GENERAL INFORMATION

A capacitor is a component which is capable of storing electrical energy. It consists of two conductive plates (electrodes) separated by insulating material which is called the dielectric. A typical formula for determining capacitance is:

$$C = \frac{.224\ KA}{t}$$

C = capacitance (picofarads)
K = dielectric constant (Vacuum = 1)
A = area in square inches
t = separation between the plates in inches (thickness of dielectric)
.224 = conversion constant (.0884 for metric system in cm)

Capacitance – The standard unit of capacitance is the farad. A capacitor has a capacitance of 1 farad when 1 coulomb charges it to 1 volt. One farad is a very large unit and most capacitors have values in the micro (10^{-6}), nano (10^{-9}) or pico (10^{-12}) farad level.

Dielectric Constant – In the formula for capacitance given above the dielectric constant of a vacuum is arbitrarily chosen as the number 1. Dielectric constants of other materials are then compared to the dielectric constant of a vacuum.

Dielectric Thickness – Capacitance is indirectly proportional to the separation between electrodes. Lower voltage requirements mean thinner dielectrics and greater capacitance per volume.

Area – Capacitance is directly proportional to the area of the electrodes. Since the other variables in the equation are usually set by the performance desired, area is the easiest parameter to modify to obtain a specific capacitance within a material group.

Energy Stored – The energy which can be stored in a capacitor is given by the formula:

$$E = \tfrac{1}{2}CV^2$$

E = energy in joules (watts-sec)
V = applied voltage
C = capacitance in farads

Potential Change – A capacitor is a reactive component which reacts against a change in potential across it. This is shown by the equation for the linear charge of a capacitor:

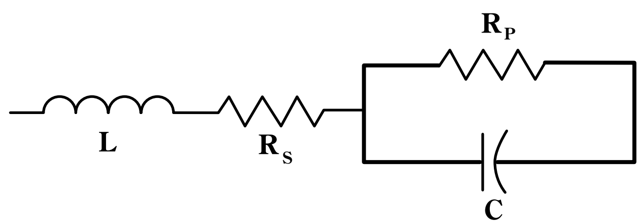
$$I_{ideal} = C\frac{dV}{dt}$$

where

I = Current
C = Capacitance
dV/dt = Slope of voltage transition across capacitor

Thus an infinite current would be required to instantly change the potential across a capacitor. The amount of current a capacitor can "sink" is determined by the above equation.

Equivalent Circuit – A capacitor, as a practical device, exhibits not only capacitance but also resistance and inductance. A simplified schematic for the equivalent circuit is:



C = Capacitance
R_s = Series Resistance
L = Inductance
R_p = Parallel Resistance

Reactance – Since the insulation resistance (R_p) is normally very high, the total impedance of a capacitor is:

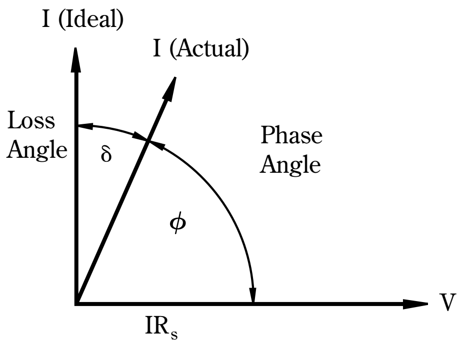
$$Z = \sqrt{R_S^2 + (X_C - X_L)^2}$$

where

Z = Total Impedance
R_s = Series Resistance
X_C = Capacitive Reactance = $\frac{1}{2\pi fC}$
X_L = Inductive Reactance = $2\pi fL$

The variation of a capacitor's impedance with frequency determines its effectiveness in many applications.

Phase Angle – Power Factor and Dissipation Factor are often confused since they are both measures of the loss in a capacitor under AC application and are often almost identical in value. In a "perfect" capacitor the current in the capacitor will lead the voltage by 90°.

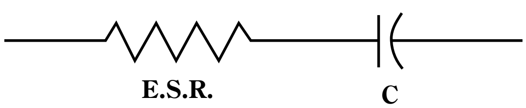


In practice the current leads the voltage by some other phase angle due to the series resistance R_S. The complement of this angle is called the loss angle and:

Power Factor (P.F.) = Cos ϕ or Sine δ
Dissipation Factor (D.F.) = tan δ

for small values of δ the tan and sine are essentially equal which has led to the common interchangeability of the two terms in the industry.

Equivalent Series Resistance – The term E.S.R. or Equivalent Series Resistance combines all losses both series and parallel in a capacitor at a given frequency so that the equivalent circuit is reduced to a simple R-C series connection.



Dissipation Factor

The DF/PF of a capacitor tells what percent of the apparent power input will turn to heat in the capacitor.

$$\textbf{Dissipation Factor} = \frac{E.S.R.}{X_c} = (2 \pi fC)(E.S.R.)$$

The watts loss are:

$$\textbf{Watts loss} = (2 \pi fCV^2)(D.F.)$$

Very low values of dissipation factor are expressed as their reciprocal for convenience. These are called the "Q" or Quality factor of capacitors.

Insulation Resistance – Insulation Resistance is the resistance measured across the terminals of a capacitor and consists principally of the parallel resistance R_P shown in the equivalent circuit. As capacitance values and hence the area of dielectric increases, the I.R. decreases and hence the product (C x IR or RC) is often specified in ohm farads or more commonly megohm microfarads. Leakage current is determined by dividing the rated voltage by IR (Ohm's Law).

Dielectric Strength – Dielectric Strength is an expression of the ability of a material to withstand an electrical stress. Although dielectric strength is ordinarily expressed in volts, it is actually dependent on the thickness of the dielectric and thus is also more generically a function of volts/mil.

Dielectric Absorption – A capacitor does not discharge instantaneously upon application of a short circuit, but drains gradually after the capacitance proper has been discharged. It is common practice to measure the dielectric absorption by determining the "reappearing voltage" which appears across a capacitor at some point in time after it has been fully discharged under short circuit conditions.

Corona – Corona is the ionization of air or other vapors which causes them to conduct current. It is especially prevalent in high voltage units but can occur with low voltages as well where high voltage gradients occur. The energy discharged degrades the performance of the capacitor and can in time cause catastrophic failures.

CERAMIC CAPACITORS

Multilayer ceramic capacitors are manufactured by mixing the ceramic powder in an organic binder (slurry) and casting it by one technique or another into thin layers typically ranging from about 3 mils in thickness down to 1 mil or thinner.

Metal electrodes are deposited onto the green ceramic layers which are then stacked to form a laminated structure. The metal electrodes are arranged so that their terminations alternate from one edge of the capacitor to another. Upon sintering at high temperature the part becomes a monolithic block which can provide extremely high capacitance values in small mechanical volumes. Figure 1 shows a pictorial view of a multilayer ceramic capacitor.

Multilayer ceramic capacitors are available in a wide range of characteristics, Electronic Industries Association (EIA) and the military have established categories to help divide the

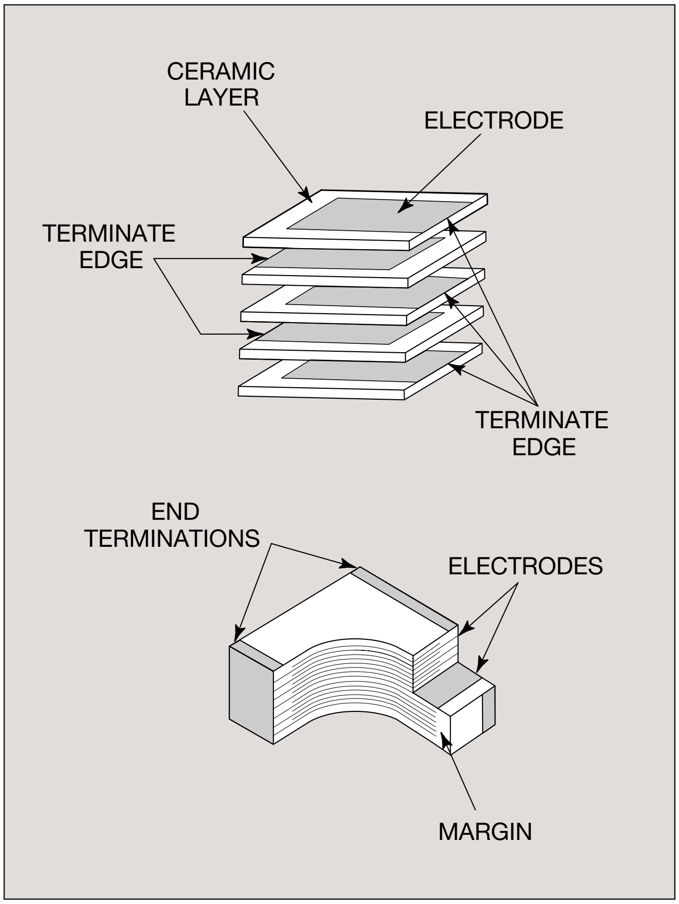


Figure 1

basic characteristics into more easily specified classes. The basic industry specification for ceramic capacitors is EIA specification RS-198 and as noted in the general section it specifies temperature compensating capacitors as Class 1 capacitors. These are specified by the military under specification MIL-C-20. General purpose capacitors with non-linear temperature coefficients are called Class 2 capacitors by EIA and are specified by the military under MIL-C-11015 and MIL-C-39014. The new high reliability military specification, MIL-C-123 covers both Class 1 and Class 2 dielectrics.

