

## Axial and Radial Leaded Multilayer Ceramic Capacitors for General Purpose

Class 1 and Class 2, 50 V<sub>DC</sub>, 100 V<sub>DC</sub>, 200 V<sub>DC</sub>, 500 V<sub>DC</sub>

### CONSTRUCTION AND ORDERING INFORMATION

#### INTERNAL CONSTRUCTION

Multilayer ceramic capacitors consist of electrodes, the RoHS interleaved ceramic dielectric and the external terminal connectors. The capacitance is given by the description:

$$C = \frac{A * n * \epsilon_0 * \epsilon_r}{d}$$

A = electrode area

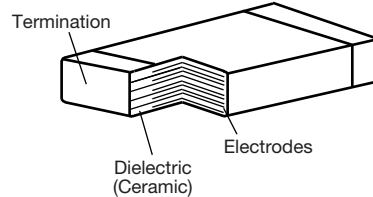
n = number of active layers

d = distance between electrodes

$\epsilon_r$  = dielectric relative

$\epsilon_0$  = dielectric constant

Whilst the values “A \* n” and “d” are respectively determined by the production process, the dielectric constant is a function of the ceramic material used.

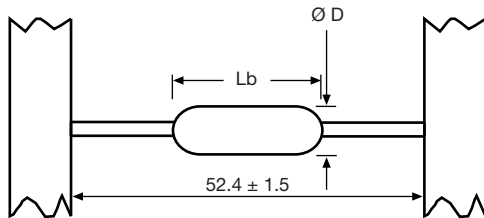


#### LEAD CONFIGURATION

##### Axial Size 15 and 20

Lead wire base material: FeCu

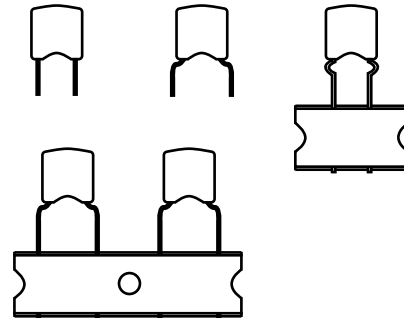
Plating: electrolytic, tinned



##### Radial Size 10, 15 and 20

Lead wire base material: FeCu

Plating: matte electrolytic, tinned



### ORDERING CODE INFORMATION

Product Type	Capacitance (pF)	Capacitance Tolerance	Size Code	TC Code	Rated Voltage	Lead Diameter	Packaging/Lead Length	Lead Style	Lead Spacing
K = radial leaded MLCC	The first two digits are the significant figures of capacitance and the last digit is a multiplier as follows: 0 = * 1 1 = * 10 2 = * 100 3 = * 1000 4 = * 10 000 5 = * 100 000	J = ± 5 % K = ± 10 % M = ± 20 %	Please refer to relevant datasheet	Please refer to relevant datasheet	F = 50 V H = 100 V K = 200 V L = 500 V	5 = 0.50 mm ± 0.05 mm	3 = bulk T = tape and reel U = ammo	Please refer to relevant datasheet	2 = 2.5 mm 5 = 5.0 mm
A = axial leaded MLCC	For example: 104 = 100 000 pF						TAA = reel UAA = ammo		

