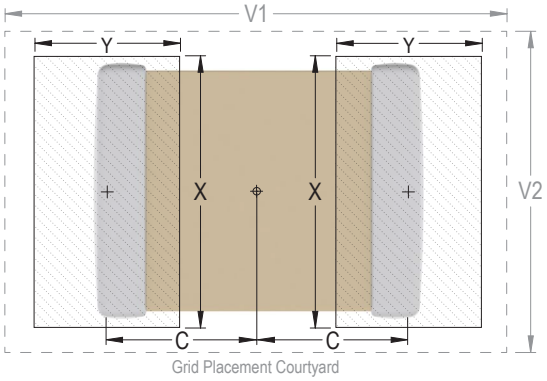
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

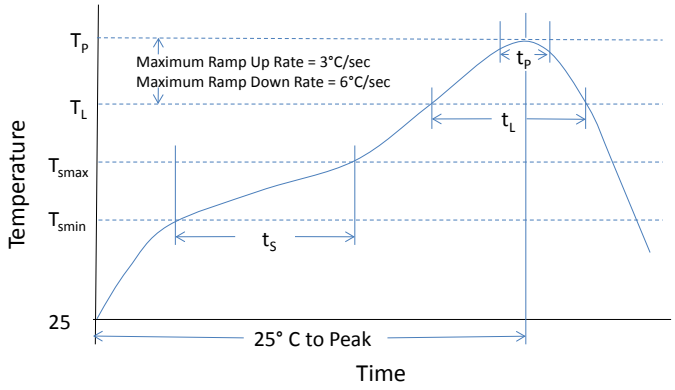
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



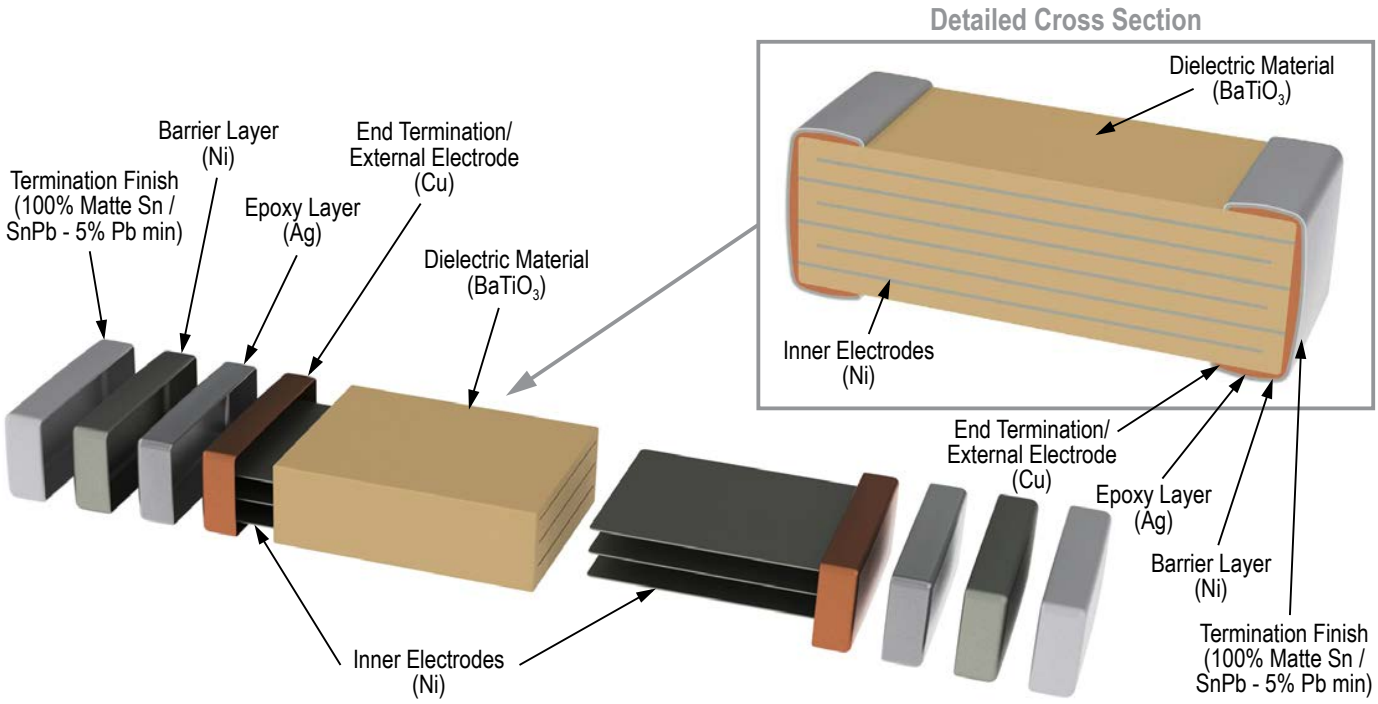
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction



# High Voltage with Flexible Termination System (HV FT-CAP), C0G Dielectric, 500 – 3,000 VDC (Commercial Grade)

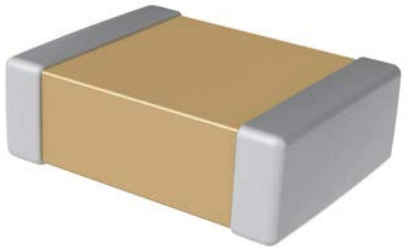
## Overview

KEMET's High Voltage with Flexible Termination (HV FT-CAP) surface mount MLCCs in C0G dielectric address the primary failure mode of MLCCs– flex cracks, which are typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Featuring several of the highest CV (capacitance/voltage) values available in the industry, these devices utilize a pliable and conductive silver epoxy between the base metal and nickel barrier layers of the termination system. The addition of this epoxy layer inhibits the transfer of board stress to the rigid ceramic body, therefore mitigating flex cracks which can result in low IR or short circuit failures. Although flexible termination technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does provide superior flex performance over standard termination systems.

KEMET's high voltage surface mount MLCCs in C0G dielectric feature a 125°C maximum operating temperature and offer the most stable voltage and temperature performance of all ceramic dielectric materials. C0G (NP0) dielectric capacitors exhibit no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +125°C.

These devices exhibit low ESR at high frequencies and find conventional use as snubbers or filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage MLCC's the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors and test/diagnostic equipment.

In addition to Commercial Grade, Automotive Grade devices are available which meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.



## Ordering Information

| C | 2225 | X | 393 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | X= Flexible Termination | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000<br>Z = 2,500<br>H = 3,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| Bulk Bag/Unmarked | Not required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

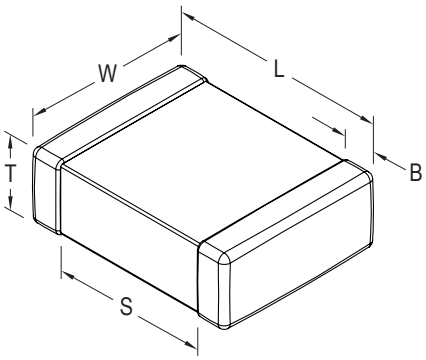
## Benefits

- −55°C to +125°C operating temperature range
- Superior flex performance (up to 5 mm)
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220 and 2225 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, 2 KV, 2.5 KV and 3 KV
- Capacitance offerings ranging from 1 pF to 39 nF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10% and ±20%
- No piezoelectric noise
- Extremely low ESR & ESL
- High thermal stability
- High ripple current capability
- Preferred capacitance solution at line frequencies & into the MHz range
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- Automotive (AEC-Q200) grade available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive.

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | Solder Wave or Solder Reflow |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Qualification/Certification

Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1,000 V<br>120% of rated voltage for voltage rating of ≥ 1,000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit at 25°C | 0.1% |
| [3]Insulation Resistance (IR) Limit at 25°C | 1,000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 seconds at 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*

*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*

*[3] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 169* | B C D | DG | DG | DG | | | | | | | | | | | LB | LB | LB | LB | LB | LB | LB |
| 10 pF | 100 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 11 pF | 110 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 12 pF | 120 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 13 pF | 130 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 15 pF | 150 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 16 pF | 160 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 18 pF | 180 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 20 pF | 200 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 22 pF | 220 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 24 pF | 240 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 27 pF | 270 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 30 pF | 300 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 33 pF | 330 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 36 pF | 360 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 39 pF | 390 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 43 pF | 430 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 47 pF | 470 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 51 pF | 510 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 56 pF | 560 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 62 pF | 620 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 68 pF | 680 | F G J K M | DG | DG | DG | ES | ES | ES | ES | ES | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 75 pF | 750 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 82 pF | 820 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 91 pF | 910 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LB | LB |
| 100 pF | 101 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB |
| 110 pF | 111 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB | LC | LB |
| 120 pF | 121 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LB |
| 130 pF | 131 | F G J K M | DG | DG | DG | ES | ES | ES | ES | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LC |
| 150 pF | 151 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LB | LC | LC |
| 160 pF | 161 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | LC |
| 180 pF | 181 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | LC |
| 200 pF | 201 | F G J K M | DG | DG | DG | ES | ES | ES | EF | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | |
| 220 pF | 221 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LA | LC | LC | |
| 240 pF | 241 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FM | FM | LA | LA | LA | LB | LC | LC | |
| 270 pF | 271 | F G J K M | DG | DG | DG | ES | ES | ES | EU | EU | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 300 pF | 301 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 330 pF | 331 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FK | LA | LA | LA | LB | LC | LC | |
| 360 pF | 361 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FS | LA | LA | LA | LB | LA | LC | |
| 390 pF | 391 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FZ | FZ | FK | FS | LA | LA | LA | LB | LA | LC | |
| 430 pF | 431 | F G J K M | DG | DG | | ES | ES | EF | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 470 pF | 471 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LA | | |
| 510 pF | 511 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 560 pF | 561 | F G J K M | DG | DG | | ES | ES | EU | EU | | FZ | FM | FM | FS | FS | LA | LB | LB | LC | LB | | |
| 620 pF | 621 | F G J K M | DG | | | ES | ES | EU | | | FZ | FM | FM | FS | FS | LA | LB | LB | LA | LC | | |
| 680 pF | 681 | F G J K M | DG | | | ES | ES | EU | | | FZ | FM | FM | FS | FS | LB | LB | LB | LA | LC | | |
| 750 pF | 751 | F G J K M | DG | | | ES | EF | EU | | | FZ | FM | FM | FM | | LB | LB | LB | LA | | | |
| 820 pF | 821 | F G J K M | DG | | | ES | EF | EU | | | FZ | FM | FM | FM | | LB | LB | LB | LA | | | |
| 910 pF | 911 | F G J K M | | | | ES | EF | EU | | | FM | FM | FM | FY | | LB | LB | LB | LA | | | |
| 1,000 pF | 102 | F G J K M | | | | ES | EF | EU | | | FM | FM | FM | FY | | LB | LB | LB | LB | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1,100 pF | 112 | F G J K M | | | | EF | EU | | | | FM | FK | FK | FS | | LC | LC | LC | LB | | | |
| 1,200 pF | 122 | F G J K M | | | | EF | EU | | | | FM | FK | FK | FS | | LC | LC | LC | LC | | | |
| 1,300 pF | 132 | F G J K M | | | | EF | EU | | | | FM | FS | FS | | | LC | LC | LC | LC | | | |
| 1,500 pF | 152 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | LC | | | |
| 1,600 pF | 162 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EU | | | | FK | FS | FS | | | LC | LC | LC | | | | |
| 2,000 pF | 202 | F G J K M | | | | EU | EQ | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,200 pF | 222 | F G J K M | | | | EU | EQ | | | | FK | FL | FS | | | LC | LA | LB | | | | |
| 2,400 pF | 242 | F G J K M | | | | EU | EQ | | | | FS | FL | FS | | | LC | LA | LB | | | | |
| 2,700 pF | 272 | F G J K M | | | | EU | EQ | | | | FS | FL | FS | | | LC | LA | LC | | | | |
| 3,000 pF | 302 | F G J K M | | | | EQ | EQ | | | | FS | FL | | | | LA | LA | | | | | |
| 3,300 pF | 332 | F G J K M | | | | EQ | EQ | | | | FS | FM | | | | LA | LA | | | | | |
| 3,600 pF | 362 | F G J K M | | | | ER | ER | | | | FL | FM | | | | LA | LB | | | | | |
| 3,900 pF | 392 | F G J K M | | | | ER | ER | | | | FL | FY | | | | LA | LB | | | | | |
| 4,300 pF | 432 | F G J K M | | | | ES | ES | | | | FM | FY | | | | LA | LC | | | | | |
| 4,700 pF | 472 | F G J K M | | | | ES | ES | | | | FM | FY | | | | LA | LC | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | | | |
| 5,200 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | FE | | | | LC | | | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| 8,200pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | Z | H |
| | | Case Size/Series | C0805X | | | C1206X | | | | | C1210X | | | | | C1808X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Cap | Cap Code | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | 100 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 11 pF | 110 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 12 pF | 120 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 13 pF | 130 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 15 pF | 150 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 16 pF | 160 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 18 pF | 180 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 20 pF | 200 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 22 pF | 220 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 24 pF | 240 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 27 pF | 270 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 30 pF | 300 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 33 pF | 330 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 36 pF | 360 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 39 pF | 390 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 43 pF | 430 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 47 pF | 470 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 51 pF | 510 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 56 pF | 560 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 62 pF | 620 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 68 pF | 680 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 75 pF | 750 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 82 pF | 820 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 91 pF | 910 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 100 pF | 101 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 110 pF | 111 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 120 pF | 121 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 130 pF | 131 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 150 pF | 151 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 160 pF | 161 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 180 pF | 181 | F G J K M | GK | GK | GK | GK | GK | GK | GK | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 200 pF | 201 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 220 pF | 221 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF | KF | KF |
| 240 pF | 241 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 270 pF | 271 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 300 pF | 301 | F G J K M | GH | GH | GH | GH | GH | GK | GM | | | | | | | | JK | JK | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 330 pF | 331 | F G J K M | GH | GH | GH | GH | GH | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 360 pF | 361 | F G J K M | GK | GK | GK | GK | GH | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 390 pF | 391 | F G J K M | GK | GK | GK | GK | GK | GK | GO | | | | | | | | JE | JE | JE | JE | JE | JK | JK | KE | KE | KE | KE | KE | KE | KF |
| 430 pF | 431 | F G J K M | GK | GK | GK | GK | GK | GK | | | | | | | | HJ | JE | JE | JE | JE | JE | JK | JE | KE | KE | KE | KE | KE | KE | KF |
| 470 pF | 471 | F G J K M | GK | GK | GK | GK | GK | GK | | | | | | | | HJ | JE | JE | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 510 pF | 511 | F G J K M | GH | GH | GH | GK | GH | GM | | | | | | | | HJ | JK | JK | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE | KE | KF |
| 560 pF | 561 | F G J K M | GH | GH | GH | GK | GH | GM | | | | | | | | HJ | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KE | KF |
| 620 pF | 621 | F G J K M | GH | GH | GH | GH | GK | GH | GM | | | | | | | HK | JK | JK | JK | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 680 pF | 681 | F G J K M | GH | GH | GH | GK | GH | GO | | | | | | | | HK | JE | JE | JE | JK | JK | JK | JL | KF | KF | KF | KF | KE | KF | KH |
| 750 pF | 751 | F G J K M | GH | GH | GH | GK | GK | | | | | | | | | | JE | JE | JE | JK | JK | JK | JL | KE | KE | KE | KF | KE | KF | KH |
| 820 pF | 821 | F G J K M | GH | GH | GH | GK | GK | | | | | | | | | | JE | JE | JE | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 910 pF | 911 | F G J K M | GH | GH | GH | GH | GM | | | | | | | | | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 1,000 pF | 102 | F G J K M | GH | GH | GH | GH | GM | | | | | | | | | | JE | JK | JK | JK | JK | JK | JN | KE | KE | KE | KF | KE | KF | KJ |
| 1,100 pF | 112 | F G J K M | GH | GK | GK | GH | GO | | | | | | | | HJ | | JE | JK | JK | JK | JK | JK | | KE | KE | KE | KF | KF | KF | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Cap | Cap Code | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,200 pF | 122 | F G J K M | GH | GK | GK | GH | GO | | | | | | | | HJ | | JE | JK | JK | JK | JK | JL | | KE | KE | KE | KF | KF | KF | |
| 1,300 pF | 132 | F G J K M | GH | GK | GK | GH | GO | | | | | | | HE | HJ | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,500 pF | 152 | F G J K M | GK | GK | GK | GK | GO | | | | | | | HE | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KF | KH | |
| 1,600 pF | 162 | F G J K M | GK | GK | GK | GK | | | | | | | | HG | HK | | JE | JK | JK | JK | JE | JL | | KE | KE | KE | KF | KE | KH | |
| 1,800 pF | 182 | F G J K M | GK | GK | GK | GM | | | | | | | | HG | | | JE | JK | JK | JK | JE | JN | | KE | KE | KE | KF | KE | KH | |
| 2,000 pF | 202 | F G J K M | GK | GK | GK | GM | | | | | | | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KE | KJ | |
| 2,200 pF | 222 | F G J K M | GK | GK | GK | GO | | | | | | | HE | HJ | | | JE | JK | JK | JE | JK | | | KE | KE | KE | KF | KF | KJ | |
| 2,400 pF | 242 | F G J K M | GK | GH | GK | GO | | | | | | | HE | HJ | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 2,700 pF | 272 | F G J K M | GK | GH | GK | GO | | | | | | | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,000 pF | 302 | F G J K M | GK | GH | GK | | | | | | | | HE | HK | | | JK | JK | JK | JE | JL | | | KE | KE | KE | KE | KH | | |
| 3,300 pF | 332 | F G J K M | GK | GH | GK | | | | | | | | HG | | | | JK | JK | JK | JK | JN | | | KE | KE | KE | KE | KJ | | |
| 3,600 pF | 362 | F G J K M | GK | GH | GM | | | | | | | | HG | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 3,900 pF | 392 | F G J K M | GK | GH | GM | | | | | | | | HJ | | | | JK | JK | JK | JK | JN | | | KE | KF | KF | KF | KJ | | |
| 4,300 pF | 432 | F G J K M | GH | GH | GO | | | | | | | | HJ | | | | JK | JK | JK | JK | | | | KE | KF | KF | KF | | | |
| 4,700 pF | 472 | F G J K M | GH | GH | GO | | | | | | | | HJ | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | | | | HE | HG | HK | | | | JK | JK | JK | JL | | | | KE | KF | KF | KH | | | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | | | | HE | HG | HK | | | | JK | JK | JK | JN | | | | KE | KF | KF | KH | | | |
| 6,200 pF | 622 | F G J K M | GH | GK | | | | | | | HE | HG | | | | | JK | JE | JE | JN | | | | KE | KF | KF | KJ | | | |
| 6,800 pF | 682 | F G J K M | GH | GM | | | | | | | HE | HJ | | | | | JK | JE | JK | JN | | | | KE | KF | KF | KJ | | | |
| 7,500 pF | 752 | F G J K M | GH | GM | | | | | | | HE | HJ | | | | | JK | JE | JK | | | | | KF | KE | KF | | | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | | | | HE | HJ | | | | | JK | JE | JL | | | | | KF | KE | KF | | | | |
| 9,100 pF | 912 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 10,000 pF | 103 | F G J K M | GM | GO | | | | | | HE | HG | HK | | | | | JE | JE | JL | | | | | KF | KE | KH | | | | |
| 12,000 pF | 123 | F G J K M | GO | | | | | | | HE | HG | | | | | | JE | JK | JN | | | | | KE | KE | KH | | | | |
| 15,000 pF | 153 | F G J K M | GO | | | | | | | HE | HJ | | | | | | JE | JL | | | | | | KE | KF | KJ | | | | |
| 18,000 pF | 183 | F G J K M | | | | | | | | HG | HK | | | | | | JE | JL | | | | | | KE | KH | | | | | |
| 22,000 pF | 223 | F G J K M | | | | | | | | HJ | | | | | | | JK | JN | | | | | | KF | KJ | | | | | |
| 27,000 pF | 273 | F G J K M | | | | | | | | HJ | | | | | | | JL | JN | | | | | | KF | KJ | | | | | |
| 33,000 pF | 333 | F G J K M | | | | | | | | HK | | | | | | | JN | | | | | | | KH | | | | | | |
| 39,000 pF | 393 | F G J K M | | | | | | | | | | | | | | | | | | | | | | KJ | | | | | | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 | 500 | 630 | 1000 | 1500 | 2000 | 2500 | 3000 |
| | | Voltage Code | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H | C | B | D | F | G | Z | H |
| | | Case Size/Series | C1812X | | | | | | | C1825X | | | | | | | C2220X | | | | | | | C2225X | | | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ES | 1206 | 1.00 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EU | 1206 | 1.60 ± 0.25 | 0 | 0 | 2,000 | 8,000 |
| EQ | 1206 | 0.78 ± 0.20 | 4000 | 10000 | 4,000 | 10,000 |
| ER | 1206 | 0.90 ± 0.20 | 0 | 0 | 4,000 | 10,000 |
| FE | 1210 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

[1] *The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*

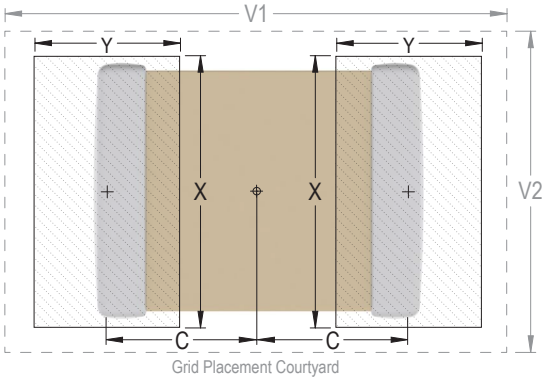
[2] *A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

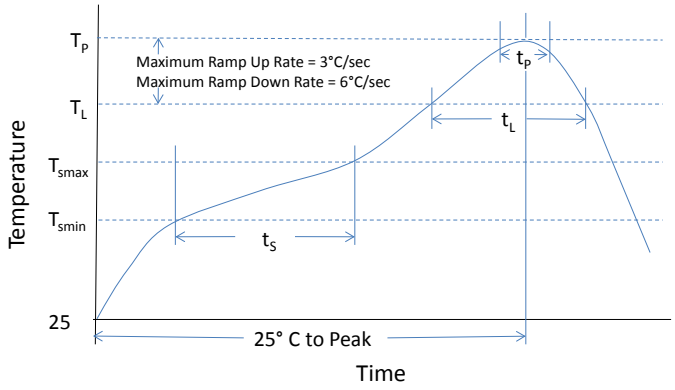
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



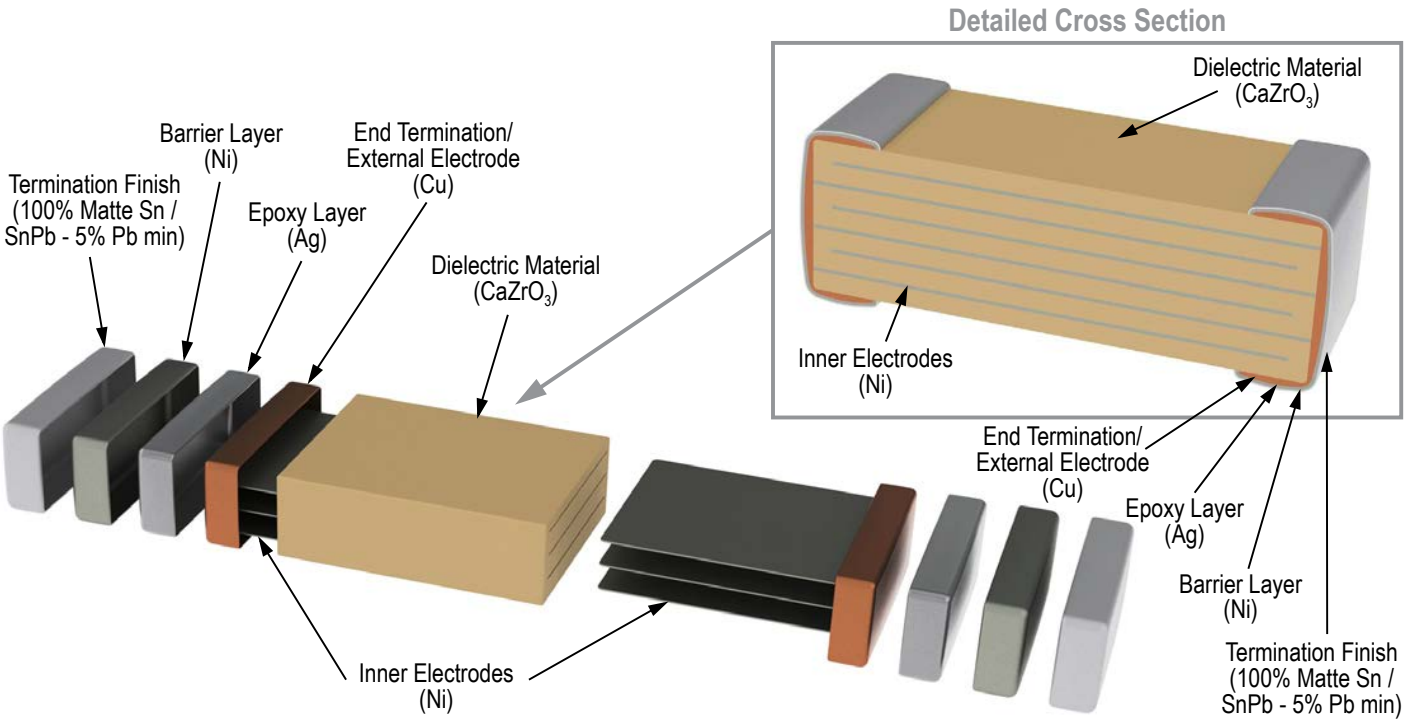
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# ArcShield™ Technology, High Voltage, X7R Dielectric, 500 – 1,000 VDC (Commercial & Automotive Grade)

## Overview

KEMET ArcShield high voltage surface mount capacitors in X7R dielectric are designed for use in high voltage applications susceptible to surface arcing (arc-over discharge).

The phenomenon of surface arcing is caused by a high voltage gradient between the two termination surfaces or between one of the termination surfaces and the counter internal electrode structure within the ceramic body. It occurs most frequently at application voltages that meet or exceed 300 V, in high humidity environments, and in chip sizes with minimal bandwidth separation (creepage distance). This phenomenon can either damage surrounding components or lead to a breakdown of the dielectric material, ultimately resulting in a short-circuit condition (catastrophic failure mode).

Patented ArcShield technology features KEMET's highly reliable base metal dielectric system combined with a unique internal shield electrode structure that is designed to suppress an arc-over event while increasing available capacitance. Developed on the principle of a partial Faraday cage, this internal system offers unrivaled performance and reliability when compared to external surface coating technologies.

For added reliability, KEMET's Flexible Termination technology is an available option that provides superior flex performance over standard termination systems. This technology was developed to address flex cracks, which are the primary failure mode of MLCCs and typically the result of excessive tensile and shear stresses produced during board flexure and thermal cycling. Flexible Termination technology inhibits the transfer of board stress to the rigid body of the MLCC, therefore mitigating flex cracks which can result in low IR or short circuit failures.

KEMET's ArcShield high voltage surface mount MLCCs are available in Automotive Grade, which undergo stricter testing protocol and inspection criteria. Whether under-hood or in-cabin, these devices are designed for mission and safety-critical automotive circuits or applications requiring proven, reliable performance in harsh environments. Automotive Grade devices meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

## Ordering Information

| C | 0603 | W | 392 | K | C | R | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[1] | Packaging/ Grade (C-Spec)[2] |
| | 0603<br>0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225 | V = ArcShield<br>W = ArcShield with Flexible Termination | Two significant digits + number of zeros. | J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000 | R = X7R | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% PB minimum) | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional termination finish options may be available. Contact KEMET for details.*

*[1, 2] SnPb termination finish option is not available on Automotive Grade product.*

*[2] Additional reeling or packaging options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type | Packaging/Grade Ordering Code (C-Spec) |
|---|---|
| **Commercial Grade**[1] | |
| Bulk Bag | Not Required (Blank) |
| 7" Reel/Unmarked | TU |
| 13" Reel/Unmarked | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Marked | TM |
| 13" Reel/Marked | 7040 (EIA 0603 and smaller case sizes)<br>7215 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 7081 |
| 13" Reel/Unmarked/2 mm pitch[2] | 7082 |
| **Automotive Grade**[3] | |
| 7" Reel | AUTO |
| 13" Reel/Unmarked | AUTO7411 (EIA 0603 and smaller case sizes)<br>AUTO7210 (EIA 0805 and larger case sizes) |
| 7" Reel/Unmarked/2 mm pitch[2] | 3190 |
| 13" Reel/Unmarked/2 mm pitch[2] | 3191 |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked.*

*[2] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[3] Reeling tape options (Paper or Plastic) are dependent on capacitor case size (L" x W") and thickness dimension. See "Chip Thickness/Tape & Reel Packaging Quantities" and "Tape & Reel Packaging Information".*

*[3] For additional Information regarding "AUTO" C-Spec options, see "Automotive C-Spec Information".*

*[3] All Automotive packaging C-Specs listed exclude the option to laser mark components. Please contact KEMET if you require a laser marked option. For more information see "Capacitor Marking".*

## Benefits

- Patented technology
- Permanent internal arc protection
- Protective surface coating not required
- Base metal electrode (BME) dielectric system
- Industry leading CV values
- -55°C to +125°C operating temperature range
- Exceptional performance at high frequencies
- Lead (Pb)-Free, RoHS and REACH compliant
- EIA 0603, 0805, 1206, 1210, 1808, 1812, 1825, 2220 and 2225 case sizes
- DC voltage ratings of 500 V, 630 V and 1 KV
- Capacitance offerings ranging from 1,000 pF to 560 nF
- Available capacitance tolerances of ±5%, ±10% and ±20%
- Low ESR & ESL
- Non-polar device, minimizing installation concerns
- Commercial & Automotive (AEC-Q200) grades available
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)
- Flexible Termination option available upon request

## Automotive C-Spec Information

KEMET Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. These products are supported by a Product Change Notification (PCN) and Production Part Approval Process warrant (PPAP).

Automotive products offered through our distribution channel have been assigned an inclusive ordering code C-Spec, "AUTO". This C-Spec was developed in order to better serve small and medium sized companies that prefer an automotive grade component without the requirement to submit a customer Source Controlled Drawing (SCD) or specification for review by a KEMET engineering specialist. This C-Spec is therefore not intended for use by KEMET's OEM Automotive customers and are not granted the same "privileges" as other automotive C-Specs. Customer PCN approval and PPAP request levels are limited (see details below).

**Product Change Notification (PCN)**

The KEMET Product Change Notification system is used to communicate primarily the following types of changes:

- Product/process changes that affect product form, fit , function, and /or reliability
- Changes in manufacturing site
- Product obsolescence

| KEMET Automotive C-Spec | Customer Notification due to: | | Days prior to implementation |
|---|---|---|---|
| | Process/Product change | Obsolescence* | |
| KEMET assigned[1] | Yes (with approval and sign off) | Yes | 180 days Minimum |
| AUTO | Yes (without approval) | Yes | 90 days Minimum |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

**Production Part Approval Process (PPAP)**

The purpose of the Production Part Approval Process is:

- To ensure that supplier can meet the manufacturability and quality requirements for the purchased parts.
- To provide the evidence that all customer engineering design record and specification requirements are properly understood and fulfilled by the manufacturing organization.
- To demonstrate that the established manufacturing process has the potential to produce the part

| KEMET Automotive C-Spec | PPAP (Product Part Approval Process) Level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| KEMET assigned[1] | ● | ● | ● | ● | ● |
| AUTO | ○ | | ○ | | |

[1] *KEMET assigned C-Specs require the submittal of a customer SCD or customer specification for review. For additional information contact KEMET.*

● Part Number specific PPAP available
○ Product family PPAP only

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting) applications.

## Application Notes

X7R dielectric is not recommended for AC line filtering or pulse applications.