Class 1 – Class 1 capacitors or temperature compensating capacitors are usually made from mixtures of titanates where barium titanate is normally not a major part of the mix. They have predictable temperature coefficients and in general, do not have an aging characteristic. Thus they are the most stable capacitor available. Normally the T.C.s of Class 1 temperature compensating capacitors are C0G (NP0) (negative-positive 0 ppm/°C). Class 1 extended temperature compensating capacitors are also manufactured in T.C.s from P100 through N2200.

Class 2 – General purpose ceramic capacitors are called Class 2 capacitors and have become extremely popular because of the high capacitance values available in very small size. Class 2 capacitors are "ferro electric" and vary in capacitance value under the influence of the environmental and electrical operating conditions. Class 2 capacitors are affected by temperature, voltage (both AC and DC), frequency and time. Temperature effects for Class 2 ceramic capacitors are exhibited as non-linear capacitance changes with temperature.

Table 1: EIA Temperature Compensating Ceramic Capacitor Codes

TC TOLERANCES [1]										
Capacitance in pF	NP0	N030	N080	N150	N220	N330	N470	N750	N1500	N2200
-55°C to +25°C in PPM/°C										
10 and Over	+30 -75	+30 -80	+30 -90	+30 -105	+30 -120	+60 -180	+60 -210	+120 -340	+250 -670	+500 -1100
+25°C to +85°C in PPM/°C										
10 and Over	±30	±30	±30	±30	±30	±60	±60	±120	±250	±500
Closest MIL-C-20D Equivalent	CG	HG	LG	PG	RG	SH	TH	UJ	NONE	NONE
EIA Desig.	C0G	S1G	U1G	P2G	R2G	S2H	T2H	U2J	P3K	R3L

[1] Table 1 indicates the tolerance available on specific temperature characteristics. It may be noted that limits are established on the basis of measurements at +25°C and +85°C and that T.C. becomes more negative at low temperature. Wider tolerances are required on low capacitance values because of the effects of stray capacitance.

Table 2: MIL and EIA Temperature Stable and General Application Codes

MIL CODE		
Symbol	**Temperature Range**	
A	-55°C to +85°C	
B	-55°C to +125°C	
C	-55°C to +150°C	
Symbol	**Cap. Change Zero Volts**	**Cap. Change Rated Volts**
R	+15%, -15%	+15%, -40%
W	+22%, -56%	+22%, -66%
X	+15%, -15%	+15%, -25%
Y	+30%, -70%	+30%, -80%
Z	+20%, -20%	+20%, -30%
Temperature characteristic is specified by combining range and change symbols, for example BR or AW. Specification slash sheets indicate the characteristic applicable to a given style of capacitor.		

EIA CODE Percent Capacity Change Over Temperature Range	
RS198	**Temperature Range**
X7	-55°C to +125°C
X5	-55°C to +85°C
Y5	-30°C to +85°C
Z5	+10°C to +85°C
Code	**Percent Capacity Change**
D	±3.3%
E	±4.7%
F	±7.5%
P	±10%
R	±15%
S	±22%
T	+22%, -33%
U	+22%, - 56%
V	+22%, -82%
EXAMPLE – A capacitor is desired with the capacitance value at 25°C to increase no more than 7.5% or decrease no more than 7.5% from -30°C to +85°C. EIA Code will be Y5F.	

In specifying capacitance change with temperature for Class 2 materials, EIA expresses the capacitance change over an operating temperature range by a 3 symbol code. The first symbol represents the cold temperature end of the temperature range, the second represents the upper limit of the operating temperature range and the third symbol represents the capacitance change allowed over the operating temperature range. Table 2 provides a detailed explanation of the EIA system.

Effects of Voltage – Variations in voltage affects only the capacitance and dissipation factor. The application of DC voltage reduces both the capacitance and dissipation factor while the application of an AC voltage within a reasonable range tends to increase both capacitance and dissipation factor readings. If a high enough AC voltage is applied, eventually it will reduce capacitance just as a DC voltage will. Figure 2 shows the effects of AC voltage.

Capacitor specifications specify the AC voltage at which to measure (normally 0.5 or 1 VAC) and application of the wrong voltage can cause spurious readings. Figure 3 gives the voltage coefficient of dissipation factor for various AC voltages at 1 kilohertz. Applications of different frequencies will affect the percentage changes versus voltages.

Cap. Change vs. A.C. Volts
AVX X7R T.C.

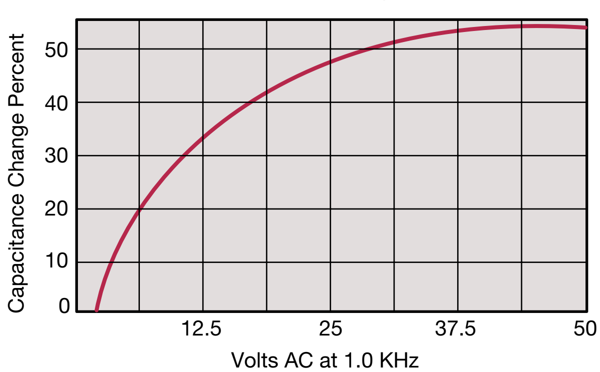


Figure 2

D.F. vs. A.C. Measurement Volts
AVX X7R T.C.

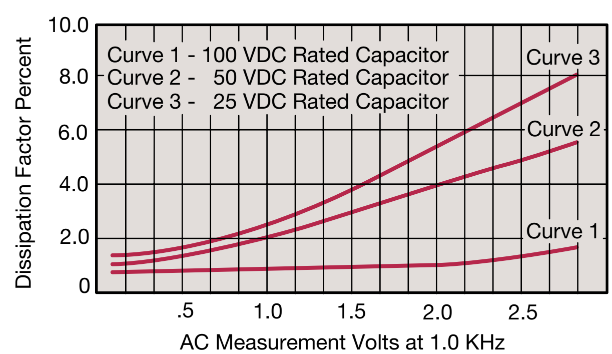


Figure 3

The effect of the application of DC voltage is shown in Figure 4. The voltage coefficient is more pronounced for higher K dielectrics. These figures are shown for room temperature conditions. The combination characteristic known as voltage temperature limits which shows the effects of rated voltage over the operating temperature range is shown in Figure 5 for the military BX characteristic.

Cap. Change vs. D.C. Volts
AVX X7R T.C.

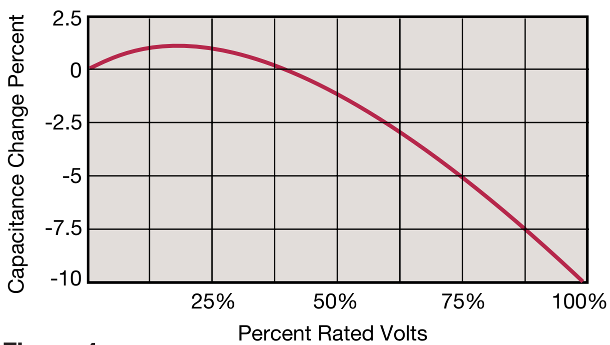


Figure 4

Typical Cap. Change vs. Temperature
AVX X7R T.C.

