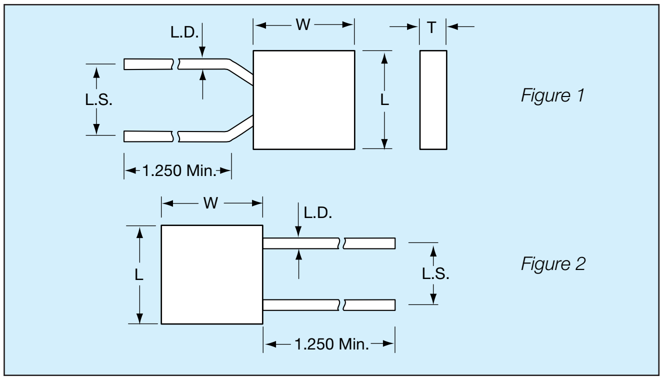
Jameco Part Number 1935158



HOW TO ORDER

Military Type Designation: Styles CK05, CK06

For values, tolerances, voltages, sizes, configurations and dielectrics not shown, contact AVX facilities directly for information.

CK05 **BX** **104** **K**

Style
CK = General purpose, ceramic dielectric, fixed capacitors
05 = Remaining two numbers identify shape and dimension

Voltage-Temperature Limits
First letter identifies temperature range.
B = -55ºC to +125ºC
Second letter identifies voltage-temperature coefficient.

Capacitance Change with Reference to 25°C		
Second Letter	No Voltage	Rated Voltage
X	+15, -15%	+15, -25%

Capacitance
First two digits are the significant figures of capacitance. Third digit indicates the additional number of zeros. For example, order 100,000 pF as 104.

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

PACKAGING

CK05 1000 per bag
CK06 1000 per bag

Radial tape and reel packaging available upon request (2500 pcs./reel).

SIZE SPECIFICATIONS

Dimensions: Millimeters (Inches)

Case Size	Per MIL Spec	
MIL-C-11015	CK05 (Fig. 1)	CK06 (Fig. 2)
Length (L)	4.83±.25 (.190±.010)	7.37±.25 (.290±.010)
Width (W)	4.83±.25 (.190±.010)	7.37±.25 (.290±.010)
Thickness (T)	2.29±.25 (.090±.010)	2.29±.25 (.090±.010)
Lead Spacing (L.S.)	5.08±.38 (.200±.015)	5.08±.38 (.200±.015)
Lead Diameter (L.D.)	.64±.05 (.025±.002)	.64±.05 (.025±.002)

MIL-C-11015/Radial Leads

MILITARY PART NUMBER IDENTIFICATION CK05 AND CK06

Military Type Designation	Capacitance (pF)	Capacitance Tolerance	WVDC
	CK05 (BX)		
CK05BX100_	10	K, M	200
CK05BX120K_	12	K	200
CK05BX150_	15	K, M	200
CK05BX180K_	18	K	200
CK05BX220_	22	K, M	200
CK05BX270K_	27	K	200
CK05BX330_	33	K, M	200
CK05BX390K_	39	K	200
CK05BX470_	47	K, M	200
CK05BX560K_	56	K	200
CK05BX680_	68	K, M	200
CK05BX820K_	82	K	200
CK05BX101_	100	K, M	200
CK05BX121K_	120	K	200
CK05BX151_	150	K, M	200
CK05BX181K_	180	K	200
CK05BX221_	220	K, M	200
CK05BX271K_	270	K	200
CK05BX331_	330	K, M	200
CK05BX391K_	390	K	200
CK05BX471_	470	K, M	200
CK05BX561K_	560	K	200
CK05BX681_	680	K, M	200
CK05BX821K_	820	K	200
CK05BX102_	1,000	K, M	200
CK05BX122_	1,200	K	100
CK05BX152_	1,500	K, M	100
CK05BX182K_	1,800	K	100
CK05BX222_	2,200	K, M	100
CK05BX272K_	2,700	K	100
CK05BX332_	3,300	K, M	100
CK05BX392K_	3,900	K	100
CK05BX472_	4,700	K, M	100
CK05BX562K_	5,600	K	100
CK05BX682_	6,800	K, M	100
CK05BX822K_	8,200	K	100
CK05BX103_	10,000	K, M	100
CK05BX123K_	12,000	K	50
CK05BX153_	15,000	K, M	50
CK05BX183K_	18,000	K	50
CK05BX223_	22,000	K, M	50
CK05BX273K_	27,000	K	50
CK05BX333_	33,000	K, M	50
CK05BX393K_	39,000	K	50
CK05BX473_	47,000	K, M	50
CK05BX563K_	56,000	K	50
CK05BX683_	68,000	K, M	50
CK05BX823K_	82,000	K	50
CK05BX104_	100,000	K, M	50