## Qualification/Certification

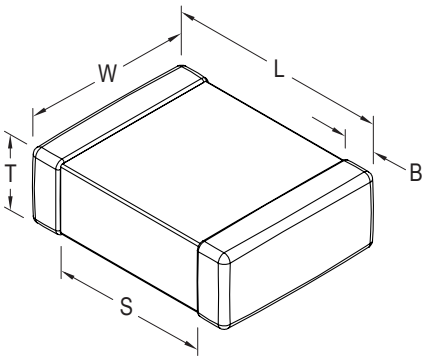
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance & Reliability.

Automotive Grade products meet or exceed the requirements outlined by the Automotive Electronics Council. Details regarding test methods and conditions are referenced in document AEC–Q200, Stress Test Qualification for Passive Components. For additional information regarding the Automotive Electronics Council and AEC–Q200, please visit their website at www.aecouncil.com.

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches) – Standard Termination




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.063) ± 0.15 (.006) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.35 (.014) ± 0.15 (.006) | 0.70 (.028) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |

## Dimensions – Millimeters (Inches) – Flexible Termination

| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0603 | 1608 | 1.60 (.064) ± 0.17 (.007) | 0.80 (.032) ± 0.15 (.006) | See Table 2 for Thickness | 0.45 (.018) ± 0.15 (.006) | 0.58 (.023) | Solder Wave or Solder Reflow |
| 0805 | 2012 | 2.00 (.079) ± 0.30 (.012) | 1.25 (.049) ± 0.30 (.012) | | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | |
| 1206 | 3216 | 3.30 (.130) ± 0.40 (.016) | 1.60 (.063) ± 0.35 (.013) | | 0.60 (.024) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.30 (.130) ± 0.40 (.016) | 2.60 (.102) ± 0.30 (.012) | | 0.60 (.024) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.178) ± 0.40 (.016) | 3.20 (.126) ± 0.30 (.012) | | 0.70 (.028) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.60 (.181) ± 0.40 (.016) | 6.40 (.252) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.90 (.232) ± 0.75 (.030) | 5.00 (.197) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.90 (.232) ± 0.75 (.030) | 6.40 (.248) ± 0.40 (.016) | | 0.70 (.028) ± 0.35 (.014) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | 100 megohm microfarads or 10GΩ<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*
*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*
*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

# Table 1 – Capacitance Range/Selection Waterfall (0603 – 1812 Case Sizes)

| Cap | Cap Code | Case Size/ Series | C0603W/V | | | C0805W/V | | | C1206W/V | | | C1210W/V | | | C1808W/V | | | C1812W/V | | | C1825W/V | | C2220W/V | | C2225W/V | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | C | B | C | B |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 500 | 630 | 500 | 630 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | | | | | |
| 1,000 pF | 102 | J K M | CG | CG | CG | | | | | | | | | | | | | | | | | | | | | |
| 1,200 pF | 122 | J K M | CG | CG | | | | | | | | | | | | | | | | | | | | | | |
| 1,500 pF | 152 | J K M | CG | CG | | | | | | | | | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J K M | CG | | | | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J K M | CG | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J K M | | | | DG | DG | DG | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J K M | | | | DG | DG | | | | | | | | | | | | | | | | | | | |
| 12,000 pF | 123 | J K M | | | | DG | DG | | EJ | EJ | EJ | | | | | | | | | | | | | | | |
| 15,000 pF | 153 | J K M | | | | DG | | | EJ | EJ | EJ | | | | | | | | | | | | | | | |
| 18,000 pF | 183 | J K M | | | | DG | | | EJ | EJ | EJ | | | | LE | LE | LE | | | | | | | | | |
| 22,000 pF | 223 | J K M | | | | DG | | | EJ | EJ | EJ | FZ | FZ | FZ | LE | LE | LE | | | | | | | | | |
| 27,000 pF | 273 | J K M | | | | | | | EJ | EJ | | FZ | FZ | FZ | LA | LA | LA | GB | GB | GB | | | | | | |
| 33,000 pF | 333 | J K M | | | | | | | EJ | EJ | | FZ | FZ | FU | LA | LA | LA | GB | GB | GB | | | | | | |
| 39,000 pF | 393 | J K M | | | | | | | EJ | | | FZ | FZ | FU | LA | LA | LA | GB | GB | GB | | | | | | |
| 47,000 pF | 473 | J K M | | | | | | | EJ | | | FZ | FU | FK | LA | LA | LB | GB | GB | GC | | | | | | |
| 56,000 pF | 563 | J K M | | | | | | | EJ | | | FZ | FU | FK | LA | LA | LB | GB | GB | GE | | | | | | |
| 62,000 pF | 623 | J K M | | | | | | | EJ | | | FZ | FK | FS | LA | LA | LC | GB | GB | GE | | | | | | |
| 68,000 pF | 683 | J K M | | | | | | | EJ | | | FZ | FK | FS | LA | LA | LC | GE | GE | GE | | | | | | |
| 82,000 pF | 823 | J K M | | | | | | | | | | FU | FK | | LA | LC | | GB | GE | GK | | | | | | |
| 0.10 µF | 104 | J K M | | | | | | | | | | FK | FS | | LA | LC | | GB | GH | GJ | | | | | | |
| 0.12 µF | 124 | J K M | | | | | | | | | | FK | | | LA | | | GE | GK | | HE | HE | | | | |
| 0.15 µF | 154 | J K M | | | | | | | | | | FK | | | LB | | | GE | GN | | HE | HE | JE | JE | | |
| 0.18 µF | 184 | J K M | | | | | | | | | | | | | | | | GF | | | HE | HG | JE | JE | KF | KE |
| 0.22 µF | 224 | J K M | | | | | | | | | | | | | | | | GJ | | | HE | HJ | JK | JK | KE | KF |
| 0.27 µF | 274 | J K M | | | | | | | | | | | | | | | | GL | | | HJ | HJ | JK | JL | KF | KH |
| 0.33 µF | 334 | J K M | | | | | | | | | | | | | | | | GS | | | HJ | | JL | JN | KF | KH |
| 0.39 µF | 394 | J K M | | | | | | | | | | | | | | | | | | | HK | | JN | | KH | KJ |
| 0.47 µF | 474 | J K M | | | | | | | | | | | | | | | | | | | | | JN | | KH | KJ |
| 0.56 µF | 564 | J K M | | | | | | | | | | | | | | | | | | | | | | | KJ | |
| Cap | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 1000 | 500 | 630 | 500 | 630 | 500 | 630 |
| | | Voltage Code | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | D | C | B | C | B | C | B |
| | | Case Size/ Series | C0603W/V | | | C0805W/V | | | C1206W/V | | | C1210W/V | | | C1808W/V | | | C1812W/V | | | C1825W/V | | C2220W/V | | C2225W/V | |

*These products are protected under US Patent 8,885,319 B2, other patents pending, and any foreign counterparts.*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

# Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size[1] | Thickness ± Range (mm) | Paper Quantity[1] | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| CG | 0603 | 0.80 ± 0.10 | 4,000 | 15,000 | 0 | 0 |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EJ | 1206 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FZ | 1210 | 1.25 ± 0.20 | 0 | 0 | 2,500 | 10,000 |
| FU | 1210 | 1.55 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LE | 1808 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GB | 1812 | 1.00 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GE | 1812 | 1.30 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GC | 1812 | 1.10 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GF | 1812 | 1.50 ± 0.10 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GJ | 1812 | 1.70 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GN | 1812 | 1.70 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GL | 1812 | 1.90 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GS | 1812 | 2.10 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| **Thickness Code** | **Case Size[1]** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity[1]** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

*[1] If ordering using the 2 mm Tape and Reel pitch option, the packaging quantity outlined in the table above will be doubled. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | Loose Packaging | |
|---|---|---|---|
| | | Bulk Bag (default) | |
| Packaging C-Spec[1] | | N/A[2] | |
| Case Size | | Packaging Quantities (pieces/unit packaging) | |
| EIA (in) | Metric (mm) | Minimum | Maximum |
| 0402 | 1005 | 1 | 50,000 |
| 0603 | 1608 | | |
| 0805 | 2012 | | |
| 1206 | 3216 | | |
| 1210 | 3225 | | |
| 1808 | 4520 | | 20,000 |
| 1812 | 4532 | | |
| 1825 | 4564 | | |
| 2220 | 5650 | | |
| 2225 | 5664 | | |

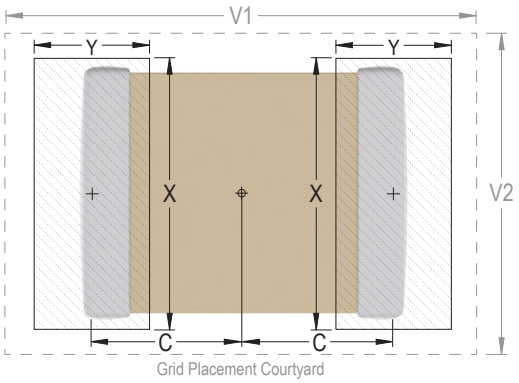
*[1] The "Packaging C-Spec" is a 4 to 8 digit code which identifies the packaging type and/or product grade. When ordering, the proper code must be included in the 15th through 22nd character positions of the ordering code. See "Ordering Information" section of this document for further details. Commercial Grade product ordered without a packaging C-Spec will default to our standard "Bulk Bag" packaging. Contact KEMET if you require a bulk bag packaging option for Automotive Grade products.*
*[2] A packaging C-Spec (see note 1 above) is not required for "Bulk Bag" packaging (excluding Anti-Static Bulk Bag and Automotive Grade products). The 15th through 22nd character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "Bulk Bag" packaging.*

# Table 3A – Land Pattern Design Recommendations per IPC–7351 – Standard Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.90 | 1.15 | 1.10 | 4.00 | 2.10 | 0.80 | 0.95 | 1.00 | 3.10 | 1.50 | 0.60 | 0.75 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 1.50 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*

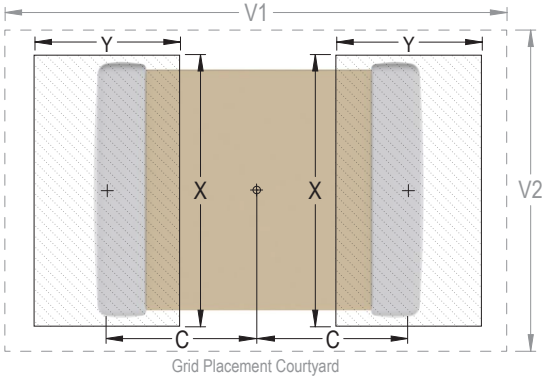


## Table 3B – Land Pattern Design Recommendations per IPC–7351 – Flexible Termination

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0603 | 1608 | 0.85 | 1.25 | 1.10 | 4.00 | 2.10 | 0.75 | 1.05 | 1.00 | 3.10 | 1.50 | 0.65 | 0.85 | 0.90 | 2.40 | 1.20 |
| 0805 | 2012 | 0.99 | 1.44 | 1.66 | 4.47 | 2.71 | 0.89 | 1.24 | 1.56 | 3.57 | 2.11 | 0.79 | 1.04 | 1.46 | 2.42 | 1.81 |
| 1206 | 3216 | 1.59 | 1.62 | 2.06 | 5.85 | 3.06 | 1.49 | 1.42 | 1.96 | 4.95 | 2.46 | 1.39 | 1.22 | 1.86 | 4.25 | 2.16 |
| 1210 | 3225 | 1.59 | 1.62 | 3.01 | 5.90 | 4.01 | 1.49 | 1.42 | 2.91 | 4.95 | 3.41 | 1.39 | 1.22 | 2.81 | 4.25 | 3.11 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.10 | 1.80 | 3.60 | 7.00 | 4.60 | 2.00 | 1.60 | 3.50 | 6.10 | 4.00 | 1.90 | 1.40 | 3.40 | 5.40 | 3.70 |
| 1825 | 4564 | 2.15 | 1.80 | 6.90 | 7.10 | 7.90 | 2.05 | 1.60 | 6.80 | 6.20 | 7.30 | 1.95 | 1.40 | 6.70 | 5.50 | 7.00 |
| 2220 | 5650 | 2.85 | 2.10 | 5.50 | 8.80 | 6.50 | 2.75 | 1.90 | 5.40 | 7.90 | 5.90 | 2.65 | 1.70 | 5.30 | 7.20 | 5.60 |
| 2225 | 5664 | 2.85 | 2.10 | 6.90 | 8.80 | 7.90 | 2.75 | 1.90 | 6.80 | 7.90 | 7.30 | 2.65 | 1.70 | 6.70 | 7.20 | 7.00 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

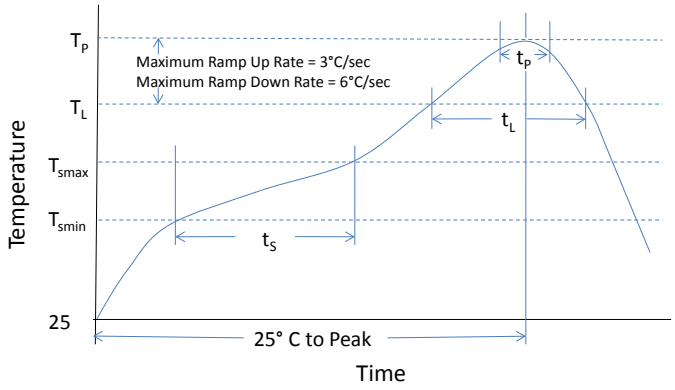
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



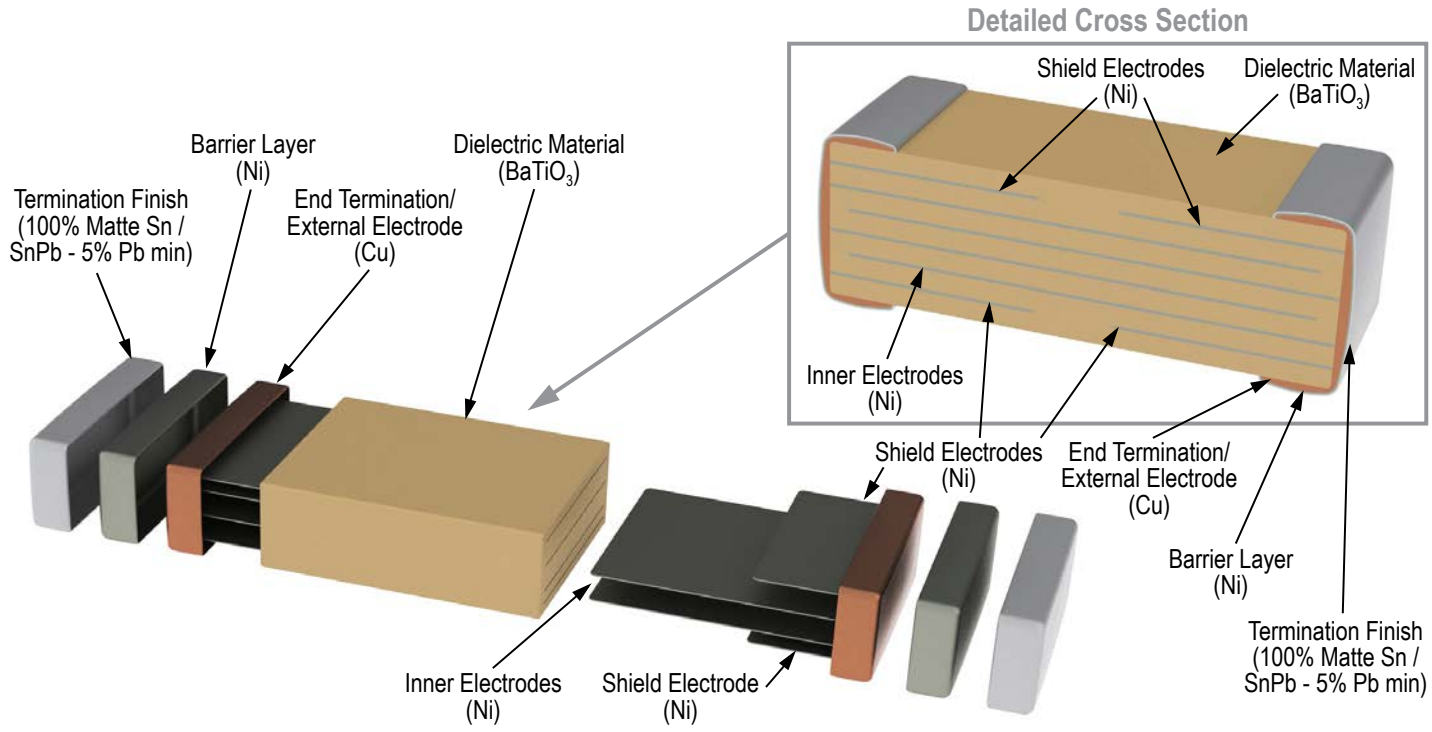
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: Standard termination system – 2.0 mm (minimum) for all except 3 mm for C0G. Flexible termination system – 3.0 mm (minimum). |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours at 155°C, dry heat at 235°C |
| | | b) Method B at 215°C category 3 |
| | | c) Method D, category 3 at 260°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (-55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Unpowered. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | -55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with 1.2 X rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 min., 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

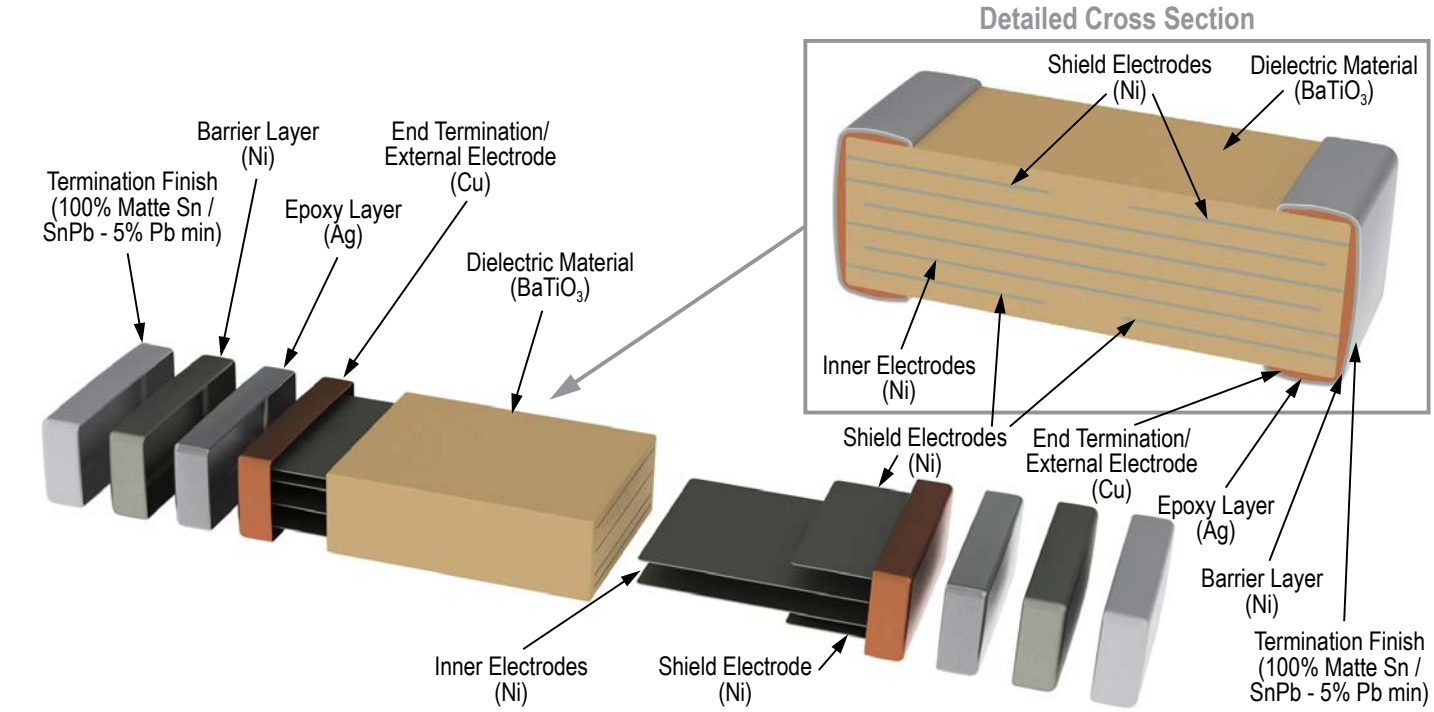
## Storage & Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction – Standard Termination




## Construction – Flexible Termination



# KPS Series, High Voltage, X7R Dielectric, 500 – 630 VDC (Commercial Grade)

## Overview

KEMET Power Solutions (KPS) High Voltage stacked capacitors utilize a proprietary lead-frame technology to vertically stack one or two multilayer ceramic chip capacitors into a single compact surface mount package. The attached lead-frame mechanically isolates the capacitor(s) from the printed circuit board, thereby offering advanced mechanical and thermal stress performance. Isolation also addresses concerns for audible microphonic noise that may occur when a bias voltage is applied. A two-chip stack offers up to double the capacitance in the same or smaller design footprint when compared to traditional surface mount MLCC devices. Providing up to 10 mm of board flex capability, KPS Series High Voltage capacitors are environmentally friendly and in compliance with RoHS legislation.

KEMET's KPS Series devices in X7R dielectric exhibit a predictable change in capacitance with respect to time and voltage, and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C. These devices are capable of Pb-Free reflow profiles and provide lower ESR, ESL and higher ripple current capability when compared to other dielectric solutions.

Conventional uses include both snubbers and filters in applications such as switching power supplies and lighting ballasts. Their exceptional performance at high frequencies has made high voltage ceramic capacitors the preferred dielectric choice of design engineers worldwide. In addition to their use in power supplies, these capacitors are widely used in industries related to automotive (hybrid), telecommunications, medical, military, aerospace, semiconductors, and test/diagnostic equipment.

## Benefits

- −55°C to +125°C operating temperature range
- Reliable and robust termination system
- EIA 2220 case size
- DC voltage ratings of 500 V and 630 V
- Capacitance offerings ranging from 0.047 µF up to 1.0 µF
- Available capacitance tolerances of ±10% and ±20%
- Higher capacitance in the same footprint
- Potential board space savings

## Ordering Information

| C | 2220 | C | 105 | M | C | R | 2 | C | 7186 |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L"x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Leadframe Finish[2] | Packaging/Grade (C-Spec) |
| | 2220 | C = Standard | Two significant digits + number of zeros. | K = ±10%<br>M = ±20% | C = 500<br>B = 630 | R = X7R | 1 = KPS Single Chip Stack<br>2 = KPS Double Chip Stack | C = 100% Matte Sn | See "Packaging C-Spec Ordering Options Table" below |

*[1] Double chip stacks ("2" in the 13th character position of the ordering code) are only available in M (±20%) capacitance tolerance. Single chip stacks ("1" in the 13th character position of the ordering code) are available in K (±10%) or M (±20%) tolerances.*

*[2] Additional leadframe finish options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type[1] | Packaging/Grade Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape)/Unmarked | 7186 |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7289 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of capacitors. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices. For more information see "Capacitor Marking".*

## Benefits cont'd

- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible microphonic noise
- Extremely low ESR and ESL
- Lead (Pb)-Free, RoHS and REACH compliant
- Capable of Pb-Free reflow profiles
- Non-polar device, minimizing installation concerns
- Film alternative

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, lighting ballasts, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control, LAN/WAN interface, analog and digital modems, and automotive (electric and hybrid vehicles, charging stations and lighting applications).

## Application Note

X7R dielectric is not recommended for AC line filtering or pulse applications.

## Qualification/Certification

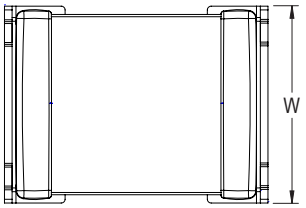
Commercial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4 , Performance and Reliability.

## Environmental Compliance

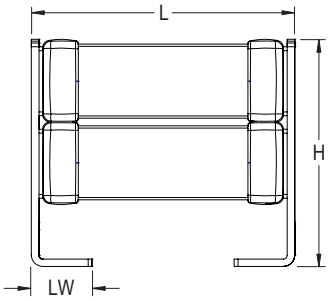
Lead (Pb)-Free, RoHS, and REACH compliant without exemptions.

## Dimensions – Millimeters (Inches)

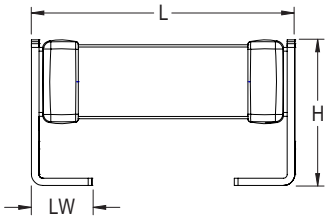
*Single or Double Chip Stack*




*Double Chip Stack*




*Single Chip Stack*




| Number of Chips | EIA Size Code | Metric Size Code | L Length | W Width | H Height | LW Lead Width | Mounting Technique |
|---|---|---|---|---|---|---|---|
| Single | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 3.50 (.138) ±0.30 (.012) | 1.60 (.063) ±0.30 (.012) | Solder Reflow Only |
| Double | 2220 | 5650 | 6.00 (0.236) ±0.50 (0.020) | 5.00 (.197) ±0.50 (.020) | 5.00 (.197) ±0.50 (.020) | 1.60 (.063) ±0.30 (.012) | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 Vdc Applied (TCC) | ±15% |
| [1]Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| [2]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000V<br>120% of rated voltage for voltage rating of ≥ 1000V<br>(5 ± 1 seconds and charge/discharge not exceeding 50mA) |
| [3]Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| [4]Insulation Resistance (IR) Minimum Limit @ 25°C | See Insulation Resistance Limit Table<br>(500VDC applied for 120 ± 5 secs @ 25°C) |

*[1]Regarding Aging Rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*

*[2]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*

*[3]Capacitance and dissipation factor (DF) measured under the following conditions:*

*1kHz ± 50Hz and 1.0 ± 0.2 Vrms if capacitance ≤10µF*

*120Hz ± 10Hz and 0.5 ± 0.1 Vrms if capacitance >10µF*

*[4]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 & Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON".*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| X7R | > 25 | All | 3.0 | ±20% | 10% of Initial Limit |
| | 16/25 | | 5.0 | | |
| | < 16 | | 7.5 | | |

## Insulation Resistance Limit Table

| EIA Case Size | 1,000 Megohm Microfarads or 100 GΩ | 100 Megohm Microfarads or 10 GΩ |
|---|---|---|
| 0805 | < 0.0039 µF | ≥ 0.0039 µF |
| 1206 | < 0.012 µF | ≥ 0.012 µF |
| 1210 | < 0.033 µF | ≥ 0.033 µF |
| 1808 | < 0.018 µF | ≥ 0.018 µF |
| 1812 | < 0.027 µF | ≥ 0.027 µF |
| ≥ 1825 | All | N/A |

## Table 1 – Capacitance Range/Selection Waterfall (2220 Case Sizes)

| Capacitance | Capacitance Code | Case Size/Series | | C2220C | | |
|---|---|---|---|---|---|---|
| | | Voltage Code | | C | B | D |
| | | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Capacitance Tolerance | | Product Availability and Chip Thickness Codes – See Table 2 for Chip Thickness Dimensions | | |
| **Single Chip Stack** | | | | | | |
| 0.047 µF | 473 | K | M | JP | JP | |
| 0.10 µF | 104 | K | M | JP | JP | |
| 0.15 µF | 154 | K | M | JP | JP | |
| 0.22 µF | 224 | K | M | JP | JP | |
| 0.33 µF | 334 | K | M | JP | | |
| 0.47 µF | 474 | K | M | JP | | |
| **Double Chip Stack** | | | | | | |
| 0.10 µF | 104 | | M | JR | JR | |
| 0.22 µF | 224 | | M | JR | JR | |
| 0.33 µF | 334 | | M | JR | JR | |
| 0.47 µF | 474 | | M | JR | JR | |
| 0.68 µF | 684 | | M | JR | | |
| 1.0 µF | 105 | | M | JR | | |
| Capacitance | Capacitance Code | Rated Voltage (VDC) | | 500 | 630 | 1000 |
| | | Voltage Code | | C | B | D |
| | | Case Size/Series | | C2220C | | |

*These products are protected under US Patent 8,331,078 other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

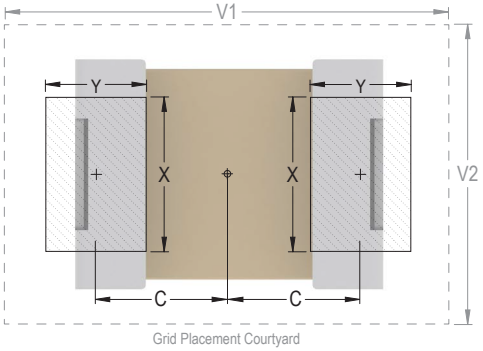
| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| JP | 2220 | 3.50 ± 0.30 | 0 | 0 | 300 | 1,300 |
| JR | 2220 | 5.00 ± 0.50 | 0 | 0 | 200 | 800 |

*Package quantity based on finished chip thickness specifications.*

## Table 3 – KPS Land Pattern Design Recommendations (mm)

| EIA SIZE CODE | METRIC SIZE CODE | Median (Nominal) Land Protrusion | | | | |
|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 |
| 1210 | 3225 | 1.50 | 1.14 | 1.75 | 5.05 | 3.40 |
| 1812 | 4532 | 2.20 | 1.35 | 2.87 | 6.70 | 4.50 |
| 2220 | 5650 | 2.69 | 2.08 | 4.78 | 7.70 | 6.00 |

*Image at right based on an EIA 1210 case size.*




## Soldering Process

KEMET's KPS Series devices are compatible with IR reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for IR reflow reflect the profile conditions of the IPC/J–STD–020D standard for moisture sensitivity testing.

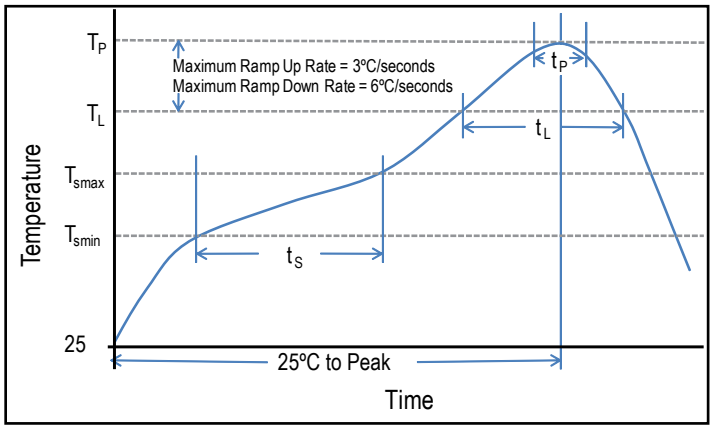
To prevent degradation of temperature cycling capability, care must be taken to prevent solder from flowing into the inner side of the lead frames (inner side of "J" lead in contact with the circuit board).