**ELECTRICAL DATA AND DIELECTRIC CHARACTERISTICS**

<b>DIELECTRIC CHARACTERISTICS</b>		
Dielectric according to EIA	C0G (NP0)	X7R
According to CECC	CG	C1 (2C1)
<b>Capacitance Range:</b> at 1 MHz, 1 V at 1 kHz, 1 V	10 pF to 1 nF	-
	1.2 nF to 10 nF	100 pF to 1 $\mu$ F
<b>Tolerance on the Capacitance:</b> where $C \geq 10$ pF	$\pm 5\%$ (J); $\pm 10\%$ (K)	$\pm 10\%$ (K); $\pm 20\%$ (M)
<b>Rated DC Voltage</b>	50 V; 100 V, 200 V; 500 V	
<b>Dielectric Strength</b>	When rated voltage is 50 V and 100 V, 250 % of rated voltage	
	When rated voltage is 200 V, 150 % rated voltage + 100 V <sub>DC</sub>	
	When rated voltage is 500 V, 130 % rated voltage + 100 V <sub>DC</sub>	
<b>Insulation Resistance (IR)</b>	When rated voltage is 50 V and 100 V, 100 G $\Omega$ or 1000 $\Omega$ F whichever is less at rated voltage within 2 min of charging	
	When rated voltage is 200 V and 500 V, 10 G $\Omega$ or 100 $\Omega$ F whichever is less at rated voltage within 2 min of charging	
<b>Temperature Coefficient of the Capacitance</b>	0 ppm/K	Refer to diagram
<b>Tolerance of the Temperature Coefficient</b>	$\pm 30$ ppm/K	Refer to diagram
<b>Maximum Capacitance Change with Respect to Capacitance at 25 °C</b>	Refer to diagram	$\pm 15\%$
<b>Dissipation Factor (DF)</b>	0.1 % max. when $C \geq 30$ pF at 1 MHz, 1 V; where $C \leq 1000$ pF at 1 kHz, 1 V; where $C > 1000$ pF For $C < 30$ pF: DF = 100/(400 + 20 * C) DF = dissipation factor in % C = capacitance value in pF	$\leq 2.5\%$ at 1 kHz, 1 V
<b>Operating Temperature Range</b>	-55 °C to +125 °C	
<b>Storage Temperature Range</b>	25 °C $\pm$ 15 °C	
<b>Aging</b>	None	Typical 1 % per time decade

**Note**

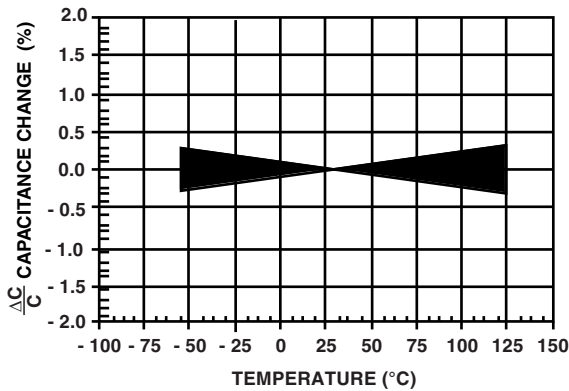
- The capacitors meet the essential requirements of "EIA 198".  
Unless stated otherwise all electrical values apply at an ambient temperature of 25 °C  $\pm$  3 °C, at barometric pressures 650 mm to 800 mm of mercury, and relative humidity not to exceed 75 %.

<b>MAIN FEATURES</b>		
	<b>CLASS 1</b>	<b>CLASS 2</b>
<b>APPLICATION</b>	For temperature compensation of frequency discriminating circuits and filters, coupling and decoupling in high frequency circuits where low losses and narrow capacitance tolerances are demanded.	As coupling and decoupling capacitors for such application where higher losses and a reduced capacitance stability are tolerated.
<b>PROPERTIES</b> Temperature Dependence Capacitance	High stability of capacitance. Low dissipation factor up to higher frequencies. Defined temperature coefficient of capacitance, positive or negative, linear and reversible. High insulation resistance. No voltage dependence. High long-term stability of electrical values.	High capacitance values with small dimensions. Non-linear dependence of capacitance on temperature.
<b>CLASSIFICATION</b>		
Classification EIA:	C0G (NP0)	X7R
Classification CECC:	CG	2C1

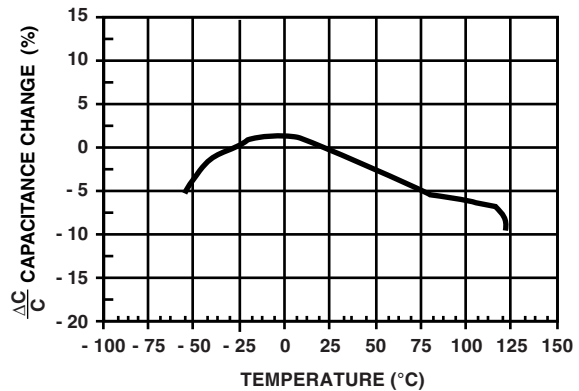


TEMPERATURE CHARACTERISTICS OF CAPACITANCE FOR CLASS 2/3 CERAMIC DIELECTRICS ACCORDING TO CECC 32100			
CODE LETTER FOR SUB CATEGORY	MAXIMUM CAPACITANCE CHANGE IN % AT THE SPECIFIED TEMPERATURE RANGE	DESIGNATION OF THE SPECIFIED TEMPERATURE RANGE	
		-55 °C/+125 °C	-30 °C/+85 °C
		1	4
2C	± 20 %	X	-
2F	+30 %/-80 %	-	X