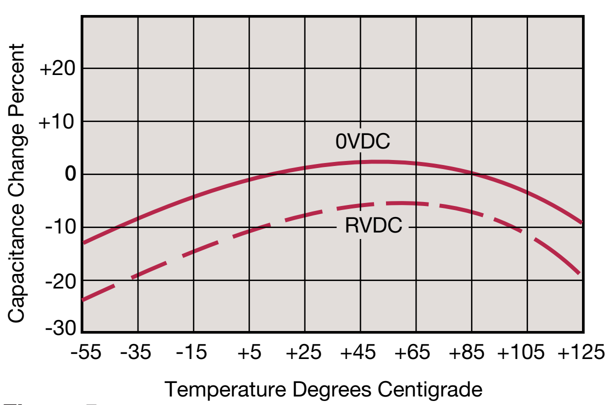


Figure 5

Cap. Change vs. Frequency

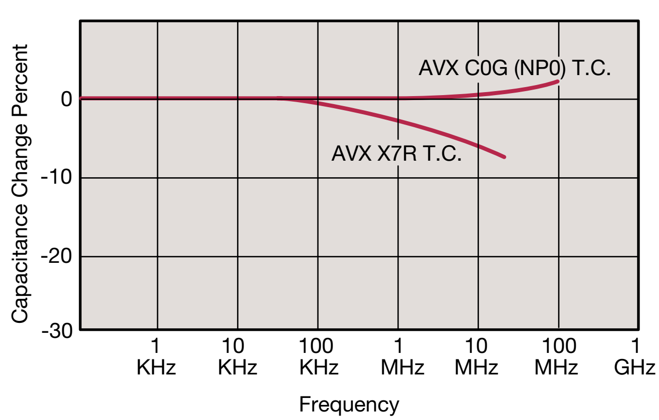


Figure 6

"Q" vs. Frequency

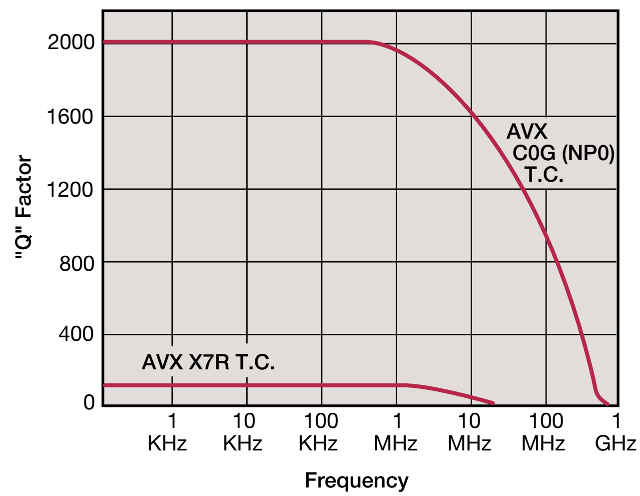


Figure 7

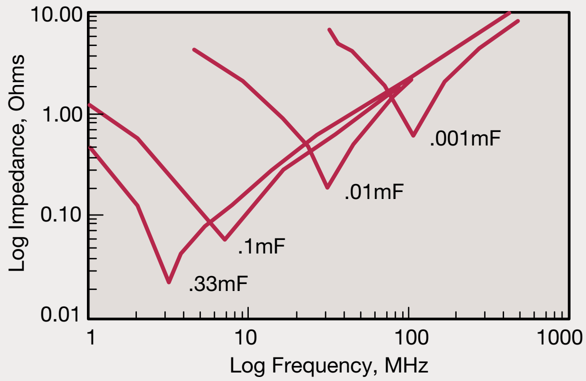
Effects of Frequency – Frequency affects capacitance and dissipation factor as shown in Figures 6 and 7.

Variation of impedance with frequency is an important consideration for decoupling capacitor applications. Lead length, lead configuration and body size all affect the impedance level over more than ceramic formulation variations. (Figure 8)

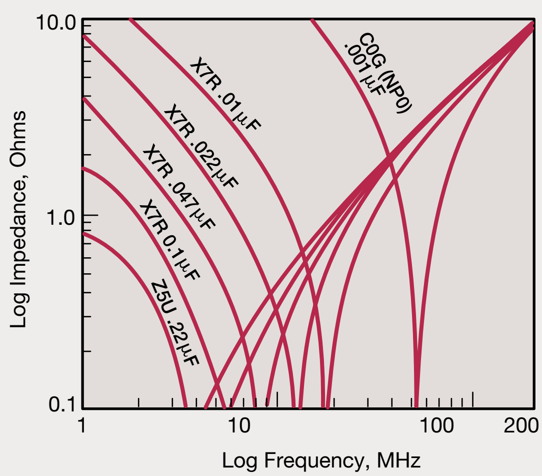
Effects of Time – Class 2 ceramic capacitors change capacitance and dissipation factor with time as well as temperature, voltage and frequency. This change with time is known as aging. Aging is caused by a gradual re-alignment of the crystalline structure of the ceramic and produces an exponential loss in capacitance and decrease in dissipation factor versus time. A typical curve of aging rate for semistable ceramics is shown in Figure 9 and a table is given showing the aging rates of various dielectrics.

If a ceramic capacitor that has been sitting on the shelf for a period of time, is heated above its curie point, (125°C for 4 hours or 150°C for ½ hour will suffice) the part will de-age and return to its initial capacitance and dissipation factor readings. Because the capacitance changes rapidly, immediately after de-aging, the basic capacitance measurements are normally referred to a time period sometime after the de-aging process. Various manufacturers use different time bases but the most popular one is one day or twenty-four hours after "last heat." Change in the aging curve can be caused by the application of voltage and other stresses. The possible changes in capacitance due to de-aging by heating the unit explain why capacitance changes are allowed after test, such as temperature cycling, moisture resistance, etc., in MIL specs. The application of high voltages such as dielectric withstanding voltages also tends to de-age capacitors and is why re-reading of capacitance after 12 or 24 hours is allowed in military specifications after dielectric strength tests have been performed.

Impedance vs. Frequency
Effect of Capacitance – AVX SpinGuards



Impedance vs. Frequency
Effect of Dielectric – AVX DIPGuards



Impedance vs. Frequency
Effect of Lead Length – Military CKR05 .01mF

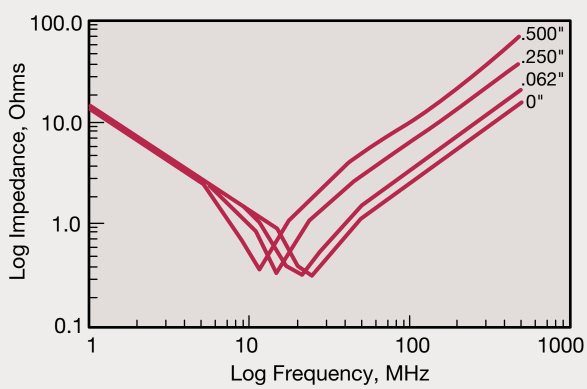
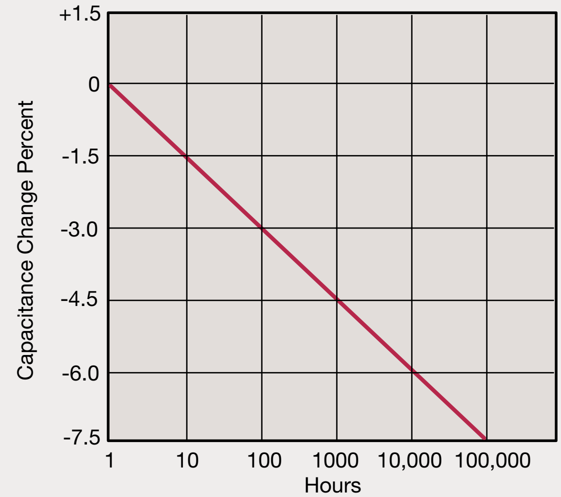


Figure 8

Typical Curve of Aging Rate
X7R Dielectric



Characteristic	Max. Aging Rate %/Decade
C0G (NP0)	None
X7R	2
Z5U	3
Y5V	5

Figure 9

Effects of Mechanical Stress – High “K” dielectric ceramic capacitors exhibit some low level piezoelectric reactions under mechanical stress. As a general statement, the piezoelectric output is higher, the higher the dielectric constant of the ceramic. It is desirable to investigate this effect before using high “K” dielectrics as coupling capacitors in extremely low level applications.

Reliability – Historically ceramic capacitors have been one of the most reliable types of capacitors in use today. The approximate formula for the reliability of a ceramic capacitor is:

$$\frac{L_o}{L_t} = \left(\frac{V_t}{V_o}\right)^X \left(\frac{T_t}{T_o}\right)^Y$$

where

L_o = operating life
L_t = test life
V_t = test voltage
V_o = operating voltage
T_t = test temperature and
T_o = operating temperature in °C
X,Y = see text

Historically for ceramic capacitors exponent X has been considered as 3. The exponent Y for temperature effects typically tends to run about 8.

GENERAL ELECTRICAL AND ENVIRONMENTAL SPECIFICATIONS

Many AVX ceramic capacitors are purchased in accordance with Military Specifications, MIL-C-39014, MIL-C-11015, MIL-C-20, MIL-C-55681, and MIL-C-123 or according to individual customer specification. When ordered to these specifications, the parts will meet the requirements set forth in these documents. The General Electrical and Environmental Specifications listed below detail test conditions which are common to the foregoing and to most ceramic capacitor specifications. If additional information is needed, AVX Application Engineers are ready to assist you.

Capacitance – Capacitance shall be tested in accordance with Method 305 of MIL-STD-202.

Class 1 dielectric to 1000 pF measured at 1 MHz, ± 100 KHz, > 1000 pF measured at 1 KHz ± 100 Hz both at 1.0 ± 0.2 VAC.
Class 2 dielectrics (except High K) to 100 pF shall be measured at 1 MHz ± 100 KHz, > 100 pF measured at 1 KHz ± 100 Hz both at 1.0 ± 0.2 VAC.
High K dielectrics measured at 1 KHz ± 100 Hz with less than 0.5 VAC or less applied.