After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the capacitor body. The iron should be used to heat the solder pad, applying solder between the pad and the lead, until reflow occurs. Once reflow occurs, the iron should be removed immediately. (Preheating is required when hand soldering to avoid thermal shock.)

| Profile Feature | SnPb Assembly | Pb-Free Assembly |
|---|---|---|
| Preheat/Soak | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 3°C/seconds maximum | 3°C/seconds maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 250°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 10 seconds maximum |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/seconds maximum | 6°C/seconds maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



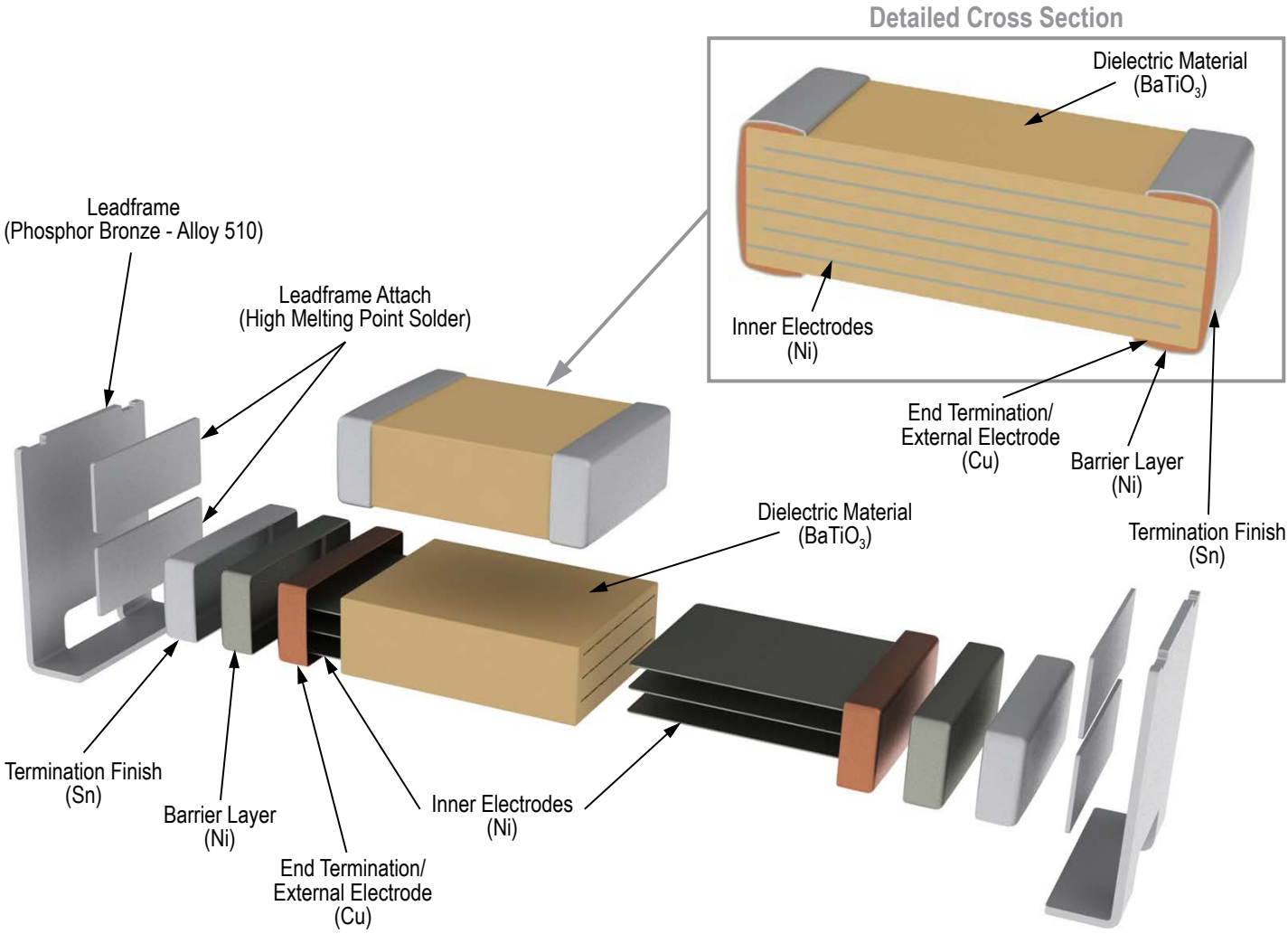
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Terminal Strength | JIS–C–6429 | Appendix 1, Note: Force of 1.8 kg for 60 seconds. |
| Board Flex | JIS–C–6429 | Appendix 2, Note: 5.0 mm minimum |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 250°C |
| Temperature Cycling | JESD22 Method JA–104 | 1,000 cycles (−55°C to +125°C). Measurement at 24 hours +/- 4 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 200 VDC maximum. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Moisture Resistance | MIL–STD–202 Method 106 | t = 24 hours/cycle. Steps 7a and 7b not required. Measurement at 24 hours +/- 4 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | −55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. Dwell time – 15 minutes. Air-Air. |
| High Temperature Life | MIL–STD–202 Method 108 | 1,000 hours at 125°C with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g's for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" X 5" PCB 0.031" thick, 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10 – 2,000 Hz. |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# KPS HV, Large Case, SM Series, C0G Dielectric, 500 – 10,000 VDC (Industrial Grade)

## Overview

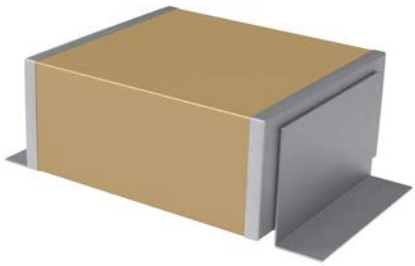
KPS HV (KEMET Power Solutions, High Voltage), Large Case (≥ 1515), SM Series capacitors in C0G dielectric are designed to meet robust performance standards required in higher reliability industrial applications. Utilizing lead-frame technology, SM Series devices isolate the multilayer ceramic chip component from the printed circuit board providing advanced mechanical and thermal stress performance. Isolation of the chip component also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does demonstrate superior performance over non-isolating systems. Available in both formed "L" and "J" lead configurations, SM Series devices offer up to 10 mm of board flex capability and exhibit lower ESR, ESL and higher current discharge capability when compared to other dielectric solutions.

Combined with the stability of an C0G dielectric, KEMET's High Voltage SM Series devices exhibit no change in capacitance with respect to time and voltage and boasts a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30 ppm/ºC from -55°C to +125°C.

KEMET's Industrial Grade products offer additional screening options for higher reliability applications. Both Group A and Group B testing/inspection options per MIL–PRF–49467 are available for the SM Series.

## Benefits

- -55°C to +125°C operating temperature range
- Large Case Sizes (≥ 1515)
- Formed “L” or “J” leadframe configurations.
- Group A and B screening per MIL–PRF–49467 available
- Reliable and robust leadframe termination system
- DC voltage ratings of 500 V, 1 KV, 2 KV, 3 KV, 4 KV, 5 KV, 7.5 KV, and 10 KV
- Capacitance offerings ranging from 10 pF up to 0.39 µF



## Ordering Information

| SM20 | | N | 472 | J | 501 | B | M |
|---|---|---|---|---|---|---|---|
| Style/Size | | Dielectric | Capacitance Code (pF) | *Capacitance Tolerance* | Rated Voltage (VDC) | Lead Configuration[1] | Testing/ Inspection Option[2] |
| SM20<br>SM21<br>SM22<br>SM23<br>SM24<br>SM25<br>SM26 | SM30<br>SM31<br>SM33<br>SM34<br>SM35<br>SM36 | N = C0G | 2 significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | 501 = 500<br>102 = 1,000<br>202 = 2,000<br>302 = 3,000<br>402 = 4,000<br>502 = 5,000<br>752 = 7,500<br>103 = 10,000 | A = Formed "L"<br>B = Formed "J" | Blank = None<br>M = Group A per MIL–PRF–49467 |

*[1] Standard lead configuration is formed "J". If the appropriate character is excluded from the ordering code, the assumed lead configuration will be formed "J".*

*[2] Group B testing/inspection option per MIL–PRF–49467 is available upon request. Please contact KEMET for ordering details.*



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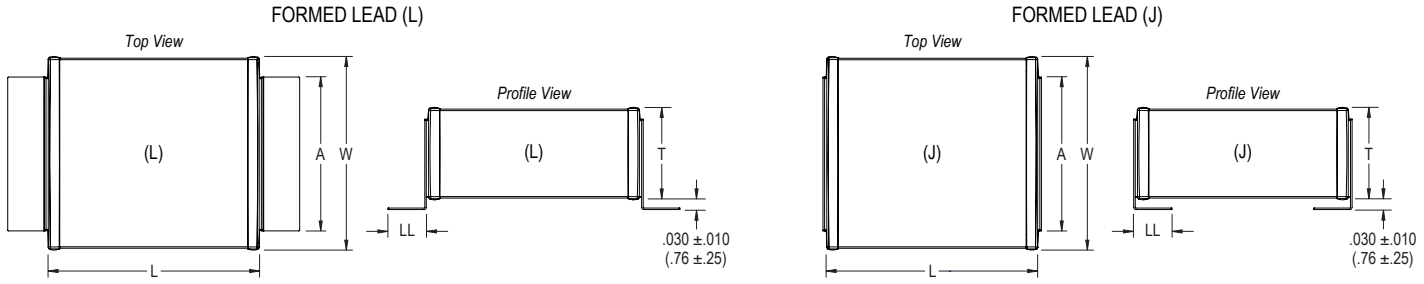
## Dimensions – Inches (Millimeters)




| Style/ Size | L Length | W Width | T Thickness Maximum | A Lead Width Maximum | LL Lead Length (Formed "L") | LL Lead Length (Formed "J") |
|---|---|---|---|---|---|---|
| SM20 | 0.150 ± 0.015 (3.81 ± 0.38) | 0.150 ± 0.015 (3.81 ± 0.38) | 0.130 (3.30) | 0.100 (2.54) | 0.100 ±0.020 (2.54 ±0.51) | 0.040 ±0.010 (1.02 ±0.25) |
| SM21 | 0.200 ± 0.020 (5.08 ± 0.51) | 0.200 ± 0.020 (5.08 ± 0.51) | 0.180 (4.57) | | | |
| SM22 | 0.250 ± 0.020 (6.35 ± 0.51) | 0.200 ± 0.020 (5.08 ± 0.51) | | | | |
| SM23 | 0.350 ± 0.030 (8.89 ± 0.76) | 0.300 ± 0.030 (7.62 ± 0.76) | 0.220 (5.59) | 0.200 (5.08) | | 0.100 ±0.020 (2.54 ±0.51) |
| SM24 | 0.450 ± 0.030 (11.43 ± 0.76) | 0.400 ± 0.030 (10.20 ± 0.76) | | 0.300 (7.62) | | |
| SM25 | 0.550 ± 0.030 (14.00 ± 0.76) | 0.500 ± 0.030 (12.70 ± 0.76) | | 0.400 (10.20) | | |
| SM26 | 0.650 ± 0.030 (16.50 ± 0.76) | 0.600 ± 0.030 (15.20 ± 0.76) | | 0.500 (12.70) | | |
| SM30 | 0.300 ± 0.030 (7.62 ± 0.76) | 0.150 ± 0.015 (3.81 ± 0.38) | 0.140 (3.55) | 0.100 (2.54) | | |
| SM31 | 0.400 ± 0.030 (10.20 ± 0.76) | 0.200 ± 0.020 (5.08 ± 0.51) | 0.130 (3.30) | | | |
| SM33 | 0.700 ± 0.030 (17.08 ± 0.76) | 0.300 ± 0.030 (7.62 ± 0.76) | 0.180 (4.57) | 0.200 (5.08) | | |
| SM34 | 0.900 ± 0.030 (22.90 ± 0.76) | 0.400 ± 0.030 (10.20 ± 0.76) | 0.220 (5.59) | 0.300 (7.62) | | |
| SM35 | 1.100 ± 0.030 (27.90 ± 0.76) | 0.500 ± 0.030 (12.70 ± 0.76) | | 0.400 (10.2) | | |
| SM36 | 1.350 ± 0.030 (33.00 ± 0.76) | 0.600 ± 0.030 (15.20 ± 0.76) | | 0.500 (12.7) | | |

## Benefits cont'd

- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible, microphonic noise
- Low ESR and ESL
- Non-polar device, minimizing installation concerns
- Silver plated copper alloy leadframe termination system

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters, noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control and Military.

## Qualification/Certification

Industrial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 3, Performance & Reliability.

## Environmental Compliance

RoHS Compliant with Exemption(s)

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of ≤ 1,250 VDC<br>120% of rated voltage for voltage rating of > 1,250 VDC<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit @ 25ºC | 0.15% |
| Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage DC applied for 120 ±5 seconds @ 25°C for voltage rating of ≤ 500 VDC)<br>(500 VDC applied for 120 ±5 seconds @ 25°C for voltage rating of > 500 VDC) |

*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*

*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 100 pF*

*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 100 pF*

*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall SM20 – SM24 Style/Size

| Style/Size | SM20 | | | | SM21 | | | | SM22 | | | | SM23 | | | | | SM24 | | | | | | Capacitance Tolerance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | | |
| Length | 0.150 ± 0.015 (3.81 ± 0.38) | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.250 ± 0.020 (6.35 ± 0.51) | | | | 0.350 ± 0.030 (8.89 ± 0.76) | | | | | 0.450 ± 0.030 (11.43 ± 0.76) | | | | | | |
| Width | 0.150 ± 0.015 (3.81 ± 0.38) | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | |
| Thickness Maximum | 0.130 (3.30) | | | | 0.180 (4.57) | | | | 0.180 (4.57) | | | | 0.220 (5.59) | | | | | 0.220 (5.59) | | | | | | |
| Lead Width Maximum | 0.100 (2.54) | | | | 0.100 (2.54) | | | | 0.100 (2.54) | | | | 0.200 (5.08) | | | | | 0.300 (7.62) | | | | | | |
| Lead Length "L" | 0.100 ± 0.020 (2.54 ± 0.51) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| Lead Length "J" | 0.040 ± 0.010 (1.02 ± 0.25) | | | | 0.040 ± 0.010 (1.02 ± 0.25) | | | | 0.040 ± 0.010 (1.02 ± 0.25) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| C0G Dielectric | | | | | | | | | | | | | | | | | | | | | | | | |
| Voltage Code | 501 | 102 | 202 | 302 | 501 | 102 | 202 | 302 | 501 | 102 | 202 | 302 | 501 | 102 | 202 | 302 | 402 | 501 | 102 | 202 | 302 | 402 | 502 | |
| Voltage DC | 500 | 1 K | 2 K | 3 K | 500 | 1 K | 2 K | 3 K | 500 | 1 K | 2 K | 3 K | 500 | 1 K | 2 K | 3 K | 4 K | 500 | 1 K | 2 K | 3 K | 4 K | 5 K | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | | |
| 22 pF | | | | | | | 220 | 220 | | | | | | | | | | | | | | | | |
| 27 pF | | | | | | | 270 | 270 | | | | | | | | | | | | | | 270 | 270 | |
| 33 pF | | | | | | | 330 | 330 | 330 | 330 | 330 | 330 | | | | | | | | | | 330 | 330 | |
| 39 pF | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | | | | | | | | | | 390 | 390 | |
| 47 pF | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | | | | | | | | | | 470 | 470 | |
| 56 pF | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | | | | | | 560 | 560 | 560 | 560 | 560 | 560 | |
| 68 pF | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | | | | | | 680 | 680 | 680 | 680 | 680 | 680 | |
| 82 pF | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | |
| 100 pF | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | |
| 120 pF | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | |
| 150 pF | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | |
| 180 pF | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | |
| 220 pF | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | |
| 270 pF | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | |
| 330 pF | 331 | 331 | 331 | | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | |
| 390 pF | 391 | 391 | 391 | | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | |
| 470 pF | 471 | 471 | 471 | | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | |
| 560 pF | 561 | 561 | 561 | | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | |
| 680 pF | 681 | 681 | 681 | | 681 | 681 | 681 | | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | |
| 820 pF | 821 | 821 | 821 | | 821 | 821 | 821 | | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | 821 | 821 | 821 | 821 | 821 | 821 | |
| 1,000 pF | 102 | 102 | | | 102 | 102 | 102 | | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | | 102 | 102 | 102 | 102 | 102 | 102 | |
| 1,200 pF | 122 | 122 | | | 122 | 122 | 122 | | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | | 122 | 122 | 122 | 122 | 122 | 122 | J, K, M, P, Z |
| 1,500 pF | 152 | 152 | | | 152 | 152 | 152 | | 152 | 152 | 152 | | 152 | 152 | 152 | 152 | | 152 | 152 | 152 | 152 | 152 | 152 | |
| 1,800 pF | 182 | 182 | | | 182 | 182 | 182 | | 182 | 182 | 182 | | 182 | 182 | 182 | 182 | | 182 | 182 | 182 | 182 | | | |
| 2,200 pF | 222 | 222 | | | 222 | 222 | | | 222 | 222 | 222 | | 222 | 222 | 222 | 222 | | 222 | 222 | 222 | 222 | | | |
| 2,700 pF | 272 | 272 | | | 272 | 272 | | | 272 | 272 | 272 | | 272 | 272 | 272 | | | 272 | 272 | 272 | 272 | | | |
| 3,300 pF | | | | | 332 | 332 | | | 332 | 332 | 332 | | 332 | 332 | 332 | | | 332 | 332 | 332 | 332 | | | |
| 3,900 pF | | | | | 392 | 392 | | | 392 | 392 | | | 392 | 392 | 392 | | | 392 | 392 | 392 | 392 | | | |
| 4,700 pF | | | | | 472 | 472 | | | 472 | 472 | | | 472 | 472 | 472 | | | 472 | 472 | 472 | 472 | | | |
| 5,600 pF | | | | | | | | | 562 | 562 | | | 562 | 562 | 562 | | | 562 | 562 | 562 | | | | |
| 6,800 pF | | | | | | | | | 682 | 682 | | | 682 | 682 | | | | 682 | 682 | 682 | | | | |
| 8,200 pF | | | | | | | | | 822 | | | | 822 | 822 | | | | 822 | 822 | 822 | | | | |
| 0.01 µF | | | | | | | | | 103 | | | | 103 | 103 | | | | 103 | 103 | 103 | | | | |
| 0.012 µF | | | | | | | | | 123 | | | | 123 | 123 | | | | 123 | 123 | | | | | |
| 0.015 µF | | | | | | | | | 153 | | | | 153 | 153 | | | | 153 | 153 | | | | | |
| 0.018 µF | | | | | | | | | 183 | | | | 183 | | | | | 183 | 183 | | | | | |
| 0.022 µF | | | | | | | | | | | | | 223 | | | | | 223 | 223 | | | | | |
| 0.027 µF | | | | | | | | | | | | | 273 | | | | | 273 | 273 | | | | | |
| 0.033 µF | | | | | | | | | | | | | 333 | | | | | 333 | 333 | | | | | |
| 0.039 µF | | | | | | | | | | | | | | | | | | 393 | 393 | | | | | |
| 0.047 µF | | | | | | | | | | | | | | | | | | 473 | 473 | | | | | |
| 0.039 µF | | | | | | | | | | | | | | | | | | 393 | | | | | | |
| 0.047 µF | | | | | | | | | | | | | | | | | | 473 | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall SM25 – SM31 Style/Size

| Style/Size | SM25 | | | | | | SM26 | | | | | | SM30 | | | | | SM31 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.550 ± 0.030 (14.00 ± 0.76) | | | | | | 0.650 ± 0.030 (16.50 ± 0.76) | | | | | | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | |
| **Width** | 0.500 ± 0.030 (12.70 ± 0.76) | | | | | | 0.600 ± 0.030 (15.20 ± 0.76) | | | | | | 0.150 ± 0.015 (3.81 ± 0.38) | | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | | | |
| **Thickness Maximum** | 0.220 (5.59) | | | | | | 0.220 (5.59) | | | | | | 0.140 (3.55) | | | | | 0.130 (3.30) | | | | | | |
| **Lead Width Maximum** | 0.400 (10.20) | | | | | | 0.500 (12.70) | | | | | | 0.100 (2.54) | | | | | 0.100 (2.54) | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| C0G Dielectric | | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **501** | **102** | **202** | **302** | **402** | **502** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | | |
| 10 pF | | | | | | | | | | | | | | | | | 100 | | | | | | | J, K, M, P, Z |
| 12 pF | | | | | | | | | | | | | | | | | 120 | | | | | | | |
| 15 pF | | | | | | | | | | | | | 150 | 150 | 150 | 150 | 150 | | | | | | | |
| 18 pF | | | | | | | | | | | | | 180 | 180 | 180 | 180 | 180 | | | | | | | |
| 22 pF | | | | | | | | | | | | | 220 | 220 | 220 | 220 | 220 | | | | | 220 | 220 | |
| 27 pF | | | | | | | | | | | | | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | |
| 33 pF | | | | | | | | | | | | | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | |
| 39 pF | | | | | | | | | | | | | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | |
| 47 pF | | | | | | | | | | | | | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | |
| 56 pF | | | | | | | | | | | | | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | |
| 68 pF | | | | | | | | | | | | | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | |
| 82 pF | | | | | | | | | | | | | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | |
| 100 pF | | | | | | | | | | | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | |
| 120 pF | | | | | | | | | | | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | |
| 150 pF | | | | | | | | | | | 151 | 151 | 151 | 151 | 151 | 151 | | 151 | 151 | 151 | 151 | 151 | 151 | |
| 180 pF | | | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | | 181 | 181 | 181 | 181 | 181 | 181 | |
| 220 pF | | | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | | 221 | 221 | 221 | 221 | | | |
| 270 pF | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | | 271 | 271 | 271 | 271 | | | |
| 330 pF | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | | 331 | 331 | 331 | 331 | | | |
| 390 pF | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | | 391 | 391 | 391 | 391 | | | |
| 470 pF | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | | 471 | 471 | 471 | 471 | | | |
| 560 pF | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | | 561 | 561 | 561 | 561 | | | |
| 680 pF | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | | 681 | 681 | 681 | 681 | | | |
| 820 pF | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | | 821 | 821 | 821 | 821 | | | |
| 1,000 pF | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | | | 102 | 102 | 102 | 102 | | | |
| 1,200 pF | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | | | 122 | 122 | 122 | 122 | | | |
| 1,500 pF | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | | | 152 | 152 | 152 | 152 | | | |
| 1,800 pF | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | | | 182 | 182 | 182 | | | | |
| 2,200 pF | 222 | 222 | 222 | 222 | | | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | | | | 222 | 222 | 222 | | | | |
| 2,700 pF | 272 | 272 | 272 | 272 | | | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | | | | 272 | 272 | 272 | | | | |
| 3,300 pF | 332 | 332 | 332 | 332 | | | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | | | | 332 | 332 | 332 | | | | |
| 3,900 pF | 392 | 392 | 392 | 392 | | | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | | | | 392 | 392 | 392 | | | | |
| 4,700 pF | 472 | 472 | 472 | 472 | | | 472 | 472 | 472 | 472 | | | 472 | 472 | | | | 472 | 472 | 472 | | | | |
| 5,600 pF | 562 | 562 | 562 | 562 | | | 562 | 562 | 562 | 562 | | | 562 | 562 | | | | 562 | 562 | 562 | | | | |
| 6,800 pF | 682 | 682 | 682 | | | | 682 | 682 | 682 | 682 | | | | | | | | 682 | 682 | | | | | |
| 8,200 pF | 822 | 822 | 822 | | | | 822 | 822 | 822 | 822 | | | | | | | | 822 | 822 | | | | | |
| 0.01 µF | 103 | 103 | 103 | | | | 103 | 103 | 103 | | | | | | | | | 103 | 103 | | | | | |
| 0.012 µF | 123 | 123 | 123 | | | | 123 | 123 | 123 | | | | | | | | | 123 | 123 | | | | | |
| 0.015 µF | 153 | 153 | | | | | 153 | 153 | 153 | | | | | | | | | 153 | | | | | | |
| 0.018 µF | 183 | 183 | | | | | 183 | 183 | 183 | | | | | | | | | 183 | | | | | | |
| 0.022 µF | 223 | 223 | | | | | 223 | 223 | 223 | | | | | | | | | 223 | | | | | | |
| 0.027 µF | 273 | 273 | | | | | 273 | 273 | | | | | | | | | | 273 | | | | | | |
| 0.033 µF | 333 | 333 | | | | | 333 | 333 | | | | | | | | | | 333 | | | | | | |
| 0.039 µF | 393 | 393 | | | | | 393 | 393 | | | | | | | | | | | | | | | | |
| 0.047 µF | 473 | 473 | | | | | 473 | 473 | | | | | | | | | | | | | | | | |
| 0.056 µF | | | | | | | 563 | 563 | | | | | | | | | | | | | | | | |
| 0.068 µF | | | | | | | 683 | 683 | | | | | | | | | | | | | | | | |

# Table 1C – Capacitance Range/Selection Waterfall SM33 – SM35 Style/Size

| Style/Size | SM33 | | | | | | | SM34 | | | | | | | | SM35 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dimensions – inches (mm)** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.700 ± 0.030 (17.08 ± 0.76) | | | | | | | 0.900 ± 0.030 (22.90 ± 0.76) | | | | | | | | 1.100 ± 0.030 (27.90 ± 0.76) | | | | | | | | |
| **Width** | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | | | 0.500 ± 0.030 (12.70 ± 0.76) | | | | | | | | |
| **Thickness Maximum** | 0.180 (4.57) | | | | | | | 0.220 (5.59) | | | | | | | | 0.220 (5.59) | | | | | | | | |
| **Lead Width Maximum** | 0.200 (5.08) | | | | | | | 0.300 (7.62) | | | | | | | | 0.400 (10.2) | | | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| **C0G Dielectric** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **10 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **10 K** | |
| **Capacitance** | **Capacitance Code** | | | | | | | | | | | | | | | | | | | | | | | |
| 27 pF | | | | | | 270 | 270 | | | | | | | | | | | | | | | | | J, K, M, P, Z |
| 33 pF | | | | | | 330 | 330 | | | | | | | | | | | | | | | | | |
| 39 pF | | | | | | 390 | 390 | | | | | | | 390 | 390 | | | | | | | | | |
| 47 pF | | | | | | 470 | 470 | | | | | 470 | 470 | 470 | 470 | | | | | | | | 470 | |
| 56 pF | | | | | | 560 | 560 | | | 560 | 560 | 560 | 560 | 560 | 560 | | | | | | | | | |
| 68 pF | | | | | | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | 680 | | | | | | | | | |
| 82 pF | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | 820 | | | | | | | | | |
| 100 pF | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | | | | | | | | | |
| 120 pF | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | 121 | | | | | | | | | |
| 150 pF | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | | |
| 180 pF | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | 181 | | |
| 220 pF | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | 221 | | |
| 270 pF | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | | |
| 330 pF | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | 331 | | |
| 390 pF | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | 391 | | |
| 470 pF | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | 471 | | |
| 560 pF | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | | |
| 680 pF | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | | 681 | 681 | 681 | 681 | 681 | 681 | 681 | | |
| 820 pF | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | |
| 1,000 pF | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | |
| 1,200 pF | 122 | 122 | 122 | 122 | 122 | 122 | | 122 | 122 | 122 | 122 | 122 | 122 | | | 122 | 122 | 122 | 122 | 122 | 122 | 122 | | |
| 1,500 pF | 152 | 152 | 152 | 152 | 152 | 152 | | 152 | 152 | 152 | 152 | 152 | 152 | | | 152 | 152 | 152 | 152 | 152 | 152 | 152 | | |
| 1,800 pF | 182 | 182 | 182 | 182 | 182 | 182 | | 182 | 182 | 182 | 182 | 182 | 182 | | | 182 | 182 | 182 | 182 | 182 | 182 | 182 | | |
| 2,200 pF | 222 | 222 | 222 | 222 | 222 | 222 | | 222 | 222 | 222 | 222 | 222 | 222 | | | 222 | 222 | 222 | 222 | 222 | 222 | | | |
| 2,700 pF | 272 | 272 | 272 | 272 | 272 | 272 | | 272 | 272 | 272 | 272 | 272 | 272 | | | 272 | 272 | 272 | 272 | 272 | 272 | | | |
| 3,300 pF | 332 | 332 | 332 | 332 | | | | 332 | 332 | 332 | 332 | | | | | 332 | 332 | 332 | 332 | 332 | 332 | | | |
| 3,900 pF | 392 | 392 | 392 | 392 | | | | 392 | 392 | 392 | 392 | | | | | 392 | 392 | 392 | 392 | 392 | 392 | | | |
| 4,700 pF | 472 | 472 | 472 | 472 | | | | 472 | 472 | 472 | 472 | | | | | 472 | 472 | 472 | 472 | | | | | |
| 5,600 pF | 562 | 562 | 562 | 562 | | | | 562 | 562 | 562 | 562 | | | | | 562 | 562 | 562 | 562 | | | | | |
| 6,800 pF | 682 | 682 | 682 | 682 | | | | 682 | 682 | 682 | 682 | | | | | 682 | 682 | 682 | 682 | | | | | |
| 8,200 pF | 822 | 822 | 822 | | | | | 822 | 822 | 822 | 822 | | | | | 822 | 822 | 822 | 822 | | | | | |
| 0.01 µF | 103 | 103 | 103 | | | | | 103 | 103 | 103 | 103 | | | | | 103 | 103 | 103 | 103 | | | | | |
| 0.012 µF | 123 | 123 | 123 | | | | | 123 | 123 | 123 | 123 | | | | | 123 | 123 | 123 | 123 | | | | | |
| 0.015 µF | 153 | 153 | 153 | | | | | 153 | 153 | 153 | 153 | | | | | 153 | 153 | 153 | 153 | | | | | |
| 0.018 µF | 183 | 183 | 183 | | | | | 183 | 183 | 183 | | | | | | 183 | 183 | 183 | 183 | | | | | |
| 0.022 µF | 223 | 223 | | | | | | 223 | 223 | 223 | | | | | | 223 | 223 | 223 | 223 | | | | | |
| 0.027 µF | 273 | 273 | | | | | | 273 | 273 | | | | | | | 273 | 273 | 273 | | | | | | |
| 0.033 µF | 333 | 333 | | | | | | 333 | 333 | | | | | | | 333 | 333 | 333 | | | | | | |
| 0.039 µF | 393 | 393 | | | | | | 393 | 393 | | | | | | | 393 | 393 | 393 | | | | | | |
| 0.047 µF | 473 | 473 | | | | | | 473 | 473 | | | | | | | 473 | 473 | 473 | | | | | | |
| 0.056 µF | 563 | | | | | | | 563 | 563 | | | | | | | 563 | 563 | | | | | | | |
| 0.068 µF | 683 | | | | | | | 683 | | | | | | | | 683 | 683 | | | | | | | |
| 0.082 µF | 823 | | | | | | | 823 | | | | | | | | 823 | 823 | | | | | | | |
| 0.1 µF | 104 | | | | | | | 104 | | | | | | | | 104 | 104 | | | | | | | |
| 0.12 µF | | | | | | | | 124 | | | | | | | | 124 | 124 | | | | | | | |
| 0.15 µF | | | | | | | | 154 | | | | | | | | 154 | 154 | | | | | | | |
| 0.18 µF | | | | | | | | | | | | | | | | 184 | | | | | | | | |
| 0.22 µF | | | | | | | | | | | | | | | | 224 | | | | | | | | |
| 0.27 µF | | | | | | | | | | | | | | | | 274 | | | | | | | | |

# Table 1D – Capacitance Range/Selection Waterfall SM36 Style/Size

| Style/Size | SM36 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | |
| **Length** | 1.350 ± 0.030 (33.00 ± 0.76) | | | | | | | | |
| **Width** | 0.600 ± 0.030 (15.20 ± 0.76) | | | | | | | | |
| **Thickness Maximum** | 0.220 (5.59) | | | | | | | | |
| **Lead Width Maximum** | 0.500 (12.7) | | | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| C0G Dielectric | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1K** | **2K** | **3K** | **4K** | **5K** | **7.5K** | **10K** | |
| Capacitance | Capacitance Code | | | | | | | | |
| 120 pF | | | | | 121 | 121 | 121 | | J, K, M, P, Z |
| 150 pF | 151 | 151 | 151 | 151 | 151 | 151 | 151 | | |
| 180 pF | 181 | 181 | 181 | 181 | 181 | 181 | 181 | | |
| 220 pF | 221 | 221 | 221 | 221 | 221 | 221 | 221 | | |
| 270 pF | 271 | 271 | 271 | 271 | 271 | 271 | 271 | | |
| 330 pF | 331 | 331 | 331 | 331 | 331 | 331 | 331 | | |
| 390 pF | 391 | 391 | 391 | 391 | 391 | 391 | 391 | | |
| 470 pF | 471 | 471 | 471 | 471 | 471 | 471 | 471 | | |
| 560 pF | 561 | 561 | 561 | 561 | 561 | 561 | 561 | | |
| 680 pF | 681 | 681 | 681 | 681 | 681 | 681 | 681 | | |
| 820 pF | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | |
| 1,000 pF | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | |
| 1,200 pF | 122 | 122 | 122 | 122 | 122 | 122 | 122 | | |
| 1,500 pF | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | |
| 1,800 pF | 182 | 182 | 182 | 182 | 182 | 182 | 182 | | |
| 2,200 pF | 222 | 222 | 222 | 222 | 222 | 222 | 222 | | |
| 2,700 pF | 272 | 272 | 272 | 272 | 272 | 272 | 272 | | |
| 3,300 pF | 332 | 332 | 332 | 332 | 332 | 332 | 332 | | |
| 3,900 pF | 392 | 392 | 392 | 392 | 392 | 392 | | | |
| 4,700 pF | 472 | 472 | 472 | 472 | 472 | 472 | | | |
| 5,600 pF | 562 | 562 | 562 | 562 | 562 | 562 | | | |
| 6,800 pF | 682 | 682 | 682 | 682 | 682 | 682 | | | |
| 8,200 pF | 822 | 822 | 822 | 822 | 822 | | | | |
| 0.01 µF | 103 | 103 | 103 | 103 | 103 | | | | |
| 0.012 µF | 123 | 123 | 123 | 123 | | | | | |
| 0.015 µF | 153 | 153 | 153 | 153 | | | | | |
| 0.018 µF | 183 | 183 | 183 | 183 | | | | | |
| 0.022 µF | 223 | 223 | 223 | 223 | | | | | |
| 0.027 µF | 273 | 273 | 273 | 273 | | | | | |
| 0.033 µF | 333 | 333 | 333 | 333 | | | | | |
| 0.039 µF | 393 | 393 | 393 | | | | | | |
| 0.047 µF | 473 | 473 | 473 | | | | | | |
| 0.056 µF | 563 | 563 | 563 | | | | | | |
| 0.068 µF | 683 | 683 | | | | | | | |
| 0.082 µF | 823 | 823 | | | | | | | |
| 0.1 µF | 104 | 104 | | | | | | | |
| 0.12 µF | 124 | 124 | | | | | | | |
| 0.15 µF | 154 | 154 | | | | | | | |
| 0.18 µF | 184 | | | | | | | | |
| 0.22 µF | 224 | | | | | | | | |
| 0.27 µF | 274 | | | | | | | | |
| 0.33 µF | 334 | | | | | | | | |
| 0.39 µF | 394 | | | | | | | | |

## Table 2 – Chip Thickness/Packaging Quantities

| Series | Style/Size | Tray Quantity Minimum[1] | Tray Quantity Maximum[1] |
|---|---|---|---|
| SM | SM20 | 1 | 50 |
| | SM21 | | |
| | SM22 | | |
| | SM23 | | |
| | SM24 | | |
| | SM25 | | |
| | SM26 | | |
| | SM30 | | |
| | SM31 | | |
| | SM33 | | 25 |
| | SM34 | | 10 |
| | SM35 | | |
| | SM36 | | |

[1] *Minimum order value applies. Contact KEMET for details.*

## Soldering Process

The capacitors and assemblies outlined in this specification sheet are susceptible to thermal shock damage due to their large ceramic mass. Temperature profiles used should provide adequate temperature rise and cool-down time to prevent damage from thermal shock. In general, KEMET recommends against hand soldering for these types of large ceramic devices.