**TEMPERATURE COEFFICIENT OF CAPACITANCE (Typical)**



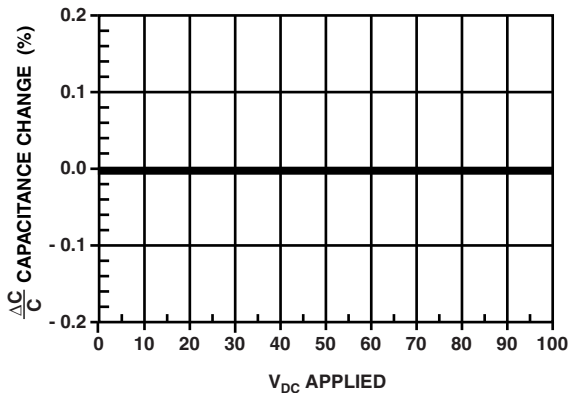
COG (NP0)/(CG)



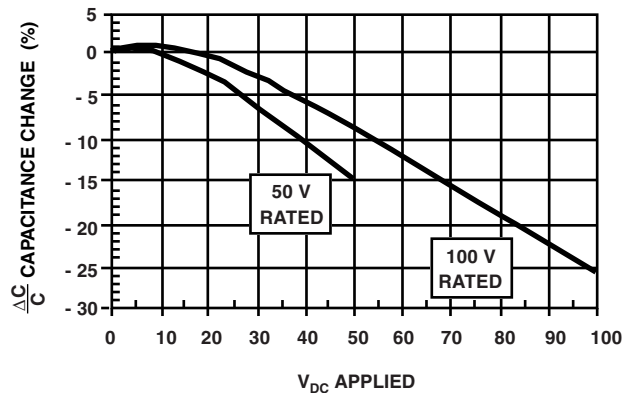
X7R/(2C1)

**VOLTAGE COEFFICIENT OF CAPACITANCE (Typical)**

When rated voltage is 50 V and 100 V



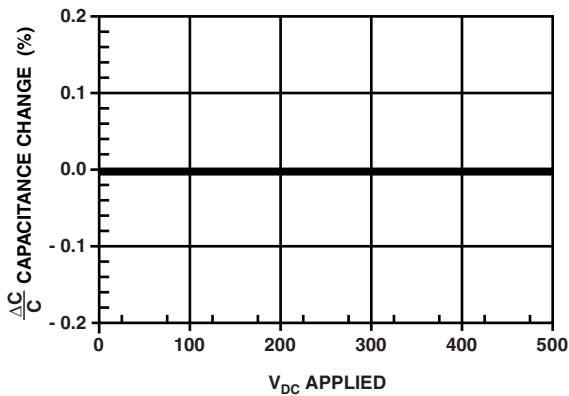
COG (NP0)/(CG)



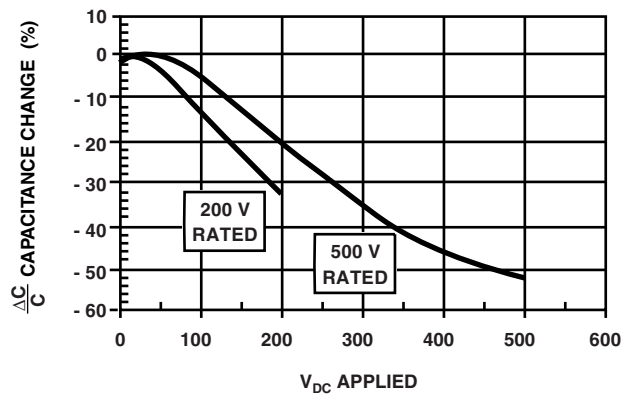
X7R/(2C1)



When rated voltage is 200 V and 500 V

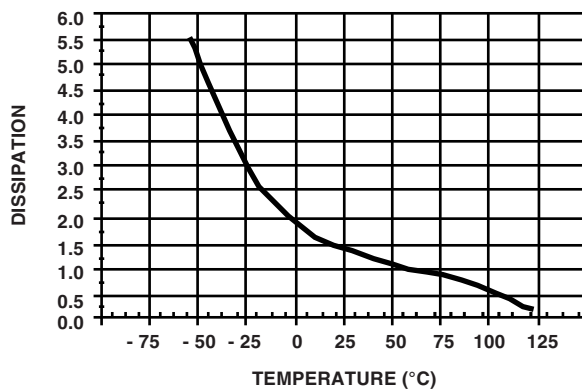


C0G (NP0)/(CG)