Dissipation Factor – D.F. shall be measured at the same frequency and voltage as specified for capacitance.

Dielectric Strength – The dielectric strength shall be measured in accordance with Method 301 of MIL-STD-202 with a suitable resistor in series with the power supply to limit the charging current to 50 ma. max.

Insulation Resistance – Insulation Resistance shall be measured in accordance with Method 302 of MIL-STD-202 with rated voltage or 200 VDC whichever is less applied. The current shall be limited to 50 ma. max. and the charging time shall be 2.0 minutes maximum.

Burn-In – (Where specified.) 100% of the parts shall be subjected to 5 cycles of Thermal Shock per Method 107 Test Condition A of MIL-STD-202 followed by voltage conditioning at twice rated voltage and maximum rated temperature for 100 hours or as specified. After Burn-In, parts shall meet all initial requirements.

Barometric Pressure – Capacitors shall be tested in accordance with Method 105 of MIL-STD-202 Test Condition D (100,000 ft.) with 100% rated voltage applied for 5 seconds with current limited to 50 ma. No evidence of flashover or damage is permitted.

Solderability – Capacitors shall be tested in accordance with Method 208 of MIL-STD-202 with 95% coverage of new solder.

Vibration – Capacitors shall be tested in accordance with Method 208 Test Condition D of MIL-STD-202 with the bodies rigidly clamped. The specimens shall be tested in 3 mutually perpendicular planes for a total of 8 hours with 125% rated DC voltage applied. No evidence of opens, intermittents or shorts is permitted.

Shock – Capacitors shall be tested in accordance with Method 213 Condition 1 (100 Gs) of MIL-STD-202 with the bodies rigidly clamped. No evidence of opens, intermittents or shorts is permitted.

Thermal Shock and Immersion – Capacitors shall be tested in accordance with Method 107 Condition A of MIL-STD-202 with high test temperature (maximum rated operating temperature) followed by Method 104 of MIL-STD-202 Test Condition B.

Moisture Resistance – Capacitors shall be tested in accordance with Method 106 of MIL-STD-202 with rated voltage or 100 VDC whichever is less applied for the first 10 cycles.

Resistance to Solder Heat – Capacitors shall be tested in accordance with Method 210 of MIL-STD-202 with immersion to .050 of body. AVX Ceralam capacitors are manufactured with solder which melts at a temperature greater than 450°F.

General Considerations – The application of voltage or temperature usually causes temporary changes in the capacitance of Class 2 ceramic capacitors. These changes are normally in the positive direction and may cause out-of-tolerance capacitance readings. If a capacitance reading is made immediately after a dielectric strength or insulation resistance test and parts are high capacitance, they should be re-read after a minimum wait of 12 hours.

BASIC CAPACITOR FORMULAS

I. Capacitance (farads)

English: $C = \frac{.224\ K\ A}{T_D}$

Metric: $C = \frac{.0884\ K\ A}{T_D}$

II. Energy stored in capacitors (Joules, watt - sec)

$E = \frac{1}{2} CV^2$

III. Linear charge of a capacitor (Amperes)

$I = C \frac{dV}{dt}$

IV. Total Impedance of a capacitor (ohms)

$Z = \sqrt{R_S^2 + (X_C - X_L)^2}$

V. Capacitive Reactance (ohms)

$x_C = \frac{1}{2\ \pi\ fC}$

VI. Inductive Reactance (ohms)

$x_L = 2\ \pi\ fL$

VII. Phase Angles:

Ideal Capacitors: Current leads voltage 90°
Ideal Inductors: Current lags voltage 90°
Ideal Resistors: Current in phase with voltage

VIII. Dissipation Factor (%)

D.F.= tan δ (loss angle) = $\frac{E.S.R.}{X_C}$ = (2 πfC) (E.S.R.)

IX. Power Factor (%)

P.F. = Sine δ (loss angle) = Cos ϕ (phase angle)
P.F. = (when less than 10%) = DF

X. Quality Factor (dimensionless)

Q = Cotan δ (loss angle) = $\frac{1}{D.F.}$

XI. Equivalent Series Resistance (ohms)

E.S.R. = (D.F.) (Xc) = (D.F.) / (2 π fC)

XII. Power Loss (watts)

Power Loss = (2 π fCV^2) (D.F.)

XIII. KVA (Kilowatts)

KVA = 2 π $fCV^2 \times 10^{-3}$

XIV. Temperature Characteristic (ppm/°C)

$T.C. = \frac{Ct - C_{25}}{C_{25}\ (T_t - 25)} \times 10^6$

XV. Cap Drift (%)

$C.D. = \frac{C_1 - C_2}{C_1} \times 100$

XVI. Reliability of Ceramic Capacitors

$\frac{L_0}{L_t} = \left(\frac{V_t}{V_o}\right)^X \left(\frac{T_t}{T_o}\right)^Y$

XVII. Capacitors in Series (current the same)

Any Number: $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} --- \frac{1}{C_N}$

Two: $C_T = \frac{C_1\ C_2}{C_1 + C_2}$

XVIII. Capacitors in Parallel (voltage the same)

$C_T = C_1 + C_2 --- + C_N$

XIX. Aging Rate

A.R. = %Δ C/decade of time

XX. Decibels

$db = 20 \log \frac{V_1}{V_2}$

METRIC PREFIXES

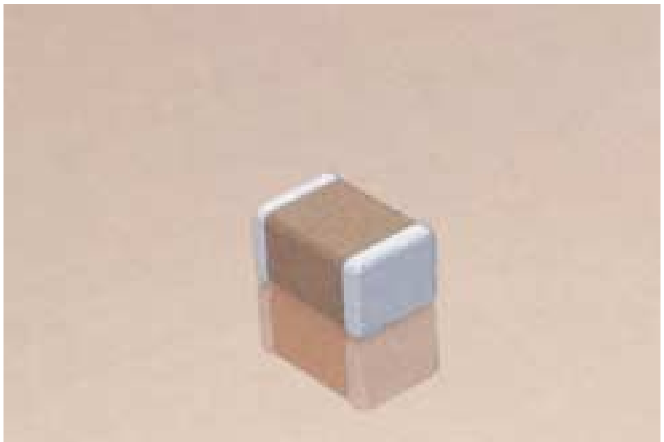
Pico	$X\ 10^{-12}$
Nano	$X\ 10^{-9}$
Micro	$X\ 10^{-6}$
Milli	$X\ 10^{-3}$
Deci	$X\ 10^{-1}$
Deca	$X\ 10^{+1}$
Kilo	$X\ 10^{+3}$
Mega	$X\ 10^{+6}$
Giga	$X\ 10^{+9}$
Tera	$X\ 10^{+12}$

SYMBOLS

K	= Dielectric Constant	f	= frequency	L_t	= Test life
A	= Area	L	= Inductance	V_t	= Test voltage
T_D	= Dielectric thickness	δ	= Loss angle	V_o	= Operating voltage
V	= Voltage	ϕ	= Phase angle	T_t	= Test temperature
t	= time	X & Y	= exponent effect of voltage and temp.	T_o	= Operating temperature
R_S	= Series Resistance	L_o	= Operating life		

X7R Dielectric

General Specifications



X7R formulations are called "temperature stable" ceramics and fall into EIA Class II materials. X7R is the most popular of these intermediate dielectric constant materials. Its temperature variation of capacitance is within ±15% from -55°C to +125°C. This capacitance change is non-linear.

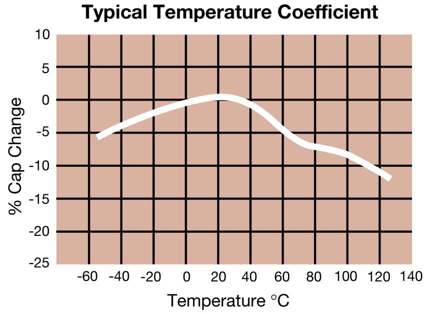
Capacitance for X7R varies under the influence of electrical operating conditions such as voltage and frequency.

X7R dielectric chip usage covers the broad spectrum of industrial applications where known changes in capacitance due to applied voltages are acceptable.