Recommended Soldering Technique:

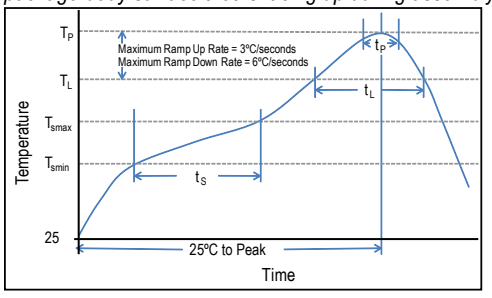
- Solder reflow only

Preheating and Reflow Profile Notes:
Due to differences in the coefficient of thermal expansion for the different materials of construction, it is critical to monitor and control the heating and cooling rates during the soldering process. During the reflow soldering process, the maximum recommended heating and cooling rate (dT/dt) is 4°C/second. To ensure optimal component reliability, KEMET's recommended heating and cooling rate is 2°C/second. After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Recommended Reflow Soldering Profile:

| Profile Feature | SnPb Assembly |
|---|---|
| Preheat/Soak | |
| Temperature Minimum ($T_{Smin}$) | 100°C |
| Temperature Maximum ($T_{Smax}$) | 150°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 90 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 2°C/seconds |
| Liquidous Temperature ($T_L$) | 183°C |
| Time Above Liquidous ($t_L$) | 95 seconds |
| Peak Temperature ($T_P$) | 240°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 5 seconds |
| Ramp-down Rate ($T_P$ to $T_L$) | 2°C/seconds |
| Time 25°C to Peak Temperature | 3.5 minutes |

*Note 1: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



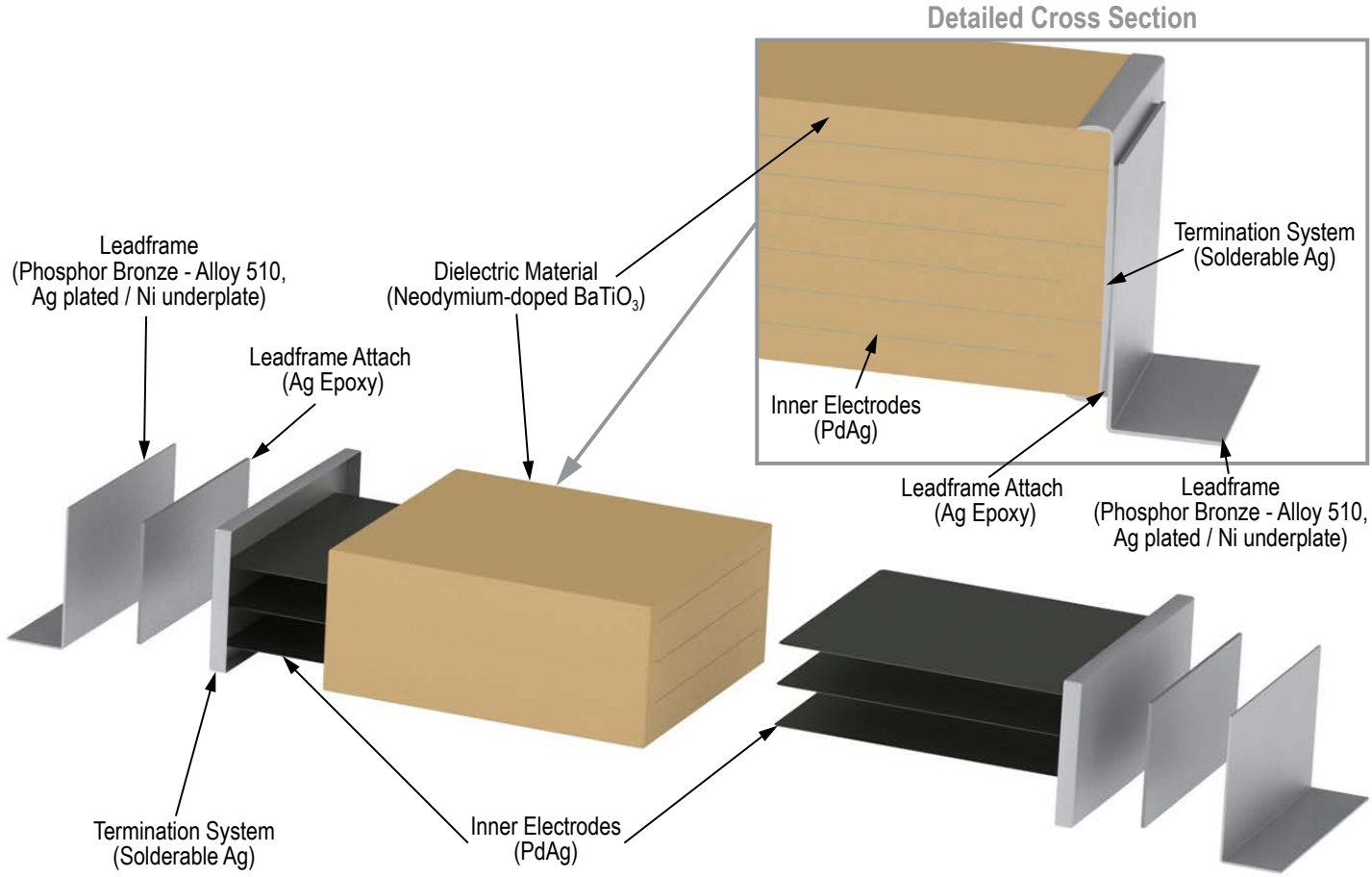
## Table 3 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Board Flex | JIS–C–6429 | Appendix 2, Note: 2 mm (minimum) for all except 3 mm for C0G. |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| | | 1,000 cycles (-55°C to +125°C). Measurement at 24 hours +/- 2 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 300 VDC Maximum Add 100 K ohm resistor. Measurement at 24 hours +/- 2 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 2 hours after test conclusion. |
| | | t = 24 hours/cycle. Steps 7a and 7b not required. Unpowered. Measurement at 24 hours +/- 2 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | -55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. D14 dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA -198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC, for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8 "X5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10–2,000 Hz. |
| Resistance to Soldering Heat | MIL–STD–202 Method 210 | Condition B. No preheat of samples. Note: single wave solder – procedure 2. |
| Terminal Strength | MIL–STD–202 Method 211 | Conditions A (2.3 kg or 5 lbs). |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Product marking is an extra-cost option. These devises will be supplied unmarked unless otherwise specified and/or requested. For more detailed information regarding marked product and how to request this option, please contact KEMET.

# KPS HV, Large Case, SM Series, X7R Dielectric, 500 – 10,000 VDC (Industrial Grade)

## Overview

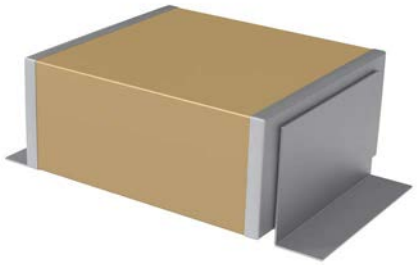
KPS HV (KEMET Power Solutions, High Voltage), Large Case (≥ 1515), SM Series capacitors in X7R dielectric are designed to meet robust performance standards required in higher reliability industrial applications. Utilizing lead-frame technology, SM Series devices isolate the multilayer ceramic chip component from the printed circuit board providing advanced mechanical and thermal stress performance. Isolation of the chip component also addresses concerns for audible, microphonic noise that may occur when a bias voltage is applied. Although this technology does not eliminate the potential for mechanical damage that may propagate during extreme environmental and handling conditions, it does demonstrate superior performance over non-isolating systems. Available in both formed "L" and "J" lead configurations, SM Series devices offer up to 10 mm of board flex capability and exhibit lower ESR, ESL and higher current discharge capability when compared to other dielectric solutions.

Combined with the stability of an X7R dielectric, KEMET's High Voltage SM Series devices exhibit a predictable change in capacitance with respect to time and voltage and boast a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from -55°C to +125°C.

KEMET's Industrial grade products offer additional screening options for higher reliability applications. Both Group A and Group B testing/inspection options per MIL–PRF–49467 are available for the SM Series.

## Benefits

- -55°C to +125°C operating temperature range
- Large Case Sizes (≥ 1515)
- Formed “L” or “J” leadframe configurations
- Group A and B screening per MIL–PRF–49467 available
- Reliable and robust leadframe termination system
- DC voltage ratings of 500 V, 1 KV, 2 KV, 3 KV, 4 KV, 5 KV, 7.5 KV, and 10 KV
- Capacitance offerings ranging from 150 pF up to 5.6 µF



## Ordering Information

| SM20 | | B | 153 | K | 501 | B | M |
|---|---|---|---|---|---|---|---|
| Style/Size | | Dielectric | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VDC) | Lead Configuration[1] | Testing/ Inspection Option[2] |
| SM20<br>SM21<br>SM22<br>SM23<br>SM24<br>SM25<br>SM26 | SM30<br>SM31<br>SM33<br>SM34<br>SM35<br>SM36 | B = X7R | Two significant digits + number of zeros | K = ±10%<br>M = ±20% | 501 = 500<br>102 = 1,000<br>202 = 2,000<br>302 = 3,000<br>402 = 4,000<br>502 = 5,000<br>752 = 7,500<br>103 = 10,000 | A = Formed "L"<br>B = Formed "J" | Blank = None<br>M = Group A per MIL–PRF–49467 |

*[1] Standard lead configuration is formed "J". If the appropriate character is excluded from the ordering code, the assumed lead configuration will be formed "J".*

*[2] Group B testing/inspection option per MIL–PRF–49467 is available upon request. Please contact KEMET for ordering details.*



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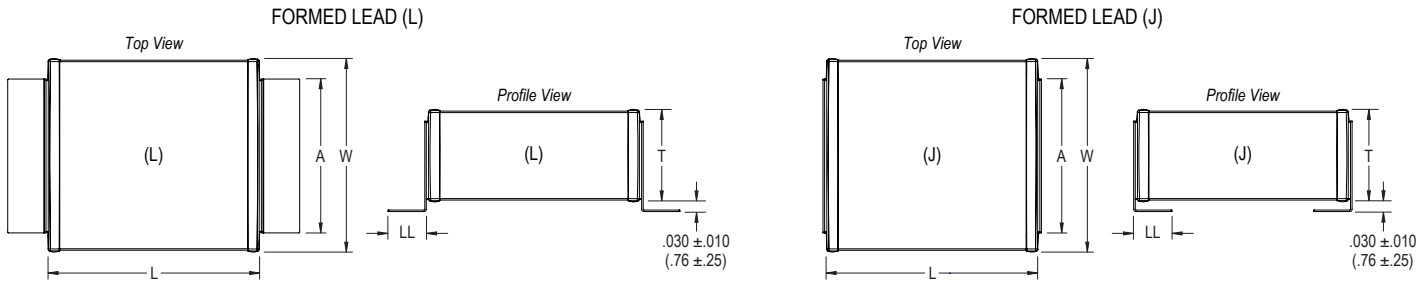
## Dimensions – Inches (Millimeters)




| Style/ Size | L Length | W Width | T Thickness Max. | A Lead Width Max. | LL Lead Length (Formed "L") | LL Lead Length (Formed "J") |
|---|---|---|---|---|---|---|
| SM20 | 0.150 ± 0.015 (3.81 ± 0.38) | 0.150 ± 0.015 (3.81 ± 0.38) | 0.130 (3.30) | 0.100 (2.54) | 0.100 ± 0.020 (2.54 ± 0.51) | 0.040 ± 0.010 (1.02 ± 0.25) |
| SM21 | 0.200 ± 0.020 (5.08 ± 0.51) | 0.200 ± 0.020 (5.08 ± 0.51) | 0.180 (4.57) | | | |
| SM22 | 0.250 ± 0.020 (6.35 ± 0.51) | 0.200 ± 0.020 (5.08 ± 0.51) | | | | |
| SM23 | 0.350 ± 0.030 (8.89 ± 0.76) | 0.300 ± 0.030 (7.62 ± 0.76) | 0.220 (5.59) | 0.200 (5.08) | | 0.100 ± 0.020 (2.54 ± 0.51) |
| SM24 | 0.450 ± 0.030 (11.43 ± 0.76) | 0.400 ± 0.030 (10.20 ± 0.76) | | 0.300 (7.62) | | |
| SM25 | 0.550 ± 0.030 (14.00 ± 0.76) | 0.500 ± 0.030 (12.70 ± 0.76) | | 0.400 (10.20) | | |
| SM26 | 0.650 ± 0.030 (16.50 ± 0.76) | 0.600 ± 0.030 (15.20 ± 0.76) | | 0.500 (12.70) | | |
| SM30 | 0.300 ± 0.030 (7.62 ± 0.76) | 0.150 ± 0.015 (3.81 ± 0.38) | 0.140 (3.55) | 0.100 (2.54) | | |
| SM31 | 0.400 ± 0.030 (10.20 ± 0.76) | 0.200 ± 0.020 (5.08 ± 0.51) | 0.130 (3.30) | | | |
| SM33 | 0.700 ± 0.030 (17.08 ± 0.76) | 0.300 ± 0.030 (7.62 ± 0.76) | 0.180 (4.57) | 0.200 (5.08) | | |
| SM34 | 0.900 ± 0.030 (22.90 ± 0.76) | 0.400 ± 0.030 (10.20 ± 0.76) | 0.220 (5.59) | 0.300 (7.62) | | |
| SM35 | 1.100 ± 0.030 (27.90 ± 0.76) | 0.500 ± 0.030 (12.70 ± 0.76) | | 0.400 (10.2) | | |
| SM36 | 1.350 ± 0.030 (33.00 ± 0.76) | 0.600 ± 0.030 (15.20 ± 0.76) | | 0.500 (12.7) | | |

## Benefits cont'd

- Advanced protection against thermal and mechanical stress
- Provides up to 10 mm of board flex capability
- Reduces audible, microphonic noise
- Low ESR and ESL
- Non-polar device, minimizing installation concerns
- Silver plated copper alloy leadframe termination system

## Applications

Typical applications include switch mode power supplies (input filters, resonators, tank circuits, snubber circuits, output filters), high voltage coupling and DC blocking, voltage multiplier circuits, DC/DC converters and coupling capacitors in Ćuk converters, noise reduction (piezoelectric/mechanical), circuits with a direct battery or power source connection, critical and safety relevant circuits without (integrated) current limitation and any application that is subject to high levels of board flexure or temperature cycling. Markets include power supply, LCD fluorescent backlight ballasts, HID lighting, telecom equipment, industrial and medical equipment/control and Military.

## Qualification/Certification

Industrial Grade products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 3, Performance & Reliability.

## Environmental Compliance

RoHS Compliant with Exemption(s)

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | -55°C to +125°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±15% |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 3.0% |
| Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of ≤ 1,250 VDC<br>120% of rated voltage for voltage rating of > 1,250 VDC<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| Dissipation Factor (DF) Maximum Limit @ 25°C | 2.5% |
| Insulation Resistance (IR) Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(Rated voltage DC applied for 120 ±5 seconds @ 25°C for voltage rating of ≤ 500 VDC)<br>(500 VDC applied for 120 ±5 seconds @ 25°C for voltage rating of > 500 VDC) |

*Regarding aging rate: Capacitance measurements (including tolerance) are indexed to a referee time of 1,000 hours.*
*To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 kHz ±50 Hz and 1.0 Vrms ±0.2 V if capacitance > 100 pF*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | |
|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift |
| X7R | All | All | 3.0 | ±20% |

# Table 1A – Capacitance Range/Selection Waterfall SM20 – SM24 Style/Size

| Style/Size | SM20 | | | SM21 | | | | SM22 | | | | SM23 | | | | | SM24 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.150 ± 0.015 (3.81 ± 0.38) | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.250 ± 0.020 (6.35 ± 0.51) | | | | 0.350 ± 0.030 (8.89 ± 0.76) | | | | | 0.450 ± 0.030 (11.43 ± 0.76) | | | | | | |
| **Width** | 0.150 ± 0.015 (3.81 ± 0.38) | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | |
| **Thickness Maximum** | 0.130 (3.30) | | | 0.180 (4.57) | | | | 0.180 (4.57) | | | | 0.220 (5.59) | | | | | 0.220 (5.59) | | | | | | |
| **Lead Width Maximum** | 0.100 (2.54) | | | 0.100 (2.54) | | | | 0.100 (2.54) | | | | 0.200 (5.08) | | | | | 0.300 (7.62) | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| **Lead Length "J"** | 0.040 ± 0.010 (1.02 ± 0.25) | | | 0.040 ± 0.010 (1.02 ± 0.25) | | | | 0.040 ± 0.010 (1.02 ± 0.25) | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| X7R Dielectric | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **501** | **102** | **202** | **302** | **501** | **102** | **202** | **302** | **501** | **102** | **202** | **302** | **402** | **501** | **102** | **202** | **302** | **402** | **502** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **500** | **1 K** | **2 K** | **3 K** | **500** | **1 K** | **2 K** | **3 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | |
| 330 pF | 331 | 331 | 331 | | | | | | | | | | | | | | | | | | | | K, M |
| 390 pF | 391 | 391 | 391 | | | | | | | | | | | | | | | | | | | | |
| 470 pF | 471 | 471 | 471 | | | | | | | | | | | | | | | | | | | | |
| 560 pF | 561 | 561 | 561 | | | | | | | | | | | | | | | | | | | | |
| 680 pF | 681 | 681 | 681 | | | | | 681 | 681 | 681 | 681 | | | | | | | | | | | | |
| 820 pF | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | | | | | | | | | | | |
| 1,000 pF | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | |
| 1,200 pF | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | |
| 1,500 pF | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | |
| 1,800 pF | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | |
| 2,200 pF | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | |
| 2,700 pF | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | |
| 3,300 pF | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | |
| 3,900 pF | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | |
| 4,700 pF | 472 | 472 | | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | |
| 5,600 pF | 562 | 562 | | 562 | 562 | 562 | | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | |
| 6,800 pF | 682 | 682 | | 682 | 682 | 682 | | 682 | 682 | 682 | | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | |
| 8,200 pF | 822 | 822 | | 822 | 822 | 822 | | 822 | 822 | 822 | | 822 | 822 | 822 | 822 | | 822 | 822 | 822 | 822 | 822 | | |
| 0.01 µF | 103 | 103 | | 103 | 103 | 103 | | 103 | 103 | 103 | | 103 | 103 | 103 | 103 | | 103 | 103 | 103 | 103 | 103 | | |
| 0.012 µF | 123 | 123 | | 123 | 123 | 123 | | 123 | 123 | 123 | | 123 | 123 | 123 | 123 | | 123 | 123 | 123 | 123 | 123 | | |
| 0.015 µF | 153 | 153 | | 153 | 153 | | | 153 | 153 | 153 | | 153 | 153 | 153 | 153 | | 153 | 153 | 153 | 153 | | | |
| 0.018 µF | 183 | 183 | | 183 | 183 | | | 183 | 183 | | | 183 | 183 | 183 | | | 183 | 183 | 183 | 183 | | | |
| 0.022 µF | 223 | 223 | | 223 | 223 | | | 223 | 223 | | | 223 | 223 | 223 | | | 223 | 223 | 223 | 223 | | | |
| 0.027 µF | 273 | | | 273 | 273 | | | 273 | 273 | | | 273 | 273 | 273 | | | 273 | 273 | 273 | 273 | | | |
| 0.033 µF | 333 | | | 333 | 333 | | | 333 | 333 | | | 333 | 333 | 333 | | | 333 | 333 | 333 | 333 | | | |
| 0.039 µF | 393 | | | 393 | 393 | | | 393 | 393 | | | 393 | 393 | | | | 393 | 393 | 393 | | | | |
| 0.047 µF | 473 | | | 473 | 473 | | | 473 | 473 | | | 473 | 473 | | | | 473 | 473 | 473 | | | | |
| 0.056 µF | 563 | | | 563 | 563 | | | 563 | 563 | | | 563 | 563 | | | | 563 | 563 | 563 | | | | |
| 0.068 µF | 683 | | | 683 | 683 | | | 683 | 683 | | | 683 | 683 | | | | 683 | 683 | 683 | | | | |
| 0.082 µF | 823 | | | 823 | | | | 823 | 823 | | | 823 | 823 | | | | 823 | 823 | 823 | | | | |
| 0.1 µF | | | | 104 | | | | 104 | 104 | | | 104 | 104 | | | | 104 | 104 | 104 | | | | |
| 0.12 µF | | | | 124 | | | | 124 | | | | 124 | 124 | | | | 124 | 124 | | | | | |
| 0.15 µF | | | | 154 | | | | 154 | | | | 154 | 154 | | | | 154 | 154 | | | | | |
| 0.18 µF | | | | 184 | | | | 184 | | | | 184 | 184 | | | | 184 | 184 | | | | | |
| 0.22 µF | | | | | | | | 224 | | | | 224 | 224 | | | | 224 | 224 | | | | | |
| 0.27 µF | | | | | | | | 274 | | | | 274 | 274 | | | | 274 | 274 | | | | | |
| 0.33 µF | | | | | | | | | | | | 334 | | | | | 334 | 334 | | | | | |
| 0.39 µF | | | | | | | | | | | | 394 | | | | | 394 | 394 | | | | | |
| 0.47 µF | | | | | | | | | | | | 474 | | | | | 474 | 474 | | | | | |
| 0.56 µF | | | | | | | | | | | | 564 | | | | | 564 | | | | | | |
| 0.68 µF | | | | | | | | | | | | | | | | | 684 | | | | | | |
| 0.82 µF | | | | | | | | | | | | | | | | | 824 | | | | | | |
| 1.0 µF | | | | | | | | | | | | | | | | | 105 | | | | | | |
| 1.2 µF | | | | | | | | | | | | | | | | | 125 | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall SM25 – SM31 Style/Size

| Style/Size | SM25 | | | | | | SM26 | | | | | | SM30 | | | | | SM31 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.550 ± 0.030 (14.00 ± 0.76) | | | | | | 0.650 ± 0.030 (16.50 ± 0.76) | | | | | | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | |
| **Width** | 0.500 ± 0.030 (12.70 ± 0.76) | | | | | | 0.600 ± 0.030 (15.20 ± 0.76) | | | | | | 0.150 ± 0.015 (3.81 ± 0.38) | | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | | | |
| **Thickness Maximum** | 0.220 (5.59) | | | | | | 0.220 (5.59) | | | | | | 0.140 (3.55) | | | | | 0.130 (3.30) | | | | | | |
| **Lead Width Maximum** | 0.400 (10.20) | | | | | | 0.500 (12.70) | | | | | | 0.100 (2.54) | | | | | 0.100 (2.54) | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| X7R Dielectric | | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **501** | **102** | **202** | **302** | **402** | **502** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | | |
| 150 pF | | | | | | | | | | | | | 151 | 151 | 151 | 151 | 151 | | | | | | | K, M |
| 180 pF | | | | | | | | | | | | | 181 | 181 | 181 | 181 | 181 | | | | | | | |
| 220 pF | | | | | | | | | | | | | 221 | 221 | 221 | 221 | 221 | | | | | | | |
| 270 pF | | | | | | | | | | | | | 271 | 271 | 271 | 271 | 271 | | | | | | | |
| 330 pF | | | | | | | | | | | | | 331 | 331 | 331 | 331 | 331 | | | | | | | |
| 390 pF | | | | | | | | | | | | | 391 | 391 | 391 | 391 | 391 | | | | | | | |
| 470 pF | | | | | | | | | | | | | 471 | 471 | 471 | 471 | 471 | | | | | | | |
| 560 pF | | | | | | | | | | | | | 561 | 561 | 561 | 561 | 561 | | | | | | | |
| 680 pF | | | | | | | | | | | | | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | 681 | |
| 820 pF | | | | | | | | | | | | | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | 821 | |
| 1,000 pF | | | | | | | | | | | | | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | |
| 1,200 pF | | | | | | | | | | | | | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | |
| 1,500 pF | | | | | | | | | | | | | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | |
| 1,800 pF | | | | | | | | | | | | | 182 | 182 | 182 | 182 | | 182 | 182 | 182 | 182 | 182 | | |
| 2,200 pF | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | | | 222 | 222 | 222 | 222 | | 222 | 222 | 222 | 222 | 222 | | |
| 2,700 pF | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | | | 272 | 272 | 272 | 272 | | 272 | 272 | 272 | 272 | 272 | | |
| 3,300 pF | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | | | 332 | 332 | 332 | 332 | | 332 | 332 | 332 | 332 | 332 | | |
| 3,900 pF | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | | | 392 | 392 | 392 | 392 | 392 | | |
| 4,700 pF | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | | | 472 | 472 | 472 | 472 | | | |
| 5,600 pF | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | | | 562 | 562 | 562 | 562 | | | |
| 6,800 pF | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | | | 682 | 682 | 682 | 682 | | | |
| 8,200 pF | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | | | 822 | 822 | 822 | 822 | | | |
| 0.01 µF | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | | | 103 | 103 | 103 | | | | |
| 0.012 µF | 123 | 123 | 123 | 123 | 123 | | 123 | 123 | 123 | 123 | 123 | 123 | 123 | 123 | | | | 123 | 123 | 123 | | | | |
| 0.015 µF | 153 | 153 | 153 | 153 | 153 | | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | | | | 153 | 153 | 153 | | | | |
| 0.018 µF | 183 | 183 | 183 | 183 | | | 183 | 183 | 183 | 183 | 183 | | 183 | 183 | | | | 183 | 183 | 183 | | | | |
| 0.022 µF | 223 | 223 | 223 | 223 | | | 223 | 223 | 223 | 223 | 223 | | 223 | 223 | | | | 223 | 223 | 223 | | | | |
| 0.027 µF | 273 | 273 | 273 | 273 | | | 273 | 273 | 273 | 273 | 273 | | 273 | 273 | | | | 273 | 273 | | | | | |
| 0.033 µF | 333 | 333 | 333 | 333 | | | 333 | 333 | 333 | 333 | 333 | | 333 | 333 | | | | 333 | 333 | | | | | |
| 0.039 µF | 393 | 393 | 393 | 393 | | | 393 | 393 | 393 | 393 | | | 393 | 393 | | | | 393 | 393 | | | | | |
| 0.047 µF | 473 | 473 | 473 | 473 | | | 473 | 473 | 473 | 473 | | | 473 | 473 | | | | 473 | 473 | | | | | |
| 0.056 µF | 563 | 563 | 563 | | | | 563 | 563 | 563 | 563 | | | 563 | 563 | | | | 563 | 563 | | | | | |
| 0.068 µF | 683 | 683 | 683 | | | | 683 | 683 | 683 | 683 | | | 683 | | | | | 683 | 683 | | | | | |
| 0.082 µF | 823 | 823 | 823 | | | | 823 | 823 | 823 | 823 | | | 823 | | | | | 823 | 823 | | | | | |
| 0.1 µF | 104 | 104 | 104 | | | | 104 | 104 | 104 | 104 | | | 104 | | | | | 104 | 104 | | | | | |
| 0.12 µF | 124 | 124 | 124 | | | | 124 | 124 | 124 | | | | 124 | | | | | 124 | | | | | | |
| 0.15 µF | 154 | 154 | | | | | 154 | 154 | 154 | | | | 154 | | | | | 154 | | | | | | |
| 0.18 µF | 184 | 184 | | | | | 184 | 184 | 184 | | | | 184 | | | | | 184 | | | | | | |
| 0.22 µF | 224 | 224 | | | | | 224 | 224 | | | | | | | | | | 224 | | | | | | |
| 0.27 µF | 274 | 274 | | | | | 274 | 274 | | | | | | | | | | 274 | | | | | | |
| 0.33 µF | 334 | 334 | | | | | 334 | 334 | | | | | | | | | | 334 | | | | | | |
| 0.39 µF | 394 | 394 | | | | | 394 | 394 | | | | | | | | | | 394 | | | | | | |
| 0.47 µF | 474 | 474 | | | | | 474 | 474 | | | | | | | | | | | | | | | | |
| 0.56 µF | 564 | | | | | | 564 | 564 | | | | | | | | | | | | | | | | |
| 0.68 µF | 684 | | | | | | 684 | 684 | | | | | | | | | | | | | | | | |
| 0.82 µF | 824 | | | | | | 824 | 824 | | | | | | | | | | | | | | | | |

# Table 1B – Capacitance Range/Selection Waterfall SM25 – SM31 Style/Size cont'd

| Style/Size | SM25 | | | | | | SM26 | | | | | | SM30 | | | | | SM31 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.550 ± 0.030 (14.00 ± 0.76) | | | | | | 0.650 ± 0.030 (16.50 ± 0.76) | | | | | | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | |
| **Width** | 0.500 ± 0.030 (12.70 ± 0.76) | | | | | | 0.600 ± 0.030 (15.20 ± 0.76) | | | | | | 0.150 ± 0.015 (3.81 ± 0.38) | | | | | 0.200 ± 0.020 (5.08 ± 0.51) | | | | | | |
| **Thickness Maximum** | 0.220 (5.59) | | | | | | 0.220 (5.59) | | | | | | 0.140 (3.55) | | | | | 0.130 (3.30) | | | | | | |
| **Lead Width Maximum** | 0.400 (10.20) | | | | | | 0.500 (12.70) | | | | | | 0.100 (2.54) | | | | | 0.100 (2.54) | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | |
| X7R Dielectric | | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **502** | **501** | **102** | **202** | **302** | **402** | **501** | **102** | **202** | **302** | **402** | **502** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | | |
| 1.0 µF | 105 | | | | | | 105 | 105 | | | | | | | | | | | | | | | | |
| 1.2 µF | 125 | | | | | | 125 | | | | | | | | | | | | | | | | | |
| 1.5 µF | 155 | | | | | | 155 | | | | | | | | | | | | | | | | | |
| 1.8 µF | 185 | | | | | | 185 | | | | | | | | | | | | | | | | | **K, M** |
| 2.2 µF | | | | | | | 225 | | | | | | | | | | | | | | | | | |
| 2.7 µF | | | | | | | 275 | | | | | | | | | | | | | | | | | |
| 2.9 µF | | | | | | | 295 | | | | | | | | | | | | | | | | | |