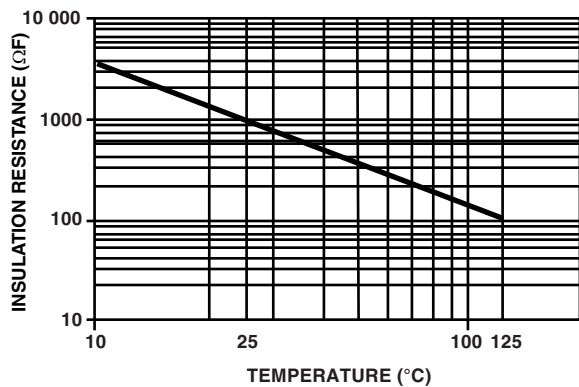
X7R/(2C1)

### DISSIPATION FACTOR VS. TEMPERATURE (Typical)

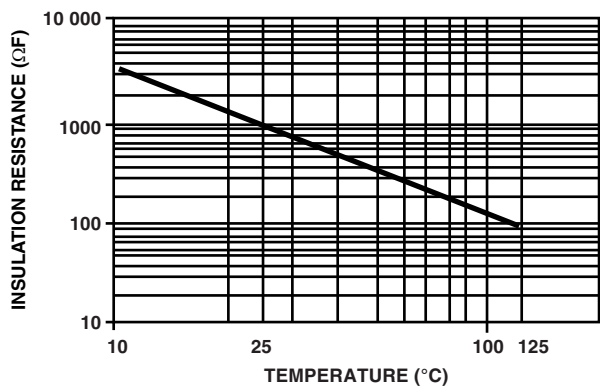


X7R/(2C1)

### MINIMUM INSULATION RESISTANCE VS. TEMPERATURE (Typical)



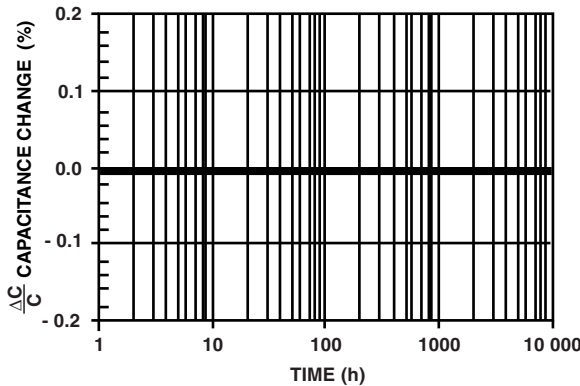
C0G (NP0)/(CG)



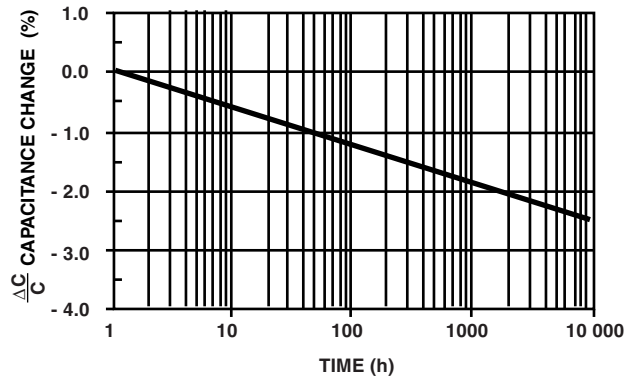
X7R/(2C1)



AGING RATE (Typical)



COG (NP0)/(CG)



X7R/(2C1)

OTHER INFORMATION

STORAGE

The capacitors must not be stored in a corrosive atmosphere where sulfide or chloride gas, acid, alkali, or salt are present. Moisture exposure should also be avoided.

The solderability of the leads is not affected by storage of up to 24 months. Temperature +10 °C to +35 °C, relative humidity up to 60 %.

With reference to class 2 ceramic dielectric capacitors, see section Capacitance “Aging” of Ceramic Capacitors this page.