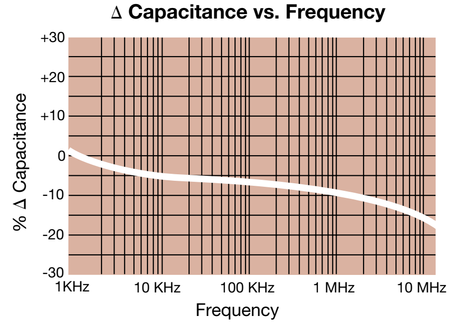
PART NUMBER (see page 2 for complete part number explanation)

0805	5	C	103	M	A	T	2	A
Size (L" x W")	**Voltage** 6.3V = 6, 10V = Z, 16V = Y, 25V = 3, 50V = 5, 100V = 1, 200V = 2	**Dielectric** X7R = C	**Capacitance Code (In pF)** 2 Sig. Digits + Number of Zeros	**Capacitance Tolerance** Preferred J = ± 5%, K = ±10%, M = ± 20%	**Failure Rate** A = Not Applicable	**Terminations** T = Plated Ni and Sn, 7 = Gold Plated	**Packaging** 2 = 7" Reel, 4 = 13" Reel, 7 = Bulk Cass., 9 = Bulk; **Contact Factory For Multiples**	**Special Code** A = Std. Product

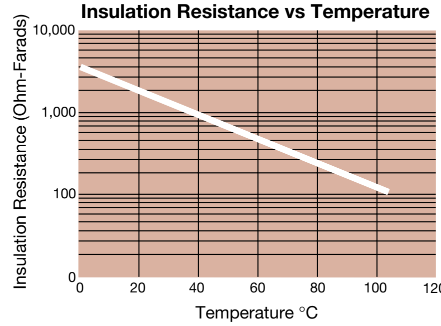
X7R Dielectric Typical Temperature Coefficient



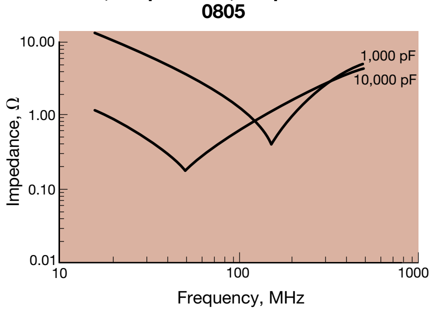
Δ Capacitance vs. Frequency



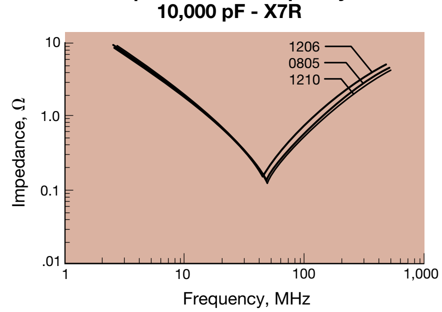
Insulation Resistance vs Temperature



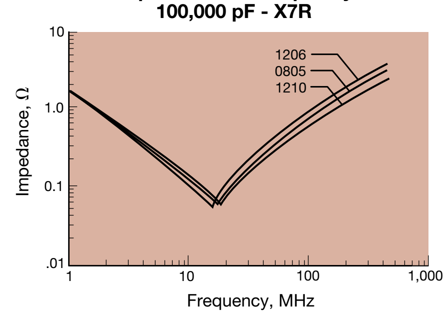
Variation of Impedance with Cap Value Impedance vs. Frequency 1,000 pF vs. 10,000 pF - X7R 0805



Variation of Impedance with Chip Size Impedance vs. Frequency 10,000 pF - X7R

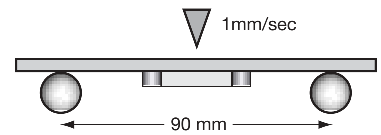


Variation of Impedance with Chip Size Impedance vs. Frequency 100,000 pF - X7R



X7R Dielectric

Specifications and Test Methods

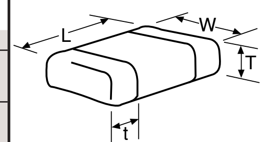
Parameter/Test		X7R Specification Limits	Measuring Conditions	
Operating Temperature Range		-55ºC to +125ºC	Temperature Cycle Chamber	
Capacitance		Within specified tolerance	Freq.: 1.0 kHz ± 10% Voltage: 1.0Vrms ± .2V For Cap > 10 µF, 0.5Vrms @ 120Hz	
Dissipation Factor		≤ 2.5% for ≥ 50V DC rating ≤ 3.0% for 25V DC rating ≤ 3.5% for 16V DC rating ≤ 5.0% for ≤ 10V DC rating		
Insulation Resistance		100,000MΩ or 1000MΩ - µF, whichever is less	Charge device with rated voltage for 60 ± 5 secs @ room temp/humidity	
Dielectric Strength		No breakdown or visual defects	Charge device with 300% of rated voltage for 1-5 seconds, w/charge and discharge current limited to 50 mA (max)	
Resistance to Flexure Stresses	Appearance	No defects	Deflection: 2mm Test Time: 30 seconds  	
	Capacitance Variation	≤ ±12%		
	Dissipation Factor	Meets Initial Values (As Above)		
	Insulation Resistance	≥ Initial Value x 0.3		
Solderability		≥ 95% of each terminal should be covered with fresh solder	Dip device in eutectic solder at 230 ± 5ºC for 5.0 ± 0.5 seconds	
Resistance to Solder Heat	Appearance	No defects, <25% leaching of either end terminal	Dip device in eutectic solder at 260ºC for 60 seconds. Store at room temperature for 24 ± 2 hours before measuring electrical properties.	
	Capacitance Variation	≤ ±7.5%		
	Dissipation Factor	Meets Initial Values (As Above)		
	Insulation Resistance	Meets Initial Values (As Above)		
	Dielectric Strength	Meets Initial Values (As Above)		
Thermal Shock	Appearance	No visual defects	Step 1: -55ºC ± 2º	30 ± 3 minutes
	Capacitance Variation	≤ ±7.5%	Step 2: Room Temp	≤ 3 minutes
	Dissipation Factor	Meets Initial Values (As Above)	Step 3: +125ºC ± 2º	30 ± 3 minutes
	Insulation Resistance	Meets Initial Values (As Above)	Step 4: Room Temp	≤ 3 minutes
	Dielectric Strength	Meets Initial Values (As Above)	Repeat for 5 cycles and measure after 24 ± 2 hours at room temperature	
Load Life	Appearance	No visual defects	Charge device with twice rated voltage in test chamber set at 125ºC ± 2ºC for 1000 hours (+48, -0) Remove from test chamber and stabilize at room temperature for 24 ± 2 hours before measuring.	
	Capacitance Variation	≤ ±12.5%		
	Dissipation Factor	≤ Initial Value x 2.0 (See Above)		
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)		
	Dielectric Strength	Meets Initial Values (As Above)		
Load Humidity	Appearance	No visual defects	Store in a test chamber set at 85ºC ± 2ºC/ 85% ± 5% relative humidity for 1000 hours (+48, -0) with rated voltage applied. Remove from chamber and stabilize at room temperature and humidity for 24 ± 2 hours before measuring.	
	Capacitance Variation	≤ ±12.5%		
	Dissipation Factor	≤ Initial Value x 2.0 (See Above)		
	Insulation Resistance	≥ Initial Value x 0.3 (See Above)		
	Dielectric Strength	Meets Initial Values (As Above)		