# Table 1C – Capacitance Range/Selection Waterfall SM33 – SM35 Style/Size

| Style/Size | SM33 | | | | | | | SM34 | | | | | | | | SM35 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | | | | | | | | | | | | | | | | |
| **Length** | 0.700 ± 0.030 (17.08 ± 0.76) | | | | | | | 0.900 ± 0.030 (22.90 ± 0.76) | | | | | | | | 1.100 ± 0.030 (27.90 ± 0.76) | | | | | | | | |
| **Width** | 0.300 ± 0.030 (7.62 ± 0.76) | | | | | | | 0.400 ± 0.030 (10.20 ± 0.76) | | | | | | | | 0.500 ± 0.030 (12.70 ± 0.76) | | | | | | | | |
| **Thickness Maximum** | 0.180 (4.57) | | | | | | | 0.220 (5.59) | | | | | | | | 0.220 (5.59) | | | | | | | | |
| **Lead Width Maximum** | 0.200 (5.08) | | | | | | | 0.300 (7.62) | | | | | | | | 0.400 (10.2) | | | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| X7R Dielectric | | | | | | | | | | | | | | | | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **10 K** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **10 K** | |
| Capacitance | Capacitance Code | | | | | | | | | | | | | | | | | | | | | | | |
| 820 pF | 821 | 821 | 821 | 821 | 821 | 821 | 821 | | | | | | | | | | | | | | | | | K, M |
| 1,000 pF | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | | | | | | | | 102 | |
| 1,200 pF | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | | | | | | | | 122 | |
| 1,500 pF | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | | | | | | | | 152 | |
| 1,800 pF | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | 182 | | | | | | | | 182 | |
| 2,200 pF | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | | | | | | | | 222 | |
| 2,700 pF | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | | | | | | | | 272 | |
| 3,300 pF | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | 332 | |
| 3,900 pF | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | 392 | |
| 4,700 pF | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | |
| 5,600 pF | 562 | 562 | 562 | 562 | 562 | 562 | | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | |
| 6,800 pF | 682 | 682 | 682 | 682 | 682 | 682 | | 682 | 682 | 682 | 682 | 682 | 682 | 682 | | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | |
| 8,200 pF | 822 | 822 | 822 | 822 | 822 | | | 822 | 822 | 822 | 822 | 822 | 822 | | | 822 | 822 | 822 | 822 | 822 | 822 | 822 | | |
| 0.01 µF | 103 | 103 | 103 | 103 | 103 | | | 103 | 103 | 103 | 103 | 103 | 103 | | | 103 | 103 | 103 | 103 | 103 | 103 | 103 | | |
| 0.012 µF | 123 | 123 | 123 | 123 | 123 | | | 123 | 123 | 123 | 123 | 123 | 123 | | | 123 | 123 | 123 | 123 | 123 | 123 | | | |
| 0.015 µF | 153 | 153 | 153 | 153 | | | | 153 | 153 | 153 | 153 | 153 | 153 | | | 153 | 153 | 153 | 153 | 153 | 153 | | | |
| 0.018 µF | 183 | 183 | 183 | 183 | | | | 183 | 183 | 183 | 183 | 183 | 183 | | | 183 | 183 | 183 | 183 | 183 | 183 | | | |
| 0.022 µF | 223 | 223 | 223 | 223 | | | | 223 | 223 | 223 | 223 | 223 | 223 | | | 223 | 223 | 223 | 223 | 223 | 223 | | | |
| 0.027 µF | 273 | 273 | 273 | 273 | | | | 273 | 273 | 273 | 273 | 273 | | | | 273 | 273 | 273 | 273 | 273 | 273 | | | |
| 0.033 µF | 333 | 333 | 333 | 333 | | | | 333 | 333 | 333 | 333 | 333 | | | | 333 | 333 | 333 | 333 | 333 | | | | |
| 0.039 µF | 393 | 393 | 393 | 393 | | | | 393 | 393 | 393 | 393 | | | | | 393 | 393 | 393 | 393 | 393 | | | | |
| 0.047 µF | 473 | 473 | 473 | | | | | 473 | 473 | 473 | 473 | | | | | 473 | 473 | 473 | 473 | 473 | | | | |
| 0.056 µF | 563 | 563 | 563 | | | | | 563 | 563 | 563 | 563 | | | | | 563 | 563 | 563 | 563 | | | | | |
| 0.068 µF | 683 | 683 | 683 | | | | | 683 | 683 | 683 | 683 | | | | | 683 | 683 | 683 | 683 | | | | | |
| 0.082 µF | 823 | 823 | 823 | | | | | 823 | 823 | 823 | 823 | | | | | 823 | 823 | 823 | 823 | | | | | |
| 0.1 µF | 104 | 104 | | | | | | 104 | 104 | 104 | | | | | | 104 | 104 | 104 | 104 | | | | | |
| 0.12 µF | 124 | 124 | | | | | | 124 | 124 | 124 | | | | | | 124 | 124 | 124 | | | | | | |
| 0.15 µF | 154 | 154 | | | | | | 154 | 154 | 154 | | | | | | 154 | 154 | 154 | | | | | | |
| 0.18 µF | 184 | 184 | | | | | | 184 | 184 | 184 | | | | | | 184 | 184 | 184 | | | | | | |
| 0.22 µF | 224 | 224 | | | | | | 224 | 224 | 224 | | | | | | 224 | 224 | 224 | | | | | | |
| 0.27 µF | 274 | 274 | | | | | | 274 | 274 | 274 | | | | | | 274 | 274 | 274 | | | | | | |
| 0.33 µF | 334 | 334 | | | | | | 334 | 334 | | | | | | | 334 | 334 | | | | | | | |
| 0.39 µF | 394 | 394 | | | | | | 394 | 394 | | | | | | | 394 | 394 | | | | | | | |
| 0.47 µF | 474 | 474 | | | | | | 474 | 474 | | | | | | | 474 | 474 | | | | | | | |
| 0.56 µF | 564 | 564 | | | | | | 564 | 564 | | | | | | | 564 | 564 | | | | | | | |
| 0.68 µF | 684 | 684 | | | | | | 684 | 684 | | | | | | | 684 | 684 | | | | | | | |
| 0.82 µF | 824 | | | | | | | 824 | 824 | | | | | | | 824 | 824 | | | | | | | |
| 1.0 µF | 105 | | | | | | | 105 | 105 | | | | | | | 105 | 105 | | | | | | | |
| 1.2 µF | 125 | | | | | | | 125 | | | | | | | | 125 | 125 | | | | | | | |
| 1.5 µF | 155 | | | | | | | 155 | | | | | | | | 155 | | | | | | | | |
| 1.8 µF | | | | | | | | 185 | | | | | | | | 185 | | | | | | | | |
| 2.2 µF | | | | | | | | 225 | | | | | | | | 225 | | | | | | | | |
| 2.7 µF | | | | | | | | | | | | | | | | 275 | | | | | | | | |
| 2.9 µF | | | | | | | | | | | | | | | | 295 | | | | | | | | |
| 3.3 µF | | | | | | | | | | | | | | | | 335 | | | | | | | | |
| 3.9 µF | | | | | | | | | | | | | | | | 395 | | | | | | | | |

# Table 1D – Capacitance Range/Selection Waterfall SM36 Style/Size

| Style/Size | SM36 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dimensions – inches (mm) | | | | | | | | | |
| **Length** | 1.350 ± 0.030 (33.00 ± 0.76) | | | | | | | | |
| **Width** | 0.600 ± 0.030 (15.20 ± 0.76) | | | | | | | | |
| **Thickness Maximum** | 0.220 (5.59) | | | | | | | | |
| **Lead Width Maximum** | 0.500 (12.7) | | | | | | | | |
| **Lead Length "L"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| **Lead Length "J"** | 0.100 ± 0.020 (2.54 ± 0.51) | | | | | | | | |
| X7R Dielectric | | | | | | | | | |
| **Voltage Code** | **501** | **102** | **202** | **302** | **402** | **502** | **752** | **103** | **Capacitance Tolerance** |
| **Voltage DC** | **500** | **1 K** | **2 K** | **3 K** | **4 K** | **5 K** | **7.5 K** | **10 K** | |
| Capacitance | Capacitance Code | | | | | | | | |
| 1,500 pF | | | | | | | | 152 | K, M, P, Z |
| 1,800 pF | | | | | | | | 182 | |
| 2,200 pF | | | | | | | | 222 | |
| 2,700 pF | | | | | | | | 272 | |
| 3,300 pF | | | | | | | | 332 | |
| 3,900 pF | | | | | | | | 392 | |
| 4,700 pF | 472 | 472 | 472 | 472 | 472 | 472 | 472 | 472 | |
| 5,600 pF | 562 | 562 | 562 | 562 | 562 | 562 | 562 | 562 | |
| 6,800 pF | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | |
| 8,200 pF | 822 | 822 | 822 | 822 | 822 | 822 | 822 | 822 | |
| 0.01 µF | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | |
| 0.012 µF | 123 | 123 | 123 | 123 | 123 | 123 | 123 | | |
| 0.015 µF | 153 | 153 | 153 | 153 | 153 | 153 | 153 | | |
| 0.018 µF | 183 | 183 | 183 | 183 | 183 | 183 | 183 | | |
| 0.022 µF | 223 | 223 | 223 | 223 | 223 | 223 | 223 | | |
| 0.027 µF | 273 | 273 | 273 | 273 | 273 | 273 | | | |
| 0.033 µF | 333 | 333 | 333 | 333 | 333 | 333 | | | |
| 0.039 µF | 393 | 393 | 393 | 393 | 393 | | | | |
| 0.047 µF | 473 | 473 | 473 | 473 | 473 | | | | |
| 0.056 µF | 563 | 563 | 563 | 563 | 563 | | | | |
| 0.068 µF | 683 | 683 | 683 | 683 | 683 | | | | |
| 0.082 µF | 823 | 823 | 823 | 823 | | | | | |
| 0.1 µF | 104 | 104 | 104 | 104 | | | | | |
| 0.12 µF | 124 | 124 | 124 | 124 | | | | | |
| 0.15 µF | 154 | 154 | 154 | 154 | | | | | |
| 0.18 µF | 184 | 184 | 184 | | | | | | |
| 0.22 µF | 224 | 224 | 224 | | | | | | |
| 0.27 µF | 274 | 274 | 274 | | | | | | |
| 0.33 µF | 334 | 334 | 334 | | | | | | |
| 0.39 µF | 394 | 394 | | | | | | | |
| 0.47 µF | 474 | 474 | | | | | | | |
| 0.56 µF | 564 | 564 | | | | | | | |
| 0.68 µF | 684 | 684 | | | | | | | |
| 0.82 µF | 824 | 824 | | | | | | | |
| 1.0 µF | 105 | 105 | | | | | | | |
| 1.2 µF | 125 | 125 | | | | | | | |
| 1.5 µF | 155 | 155 | | | | | | | |
| 1.8 µF | 185 | 185 | | | | | | | |
| 2.2 µF | 225 | 225 | | | | | | | |
| 2.7 µF | 275 | | | | | | | | |
| 2.9 µF | 295 | | | | | | | | |
| 3.3 µF | 335 | | | | | | | | |
| 3.9 µF | 395 | | | | | | | | |
| 4.7 µF | 475 | | | | | | | | |
| 5.6 µF | 565 | | | | | | | | |

## Table 2 – Chip Thickness/Packaging Quantities

| Series | Style/Size | Tray Quantity Minimum[1] | Tray Quantity Maximum[1] |
|---|---|---|---|
| SM | SM20 | 1 | 50 |
| | SM21 | | |
| | SM22 | | |
| | SM23 | | |
| | SM24 | | |
| | SM25 | | |
| | SM26 | | |
| | SM30 | | |
| | SM31 | | |
| | SM33 | | 25 |
| | SM34 | | 10 |
| | SM35 | | |
| | SM36 | | |

*[1] Minimum order value applies. Contact KEMET for details.*

## Soldering Process

The capacitors and assemblies outlined in this specification sheet are susceptible to thermal shock damage due to their large ceramic mass. Temperature profiles used should provide adequate temperature rise and cool-down time to prevent damage from thermal shock. In general, KEMET recommends against hand soldering for these types of large ceramic devices.

Recommended Soldering Technique:

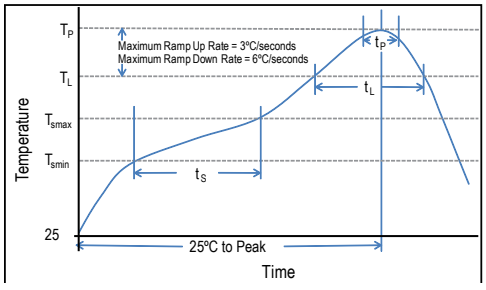
- Solder reflow only

Preheating and Reflow Profile Notes:
Due to differences in the coefficient of thermal expansion for the different materials of construction, it is critical to monitor and control the heating and cooling rates during the soldering process. During the reflow soldering process, the maximum recommended heating and cooling rate (dT/dt) is 4°C/second. To ensure optimal component reliability, KEMET's recommended heating and cooling rate is 2°C/second. After soldering, the capacitors should be air cooled to room temperature before further processing. Forced air cooling is not recommended.

Recommended Reflow Soldering Profile:

| Profile Feature | SnPb Assembly |
|---|---|
| Preheat/Soak | |
| Temperature Minimum ($T_{Smin}$) | 100°C |
| Temperature Maximum ($T_{Smax}$) | 150°C |
| Time ($t_s$) from $T_{smin}$ to $T_{smax}$) | 60 – 90 seconds |
| Ramp-up Rate ($T_L$ to $T_P$) | 2°C/seconds |
| Liquidous Temperature ($T_L$) | 183°C |
| Time Above Liquidous ($t_L$) | 95 seconds |
| Peak Temperature ($T_P$) | 240°C |
| Time within 5°C of Maximum Peak Temperature ($t_P$) | 5 seconds |
| Ramp-down Rate ($T_P$ to $T_L$) | 2°C/seconds |
| Time 25°C to Peak Temperature | 3.5 minutes |

*Note 1: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.*



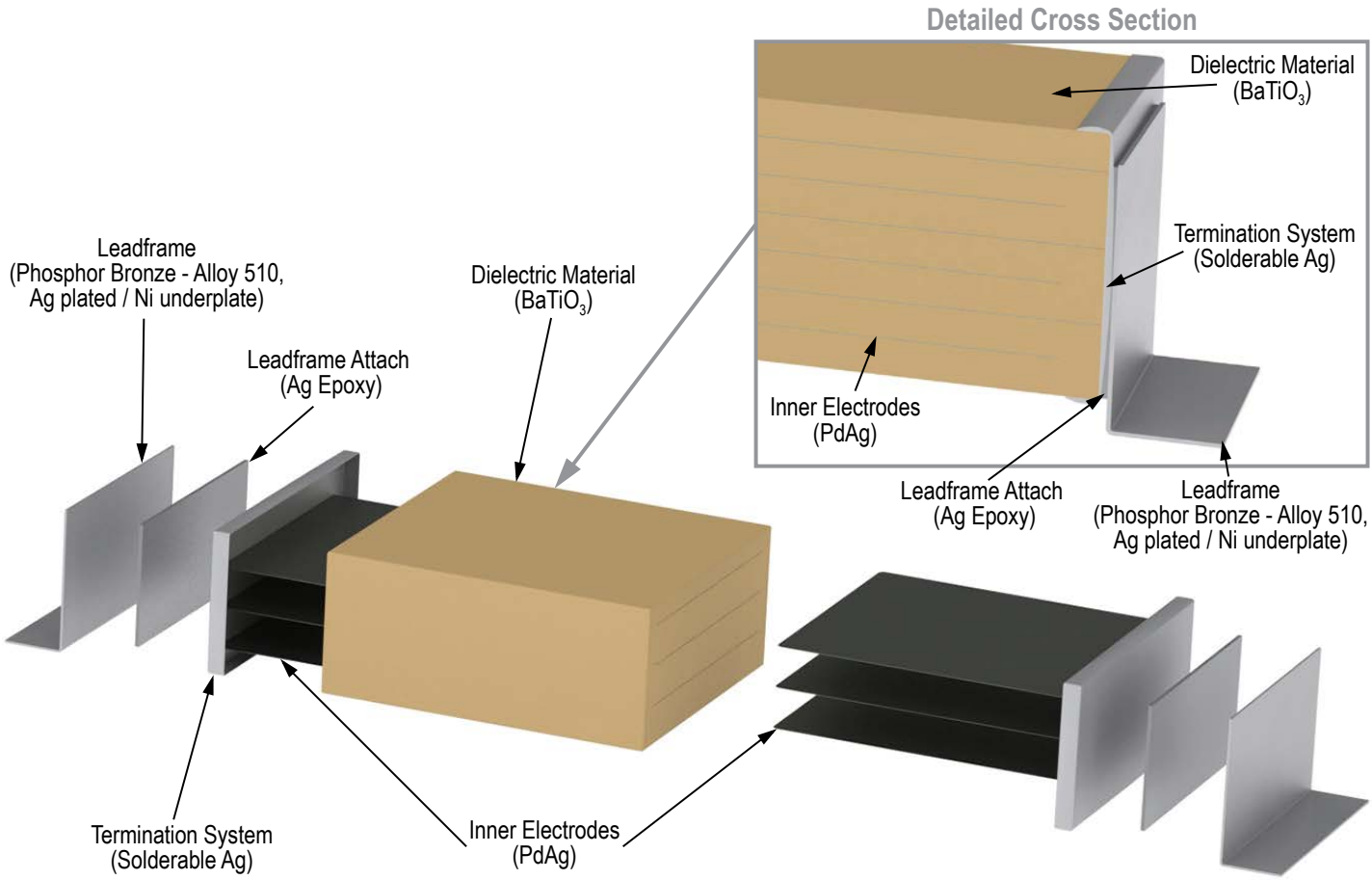
## Table 3 – Performance & Reliability: Test Methods and Conditions

| Stress | Reference | Test or Inspection Method |
|---|---|---|
| Board Flex | JIS–C–6429 | Appendix 2, Note: 2 mm (minimum) for all except 3 mm for C0G. |
| Solderability | J–STD–002 | Magnification 50 X. Conditions: |
| | | a) Method B, 4 hours @ 155°C, dry heat @ 235°C |
| | | b) Method B @ 215°C category 3 |
| | | c) Method D, category 3 @ 260°C |
| | | 1,000 cycles (-55°C to +125°C). Measurement at 24 hours +/- 2 hours after test conclusion. |
| Biased Humidity | MIL–STD–202 Method 103 | Load Humidity: 1,000 hours 85°C/85% RH and 300 VDC Maximum Add 100 K ohm resistor. Measurement at 24 hours +/- 2 hours after test conclusion. |
| | | Low Volt Humidity: 1,000 hours 85°C/85% RH and 1.5 V. Add 100 K ohm resistor. Measurement at 24 hours +/- 2 hours after test conclusion. |
| | | t = 24 hours/cycle. Steps 7a and 7b not required. Unpowered. Measurement at 24 hours +/- 2 hours after test conclusion. |
| Thermal Shock | MIL–STD–202 Method 107 | -55°C/+125°C. Note: Number of cycles required – 300. Maximum transfer time – 20 seconds. D14 dwell time – 15 minutes. Air – Air. |
| High Temperature Life | MIL–STD–202 Method 108 /EIA -198 | 1,000 hours at 125°C (85°C for X5R, Z5U and Y5V) with rated voltage applied. |
| Storage Life | MIL–STD–202 Method 108 | 150°C, 0 VDC, for 1,000 hours. |
| Vibration | MIL–STD–202 Method 204 | 5 g for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8 "X5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10–2,000 Hz. |
| Resistance to Soldering Heat | MIL–STD–202 Method 210 | Condition B. No preheat of samples. Note: single wave solder – procedure 2. |
| Terminal Strength | MIL–STD–202 Method 211 | Conditions A (2.3 kg or 5 lbs). |
| Mechanical Shock | MIL–STD–202 Method 213 | Figure 1 of Method 213, Condition F. |
| Resistance to Solvents | MIL–STD–202 Method 215 | Add aqueous wash chemical, OKEM Clean or equivalent. |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Product Marking

Product marking is an extra-cost option. These devises will be supplied unmarked unless otherwise specified and/or requested. For more detailed information regarding marked product and how to request this option, please contact KEMET.

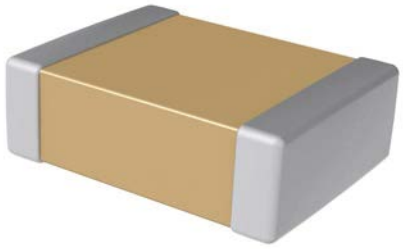
# HV-HT Series, High Voltage, High Temperature 200°C, C0G Dielectric, 500 – 2,000 VDC (Industrial Grade)

## Overview

KEMET's High Voltage-High Temperature (HV-HT) series surface mount C0G Multilayer Ceramic Capacitors (MLCCs) are constructed of a robust and proprietary base metal electrode (BME) dielectric system that offers industry-leading performance at extreme temperatures. These surface mountable devices feature a 200ºC maximum operating temperature and are specifically designed to withstand the demands of harsh industrial environments such as oil exploration and automotive/avionics engine compartment circuitry. They also offer higher and more uniform breakdown voltage performance than competitive products, resulting in increased yields in customer field applications. When dealing with expensive high temperature circuitry and systems, higher yields can quickly result in significant cost savings.

KEMET's HV-HT series MLCCs are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. They exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. Capacitance change is limited to ±30ppm/ºC from −55°C to +200°C. In addition, these capacitors exhibit high insulation resistance with low dissipation factor at elevated temperatures up to 200°C. They also exhibit low ESR at high frequencies and offer superior volumetric efficiency over competitive high temperature precious metal electrode (PME) and base metal electrode (BME) dielectric system devices.

These devices are Lead (Pb)-Free, RoHS and REACH compliant without the need of any exemptions.



## Ordering Information

| C | 2225 | H | 393 | J | C | G | A | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance[1] | Rated Voltage (VDC) | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec) |
| | 0805<br>1206<br>1210<br>1808<br>1812<br>1825<br>2220<br>2225<br>2824<br>3040<br>3640<br>4540 | H = High Temperature (200°C) | Two significant digits + number of zeros. | B = ±0.10 pF<br>C = ±0.25 pF<br>D = ±0.5 pF<br>F = ±1%<br>G = ±2%<br>J = ±5%<br>K = ±10%<br>M = ±20% | C = 500<br>B = 630<br>D = 1,000<br>F = 1,500<br>G = 2,000 | G = C0G | A = N/A | C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | See "Packaging C-Spec Ordering Options Table" below |

*[1] Additional capacitance tolerance offerings may be available. Contact KEMET for details.*

*[2] Gold(Au) termination finish options are not available on 2824, 3040, 3640 and 4540 case sizes.*



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## Packaging C-Spec Ordering Options Table

| Termination Finish Options | Packaging Type/Options | Packaging Ordering Code (C-Spec) |
|---|---|---|
| **Standard Packaging – Unmarked[3]** | | |
| C = 100% Matte Sn<br>L = SnPb (5% Pb min.)<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Bulk Bag | Blank[1] |
| | Waffle Tray[2] | 7292 |
| | 7" Tape & Reel | TU |
| | 13" Reel | 7411 (EIA 0603 and smaller case sizes)<br>7210 (EIA 0805 and larger case sizes) |
| | 7" Tape & Reel/2 mm pitch[4] | 7081 |
| | 7" Tape & Reel – 50 pcs | T050 |
| | 7" Tape & Reel – 100 pcs | T100 |
| | 7" Tape & Reel – 250 pcs | T250 |
| | 7" Tape & Reel – 500 pcs | T500 |
| | 7" Tape & Reel – 1,000 pcs | T1K0 |
| **Moisture Sensitive Packaging[5] – Unmarked[3]** | | |
| E = Gold (Au) 1.97 – 11.8 µin<br>F = Gold (Au) 30 – 50 µin<br>G = Gold (Au) 100 µin min. | Waffle Tray[2] | 7282 |
| | 7" Tape & Reel | 7130 |
| | 7" Tape & Reel – 50 pcs | Contact KEMET[6] |
| | 7" Tape & Reel – 100 pcs | |
| | 7" Tape & Reel – 250 pcs | |
| | 7" Tape & Reel – 500 pcs | |
| | 7" Tape & Reel – 1,000 pcs | |

*[1] Default packaging is "Bulk Bag". An ordering code C-Spec is not required for "Bulk Bag" packaging.*

*[1] "Bulk Bag" packaging option is not available for Gold (Au) termination finish options and case sizes larger than 2225 (5664 Metric).*

*[2] "Waffle Tray" packaging option is not available for case sizes larger than 2225 (5664 Metric).*

*[3] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*

*3 Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "T1K0" packaging option, 1812 thru 2225 case size devices with chip thickness of ≥ 1.9mm (nominal) may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*

*[4] The 2 mm pitch option allows for double the packaging quantity of capacitors on a given reel size. This option is limited to EIA 0603 (1608 metric) case size devices. For more information regarding 2 mm pitch option see "Tape & Reel Packaging Information".*

*[5] Moisture sensitive packaging is required for Gold (Au) termination option "E" (1.97 – 11.8 µin)*

*[6] Additional reeling or packaging options may be available. Contact KEMET for details.*

## Benefits

- Operating temperature range of −55°C to +200°C
- Lead (Pb)-Free, RoHS, and REACH compliant
- EIA 0805, 1206, 1210, 1808, 1812, 1825, 2220, 2225, 2824, 3040, 3640 and 4540 case sizes
- DC voltage ratings of 500 V, 630 V, 1 KV, 1.5 KV, and 2 KV
- Capacitance offerings ranging from 1 pF to 0.150 µF
- Available capacitance tolerances of ±0.10 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, ±5%, ±10%, and ±20%
- No piezoelectric noise
- Extremely low ESR & ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +125°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability
- SnPb plated termination finish option available upon request (5% Pb minimum)
- Gold (Au), Tin/Lead (Sn/Pb) and 100% pure matte Tin (Sn) termination finishes available

## Applications

Typical applications include critical timing, tuning, circuits requiring low loss, circuits with pulse, high current, switch mode power supplies (input filters, resonators, tank circuits, snubbed circuits, output filters), high voltage coupling, DC blocking and voltage multiplier circuits in extreme environments such as down-hole exploration, aerospace engine compartments and geophysical probes. Markets include power supply, HID lighting, industrial equipment/control, automotive, aerospace, and munitions.

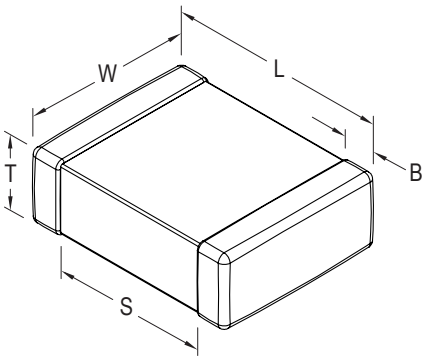
## Qualification/Certification

High temperature (200ºC) Industrial grade products meet or exceed the requirements outlined in Table 4, Performance & Reliability. Qualification packages are available for review and download on our website at www.kemet.com/hightemp

## Environmental Compliance

Lead (Pb)-Free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Dimensions – Millimeters (Inches)




| EIA Size Code | Metric Size Code | L Length | W Width | T Thickness | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|---|
| 0805 | 2012 | 2.00 (.079) ± 0.20 (.008) | 1.25 (.049) ± 0.20 (.008) | See Table 2 for Thickness | 0.50 (0.02) ± 0.25 (.010) | 0.75 (.030) | "Solder Wave or Solder Reflow" |
| 1206 | 3216 | 3.20 (.126) ± 0.20 (.008) | 1.60 (.063) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | N/A | |
| 1210 | 3225 | 3.20 (.126) ± 0.20 (.008) | 2.50 (.098) ± 0.20 (.008) | | 0.50 (0.02) ± 0.25 (.010) | | Solder Reflow Only |
| 1808 | 4520 | 4.70 (.185) ± 0.50 (.020) | 2.00 (.079) ± 0.20 (.008) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1812 | 4532 | 4.50 (.177) ± 0.30 (.012) | 3.20 (.126) ± 0.30 (.012) | | 0.60 (.024) ± 0.35 (.014) | | |
| 1825 | 4564 | 4.50 (.177) ± 0.30 (.012) | 6.40 (.252) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2220 | 5650 | 5.70 (.224) ± 0.40 (.016) | 5.00 (.197) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2225 | 5664 | 5.60 (.220) ± 0.40 (.016) | 6.40 (.248) ± 0.40 (.016) | | 0.60 (.024) ± 0.35 (.014) | | |
| 2824 | 7260 | 7.10 (.280) ± 0.40 (.016) | 6.10 (.240) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3040 | 7610 | 7.60 (.300) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 3640 | 9210 | 9.10 (.358) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |
| 4540 | - | 11.40 (.449) ± 0.40 (.016) | 10.20 (.402) ± 0.40 (.016) | | 1.27 (.050) ± 0.40 (.016) | | |

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C (up to +200°C) |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | 150% of rated voltage for voltage rating of < 1000 V<br>120% of rated voltage for voltage rating of ≥ 1000 V<br>(5 ±1 seconds and charge/discharge not exceeding 50 mA) |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 secs @ 25°C) |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2] Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ± 50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3] To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes)

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 1.0 - 9.1 pF* | 109 - 919* | B C D F G J K M | DG | DG | DG | | | | | | | | | | | | | | | |
| 10 pF - 47pF* | 100 - 470* | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 51 pF | 510 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 56 pF | 560 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 62 pF | 620 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 68 pF | 680 | F G J K M | DG | DG | DG | ED | ED | ED | ED | ED | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 75 pF | 750 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 82 pF | 820 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 91 pF | 910 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 100 pF | 101 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EF | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 110 pF | 111 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FM | FM | FM | FM | FM | LB | LB | LB | LB | LB |
| 120 pF | 121 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 130 pF | 131 | F G J K M | DG | DG | DG | ED | ED | ED | ED | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 150 pF | 151 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LB |
| 160 pF | 161 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 180 pF | 181 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 200 pF | 201 | F G J K M | DG | DG | DG | ED | ED | ED | EF | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 220 pF | 221 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LA | LC |
| 240 pF | 241 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FM | FM | LA | LA | LA | LB | LC |
| 270 pF | 271 | F G J K M | DG | DG | DG | ED | ED | ED | EG | EG | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 300 pF | 301 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 330 pF | 331 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FK | LA | LA | LA | LB | LC |
| 360 pF | 361 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 390 pF | 391 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FG | FG | FK | FS | LA | LA | LA | LB | LA |
| 430 pF | 431 | F G J K M | DG | DG | | ED | ED | EF | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 470 pF | 471 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LA |
| 510 pF | 511 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 560 pF | 561 | F G J K M | DG | DG | | ED | ED | EG | EG | | FG | FM | FM | FS | FS | LA | LB | LB | LC | LB |
| 620 pF | 621 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 680 pF | 681 | F G J K M | DG | | | ED | ED | EG | | | FG | FM | FM | FS | FS | LA | LB | LB | LA | LC |
| 750 pF | 751 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 820 pF | 821 | F G J K M | DG | | | ED | EF | EG | | | FG | FM | FM | FM | | LB | LB | LB | LA | |
| 910 pF | 911 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LA | |
| 1,000 pF | 102 | F G J K M | | | | ED | EF | EG | | | FM | FM | FM | FY | | LB | LB | LB | LB | |
| 1,100 pF | 112 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LB | |
| 1,200 pF | 122 | F G J K M | | | | EF | EG | | | | FM | FK | FK | FS | | LC | LC | LC | LC | |
| 1,300 pF | 132 | F G J K M | | | | EF | EG | | | | FM | FS | FS | | | LC | LC | LC | LC | |
| 1,500 pF | 152 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | LC | |
| 1,600 pF | 162 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 1,800 pF | 182 | F G J K M | | | | EF | EG | | | | FK | FS | FS | | | LC | LC | LC | | |
| 2,000 pF | 202 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,200 pF | 222 | F G J K M | | | | EG | | | | | FK | FL | FS | | | LC | LA | LB | | |
| 2,400 pF | 242 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LB | | |
| 2,700 pF | 272 | F G J K M | | | | EG | | | | | FS | FL | FS | | | LC | LA | LC | | |
| 3,000 pF | 302 | F G J K M | | | | | | | | | FS | FL | | | | LA | LA | | | |
| 3,300 pF | 332 | F G J K M | | | | | | | | | FS | FM | | | | LA | LA | | | |
| 3,600 pF | 362 | F G J K M | | | | | | | | | FL | FM | | | | LA | LB | | | |
| 3,900 pF | 392 | F G J K M | | | | | | | | | FL | FY | | | | LA | LB | | | |
| 4,300 pF | 432 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| 4,700 pF | 472 | F G J K M | | | | | | | | | FM | FY | | | | LA | LC | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