SOLDERING

SOLDERING SPECIFICATIONS		
Soldering test for capacitors with wire leads: (according to IEC 60068-2-20, solder bath method)		
	SOLDERABILITY	RESISTANCE TO SOLDERING HEAT
Soldering temperature	235 °C ± 5 °C	260 °C ± 5 °C
Soldering duration	2 s ± 0.5 s	10 s ± 1 s
Distance from component body	≥ 2 mm	≥ 5 mm

SOLDERING RECOMMENDATIONS

Soldering of the component should be achieved using a Sn96.5/Ag3.0/Cu0.5, a Sn60/40 type or a silver-bearing type solder. As ceramic capacitors are very sensitive to rapid changes in temperature (thermal shock), the solder heat resistance specification (see above Soldering Specifications table) should not be exceeded. Subjecting the capacitor to excessive heat may result in thermal shocks that can crack the ceramic body and melt the internal solder junction.

CLEANING

The components should be cleaned with vapor degreasers immediately following the soldering operation.

SOLVENT RESISTANCE

The coating and marking of the capacitors are resistant to the following test method: IEC 60068-2-45 (Method XA). The epoxy material is approved according to UL 94 V-0.

MOUNTING

We do not recommend modifying the lead terminals, e.g. bending or cropping as this action could break the coating or crack the ceramic insert. However, if the lead must be modified in such a way, we recommend supporting the lead with a clamping fixture next to the coating.

## CAPACITANCE “AGING” OF CERAMIC CAPACITORS

Following the final heat treatment, all class 2 ceramic capacitors reduce their capacitance value. According to logarithmic law, this is due to their special crystalline construction. This change is called “aging”. If the capacitors are heat treated (for example when soldering), the capacitance increases again to a higher value deaging, and the aging process begins again.

$$K = \frac{100 * (C_{11} - C_{12})}{C_{11} * \log_{10}(t_2/t_1)}$$

$t_1, t_2$  = measuring time point (h)

$C_{11}, C_{12}$  = capacitance values for the times  $t_1, t_2$

$K$  = aging constant (%)

$$C_{12} = C_{11} * [1 - K/100 * \log_{10}(t_2/t_1)]$$

## REFERENCE MEASUREMENT

Due to aging, it is necessary to quote an age for reference measurements which can be related to the capacitance with fixed tolerance. According to EN 130700, this time period is 1000 h.

If the shelf-life of the capacitor is known, the capacitance for  $t = 1000$  h can be calculated with the aging constant.

In order to avoid the influence of aging, it is important to deage the capacitors before stress-testing. The following procedure is adopted (see also EN 130700):

- Deaging at 125 °C
- One hour storage for 24 h at normal climate temperature
- Initial measurement
- Stress
- Deaging at 125 °C, 1 h
- Storage for 24 h at normal climate temperature
- Final measurement

## CAUTION

### 1. OPERATING VOLTAGE AND FREQUENCY CHARACTERISTIC

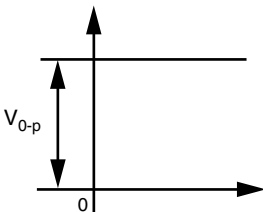
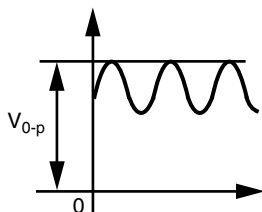
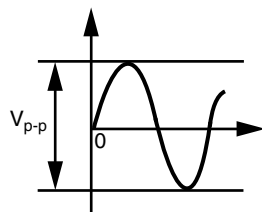
When sinusoidal or ripple voltage applied to DC ceramic disc capacitors, be sure to maintain the peak-to-peak value or the peak value of the sum of both AC and DC within the rated voltage.

When start or stop applying the voltage, resonance may generate irregular voltage.

When rectangular or pulse wave voltage is applied to DC ceramic disc capacitors, the self-heating generated by the capacitor is higher than the sinusoidal application with the same frequency. The allowable voltage rating for the rectangular or pulse wave corresponds approximately with the allowable voltage of a sinusoidal wave with the double fundamental frequency.

The allowable voltage varies, depending on the voltage and the waveform.

Diagrams of the limiting values are available for each capacitor series on request.

VOLTAGE	DC	DC AND AC	AC
WAVEFORM FIGURE			

### 2. OPERATING TEMPERATURE AND SELF-GENERATED HEAT

The surface temperature of the capacitors must not exceed the upper limit of its rated operating temperature.

During operation in a high-frequency circuit or a pulse signal circuit, the capacitor itself generates heat due to dielectric losses. Applied voltage should be the load such as self-generated heat is within 20 °C on the condition of environmental temperature 25 °C.

Note, that excessive heat may lead to deterioration of the capacitor’s characteristics.