X7R Dielectric

Capacitance Range

PREFERRED SIZES ARE SHADED

SIZE	0201		0402					0603							0805						1206					
Soldering	Reflow Only		Reflow Only					Reflow/Wave							Reflow/Wave						Reflow/Wave					
Packaging	All Paper		All Paper					All Paper							Paper/Embossed						Paper/Embossed					
(L) Length MM (in.)	0.60 ± 0.03 (0.024 ± 0.001)		1.00 ± 0.10 (0.040 ± 0.004)					1.60 ± 0.15 (0.063 ± 0.006)							2.01 ± 0.20 (0.079 ± 0.008)						3.20 ± 0.20 (0.126 ± 0.008)					
(W) Width MM (in.)	0.30 ± 0.03 (0.011 ± 0.001)		0.50 ± 0.10 (0.020 ± 0.004)					0.81 ± 0.15 (0.032 ± 0.006)							1.25 ± 0.20 (0.049 ± 0.008)						1.60 ± 0.20 (0.063 ± 0.008)					
(t) Terminal MM (in.)	0.15 ± 0.05 (0.006 ± 0.002)		0.25 ± 0.15 (0.010 ± 0.006)					0.35 ± 0.15 (0.014 ± 0.006)							0.50 ± 0.25 (0.020 ± 0.010)						0.50 ± 0.25 (0.020 ± 0.010)					
WVDC	10	16	6.3	10	16	25	50	6.3	10	16	25	50	100	200	10	16	25	50	100	200	10	16	25	50	100	200
Cap (pF) 100	A	A	C	C	C	C	C																			
120	A	A	C	C	C	C	C																			
150	A	A	C	C	C	C	C																			
180	A	A	C	C	C	C	C	G	G	G	G	G	G	G												
220	A	A	C	C	C	C	C	G	G	G	G	G	G	G												
270	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
330	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
390	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
470	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
560	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
680	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
820	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E						
1000	A	A	C	C	C	C	C	G	G	G	G	G	G	G	E	E	E	E	E	E	J	J	J	J	J	J
1200			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
1500			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
1800			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
2200			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
2700			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
3300			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
3900			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	E	J	J	J	J	J	J	J
4700			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	J	J	J	J	J	J	J	J
5600			C	C	C	C	C	G	G	G	G	G	G		E	E	E	E	J	J	J	J	J	J	J	J
6800			C	C	C	C		G	G	G	G	G	G		E	E	E	E	J	J	J	J	J	J	J	J
8200			C	C	C	C		G	G	G	G	G	G		E	E	E	E	J	J	J	J	J	J	J	J
Cap. (µF) 0.010			C	C	C			G	G	G	G	G	G		E	E	E	E	J	J	J	J	J	J	J	J
0.012			C	C	C			G	G	G	G	G	G		J	J	J	J	J	J	J	J	J	J	J	M
0.015			C	C	C			G	G	G	G	G			J	J	J	J	J	J	J	J	J	J	J	M
0.018			C	C	C			G	G	G	G	G			J	J	J	J	J	M	J	J	J	J	J	M
0.022			C	C	C			G	G	G	G	G			J	J	J	J	J	M	J	J	J	J	J	M
0.027			C	C				G	G	G	G	G			J	J	J	J	J		J	J	J	J	J	M
0.033			C	C				G	G	G	G	G			J	J	J	J	M		J	J	J	J	J	M
0.039			C	C				G	G	G	G	G			J	J	J	J	M		J	J	J	J	J	M
0.047								G	G	G	G				J	J	J	J	M		J	J	J	J	J	M
0.056								G	G	G					J	J	J	J			J	J	J	J	J	P
0.068								G	G	G					J	J	J	J			J	J	J	J	J	P
0.082								G	G	G					J	J	J	J			J	J	J	J	M	
0.10								G	G	G					J	J	J	J			J	J	J	J	M	
0.12								G	G						J	J	J	M			J	J	J	J		
0.15								G	G						J	J	J				J	J	J	J		
0.18								G	G						J	J	M				J	J	J	J		
0.22								G	G						J	J	M				J	J	J	J		
0.27															M	M					J	J	J	M		
0.33															M	M					J	J	M	M		
0.47															N	M					M	M	M	M		
0.56															N						M	M	Q			
0.68															N						M	M	Q			
0.82															N						M	M	Q			
1.0															N						M	M	Q			
1.2																					P					
1.5																					P					
1.8																					P					
2.2																					Q					
3.3																										
4.7																										
10																										
22																										
47																										
100																										
WVDC	10	16	6.3	10	16	25	50	6.3	10	16	25	50	100	200	10	16	25	50	100	200	10	16	25	50	100	200
SIZE	0201		0402					0603							0805						1206					



Letter	A	C	E	G	J	K	M	N	P	Q	X	Y	Z	BB	CC
Max. Thickness	0.33 (0.013)	0.56 (0.022)	0.71 (0.028)	0.86 (0.034)	0.94 (0.037)	1.02 (0.040)	1.27 (0.050)	1.40 (0.055)	1.52 (0.060)	1.78 (0.070)	2.29 (0.090)	2.54 (0.100)	2.79 (0.110)	3.05 (0.120)	3.175 (0.125)
	PAPER					EMBOSSED									

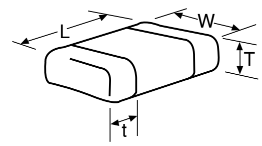
Contact Factory for Multiples

X7R Dielectric

Capacitance Range

PREFERRED SIZES ARE SHADED

SIZE	1210					1812				1825		2220			2225	
Soldering	Reflow/Wave					Reflow Only				Reflow Only		Reflow Only			Reflow Only	
Packaging	Paper/Embossed					All Embossed				All Embossed		All Embossed			All Embossed	
(L) Length MM (in.)	3.20 ± 0.20 (0.126 ± 0.008)					4.50 ± 0.30 (0.177 ± 0.012)				4.50 ± 0.30 (0.177 ± 0.012)		5.7 ± 0.40 (0.224 ± 0.016)			5.72 ± 0.25 (0.225 ± 0.010)	
(W) Width MM (in.)	2.50 ± 0.20 (0.098 ± 0.008)					3.20 ± 0.20 (0.126 ± 0.008)				6.40 ± 0.40 (0.252 ± 0.016)		5.0 ± 0.40 (0.197 ± 0.016)			6.35 ± 0.25 (0.250 ± 0.010)	
(t) Terminal MM (in.)	0.50 ± 0.25 (0.020 ± 0.010)					0.61 ± 0.36 (0.024 ± 0.014)				0.61 ± 0.36 (0.024 ± 0.014)		0.64 ± 0.39 (0.025 ± 0.015)			0.64 ± 0.39 (0.025 ± 0.015)	
WVDC	10	16	25	50	100	16	25	50	100	50	100	50	100	200	50	100
Cap (pF) 100																
120																
150																
180																
220																
270																
330																
390																
470																
560																
680																
820																
1000	J	J	J	J	J											
1200	J	J	J	J	J											
1500	J	J	J	J	J											
1800	J	J	J	J	J											
2200	J	J	J	J	J											
2700	J	J	J	J	J											
3300	J	J	J	J	J											
3900	J	J	J	J	J											
4700	J	J	J	J	J											
5600	J	J	J	J	J											
6800	J	J	J	J	J											
8200	J	J	J	J	J											
Cap. (μF) 0.010	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.012	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.015	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.018	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.022	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.027	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.033	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.039	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.047	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.056	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.068	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.082	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.10	J	J	J	J	J			K	K	M	M	X	X	X	M	M
0.12	J	J	J	J	M			K	K	M	M	X	X	X	M	M
0.15	J	J	J	J	M			K	K	M	M	X	X	X	M	M
0.18	J	J	J	J	P			K	K	M	M	X	X	X	M	M
0.22	J	J	J	J	P			K	K	M	M	X	X	X	M	M
0.27	J	J	J	J	Z			K	M	M	M	X	X		M	M
0.33	J	J	J	J	Z			K	M	M	M	X	X		M	M
0.47	M	M	M	M	Z			K	P	M	M	X	X		M	M
0.56	M	M	M		Z			M	Q	M	M	X	X		M	M
0.68	M	M	P		Z			M	X	M	Q	X	X		M	M
0.82	M	M	P					M	X	M	Q	X			M	M
1.0	N	N	P	X	Z			M	X	M	Q	X			M	M
1.2	N	N					M			M		X			M	P
1.5	N	N								M					M	P
1.8	N	P													M	
2.2			X										Z		M	
3.3																
4.7	Q	Z														
10						Z										
22																
47																
100																
WVDC	10	16	25	50	100	16	25	50	100	50	100	50	100	200	50	100
SIZE	1210					1812				1825		2220			2225	



Letter	A	C	E	G	J	K	M	N	P	Q	X	Y	Z	BB	CC
Max. Thickness	0.33 (0.013)	0.56 (0.022)	0.71 (0.028)	0.86 (0.034)	0.94 (0.037)	1.02 (0.040)	1.27 (0.050)	1.40 (0.055)	1.52 (0.060)	1.78 (0.070)	2.29 (0.090)	2.54 (0.100)	2.79 (0.110)	3.05 (0.120)	3.175 (0.125)
	PAPER					EMBOSSED									

Contact Factory for Multiples

C0G (NP0) Dielectric

General Specifications

C0G (NP0) is the most popular formulation of the “temperature-compensating,” EIA Class I ceramic materials. Modern C0G (NP0) formulations contain neodymium, samarium and other rare earth oxides.

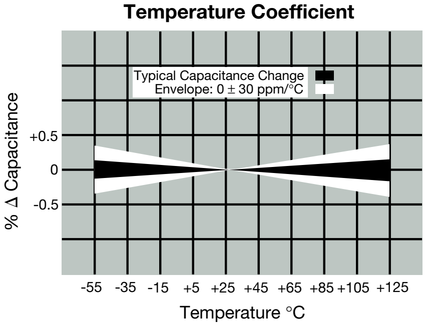
C0G (NP0) ceramics offer one of the most stable capacitor dielectrics available. Capacitance change with temperature is 0 ±30ppm/°C which is less than ±0.3% Δ C from -55°C to +125°C. Capacitance drift or hysteresis for C0G (NP0) ceramics is negligible at less than ±0.05% versus up to ±2% for films. Typical capacitance change with life is less than ±0.1% for C0G (NP0), one-fifth that shown by most other dielectrics. C0G (NP0) formulations show no aging characteristics.

The C0G (NP0) formulation usually has a “Q” in excess of 1000 and shows little capacitance or “Q” changes with frequency. Their dielectric absorption is typically less than 0.6% which is similar to mica and most films.