# Table 1A – Capacitance Range/Selection Waterfall (0805 – 1808 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | | | | | | | | | FY | FS | | | | LA | | | | |
| 5,600 pF | 562 | F G J K M | | | | | | | | | FY | FS | | | | LB | | | | |
| 6,200pF | 622 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 6,800pF | 682 | F G J K M | | | | | | | | | FY | | | | | LC | | | | |
| 7,500pF | 752 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| 8,200 pF | 822 | F G J K M | | | | | | | | | FS | | | | | | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C0805H | | | C1206H | | | | | C1210H | | | | | C1808H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*

*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*

*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes)

| Capacitance | Cap Code | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 pF - 47pF* | 100 - 470* | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 51 pF | 510 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 56 pF | 560 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 62 pF | 620 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 68 pF | 680 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 75 pF | 750 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 82 pF | 820 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 91 pF | 910 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 100 pF | 101 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 110 pF | 111 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 120 pF | 121 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 130 pF | 131 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 150 pF | 151 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 160 pF | 161 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 180 pF | 181 | F | G | J | K | M | GK | GK | GK | GK | GK | HG | HG | HG | HG | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 200 pF | 201 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 220 pF | 221 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KF |
| 240 pF | 241 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 270 pF | 271 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 300 pF | 301 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KE | KE | KE | KE | KE |
| 330 pF | 331 | F | G | J | K | M | GH | GH | GH | GH | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 360 pF | 361 | F | G | J | K | M | GK | GK | GK | GK | GH | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 390 pF | 391 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 430 pF | 431 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KE | KE | KE | KE | KE |
| 470 pF | 471 | F | G | J | K | M | GK | GK | GK | GK | GK | HE | HE | HE | HE | HE | JE | JE | JE | JE | JE | KF | KF | KF | KF | KE |
| 510 pF | 511 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HE | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 560 pF | 561 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 620 pF | 621 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JK | JK | JK | JK | JK | KF | KF | KF | KF | KE |
| 680 pF | 681 | F | G | J | K | M | GH | GH | GH | GK | GH | HE | HE | HE | HE | HG | JE | JE | JE | JK | JK | KF | KF | KF | KF | KE |
| 750 pF | 751 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 820 pF | 821 | F | G | J | K | M | GH | GH | GH | GK | GK | HE | HE | HE | HG | HG | JE | JE | JE | JK | JK | KE | KE | KE | KF | KE |
| 910 pF | 911 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,000 pF | 102 | F | G | J | K | M | GH | GH | GH | GH | GM | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KE |
| 1,100 pF | 112 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,200 pF | 122 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HG | JE | JK | JK | JK | JK | KE | KE | KE | KF | KF |
| 1,300 pF | 132 | F | G | J | K | M | GH | GK | GK | GH | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,500 pF | 152 | F | G | J | K | M | GK | GK | GK | GK | GO | HE | HE | HE | HG | HE | JE | JK | JK | JK | JE | KE | KE | KE | KF | KF |
| 1,600 pF | 162 | F | G | J | K | M | GK | GK | GK | GK | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 1,800 pF | 182 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HG | HG | JE | JK | JK | JK | JE | KE | KE | KE | KF | KE |
| 2,000 pF | 202 | F | G | J | K | M | GK | GK | GK | GM | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KE |
| 2,200 pF | 222 | F | G | J | K | M | GK | GK | GK | GO | | HE | HG | HG | HE | HJ | JE | JK | JK | JE | JK | KE | KE | KE | KF | KF |
| 2,400 pF | 242 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HJ | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 2,700 pF | 272 | F | G | J | K | M | GK | GH | GK | GO | | HE | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,000 pF | 302 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HE | HK | JK | JK | JK | JE | JL | KE | KE | KE | KE | KH |
| 3,300 pF | 332 | F | G | J | K | M | GK | GH | GK | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KE | KE | KE | KJ |
| 3,600 pF | 362 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HG | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 3,900 pF | 392 | F | G | J | K | M | GK | GH | GM | | | HG | HG | HG | HJ | | JK | JK | JK | JK | JN | KE | KF | KF | KF | KJ |
| 4,300 pF | 432 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JK | | KE | KF | KF | KF | |
| 4,700 pF | 472 | F | G | J | K | M | GH | GH | GO | | | HG | HG | HG | HJ | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | | | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1B – Capacitance Range/Selection Waterfall (1812 – 2225 Case Sizes) cont'd

| Capacitance | Cap Code | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 5,100 pF | 512 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JL | | KE | KF | KF | KH | |
| 5,600 pF | 562 | F G J K M | GH | GK | GO | | | HG | HE | HG | HK | | JK | JK | JK | JN | | KE | KF | KF | KH | |
| 6,200pF | 622 | F G J K M | GH | GK | | | | HG | HE | HG | | | JK | JE | JE | JN | | KE | KF | KF | KJ | |
| 6,800pF | 682 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | JN | | KE | KF | KF | KJ | |
| 7,500pF | 752 | F G J K M | GH | GM | | | | HG | HE | HJ | | | JK | JE | JK | | | KF | KE | KF | | |
| 8,200 pF | 822 | F G J K M | GK | GO | | | | HG | HE | HJ | | | JK | JE | JL | | | KF | KE | KF | | |
| 9,100 pF | 912 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 10,000 pF | 103 | | GM | GO | | | | HE | HG | HK | | | JE | JE | JL | | | KF | KE | KH | | |
| 12,000 pF | 123 | | GO | | | | | HE | HG | | | | JE | JK | JN | | | KE | KE | KH | | |
| 15,000 pF | 153 | | GO | | | | | HE | HJ | | | | JE | JL | | | | KE | KF | KJ | | |
| 18,000 pF | 183 | | | | | | | HG | HK | | | | JE | JL | | | | KE | KH | | | |
| 22,000 pF | 223 | | | | | | | HJ | | | | | JK | JN | | | | KF | KJ | | | |
| 27,000 pF | 273 | | | | | | | HJ | | | | | JL | JN | | | | KF | KJ | | | |
| 33,000 pF | 333 | | | | | | | HK | | | | | JN | | | | | KH | | | | |
| 39,000 pF | 393 | | | | | | | | | | | | | | | | | KJ | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | C1812H | | | | | C1825H | | | | | C2220H | | | | | C2225H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

# Table 1C – Capacitance Range/Selection Waterfall (2824 – 4540 Case Sizes)

| Capacitance | Cap Code | Case Size/ Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 10 - 2,000 pF | 100 - 202 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,400 pF | 242 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,000 pF | 302 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J | K | M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,600 pF | 362 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 3,900 pF | 392 | J | K | M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,300 pF | 432 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 4,700 pF | 472 | J | K | M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,100 pF | 512 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 5,600 pF | 562 | J | K | M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,200 pF | 622 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 6,800 pF | 682 | J | K | M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 7,500 pF | 752 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 8,200 pF | 822 | J | K | M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 9,100 pF | 912 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 10,000 pF | 103 | J | K | M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J | K | M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J | K | M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J | K | M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J | K | M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J | K | M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J | K | M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J | K | M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J | K | M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J | K | M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J | K | M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J | K | M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.1 µF | 104 | J | K | M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J | K | M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J | K | M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Rated Voltage (VDC) | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Voltage Code | | | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G | C | B | D | F | G |
| | | Case Size/Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |

**Capacitance range Includes E24 decade values only. (i.e., 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82 and 91)*
*KEMET reserves the right to substitute product with an improved temperature characteristic, tighter capacitance tolerance and/or higher voltage capability within the same form factor (configuration and dimensions).*
*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2A – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| DG | 0805 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| ED | 1206 | 1.00 ± 0.10 | 0 | 0 | 2,500 | 10,000 |
| EF | 1206 | 1.20 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| EG | 1206 | 1.60 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FG | 1210 | 1.25 ± 0.15 | 0 | 0 | 2,500 | 10,000 |
| FL | 1210 | 1.40 ± 0.15 | 0 | 0 | 2,000 | 8,000 |
| FM | 1210 | 1.70 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FY | 1210 | 2.00 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FK | 1210 | 2.10 ± 0.20 | 0 | 0 | 2,000 | 8,000 |
| FS | 1210 | 2.50 ± 0.30 | 0 | 0 | 1,000 | 4,000 |
| LA | 1808 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LB | 1808 | 1.60 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| LC | 1808 | 2.00 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GH | 1812 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| GK | 1812 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| GM | 1812 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| GO | 1812 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HE | 1825 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| HG | 1825 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| HJ | 1825 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| HK | 1825 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JE | 2220 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| JK | 2220 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| JL | 2220 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| JN | 2220 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KE | 2225 | 1.40 ± 0.15 | 0 | 0 | 1,000 | 4,000 |
| KF | 2225 | 1.60 ± 0.20 | 0 | 0 | 1,000 | 4,000 |
| KH | 2225 | 2.00 ± 0.20 | 0 | 0 | 500 | 2,000 |
| KJ | 2225 | 2.50 ± 0.20 | 0 | 0 | 500 | 2,000 |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

*Package quantity based on finished chip thickness specifications.*

## Table 2B – Bulk Packaging Quantities

| Packaging Type | | | Loose Packaging | | Secure Packaging | |
|---|---|---|---|---|---|---|
| | | | Bulk Bag (default) | | 2” x 2” Waffle Pack/Tray[3] | |
| Packaging C-Spec[1] | | | N/A[2] | | 7282 / 7292 | |
| Case Size | | Chip Thickness (mm) | Packaging Quantities (pieces/unit packaging) | | | |
| EIA (in) | Metric (mm) | | Minimum | Maximum | Minimum | Maximum |
| 0402 | 1005 | All | 1 | 50,000 | 1 | 368 |
| 0603 | 1608 | | | | | 368 |
| 0805 | 2012 | | | | | 100 |
| 1206 | 3216 | ≤ 1.25 (nominal) | | | | 126 |
| 1206 | 3216 | > 1.25 (nominal) | | | | 50 |
| 1210 | 3225 | All | | | | 80 |
| 1808 | 4520 | | | 20,000 | | 50 |
| 1812 | 4532 | | | | | 42 |
| 1825 | 4564 | | | | | 20 |
| 2220 | 5650 | | | | | 20 |
| 2225 | 5664 | | | | | 20 |

*[1] The "Packaging C-Spec" is a 4-digit code which identifies the packaging type. When ordering, the proper code must be included in the 15th through 18th character positions of the ordering code. See "Ordering Information" section of this document for further details. Product ordered without a packaging C-Spec will default to our standard " bulk bag" packaging.*

*[2] A packaging C-Spec (see note 1 above) is not required For "bulk bag" packaging (excluding Anti-Static Bulk Bag). The 15th through 18th character positions of the ordering code should be left blank. All product ordered without a packaging C-Spec will default to out standard "bulk bag" packaging.*

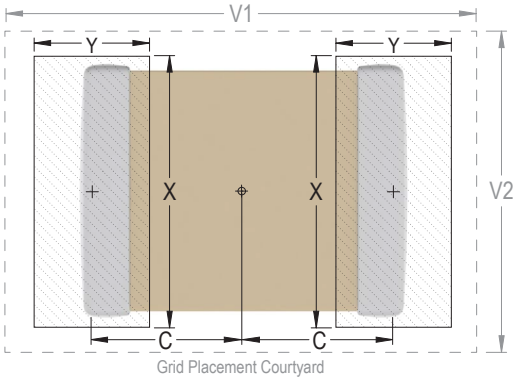
*[3] Also commonly referred to as “Chip Carrier” or “Molded Tray”. All tray packaging options offer static protection.*

# Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| EIA Size Code | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 0805 | 2012 | 1.00 | 1.35 | 1.55 | 4.40 | 2.60 | 0.90 | 1.15 | 1.45 | 3.50 | 2.00 | 0.75 | 0.95 | 1.35 | 2.80 | 1.70 |
| 1206 | 3216 | 1.60 | 1.35 | 1.90 | 5.60 | 2.90 | 1.50 | 1.15 | 1.80 | 4.70 | 2.30 | 1.40 | 0.95 | 1.70 | 4.00 | 2.00 |
| 1210 | 3225 | 1.60 | 1.35 | 2.80 | 5.65 | 3.80 | 1.50 | 1.15 | 2.70 | 4.70 | 3.20 | 1.40 | 0.95 | 2.60 | 4.00 | 2.90 |
| 1808 | 4520 | 2.30 | 1.75 | 2.30 | 7.40 | 3.30 | 2.20 | 1.55 | 2.20 | 6.50 | 2.70 | 2.10 | 1.35 | 2.10 | 5.80 | 2.40 |
| 1812 | 4532 | 2.15 | 1.60 | 3.60 | 6.90 | 4.60 | 2.05 | 1.40 | 3.50 | 6.00 | 4.00 | 1.95 | 1.20 | 3.40 | 5.30 | 3.70 |
| 1825 | 4564 | 2.15 | 1.60 | 6.90 | 6.90 | 7.90 | 2.05 | 1.40 | 6.80 | 6.00 | 7.30 | 1.95 | 1.20 | 6.70 | 5.30 | 7.00 |
| 2220 | 5650 | 2.75 | 1.70 | 5.50 | 8.20 | 6.50 | 2.65 | 1.50 | 5.40 | 7.30 | 5.90 | 2.55 | 1.30 | 5.30 | 6.60 | 5.60 |
| 2225 | 5664 | 2.70 | 1.70 | 6.90 | 8.10 | 7.90 | 2.60 | 1.50 | 6.80 | 7.20 | 7.30 | 2.50 | 1.30 | 6.70 | 6.50 | 7.00 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Recommended for wave solder applications and provides a wider process window for reflow solder processes. KEMET only recommends wave soldering of EIA 0603, 0805 and 1206 case sizes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for an EIA 1210 case size.*



## Soldering Process

**Recommended Soldering Technique:**

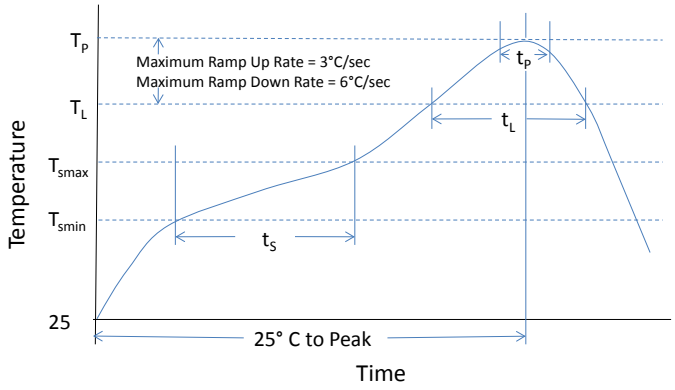
- Solder wave or solder reflow for EIA case sizes 0603, 0805 and 1206
- All other EIA case sizes are limited to solder reflow only

**Recommended Reflow Soldering Profile:**

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| Load Humidity | 85°C/85%RH and 200 VDC maximum, 1,000 Hours |
| Low Voltage Humidity | 85°C/85%RH, 1.5V, 1,000 Hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 Cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical – OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes, 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

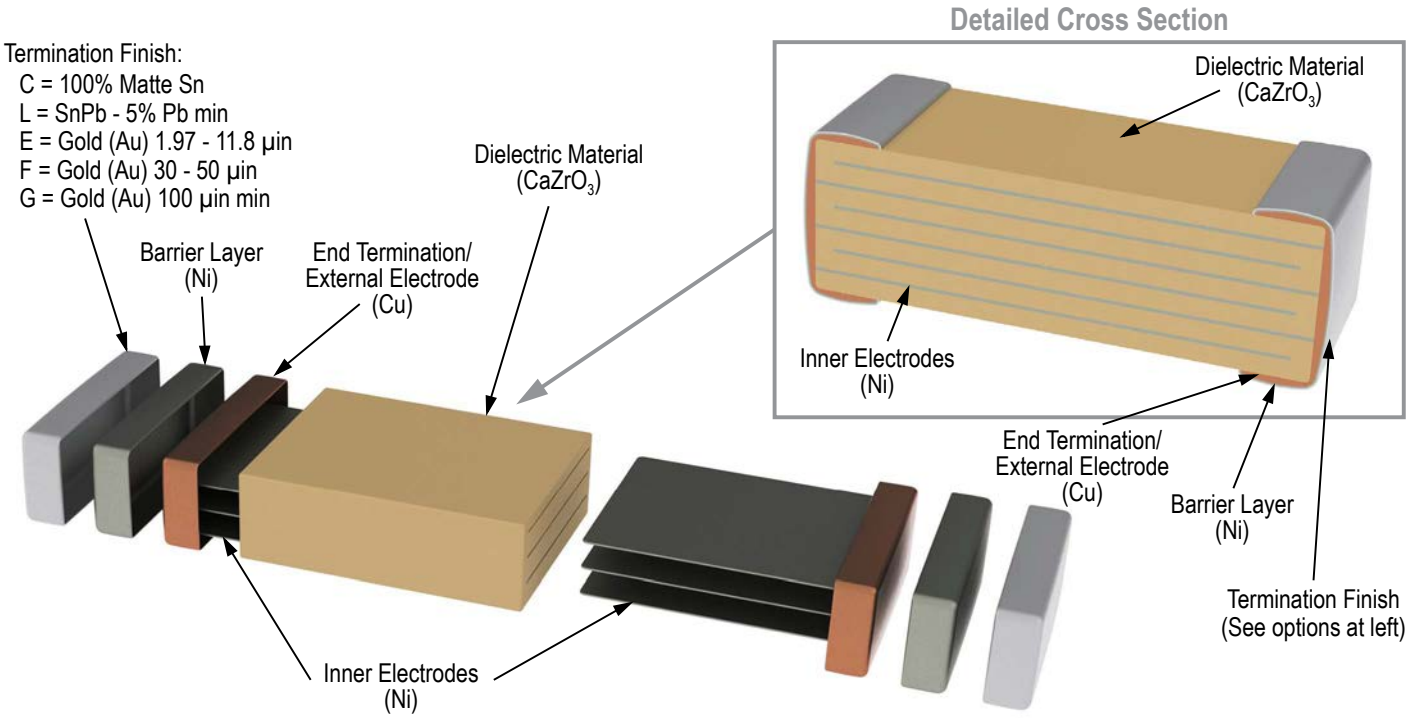
Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40°C and maximum storage humidity not exceed 70% relative humidity. In addition, temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within the time frame outlined in the table below:

| Termination Finish | Termination Finish Ordering Code[1] | Storage Life |
|---|---|---|
| 100% Matte Tin (Sn) | C | 1.5 years upon receipt |
| SnPb (5% Pb min.) | L | 1.5 years upon receipt |
| Gold (Au) 1.97 – 11.8 µin[2] | E | 6 months upon receipt[2] |
| Gold (Au) 30 – 50 µin | F | 1.5 years upon receipt |
| Gold (Au) 100 µin min. | G | 1.5 years upon receipt |

*[1] The fourteenth (14th) character position of the KEMET part number is assigned to identify and/or define the termination finish. For more information, see "Ordering Information" section of this document.*

*[2] Gold plating option "E" devices should remain in its factory sealed moisture sensitive packaging during storage. If the factory sealed packaging is disturbed please store any remaining packaged components in a dry box container to prevent oxidation of the termination finish.*

## Construction (Typical)




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

# Pulse Discharge, High Voltage, High Temperature 200°C C0G Dielectric, 1,000 VDC – 3,500 VDC (Industrial Grade)

## Overview

KEMET's Industrial Grade Pulse Discharge Series surface mount capacitors in C0G Dielectric deliver reliable high voltage and high temperature performance required for operation in harsh environments, specifically discharge circuitry. Constructed of a robust and proprietary base metal electrode (BME) dielectric system, these devices offer industry-leading performance relative to capacitance and case size. KEMET Pulse Discharge capacitors average greater than 30% higher breakdown voltage than competitive precious metal electrode (PME) devices with similar capacitance & voltage ratings.

Designed for down-hole oil exploration and perforation, these devices feature a 200°C maximum operating temperature. The Electronics Industries Alliance (EIA) characterizes C0G dielectric as a Class I material. Components of this classification are temperature compensating and are suited for resonant circuit applications or those where Q and stability of capacitance characteristics are required. Pulse Discharge series capacitors in C0G dielectric exhibit no change in capacitance with respect to time and voltage and boast a negligible change in capacitance with reference to ambient temperature. These devices retain high insulation resistance with low dissipation factor at elevated temperatures up 200°C.

KEMET's Pulse Discharge surface mount MLCCs are manufactured in state-of-the-art ISO/TS 16949:2009 certified facilities and are proven to function reliably in harsh, high temperature and high humidity, down-hole environments.

## Ordering Information

| C | 2824 | H | 393 | K | U | G | W | C | TU |
|---|---|---|---|---|---|---|---|---|---|
| Ceramic | Case Size (L" x W") | Specification/ Series | Capacitance Code (pF) | Capacitance Tolerance | Dielectric Withstanding Voltage (VDC)[1] | Dielectric | Failure Rate/ Design | Termination Finish[2] | Packaging/Grade (C-Spec)[3] |
| | 2824<br>3040<br>3640<br>4540 | H = High Temp (200°C) | Two significant digits + number of zeros | J = ±5%<br>K = ±10%<br>M = ±20% | D = 1,000<br>U = 1,250<br>G = 2,000<br>H = 3,000<br>V = 3,500 | G = C0G | W = Pulse Discharge | C = 100% Matte Sn<br>L = SnPb (5% Pb min.) | See "Packaging C-Spec Ordering Options Table" below |

*[1] DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor. See waterfall table for working voltage.*

*[2] Additional termination finish options may be available. Contact KEMET for details.*

*[3] Additional reeling or packaging options may be available. Contact KEMET for details.*



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## Packaging C-Spec Ordering Options Table

| Packaging Type/Options[1] | Packaging Ordering Code (C-Spec)[2] |
|---|---|
| 7" Reel (Embossed Plastic Tape)/Unmarked | TU |
| 13" Reel (Embossed Plastic Tape)/Unmarked | 7210 |
| Reel (Embossed Plastic Tape)/Unmarked - 50 pieces | T050 |
| Reel (Embossed Plastic Tape)/Unmarked - 100 pieces | T100 |
| Reel (Embossed Plastic Tape)/Unmarked - 250 pieces | T250 |
| Reel (Embossed Plastic Tape)/Unmarked - 500 pieces | T500 |
| Reel (Embossed Plastic Tape)/Unmarked - 1,000 pieces | T1K0 |

*[1] The terms "Marked" and "Unmarked" pertain to laser marking option of components. All packaging options labeled as "Unmarked" will contain capacitors that have not been laser marked. The option to laser mark is not available on these devices.*

*[2] Reeling quantities are dependent upon chip size and thickness dimension. When ordering using the "Txxx" packaging ordering codes (C-Specs) outlined above, product may be shipped on multiple 7" reels or a single 13" reel. Additional reeling or packaging options may be available. Contact KEMET for details.*

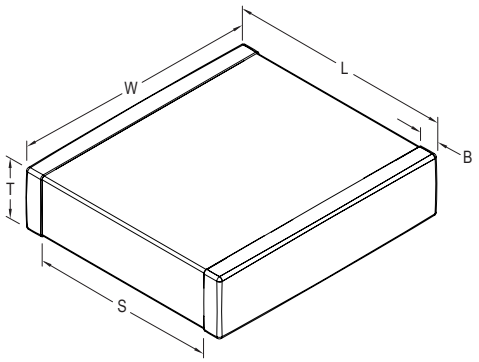
## Benefits

- Operating temperature range of −55°C to +200°C
- Lead (Pb)-Free, RoHS and REACH compliant
- Base metal technology
- Higher UVBD capability than competitive dielectric technologies
- Capacitance offerings ranging from 2.2 nF up to 150 nF
- Available capacitance tolerances of ±5%, ±10% or ±20%
- Extremely low ESR and ESL
- High thermal stability
- High ripple current capability
- No capacitance change with respect to applied rated DC voltage
- Negligible capacitance change with respect to temperature from −55°C to +200°C
- No capacitance decay with time
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish allowing for excellent solderability

## Applications

Typical applications include high temperature discharge circuits for munitions and down-hole oil exploration/perforation.

## Dimensions – Millimeters (Inches)




| Size Code | L Length | W Width | T Thickness Maximum | B Bandwidth | S Separation Minimum | Mounting Technique |
|---|---|---|---|---|---|---|
| 2824 | 7.10 ± 0.40 (0.280 ± 0.016) | 6.10 ± 0.40 (0.240 ± 0.016) | See Table 2 | 1.27 ± 0.40 (0.050 ± 0.016) | N/A | Solder Reflow Only |
| 3040 | 7.60 ± 0.40 (0.300 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |
| 3640 | 9.10 ± 0.40 (0.358 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |
| 4540 | 11.40 ± 0.40 (0.449 ± 0.016) | 10.20 ± 0.40 (0.402 ± 0.016) | | | | |

## Qualification/Certification

Industrial grade pulse discharge products are subject to internal qualification. Details regarding test methods and conditions are referenced in Table 4, Performance and Reliability.

## Environmental Compliance

Lead (Pb)-free, RoHS, and REACH compliant without exemptions (excluding SnPb termination finish option).

## Electrical Parameters/Characteristics

| Item | Parameters/Characteristics |
|---|---|
| Operating Temperature Range | −55°C to +200°C |
| Capacitance Change with Reference to +25°C and 0 VDC Applied (TCC) | ±30 ppm/°C |
| Aging Rate (Maximum % Capacitance Loss/Decade Hour) | 0% |
| [1]Dielectric Withstanding Voltage (DWV) | See product selection table (product waterfall) for available ratings |
| [2]Dissipation Factor (DF) Maximum Limit @ 25°C | 0.1% |
| [3]Insulation Resistance (IR) Minimum Limit @ 25°C | 1,000 megohm microfarads or 100 GΩ<br>(500 VDC applied for 120 ±5 seconds @ 25°C) |

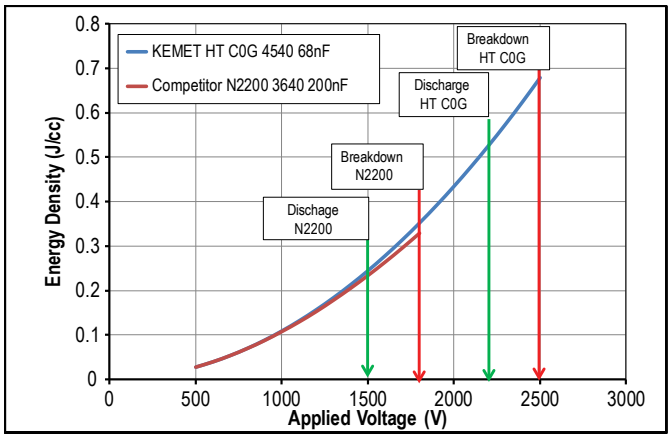
*[1]DWV is the voltage a capacitor can withstand (survive) for a short period of time. It exceeds the nominal and continuous working voltage of the capacitor.*
*[2]Capacitance and dissipation factor (DF) measured under the following conditions:*
*1 MHz ±100 kHz and 1.0 Vrms ±0.2 V if capacitance ≤ 1,000 pF*
*1 kHz ± 50 Hz and 1.0 Vrms ±0.2 V if capacitance > 1,000 pF*
*[3]To obtain IR limit, divide MΩ-µF value by the capacitance and compare to GΩ limit. Select the lower of the two limits.*
*Note: When measuring capacitance it is important to ensure the set voltage level is held constant. The HP4284 and Agilent E4980 have a feature known as Automatic Level Control (ALC). The ALC feature should be switched to "ON."*

## Post Environmental Limits

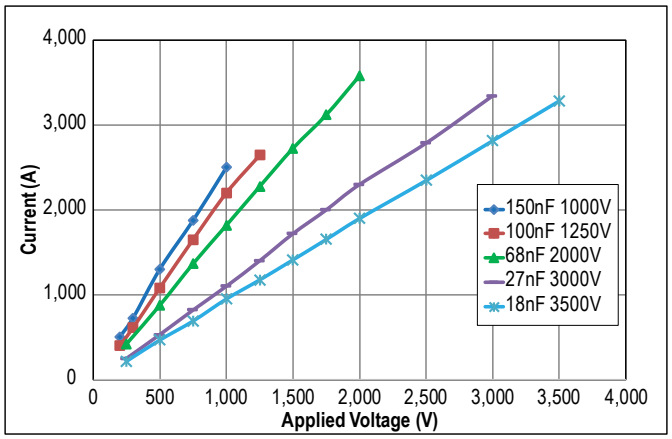
| High Temperature Life, Biased Humidity, Moisture Resistance | | | | | |
|---|---|---|---|---|---|
| Dielectric | Rated DC Voltage | Capacitance Value | Dissipation Factor (Maximum %) | Capacitance Shift | Insulation Resistance |
| C0G | All | All | 0.5 | 0.3% or ±0.25 pF | 10% of Initial Limit |

## Electrical Characteristics

### Energy Density vs. Applied Voltage




### Discharge Current vs. Applied Voltage



# Table 1 – Pulse Discharge Series, Capacitance Range Waterfall

| Capacitance | Cap Code | Case Size/ Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage Code | | | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V |
| | | Dielectric Withstanding Voltage (DWV) | | | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 |
| | | Working Voltage | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Capacitance Tolerance | | | Product Availability and Chip Thickness Codes See Table 2 for Chip Thickness Dimensions | | | | | | | | | | | | | | | | | | | |
| 1,800 pF | 182 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,000 pF | 202 | J | K | M | | | | | | | | | | | | | | | | | | | | |
| 2,200 pF | 222 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 2,700 pF | 272 | J | K | M | TA | TA | TA | TA | TA | | | | | | | | | | | | | | | |
| 3,300 pF | 332 | J | K | M | TA | TA | TA | TA | TA | QB | QB | QB | QB | QB | | | | | | | | | | |
| 3,900 pF | 392 | J | K | M | TA | TA | TA | TA | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | | | | | |
| 4,700 pF | 472 | J | K | M | TA | TA | TA | TB | TB | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 5,600 pF | 562 | J | K | M | TA | TA | TA | TB | TC | QB | QB | QB | QB | QB | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 6,800 pF | 682 | J | K | M | TA | TA | TA | TB | | QB | QB | QB | QB | QC | MA | MA | MA | MA | MA | SA | SA | SA | SA | SA |
| 8,200 pF | 822 | J | K | M | TA | TA | TA | TC | | QB | QB | QB | QC | QC | MA | MA | MA | MA | MB | SA | SA | SA | SA | SA |
| 10,000 pF | 103 | J | K | M | TA | TA | TA | | | QB | QB | QB | QC | QD | MA | MA | MA | MA | MB | SA | SA | SA | SA | SB |
| 12,000 pF | 123 | J | K | M | TA | TA | TA | | | QB | QB | QB | QD | | MA | MA | MA | MB | MB | SA | SA | SA | SA | SB |
| 15,000 pF | 153 | J | K | M | TA | TA | TB | | | QB | QB | QB | QD | | MA | MA | MA | MB | MC | SA | SA | SA | SB | SB |
| 18,000 pF | 183 | J | K | M | TA | TA | TB | | | QB | QB | QB | | | MA | MA | MA | MC | | SA | SA | SA | SB | SC |
| 22,000 pF | 223 | J | K | M | TA | TB | TC | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SB | |
| 27,000 pF | 273 | J | K | M | TA | TB | | | | QB | QB | QC | | | MA | MA | MA | | | SA | SA | SA | SC | |
| 33,000 pF | 333 | J | K | M | TB | TB | | | | QB | QC | QC | | | MA | MA | MB | | | SA | SA | SA | | |
| 39,000 pF | 393 | J | K | M | TB | TC | | | | QB | QC | QD | | | MA | MA | MB | | | SA | SA | SB | | |
| 47,000 pF | 473 | J | K | M | TB | | | | | QB | QC | | | | MA | MB | MC | | | SA | SA | SB | | |
| 56,000 pF | 563 | J | K | M | TC | | | | | QC | QD | | | | MA | MB | | | | SA | SA | SB | | |
| 68,000 pF | 683 | J | K | M | | | | | | QC | QD | | | | MB | MC | | | | SA | SB | SC | | |
| 82,000 pF | 823 | J | K | M | | | | | | QC | | | | | MB | | | | | SA | SB | | | |
| 0.10 µF | 104 | J | K | M | | | | | | QD | | | | | MC | | | | | SB | SC | | | |
| 0.12 µF | 124 | J | K | M | | | | | | | | | | | MC | | | | | SB | | | | |
| 0.15 µF | 154 | J | K | M | | | | | | | | | | | | | | | | SC | | | | |
| Capacitance | Cap Code | Working Voltage | | | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 | 500 | 630 | 1000 | 1500 | 2000 |
| | | Dielectric Withstanding Voltage (DWV) | | | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 | 1000 | 1250 | 2000 | 3000 | 3500 |
| | | Voltage Code | | | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V | D | U | G | H | V |
| | | Case Size/Series | | | C2824H | | | | | C3040H | | | | | C3640H | | | | | C4540H | | | | |

*These products are protected under US Patents 7,172,985 and 7,670,981, other patents pending, and any foreign counterparts.*

## Table 2 – Chip Thickness/Tape & Reel Packaging Quantities

| Thickness Code | Case Size | Thickness ± Range (mm) | Paper Quantity | | Plastic Quantity | |
|---|---|---|---|---|---|---|
| | | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| TA | 2824 | 1.40 ± 0.15 | 0 | 0 | 750 | 2,500 |
| TB | 2824 | 2.00 ± 0.20 | 0 | 0 | 300 | 2,000 |
| TC | 2824 | 2.50 ± 0.20 | 0 | 0 | 300 | 2,000 |
| QB | 3040 | 1.40 ± 0.15 | 0 | 0 | 500 | 1,650 |
| QC | 3040 | 2.00 ± 0.20 | 0 | 0 | 500 | 1,650 |
| QD | 3040 | 2.50 ± 0.20 | 0 | 0 | 350 | 1,400 |
| MA | 3640 | 1.40 ± 0.15 | 0 | 0 | 250 | 1,550 |
| MB | 3640 | 2.00 ± 0.20 | 0 | 0 | 250 | 1,550 |
| MC | 3640 | 2.50 ± 0.20 | 0 | 0 | 250 | 1,550 |
| SA | 4540 | 1.40 ± 0.15 | 0 | 0 | 200 | 1,500 |
| SB | 4540 | 2.00 ± 0.20 | 0 | 0 | 200 | 1,500 |
| SC | 4540 | 2.50 ± 0.20 | 0 | 0 | 200 | 1,500 |
| **Thickness Code** | **Case Size** | **Thickness ± Range (mm)** | **7" Reel** | **13" Reel** | **7" Reel** | **13" Reel** |
| | | | **Paper Quantity** | | **Plastic Quantity** | |

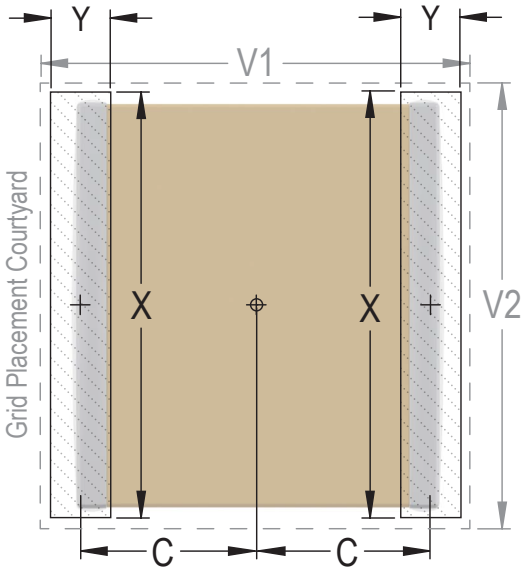
*Package quantity based on finished chip thickness specifications.*

## Table 3 – Chip Capacitor Land Pattern Design Recommendations per IPC–7351

| Size Code (In.) | Metric Size Code | Density Level A: Maximum (Most) Land Protrusion (mm) | | | | | Density Level B: Median (Nominal) Land Protrusion (mm) | | | | | Density Level C: Minimum (Least) Land Protrusion (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 | C | Y | X | V1 | V2 |
| 2824 | 7260 | 3.45 | 1.70 | 6.60 | 9.60 | 7.60 | 3.35 | 1.50 | 6.50 | 8.70 | 7.00 | 3.25 | 1.30 | 6.40 | 8.00 | 6.70 |
| 3040 | 7610 | 3.70 | 1.70 | 10.70 | 10.10 | 11.70 | 3.60 | 1.50 | 10.60 | 9.20 | 11.10 | 3.50 | 1.30 | 10.50 | 8.50 | 10.80 |
| 3640 | 9210 | 4.45 | 1.70 | 10.70 | 11.60 | 11.70 | 4.35 | 1.50 | 10.60 | 10.70 | 11.10 | 4.25 | 1.30 | 10.50 | 10.00 | 10.80 |
| 4540 | - | 5.60 | 1.70 | 10.70 | 13.90 | 11.70 | 5.50 | 1.50 | 10.60 | 13.00 | 11.10 | 5.40 | 1.30 | 10.50 | 12.30 | 10.80 |

***Density Level A:*** *For low-density product applications. Provides a wider process window for reflow solder processes.*
***Density Level B:*** *For products with a moderate level of component density. Provides a robust solder attachment condition for reflow solder processes.*
***Density Level C:*** *For high component density product applications. Before adapting the minimum land pattern variations, the user should perform qualification testing based on the conditions outlined in IPC Standard 7351 (IPC–7351).*

*Image below based on Density Level B for a 3640 case size.*



# Soldering Process

### Recommended Soldering Technique:

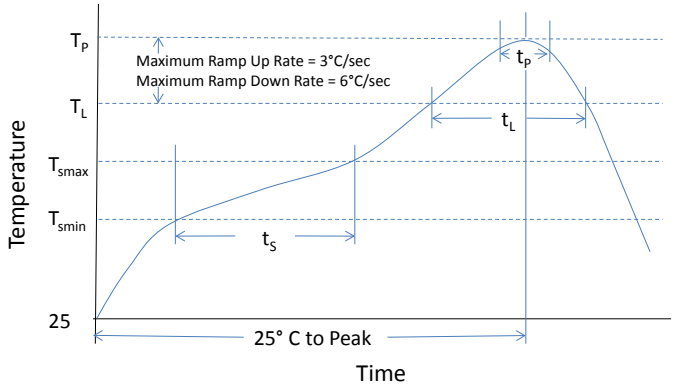
- Solder reflow only

### Recommended Reflow Soldering Profile:

KEMET's families of surface mount multilayer ceramic capacitors (SMD MLCCs) are compatible with wave (single or dual), convection, IR or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020 standard for moisture sensitivity testing. These devices can safely withstand a maximum of three reflow passes at these conditions.

| Profile Feature | Termination Finish | |
|---|---|---|
| | SnPb | 100% Matte Sn |
| **Preheat/Soak** | | |
| Temperature Minimum ($T_{Smin}$) | 100°C | 150°C |
| Temperature Maximum ($T_{Smax}$) | 150°C | 200°C |
| Time ($t_S$) from $T_{Smin}$ to $T_{Smax}$ | 60 – 120 seconds | 60 – 120 seconds |
| Ramp-Up Rate ($T_L$ to $T_P$) | 3°C/second maximum | 3°C/second maximum |
| Liquidous Temperature ($T_L$) | 183°C | 217°C |
| Time Above Liquidous ($t_L$) | 60 – 150 seconds | 60 – 150 seconds |
| Peak Temperature ($T_P$) | 235°C | 260°C |
| Time Within 5°C of Maximum Peak Temperature ($t_P$) | 20 seconds maximum | 30 seconds maximum |
| Ramp-Down Rate ($T_P$ to $T_L$) | 6°C/second maximum | 6°C/second maximum |
| Time 25°C to Peak Temperature | 6 minutes maximum | 8 minutes maximum |

*Note 1: All temperatures refer to the center of the package, measured on the capacitor body surface that is facing up during assembly reflow.*



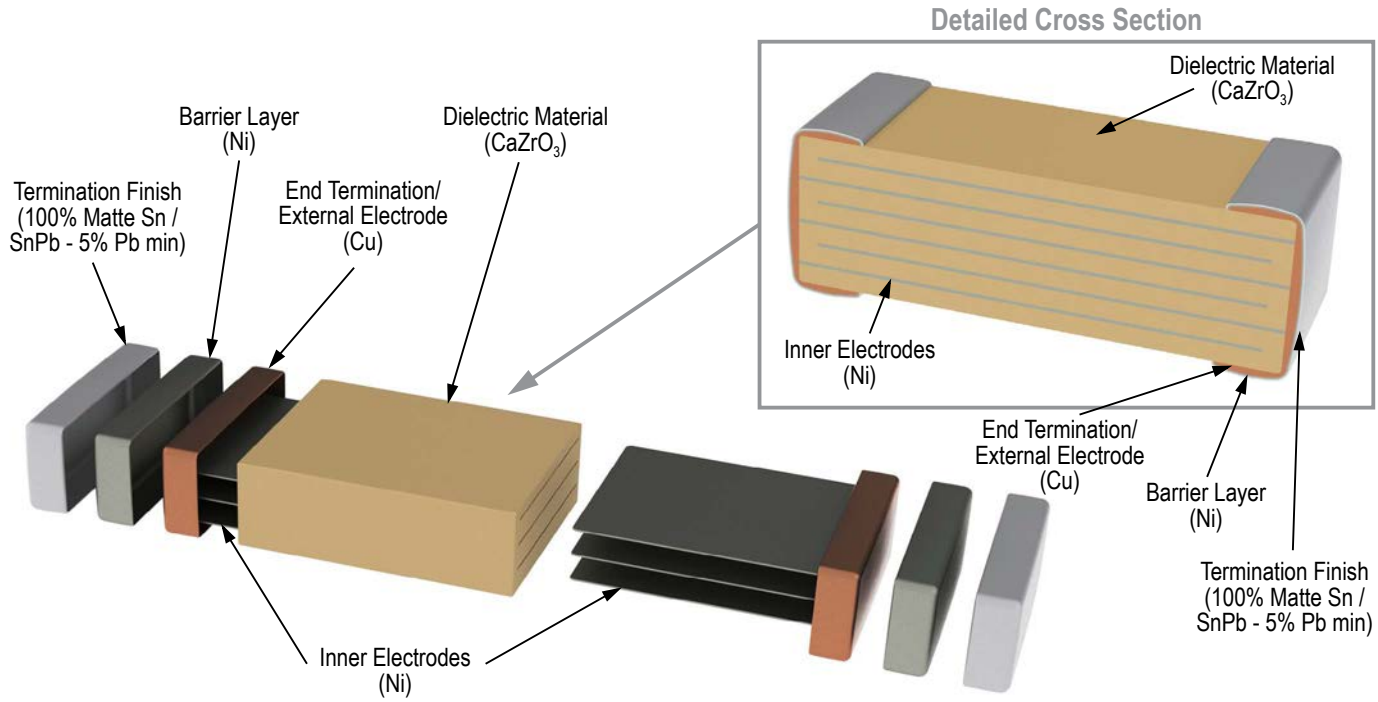
## Table 4 – Performance & Reliability: Test Methods and Conditions

| Product Qualification Test Plan | |
|---|---|
| Reliability/Environmental Tests per MIL–STD–202//JESD22 | |
| Load Humidity | 85°C/85%RH and 200 VDC maximum, 1,000 Hours |
| Low Voltage Humidity | 85°C/85%RH, 1.5V, 1,000 Hours |
| Temperature Cycling | −55°C to +200°C, 50 Cycles |
| Thermal Shock | −55°C to +150°C, 20 seconds transfer, 15 minute dwell, 300 Cycles |
| Moisture Resistance | Cycled Temp/RH 0 V, 10 cycles @ 24 hours each |
| Physical, Mechanical & Process Tests per MIL–STD 202/JIS–C–6429 | |
| Resistance to Solvents | Include Aqueous wash chemical – OKEM Clean or equivalent |
| Mechanical Shock and Vibration | Method 213: Figure 1, Condition F Method 204: 5 gs for 20 minutes, 12 cycles |
| Resistance to Soldering Heat | Condition B, no per-heat of samples, Single Wave Solder |
| Terminal Strength | Force of 1.8 kg for 60 seconds |
| Board Flex | Appendix 2, Note: 3.0 mm (minimum) |

## Storage and Handling

Ceramic chip capacitors should be stored in normal working environments. While the chips themselves are quite robust in other environments, solderability will be degraded by exposure to high temperatures, high humidity, corrosive atmospheres, and long term storage. In addition, packaging materials will be degraded by high temperature– reels may soften or warp and tape peel force may increase. KEMET recommends that maximum storage temperature not exceed 40ºC and maximum storage humidity not exceed 70% relative humidity. Temperature fluctuations should be minimized to avoid condensation on the parts and atmospheres should be free of chlorine and sulfur bearing compounds. For optimized solderability chip stock should be used promptly, preferably within 1.5 years of receipt.

## Construction




## Capacitor Marking (Optional):

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive grade stacked devices.

These capacitors are supplied unmarked only.

## Packaging

Please contact KEMET for details regarding available packaging options.

## Capacitor Marking (Optional):

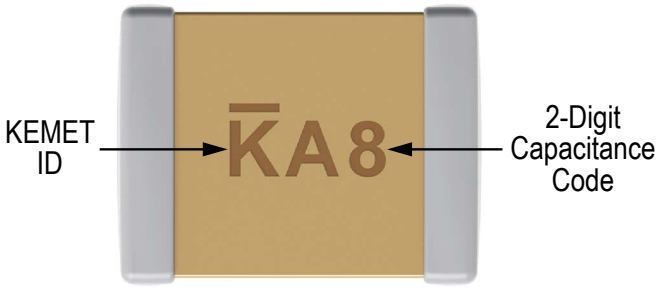
These surface mount multilayer ceramic capacitors are normally supplied unmarked. If required, they can be marked as an extra cost option. Marking is available on most KEMET devices but must be requested using the correct ordering code identifier(s). If this option is requested, two sides of the ceramic body will be laser marked with a "K" to identify KEMET, followed by two characters (per EIA–198 - see table below) to identify the capacitance value. EIA 0603 case size devices are limited to the "K" character only.

Laser marking option is not available on:

- C0G, Ultra Stable X8R and Y5V dielectric devices
- EIA 0402 case size devices
- EIA 0603 case size devices with Flexible Termination option.
- KPS Commercial and Automotive Grade stacked devices.
- X7R dielectric products in capacitance values outlined below

| EIA Case Size | Metric Size Code | Capacitance |
|---|---|---|
| 0603 | 1608 | ≤ 170 pF |
| 0805 | 2012 | ≤ 150 pF |
| 1206 | 3216 | ≤ 910 pF |
| 1210 | 3225 | ≤ 2,000 pF |
| 1808 | 4520 | ≤ 3,900 pF |
| 1812 | 4532 | ≤ 6,700 pF |
| 1825 | 4564 | ≤ 0.018 µF |
| 2220 | 5650 | ≤ 0.027 µF |
| 2225 | 5664 | ≤ 0.033 µF |

Marking appears in legible contrast. Illustrated below is an example of an MLCC with laser marking of "KA8", which designates a KEMET device with rated capacitance of 100 µF. Orientation of marking is vendor optional.

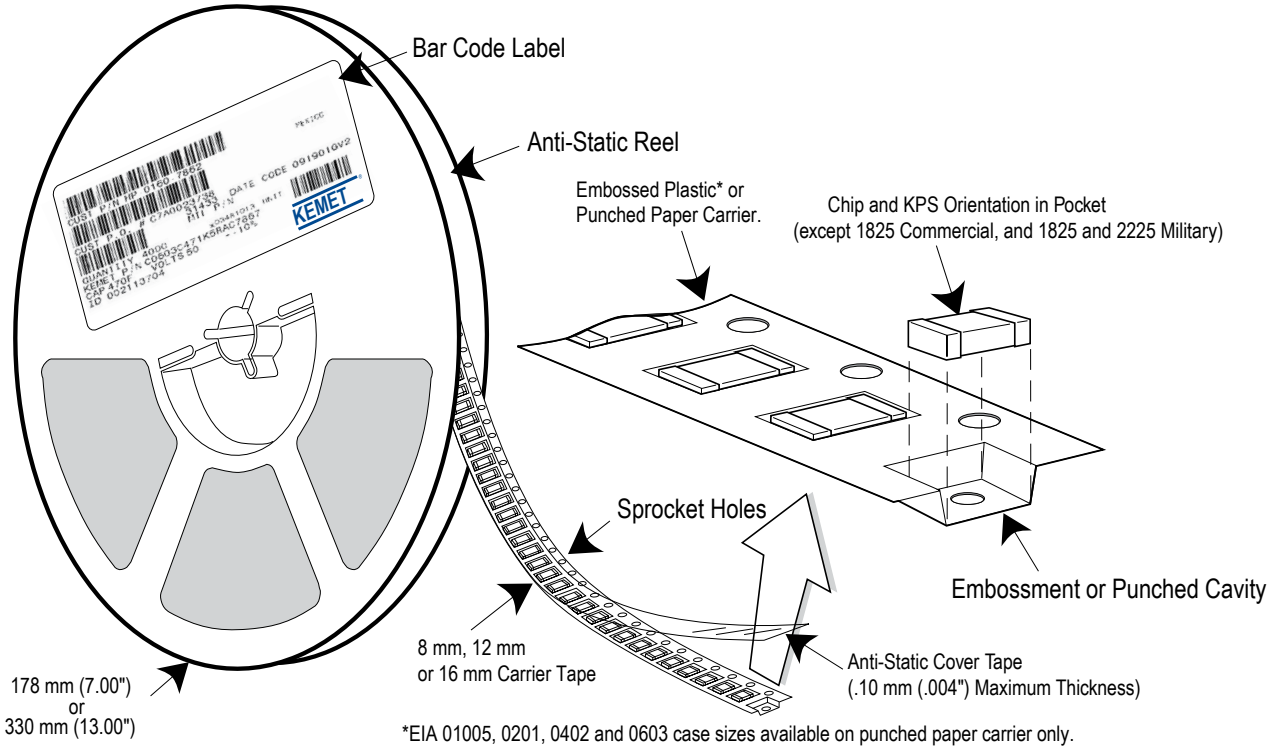


# Capacitor Marking (Optional) cont'd

| Capacitance (pF) For Various Alpha/Numeral Identifiers | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Alpha Character | Numeral | | | | | | | | | |
| | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Capacitance (pF) | | | | | | | | | |
| A | 0.1 | 1 0 | 10 | 100 | 1,000 | 10,000 | 100,000 | 1,000,000 | 10,000,000 | 100,000,000 |
| B | 0.11 | 1.1 | 11 | 110 | 1,100 | 11,000 | 110,000 | 1,100,000 | 11,000,000 | 110,000,000 |
| C | 0.12 | 1 2 | 12 | 120 | 1,200 | 12,000 | 120,000 | 1,200,000 | 12,000,000 | 120,000,000 |
| D | 0.13 | 1 3 | 13 | 130 | 1,300 | 13,000 | 130,000 | 1,300,000 | 13,000,000 | 130,000,000 |
| E | 0.15 | 1 5 | 15 | 150 | 1,500 | 15,000 | 150,000 | 1,500,000 | 15,000,000 | 150,000,000 |
| F | 0.16 | 1 6 | 16 | 160 | 1,600 | 16,000 | 160,000 | 1,600,000 | 16,000,000 | 160,000,000 |
| G | 0.18 | 1 8 | 18 | 180 | 1,800 | 18,000 | 180,000 | 1,800,000 | 18,000,000 | 180,000,000 |
| H | 0.2 | 2 0 | 20 | 200 | 2,000 | 20,000 | 200,000 | 2,000,000 | 20,000,000 | 200,000,000 |
| J | 0.22 | 2 2 | 22 | 220 | 2,200 | 22,000 | 220,000 | 2,200,000 | 22,000,000 | 220,000,000 |
| K | 0.24 | 2.4 | 24 | 240 | 2,400 | 24,000 | 240,000 | 2,400,000 | 24,000,000 | 240,000,000 |
| L | 0.27 | 2.7 | 27 | 270 | 2,700 | 27,000 | 270,000 | 2,700,000 | 27,000,000 | 270,000,000 |
| M | 0.3 | 3 0 | 30 | 300 | 3,000 | 30,000 | 300,000 | 3,000,000 | 30,000,000 | 300,000,000 |
| N | 0.33 | 3 3 | 33 | 330 | 3,300 | 33,000 | 330,000 | 3,300,000 | 33,000,000 | 330,000,000 |
| P | 0.36 | 3 6 | 36 | 360 | 3,600 | 36,000 | 360,000 | 3,600,000 | 36,000,000 | 360,000,000 |
| Q | 0.39 | 3 9 | 39 | 390 | 3,900 | 39,000 | 390,000 | 3,900,000 | 39,000,000 | 390,000,000 |
| R | 0.43 | 4 3 | 43 | 430 | 4,300 | 43,000 | 430,000 | 4,300,000 | 43,000,000 | 430,000,000 |
| S | 0.47 | 4.7 | 47 | 470 | 4,700 | 47,000 | 470,000 | 4,700,000 | 47,000,000 | 470,000,000 |
| T | 0.51 | 5.1 | 51 | 510 | 5,100 | 51,000 | 510,000 | 5,100,000 | 51,000,000 | 510,000,000 |
| U | 0.56 | 5 6 | 56 | 560 | 5,600 | 56,000 | 560,000 | 5,600,000 | 56,000,000 | 560,000,000 |
| V | 0.62 | 6 2 | 62 | 620 | 6,200 | 62,000 | 620,000 | 6,200,000 | 62,000,000 | 620,000,000 |
| W | 0.68 | 6 8 | 68 | 680 | 6,800 | 68,000 | 680,000 | 6,800,000 | 68,000,000 | 680,000,000 |
| X | 0.75 | 7 5 | 75 | 750 | 7,500 | 75,000 | 750,000 | 7,500,000 | 75,000,000 | 750,000,000 |
| Y | 0.82 | 8 2 | 82 | 820 | 8,200 | 82,000 | 820,000 | 8,200,000 | 82,000,000 | 820,000,000 |
| Z | 0.91 | 9.1 | 91 | 910 | 9,100 | 91,000 | 910,000 | 9,100,000 | 91,000,000 | 910,000,000 |
| a | 0.25 | 2 5 | 25 | 250 | 2,500 | 25,000 | 250,000 | 2,500,000 | 25,000,000 | 250,000,000 |
| b | 0.35 | 3 5 | 35 | 350 | 3,500 | 35,000 | 350,000 | 3,500,000 | 35,000,000 | 350,000,000 |
| d | 0.4 | 4 0 | 40 | 400 | 4,000 | 40,000 | 400,000 | 4,000,000 | 40,000,000 | 400,000,000 |
| e | 0.45 | 4 5 | 45 | 450 | 4,500 | 45,000 | 450,000 | 4,500,000 | 45,000,000 | 450,000,000 |
| f | 0.5 | 5 0 | 50 | 500 | 5,000 | 50,000 | 500,000 | 5,000,000 | 50,000,000 | 500,000,000 |
| m | 0.6 | 6 0 | 60 | 600 | 6,000 | 60,000 | 600,000 | 6,000,000 | 60,000,000 | 600,000,000 |
| n | 0.7 | 7 0 | 70 | 700 | 7,000 | 70,000 | 700,000 | 7,000,000 | 70,000,000 | 700,000,000 |
| t | 0.8 | 8 0 | 80 | 800 | 8,000 | 80,000 | 800,000 | 8,000,000 | 80,000,000 | 800,000,000 |
| y | 0.9 | 9 0 | 90 | 900 | 9,000 | 90,000 | 900,000 | 9,000,000 | 90,000,000 | 900,000,000 |

## Tape & Reel Packaging Information – Surface Mount Devices

KEMET offers multilayer ceramic chip capacitors packaged in 8, 12 and 16 mm tape on 7" and 13" reels in accordance with EIA Standard 481. This packaging system is compatible with all tape-fed automatic pick and place systems. See Table 2 for details on reeling quantities for commercial chips.




*EIA 01005, 0201, 0402 and 0603 case sizes available on punched paper carrier only.

## Table 5 – Carrier Tape Configuration, Embossed Plastic & Punched Paper (mm)

| EIA Case Size | Tape Size (W)* | Embossed Plastic | | Punched Paper | |
|---|---|---|---|---|---|
| | | 7" Reel | 13" Reel | 7" Reel | 13" Reel |
| | | Pitch ($P_1$)* | | Pitch ($P_1$)* | |
| 01005 – 0402 | 8 | | | 2 | 2 |
| 0603 | 8 | | | 2/4 | 2/4 |
| 0805 | 8 | 4 | 4 | 4 | 4 |
| 1206 – 1210 | 8 | 4 | 4 | 4 | 4 |
| 1805 – 1808 | 12 | 4 | 4 | | |
| ≥ 1812 | 12 | 8 | 8 | | |
| KPS 1210 | 12 | 8 | 8 | | |
| KPS 1812 & 2220 | 16 | 12 | 12 | | |
| Array 0508 & 0612 | 8 | 4 | 4 | | |

*Refer to Figures 1 & 2 for W and $P_1$ carrier tape reference locations.*
*Refer to Tables 6 & 7 for tolerance specifications.*

**New 2 mm Pitch Reel Options***

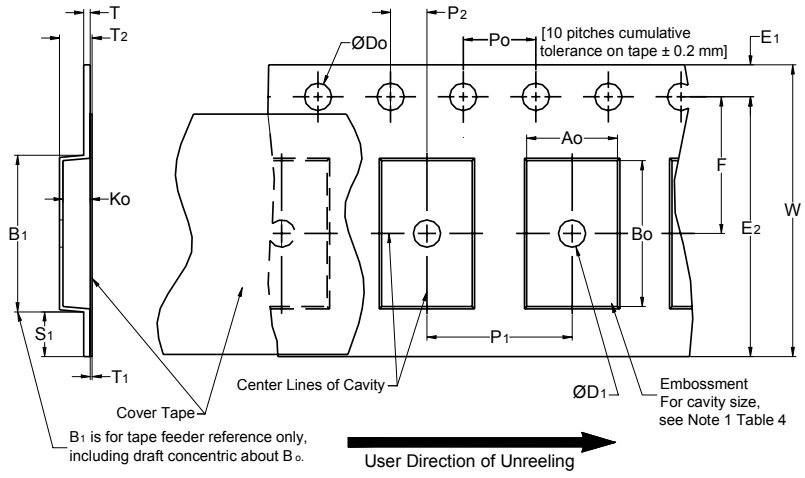
| Packaging Ordering Code (C-Spec) | Packaging Type/Options |
|---|---|
| C-3190 | Automotive grade 7" reel unmarked |
| C-3191 | Automotive grade 13" reel unmarked |
| C-7081 | Commercial grade 7" reel unmarked |
| C-7082 | Commercial grade 13" reel unmarked |

** 2 mm pitch reel only available for 0603 EIA case size.*
*2 mm pitch reel for 0805 EIA case size under development.*

**Benefits of Changing from 4 mm to 2 mm Pitching Spacing**

- Lower placement costs
- Double the parts on each reel results in fewer reel changes and increased efficiency
- Fewer reels result in lower packaging, shipping and storage costs, reducing waste

## Figure 1 – Embossed (Plastic) Carrier Tape Dimensions




## Table 6 – Embossed (Plastic) Carrier Tape Dimensions

Metric will govern

| Constant Dimensions — Millimeters (Inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tape Size | $D_0$ | $D_1$ Minimum Note 1 | $E_1$ | $P_0$ | $P_2$ | R Reference Note 2 | $S_1$ Minimum Note 3 | T Maximum | $T_1$ Maximum |
| 8 mm | 1.5 +0.10/-0.0 (0.059 +0.004/-0.0) | 1.0 (0.039) | 1.75 ±0.10 (0.069 ±0.004) | 4.0 ±0.10 (0.157 ±0.004) | 2.0 ±0.05 (0.079 ±0.002) | 25.0 (0.984) | 0.600 (0.024) | 0.600 (0.024) | 0.100 (0.004) |
| 12 mm | | 1.5 (0.059) | | | | 30 (1.181) | | | |
| 16 mm | | | | | | | | | |

| Variable Dimensions — Millimeters (Inches) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tape Size | Pitch | $B_1$ Maximum Note 4 | $E_2$ Minimum | F | $P_1$ | $T_2$ Maximum | W Maximum | $A_0$,$B_0$ & $K_0$ |
| 8 mm | Single (4 mm) | 4.35 (0.171) | 6.25 (0.246) | 3.5 ±0.05 (0.138 ±0.002) | 4.0 ±0.10 (0.157 ±0.004) | 2.5 (0.098) | 8.3 (0.327) | Note 5 |
| 12 mm | Single (4 mm) & Double (8 mm) | 8.2 (0.323) | 10.25 (0.404) | 5.5 ±0.05 (0.217 ±0.002) | 8.0 ±0.10 (0.315 ±0.004) | 4.6 (0.181) | 12.3 (0.484) | |
| 16 mm | Triple (12 mm) | 12.1 (0.476) | 14.25 (0.561) | 7.5 ±0.05 (0.138 ±0.002) | 12.0 ±0.10 (0.157 ±0.004) | 4.6 (0.181) | 16.3 (0.642) | |

*1. 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.*

*2. The tape with or without components shall pass around R without damage (see Figure 6).*

*3. If $S_1$ < 1.0 mm, there may not be enough area for cover tape to be properly applied (see EIA Standard 481 paragraph 4.3 section b).*

*4. $B_1$ dimension is a reference dimension for tape feeder clearance only.*

*5. The cavity defined by $A_0$, $B_0$ and $K_0$ shall surround the component with sufficient clearance that:*

*(a) the component does not protrude above the top surface of the carrier tape.*

*(b) the component can be removed from the cavity in a vertical direction without mechanical restriction, after the top cover tape has been removed.*

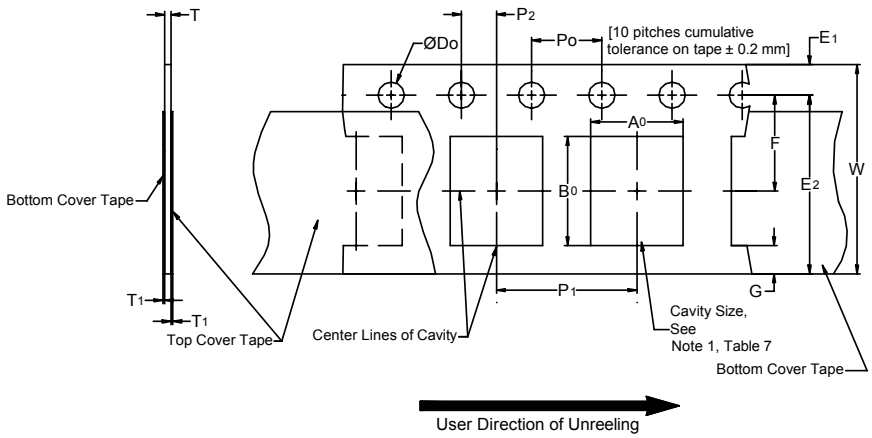
*(c) rotation of the component is limited to 20° maximum for 8 and 12 mm tapes and 10° maximum for 16 mm tapes (see Figure 3).*

*(d) lateral movement of the component is restricted to 0.5 mm maximum for 8 and 12 mm wide tape and to 1.0 mm maximum for 16 mm tape (see Figure 4).*