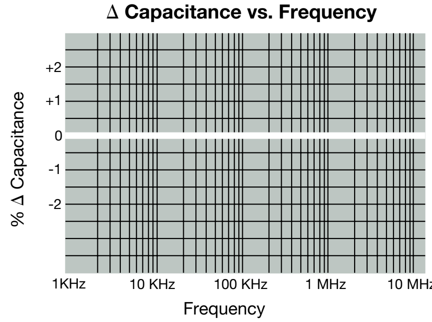
PART NUMBER (see page 2 for complete part number explanation)

0805	5	A	101	J	A	T	2	A
Size (L" x W")	**Voltage** 6.3V = 6 10V = Z 16V = Y 25V = 3 50V = 5 100V = 1 200V = 2	**Dielectric** C0G (NP0) = A	**Capacitance Code (In pF)** 2 Sig. Digits + Number of Zeros	**Capacitance Tolerance** B = ±.10 pF (<10pF) C = ±.25 pF (<10pF) D = ±.50 pF (<10pF) F = ±1% (≥ 25 pF) G = ±2% (≥ 13 pF) J = ±5% K = ±10%	**Failure Rate** A = Not Applicable	**Terminations** T = Plated Ni and Sn 7 = Gold Plated **Contact Factory For 1 = Pd/Ag Term**	**Packaging** 2 = 7" Reel 4 = 13" Reel 7 = Bulk Cass. 9 = Bulk **Contact Factory For Multiples**	**Special Code** A = Std. Product

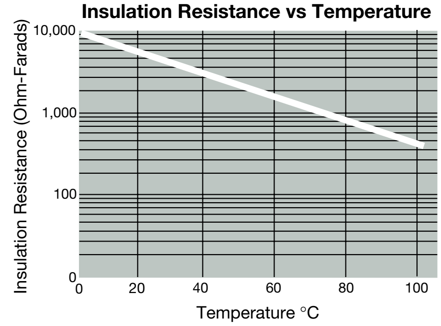
Temperature Coefficient



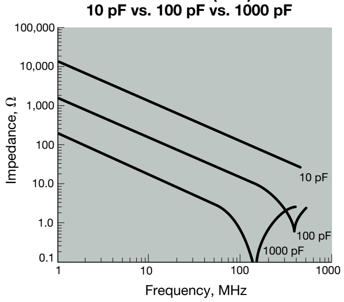
Δ Capacitance vs. Frequency



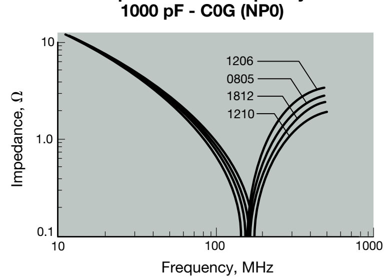
Insulation Resistance vs Temperature



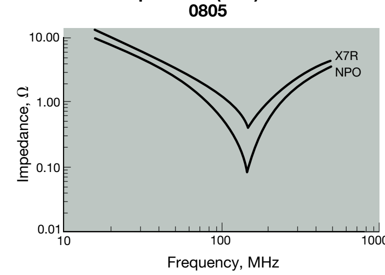
Variation of Impedance with Cap Value
Impedance vs. Frequency
0805 - C0G (NP0)
10 pF vs. 100 pF vs. 1000 pF



Variation of Impedance with Chip Size
Impedance vs. Frequency
1000 pF - C0G (NP0)

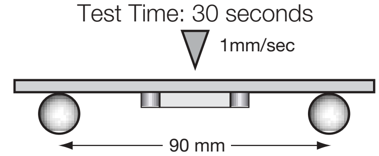


Variation of Impedance with Ceramic Formulation
Impedance vs. Frequency
1000 pF - C0G (NP0) vs X7R
0805



C0G (NP0) Dielectric

Specifications and Test Methods

<table>
<tr><th colspan="2">Parameter/Test</th><th>NP0 Specification Limits</th><th colspan="2">Measuring Conditions</th></tr>
<tr><td colspan="2">Operating Temperature Range</td><td>-55ºC to +125ºC</td><td colspan="2">Temperature Cycle Chamber</td></tr>
<tr><td colspan="2">Capacitance</td><td>Within specified tolerance</td><td colspan="2" rowspan="2">Freq.: 1.0 MHz ± 10% for cap ≤ 1000 pF
1.0 kHz ± 10% for cap > 1000 pF
Voltage: 1.0Vrms ± .2V</td></tr>
<tr><td colspan="2">Q</td><td><30 pF: Q≥ 400+20 x Cap Value
≥30 pF: Q≥ 1000</td></tr>
<tr><td colspan="2">Insulation Resistance</td><td>100,000MΩ or 1000MΩ - µF,
whichever is less</td><td colspan="2">Charge device with rated voltage for
60 ± 5 secs @ room temp/humidity</td></tr>
<tr><td colspan="2">Dielectric Strength</td><td>No breakdown or visual defects</td><td colspan="2">Charge device with 300% of rated voltage for 1-5 seconds, w/charge and discharge current limited to 50 mA (max)</td></tr>
<tr><td rowspan="4">Resistance to Flexure Stresses</td><td>Appearance</td><td>No defects</td><td colspan="2" rowspan="4">Deflection: 2mm
Test Time: 30 seconds
</td></tr>
<tr><td>Capacitance Variation</td><td>±5% or ±.5 pF, whichever is greater</td></tr>
<tr><td>Q</td><td>Meets Initial Values (As Above)</td></tr>
<tr><td>Insulation Resistance</td><td>≥ Initial Value x 0.3</td></tr>
<tr><td colspan="2">Solderability</td><td>≥ 95% of each terminal should be covered with fresh solder</td><td colspan="2">Dip device in eutectic solder at 230 ± 5ºC
for 5.0 ± 0.5 seconds</td></tr>
<tr><td rowspan="5">Resistance to Solder Heat</td><td>Appearance</td><td>No defects, <25% leaching of either end terminal</td><td colspan="2" rowspan="5">Dip device in eutectic solder at 260ºC for 60 seconds. Store at room temperature for 24 ± 2 hours before measuring electrical properties.</td></tr>
<tr><td>Capacitance Variation</td><td>≤ ±2.5% or ±.25 pF, whichever is greater</td></tr>
<tr><td>Q</td><td>Meets Initial Values (As Above)</td></tr>
<tr><td>Insulation Resistance</td><td>Meets Initial Values (As Above)</td></tr>
<tr><td>Dielectric Strength</td><td>Meets Initial Values (As Above)</td></tr>
<tr><td rowspan="5">Thermal Shock</td><td>Appearance</td><td>No visual defects</td><td>Step 1: -55ºC ± 2º</td><td>30 ± 3 minutes</td></tr>
<tr><td>Capacitance Variation</td><td>≤ ±2.5% or ±.25 pF, whichever is greater</td><td>Step 2: Room Temp</td><td>≤ 3 minutes</td></tr>
<tr><td>Q</td><td>Meets Initial Values (As Above)</td><td>Step 3: +125ºC ± 2º</td><td>30 ± 3 minutes</td></tr>
<tr><td>Insulation Resistance</td><td>Meets Initial Values (As Above)</td><td>Step 4: Room Temp</td><td>≤ 3 minutes</td></tr>
<tr><td>Dielectric Strength</td><td>Meets Initial Values (As Above)</td><td colspan="2">Repeat for 5 cycles and measure after
24 hours at room temperature</td></tr>
<tr><td rowspan="5">Load Life</td><td>Appearance</td><td>No visual defects</td><td colspan="2" rowspan="5">Charge device with twice rated voltage in test chamber set at 125ºC ± 2ºC for 1000 hours (+48, -0).

Remove from test chamber and stabilize at room temperature for 24 hours before measuring.</td></tr>
<tr><td>Capacitance Variation</td><td>≤ ±3.0% or ± .3 pF, whichever is greater</td></tr>
<tr><td>Q
(C=Nominal Cap)</td><td>≥ 30 pF: Q≥ 350
≥10 pF, <30 pF: Q≥ 275 +5C/2
<10 pF: Q≥ 200 +10C</td></tr>
<tr><td>Insulation Resistance</td><td>≥ Initial Value x 0.3 (See Above)</td></tr>
<tr><td>Dielectric Strength</td><td>Meets Initial Values (As Above)</td></tr>
<tr><td rowspan="5">Load Humidity</td><td>Appearance</td><td>No visual defects</td><td colspan="2" rowspan="5">Store in a test chamber set at 85ºC ± 2ºC/ 85% ± 5% relative humidity for 1000 hours (+48, -0) with rated voltage applied.