*(e) for KPS Series product, $A_0$ and $B_0$ are measured on a plane 0.3 mm above the bottom of the pocket.*

*(f) see Addendum in EIA Standard 481 for standards relating to more precise taping requirements.*

## Figure 2 – Punched (Paper) Carrier Tape Dimensions




## Table 7 – Punched (Paper) Carrier Tape Dimensions

Metric will govern

| Constant Dimensions — Millimeters (Inches) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tape Size | $D_0$ | $E_1$ | $P_0$ | $P_2$ | $T_1$ Maximum | G Minimum | R Reference Note 2 |
| 8 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) | 0.10 (0.004) Maximum | 0.75 (0.030) | 25 (0.984) |

| Variable Dimensions — Millimeters (Inches) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tape Size | Pitch | E2 Minimum | F | $P_1$ | T Maximum | W Maximum | $A_0$ $B_0$ |
| 8 mm | Half (2 mm) | 6.25 (0.246) | 3.5 ±0.05 (0.138 ±0.002) | 2.0 ±0.05 (0.079 ±0.002) | 1.1 (0.098) | 8.3 (0.327) | Note 1 |
| 8 mm | Single (4 mm) | | | 4.0 ±0.10 (0.157 ±0.004) | | 8.3 (0.327) | |

*1. The cavity defined by $A_0$, $B_0$ and T shall surround the component with sufficient clearance that:*
*a) the component does not protrude beyond either surface of the carrier tape.*
*b) the component can be removed from the cavity in a vertical direction without mechanical restriction, after the top cover tape has been removed.*
*c) rotation of the component is limited to 20° maximum (see Figure 3).*
*d) lateral movement of the component is restricted to 0.5 mm maximum (see Figure 4).*
*e) see Addendum in EIA Standard 481 for standards relating to more precise taping requirements.*
*2. The tape with or without components shall pass around R without damage (see Figure 6).*

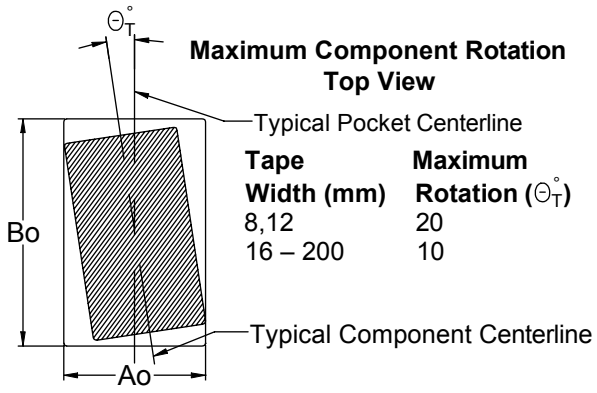
## Packaging Information Performance Notes

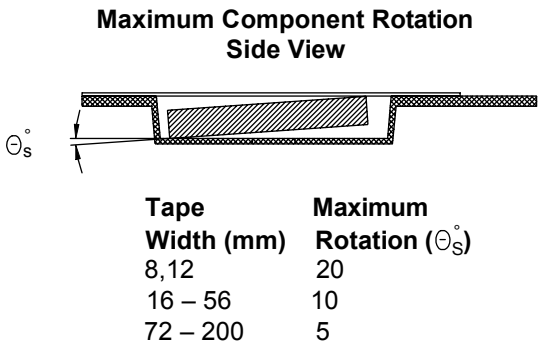
**1. Cover Tape Break Force:** 1.0 Kg minimum.
**2. Cover Tape Peel Strength:** The total peel strength of the cover tape from the carrier tape shall be:

| Tape Width | Peel Strength |
|---|---|
| 8 mm | 0.1 to 1.0 Newton (10 to 100 gf) |
| 12 and 16 mm | 0.1 to 1.3 Newton (10 to 130 gf) |

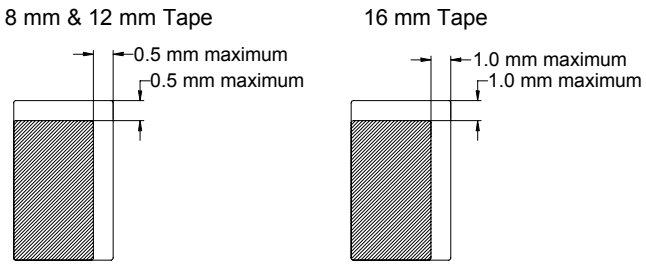
The direction of the pull shall be opposite the direction of the carrier tape travel. The pull angle of the carrier tape shall be 165° to 180° from the plane of the carrier tape. During peeling, the carrier and/or cover tape shall be pulled at a velocity of 300 ±10 mm/minute.
**3. Labeling:** Bar code labeling (standard or custom) shall be on the side of the reel opposite the sprocket holes. *Refer to EIA Standards 556 and 624.*

## Figure 3 – Maximum Component Rotation

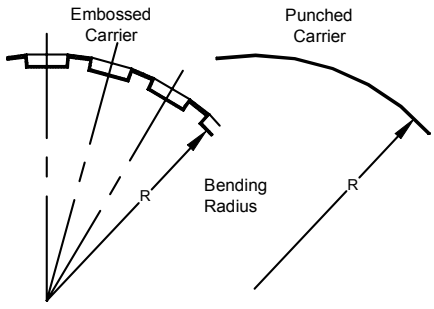


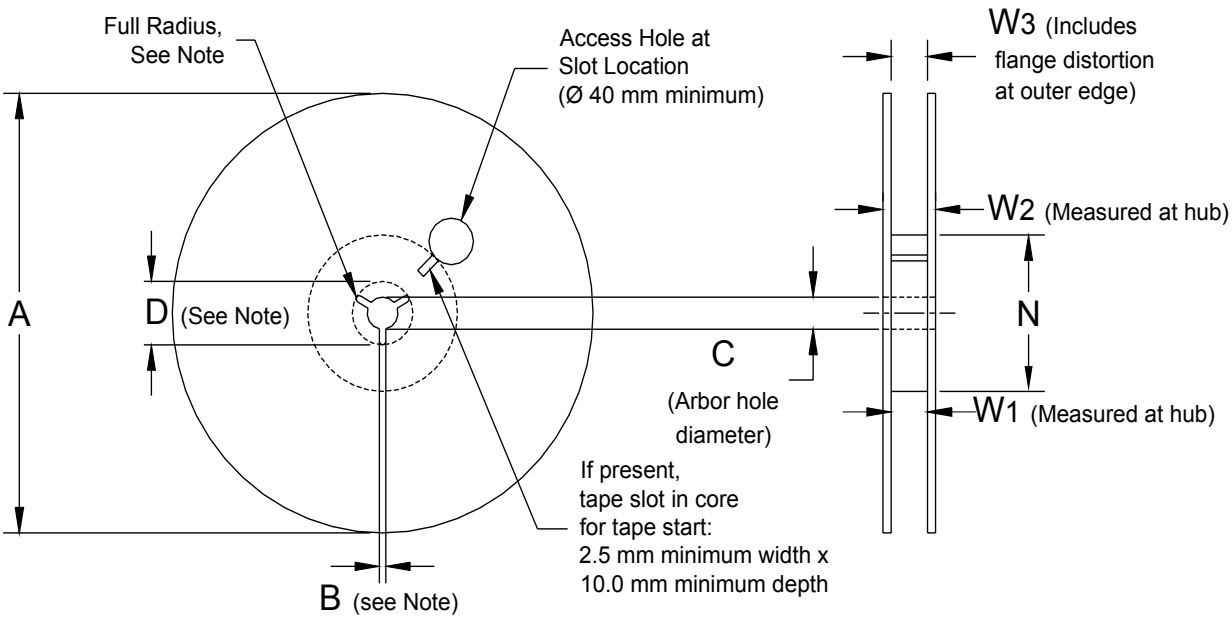

## Figure 4 – Maximum Lateral Movement




## Figure 5 – Bending Radius



## Figure 6 – Reel Dimensions




Note: Drive spokes optional; if used, dimensions B and D shall apply.

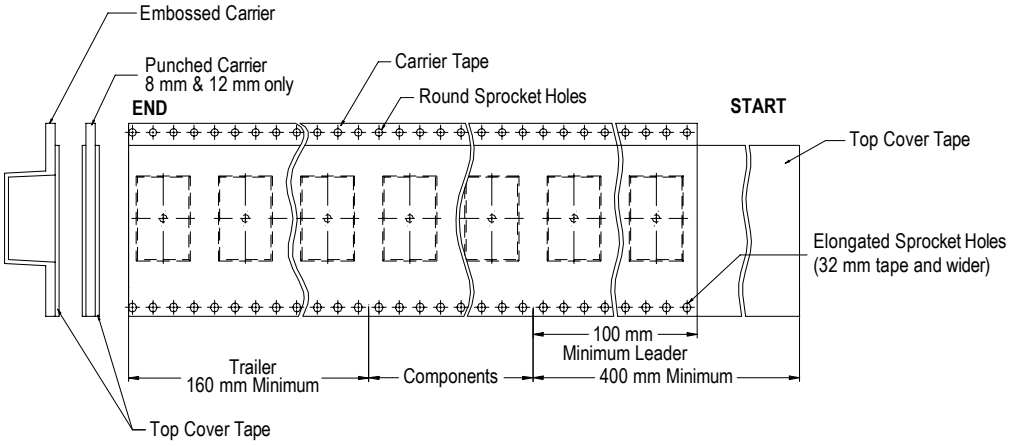
## Table 8 – Reel Dimensions

Metric will govern

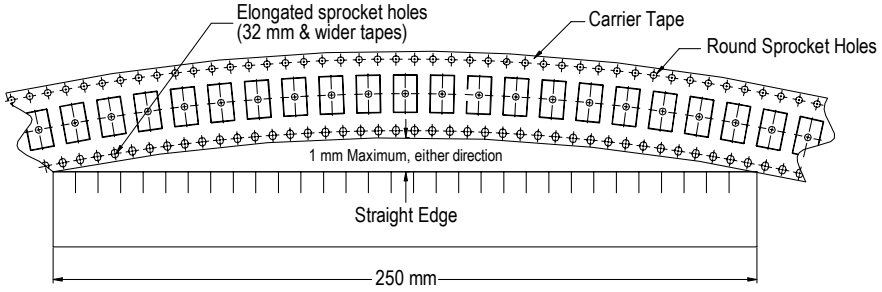
| Constant Dimensions — Millimeters (Inches) | | | | |
|---|---|---|---|---|
| Tape Size | A | B Minimum | C | D Minimum |
| 8 mm | 178 ±0.20 (7.008 ±0.008) or 330 ±0.20 (13.000 ±0.008) | 1.5 (0.059) | 13.0 +0.5/-0.2 (0.521 +0.02/-0.008) | 20.2 (0.795) |
| 12 mm | | | | |
| 16 mm | | | | |

| Variable Dimensions — Millimeters (Inches) | | | | |
|---|---|---|---|---|
| Tape Size | N Minimum | $W_1$ | $W_2$ Maximum | $W_3$ |
| 8 mm | 50 (1.969) | 8.4 +1.5/-0.0 (0.331 +0.059/-0.0) | 14.4 (0.567) | Shall accommodate tape width without interference |
| 12 mm | | 12.4 +2.0/-0.0 (0.488 +0.078/-0.0) | 18.4 (0.724) | |
| 16 mm | | 16.4 +2.0/-0.0 (0.646 +0.078/-0.0) | 22.4 (0.882) | |

## Figure 7 – Tape Leader & Trailer Dimensions

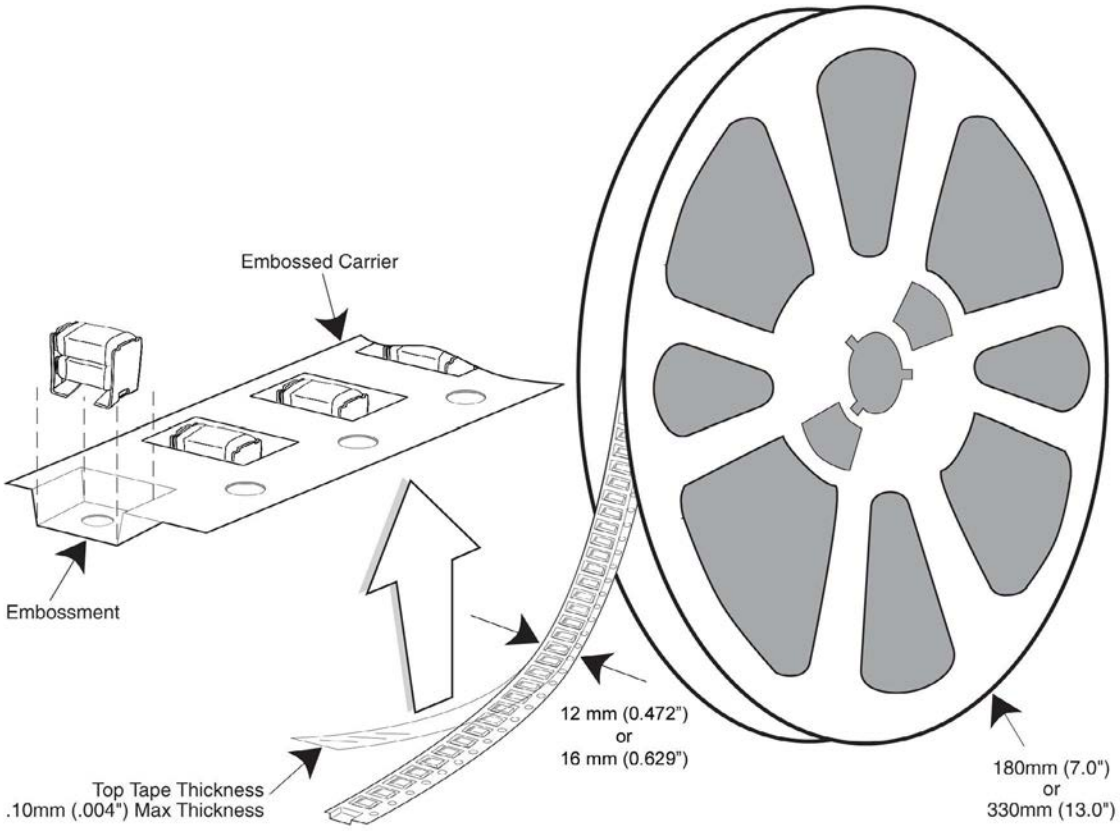



## Figure 8 – Maximum Camber



## Tape & Reel Packaging Information – KPS Devices

KEMET offers multilayer ceramic chip capacitors packaged in 8, 12 and 16 mm tape on 7" and 13" reels in accordance with EIA Standard 481. This packaging system is compatible with all tape-fed automatic pick and place systems. See Table 2 for details on reeling quantities for commercial chips.

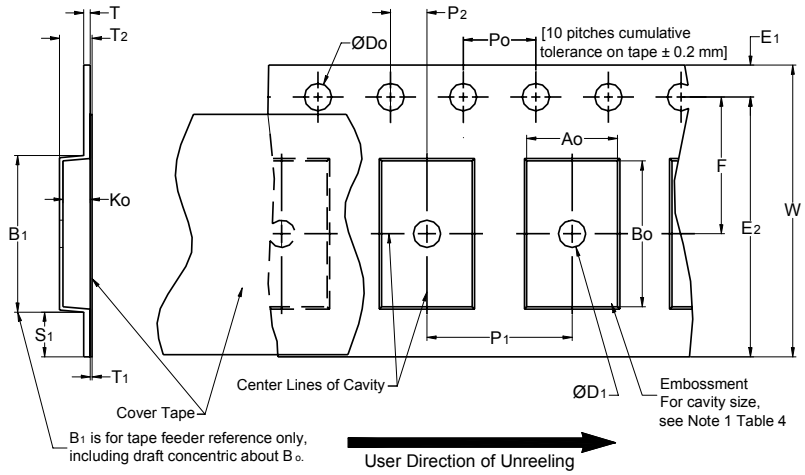



## Table 5 – Carrier Tape Configuration – Embossed Plastic (mm)

| EIA Case Size | Tape Size (W)* | Pitch ($P_1$)* |
|---|---|---|
| 01005 – 0402 | 8 | 2 |
| 0603 – 1210 | 8 | 4 |
| 1805 – 1808 | 12 | 4 |
| ≥ 1812 | 12 | 8 |
| KPS 1210 | 12 | 8 |
| KPS 1812 & 2220 | 16 | 12 |
| Array 0508 & 0612 | 8 | 4 |

**Refer to Figure 1 for W and $P_1$ carrier tape reference locations.*
**Refer to Table 5 for tolerance specifications.*

## Figure 1 – Embossed (Plastic) Carrier Tape Dimensions




## Table 6 – Embossed (Plastic) Carrier Tape Dimensions

Metric will govern

| Constant Dimensions — Millimeters (Inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tape Size | $D_0$ | $D_1$ Minimum Note 1 | $E_1$ | $P_0$ | $P_2$ | R Reference Note 2 | $S_1$ Minimum Note 3 | T Maximum | $T_1$ Maximum |
| 8 mm | 1.5 +0.10/-0.0 (0.059 +0.004/-0.0) | 1.0 (0.039) | 1.75 ±0.10 (0.069 ±0.004) | 4.0 ±0.10 (0.157 ±0.004) | 2.0 ±0.05 (0.079 ±0.002) | 25.0 (0.984) | 0.600 (0.024) | 0.600 (0.024) | 0.100 (0.004) |
| 12 mm | | 1.5 (0.059) | | | | 30 (1.181) | | | |
| 16 mm | | | | | | | | | |

| Variable Dimensions — Millimeters (Inches) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tape Size | Pitch | $B_1$ Maximum Note 4 | $E_2$ Minimum | F | $P_1$ | $T_2$ Maximum | W Maximum | $A_0$,$B_0$ & $K_0$ |
| 8 mm | Single (4 mm) | 4.35 (0.171) | 6.25 (0.246) | 3.5 ±0.05 (0.138 ±0.002) | 4.0 ±0.10 (0.157 ±0.004) | 2.5 (0.098) | 8.3 (0.327) | Note 5 |
| 12 mm | Single (4 mm) & Double (8 mm) | 8.2 (0.323) | 10.25 (0.404) | 5.5 ±0.05 (0.217 ±0.002) | 8.0 ±0.10 (0.315 ±0.004) | 4.6 (0.181) | 12.3 (0.484) | |
| 16 mm | Triple (12 mm) | 12.1 (0.476) | 14.25 (0.561) | 7.5 ± 0.05 (0.138 ± 0.002) | 12.0 ± 0.10 (0.157 ± 0.004) | 4.6 (0.181) | 16.3 (0.642) | |

*1. 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.*

*2. The tape with or without components shall pass around R without damage (see Figure 5).*

*3. If $S_1$ < 1.0 mm, there may not be enough area for cover tape to be properly applied (see EIA Standard 481 paragraph 4.3 section b).*

*4. $B_1$ dimension is a reference dimension for tape feeder clearance only.*

*5. The cavity defined by $A_0$, $B_0$ and $K_0$ shall surround the component with sufficient clearance that:*

*(a) the component does not protrude above the top surface of the carrier tape.*

*(b) the component can be removed from the cavity in a vertical direction without mechanical restriction, after the top cover tape has been removed.*

*(c) rotation of the component is limited to 20° maximum for 8 and 12 mm tapes and 10° maximum for 16 mm tapes (see Figure 2).*

*(d) lateral movement of the component is restricted to 0.5 mm maximum for 8 and 12 mm wide tape and to 1.0 mm maximum for 16 mm tape (see Figure 3).*

*(e) for KPS Series product, $A_0$ and $B_0$ are measured on a plane 0.3 mm above the bottom of the pocket.*

*(f) see Addendum in EIA Standard 481 for standards relating to more precise taping requirements.*

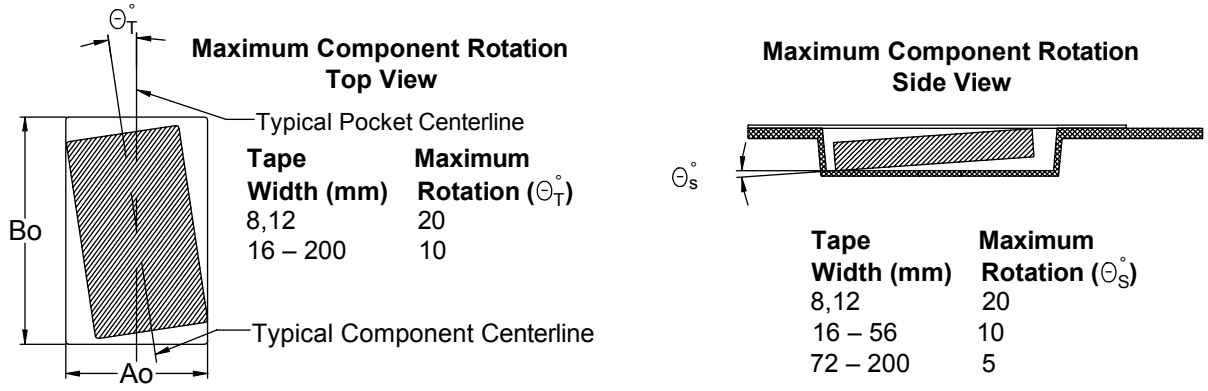
## Packaging Information Performance Notes

**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:

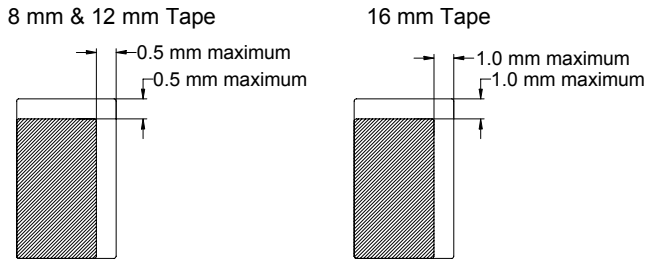
| Tape Width | Peel Strength |
|---|---|
| 8 mm | 0.1 to 1.0 Newton (10 to 100 gf) |
| 12 and 16 mm | 0.1 to 1.3 Newton (10 to 130 gf) |

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. Labeling:** Bar code labeling (standard or custom) shall be on the side of the reel opposite the sprocket holes. *Refer to EIA Standards 556 and 624.*

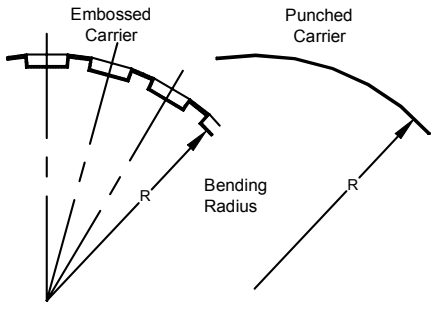
## Figure 2 – Maximum Component Rotation



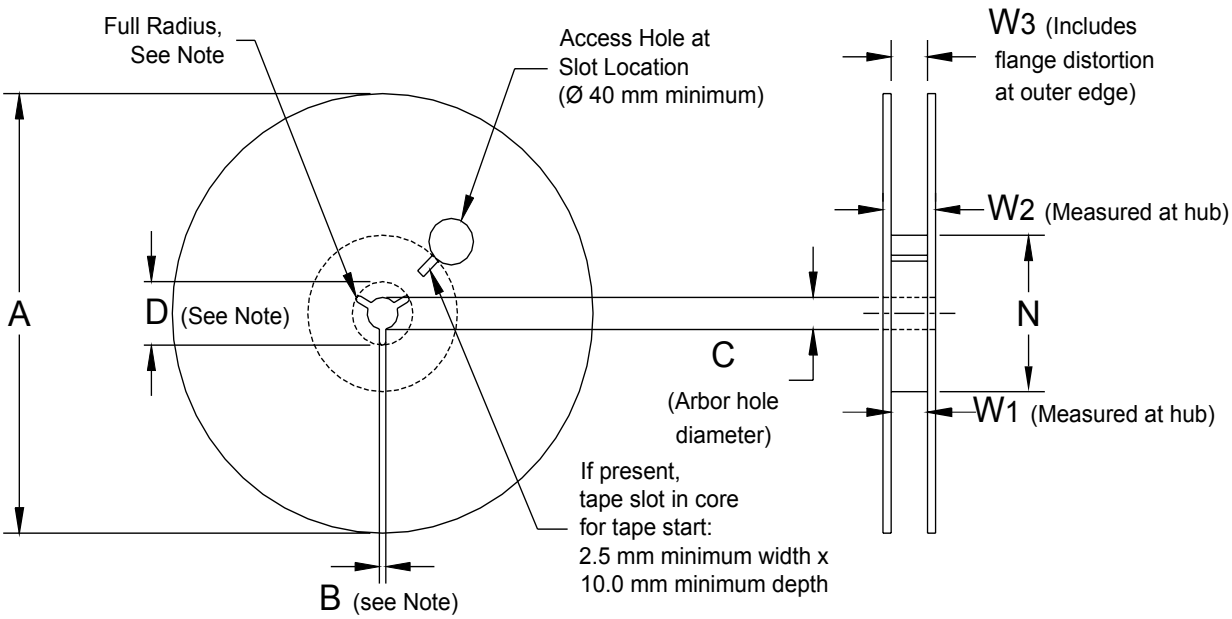

## Figure 3 – Maximum Lateral Movement




## Figure 4 – Bending Radius



## Figure 5 – Reel Dimensions




Note: Drive spokes optional; if used, dimensions B and D shall apply.

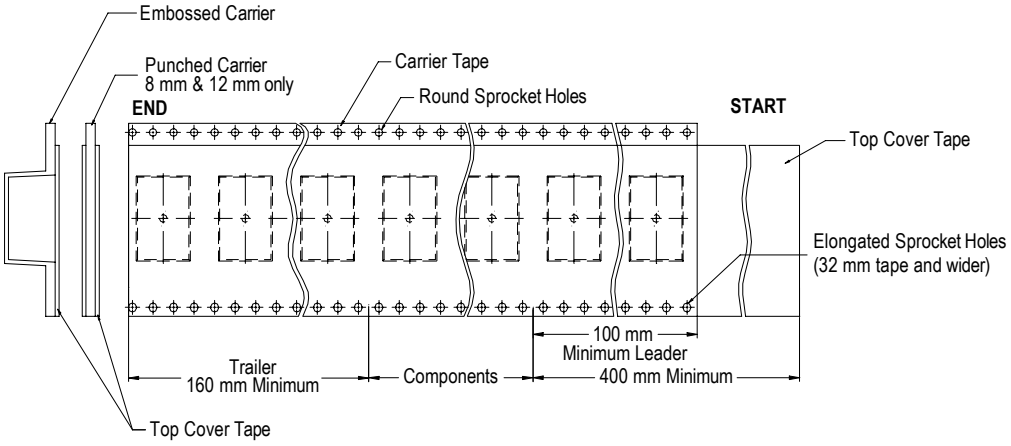
## Table 7 – Reel Dimensions

Metric will govern

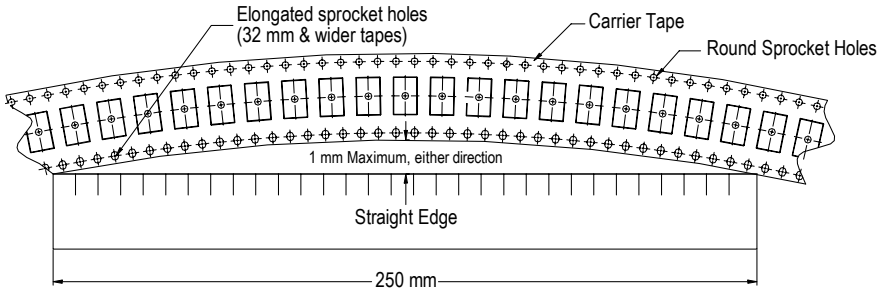
| Constant Dimensions — Millimeters (Inches) | | | | |
|---|---|---|---|---|
| Tape Size | A | B Minimum | C | D Minimum |
| 8 mm | 178 ±0.20 (7.008 ±0.008) or 330 ±0.20 (13.000 ±0.008) | 1.5 (0.059) | 13.0 +0.5/-0.2 (0.521 +0.02/-0.008) | 20.2 (0.795) |
| 12 mm | | | | |
| 16 mm | | | | |

| Variable Dimensions — Millimeters (Inches) | | | | |
|---|---|---|---|---|
| Tape Size | N Minimum | $W_1$ | $W_2$ Maximum | $W_3$ |
| 8 mm | 50 (1.969) | 8.4 +1.5/-0.0 (0.331 +0.059/-0.0) | 14.4 (0.567) | Shall accommodate tape width without interference |
| 12 mm | | 12.4 +2.0/-0.0 (0.488 +0.078/-0.0) | 18.4 (0.724) | |
| 16 mm | | 16.4 +2.0/-0.0 (0.646 +0.078/-0.0) | 22.4 (0.882) | |

## Figure 6 – Tape Leader & Trailer Dimensions




## Figure 7 – Maximum Camber



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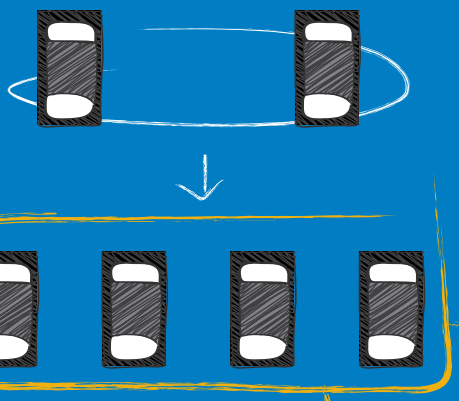
# BENEFITS OF CHANGING FROM 4 MM TO 2 MM PITCH SPACING ON CERAMIC REELS



Double the parts on each reel = Fewer reel changes

**1. Lower placement cost**

**2. Lower storage cost**

Fewer Reels Needed

Reduce cost

**3. Environmentally friendly**

Less packaging material

Reduce waste

For 0603s

**4. Shipping available worldwide**

More parts in the same space = lower shipping costs

Increase efficiency

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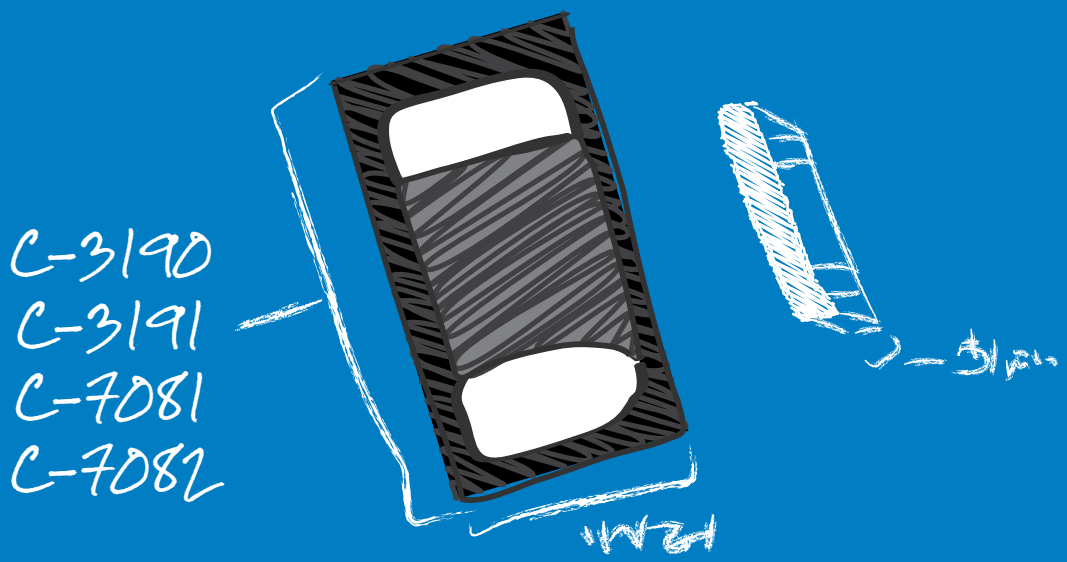
# PART TYPE DESCRIPTION




C-3190 = Automotive grade 7" reel unmarked
C-3191 = Automotive grade 13" reel unmarked
C-7081 = Commercial grade 7" reel unmarked
C-7082 = Commercial grade 13" reel unmarked

Coming soon: 0805 EIA case size under development

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