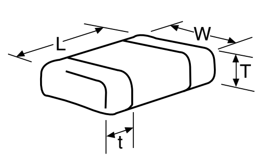
Remove from chamber and stabilize at room temperature for 24 ± 2 hours before measuring.</td></tr>
<tr><td>Capacitance Variation</td><td>≤ ±5.0% or ± .5 pF, whichever is greater</td></tr>
<tr><td>Q</td><td>≥ 30 pF: Q≥ 350
≥10 pF, <30 pF: Q≥ 275 +5C/2
<10 pF: Q≥ 200 +10C</td></tr>
<tr><td>Insulation Resistance</td><td>≥ Initial Value x 0.3 (See Above)</td></tr>
<tr><td>Dielectric Strength</td><td>Meets Initial Values (As Above)</td></tr>
</table>

C0G (NP0) Dielectric

Capacitance Range

PREFERRED SIZES ARE SHADED

SIZE		0201			0402			0603				0805					1206				
Soldering		Reflow Only			Reflow Only			Reflow/Wave				Reflow/Wave					Reflow/Wave				
Packaging		All Paper			All Paper			All Paper				Paper/Embossed					Paper/Embossed				
(L) Length	MM (in.)	0.60 ± 0.03 (0.024 ± 0.001)			1.00 ± 0.10 (0.040 ± 0.004)			1.60 ± 0.15 (0.063 ± 0.006)				2.01 ± 0.20 (0.079 ± 0.008)					3.20 ± 0.20 (0.126 ± 0.008)				
(W) Width	MM (in.)	0.30 ± 0.03 (0.011 ± 0.001)			0.50 ± 0.10 (0.020 ± 0.004)			0.81 ± 0.15 (0.032 ± 0.006)				1.25 ± 0.20 (0.049 ± 0.008)					1.60 ± 0.20 (0.063 ± 0.008)				
(t) Terminal	MM (in.)	0.15 ± 0.05 (0.006 ± 0.002)			0.25 ± 0.15 (0.010 ± 0.006)			0.35 ± 0.15 (0.014 ± 0.006)				0.50 ± 0.25 (0.020 ± 0.010)					0.50 ± 0.25 (0.020 ± 0.010)				
WVDC		10	16	25	16	25	50	6.3	25	50	100	16	25	50	100	200	16	25	50	100	200
Cap (pF)	0.5	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	1.0	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	1.2	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	1.5	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	1.8	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	2.2	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	2.7	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	3.3	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	3.9	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	4.7	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	5.6	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	6.8	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	8.2	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	10	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	12	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	15	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	18	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	22	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	27	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	33	A	A	A	C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	39	A	A		C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	47	A	A		C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	56	A	A		C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	68	A	A		C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	82	A			C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	100	A			C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	120				C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	150				C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	180				C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	220				C	C	C	G	G	G	G	E	E	E	E	J	J	J	J	J	J
	270				C	C		G	G	G	G	E	E	E	J	M	J	J	J	J	J
	330				C	C		G	G	G	G	E	E	E	J	M	J	J	J	J	J
	390							G	G	G		J	J	J	J	M	J	J	J	J	J
	470							G	G	G		J	J	J	J	M	J	J	J	J	J
	560							G	G	G		J	J	J	J		J	J	J	J	J
	680							G	G	G		J	J	J	J		J	J	J	J	J
	820							G	G	G		J	J	J	J		J	J	J	J	M
	1000							G	G	G		J	J	J	J		J	J	J	J	Q
	1200							G	G			J	J	J			J	J	J	J	Q
	1500							G	G			J	J	J			J	J	J	M	Q
	1800											J	J	J			J	J	M	M	
	2200											J	J	M			J	J	M	P	
	2700											J	J	M			J	J	M	P	
	3300											N	N	M			J	J	M	P	
	3900											N	N	M			J	J	M	P	
	4700											N	N				J	J	M	P	
	5600											N	N				J	J	M		
	6800											N					M	M			
	8200											N					M	M			
Cap (μF)	0.010											N					M	M			
	0.012																M	M			
	0.015																M	M			
	0.018																				
	0.022																				
	0.027																				
	0.033																				
	0.039																				
	0.047																				
	0.068																				
	0.082																				
	0.1																				
WVDC		10	16	25	16	25	50	6.3	25	50	100	16	25	50	100	200	16	25	50	100	200
SIZE		0201			0402			0603				0805					1206				



Letter	A	C	E	G	J	K	M	N	P	Q	X	Y	Z	BB	CC
Max. Thickness	0.33 (0.013)	0.56 (0.022)	0.71 (0.028)	0.86 (0.034)	0.94 (0.037)	1.02 (0.040)	1.27 (0.050)	1.40 (0.055)	1.52 (0.060)	1.78 (0.070)	2.29 (0.090)	2.54 (0.100)	2.79 (0.110)	3.05 (0.120)	3.175 (0.125)
	PAPER					EMBOSSED									

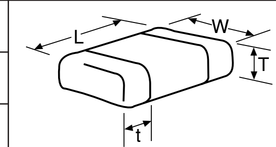
Contact Factory for Multiples

C0G (NP0) Dielectric

Capacitance Range

PREFERRED SIZES ARE SHADED

SIZE	1210				1812				1825			2220			2225		
Soldering	Reflow/Wave				Reflow Only				Reflow Only			Reflow Only			Reflow Only		
Packaging	Paper/Embossed				All Embossed				All Embossed			All Embossed			All Embossed		
(L) Length MM (in.)	3.20 ± 0.20 (0.126 ± 0.008)				4.50 ± 0.30 (0.177 ± 0.012)				4.50 ± 0.30 (0.177 ± 0.012)			5.70 ± 0.40 (0.224 ± 0.016)			5.72 ± 0.25 (0.225 ± 0.010)		
(W) Width MM (in.)	2.50 ± 0.20 (0.098 ± 0.008)				3.20 ± 0.20 (0.126 ± 0.008)				6.40 ± 0.40 (0.252 ± 0.016)			5.00 ± 0.40 (0.197 ± 0.016)			6.35 ± 0.25 (0.250 ± 0.010)		
(t) Terminal MM (in.)	0.50 ± 0.25 (0.020 ± 0.010)				0.61 ± 0.36 (0.024 ± 0.014)				0.61 ± 0.36 (0.024 ± 0.014)			0.64 ± 0.39 (0.025 ± 0.015)			0.64 ± 0.39 (0.025 ± 0.015)		
WVDC	25	50	100	200	25	50	100	200	50	100	200	50	100	200	50	100	200
Cap (pF) 0.5																	
1.0																	
1.2																	
1.5																	
1.8																	
2.2																	
2.7																	
3.3																	
3.9																	
4.7																	
5.6																	
6.8																	
8.2																	
10																	
12																	
15																	
18																	
22																	
27																	
33																	
39																	
47																	
56																	
68																	
82																	
100																	
120																	
150																	
180																	
220																	
270																	
330																	
390																	
470																	
560	J	J	J	J													
680	J	J	J	J													
820	J	J	J	J													
1000	J	J	J	J	K	K	K	K	M	M	M	X	X	X	P	P	P
1200	J	J	J	M	K	K	K	K	M	M	M	X	X	X	P	P	P
1500	J	J	J	M	K	K	K	K	M	M	M	X	X	X	P	P	P
1800	J	J	J	M	K	K	K	K	M	M	M	X	X	X	P	P	P
2200	J	J	M	Q	K	K	K	K	M	M	M	X	X	X	P	P	P
2700	J	J	M	Q	K	K	K	P	M	M	M	X	X	X	P	P	P
3300	J	J	M		K	K	K	P	M	M	M	X	X	X	P	P	P
3900	J	J	M		K	K	K	P	M	M	M	X	X	X	P	P	P
4700	J	J	M		K	K	K	P	M	M	M	X	X	X	P	P	P
5600	J	J	M		K	M	M	P	M	M	M	X	X	X	P	P	P
6800	J	J	M		K	M	M	X	M	M	M	X	X	X	P	P	P
8200	J	J			K	P	X	X	M	M		X	X	X	P	P	P
Cap (μF) 0.010	N	N			K	P	X	X	M	M		X	X	X	P	P	P
0.012	N	N			K	P	X		M	M		X	X	X	P	P	P
0.015					M	P	X		P	M		X	X	X	P	P	Y
0.018					M	P			P	M		X	X	X	P	P	Y
0.022					M	CC			P			X	X		P	Y	Y
0.027					M	CC			P			X	X		P	Y	Y
0.033					M	CC			P			X	X		P	Y	Y
0.039					M	CC			P						P	Y	Y
0.047					CC	CC			P						P		
0.068					CC	CC									P		
0.082					CC	CC									P		
0.1					CC	CC									P		
WVDC	25	50	100	200	25	50	100	200	50	100	200	50	100	200	50	100	200
SIZE	1210				1812				1825			2220			2225		



Letter	A	C	E	G	J	K	M	N	P	Q	X	Y	Z	BB	CC
Max. Thickness	0.33 (0.013)	0.56 (0.022)	0.71 (0.028)	0.86 (0.034)	0.94 (0.037)	1.02 (0.040)	1.27 (0.050)	1.40 (0.055)	1.52 (0.060)	1.78 (0.070)	2.29 (0.090)	2.54 (0.100)	2.79 (0.110)	3.05 (0.120)	3.175 (0.125)
	PAPER					EMBOSSED									

Contact Factory for Multiples