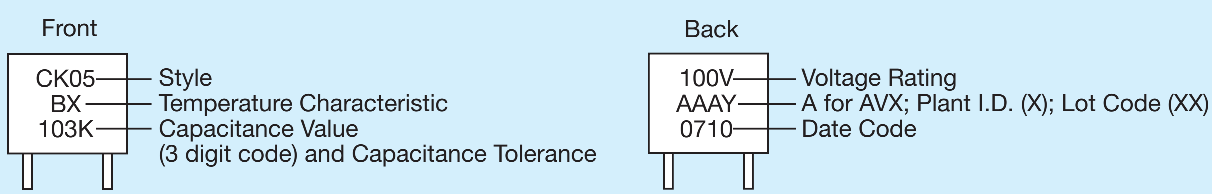
Add Capacitance Tolerance Letter K = ±10% or M = ±20%

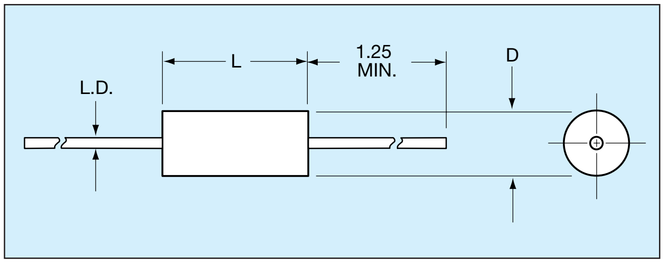
Military Type Designation	Capacitance (pF)	Capacitance Tolerance	WVDC
	CK06 (BX)		
CK06BX122K_	1,200	K	200
CK06BX152_	1,500	K, M	200
CK06BX182K_	1,800	K	200
CK06BX222_	2,200	K, M	200
CK06BX272K_	2,700	K	200
CK06BX332_	3,300	K, M	200
CK06BX392K_	3,900	K	200
CK06BX472_	4,700	K, M	200
CK06BX562K_	5,600	K	200
CK06BX682_	6,800	K, M	200
CK06BX822K_	8,200	K	200
CK06BX103_	10,000	K, M	200
CK06BX123K_	12,000	K	100
CK06BX153_	15,000	K, M	100
CK06BX183K_	18,000	K	100
CK06BX223_	22,000	K, M	100
CK06BX273K_	27,000	K	100
CK06BX333_	33,000	K, M	100
CK06BX393K_	39,000	K	100
CK06BX473_	47,000	K, M	100
CK06BX563K_	56,000	K	100
CK06BX683_	68,000	K, M	100
CK06BX823K_	82,000	K	100
CK06BX104_	100,000	K, M	100
CK06BX124K_	120,000	K	50
CK06BX154_	150,000	K, M	50
CK06BX184K_	180,000	K	50
CK06BX224_	220,000	K, M	50
CK06BX274K_	270,000	K	50
CK06BX334_	330,000	K, M	50
CK06BX394K_	390,000	K	50
CK06BX474_	470,000	K, M	50
CK06BX564K_	560,000	K	50
CK06BX684_	680,000	K, M	50
CK06BX824K_	820,000	K	50
CK06BX105_	1.0 mfd	K, M	50

Add Capacitance Tolerance Letter K = ±10% or M = ±20%

MARKING

CK05/CK06





HOW TO ORDER

Military Type Designation: Styles CK12, CK13, CK14, CK15, CK16

CK12 — **Style**
CK = General purpose, ceramic dielectric, fixed capacitors
12 = Remaining two numbers identify shape and dimension

BX — **Voltage-Temperature Limits**
First letter identifies temperature range.
B = -55ºC to +125ºC
Second letter identifies voltage-temperature coefficient.

Capacitance Change with Reference to 25°C		
Second Letter	No Voltage	Rated Voltage
R	+15, -15%	+15, -40%
X	+15, -15%	+15, -25%

103 — **Capacitance**
First two digits are the significant figures of capacitance. Third digit indicates the additional number of zeros. For example, order 10,000 pF as 103.

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

PACKAGING REQUIREMENTS

Packaging: Bulk

CK12, 13 & 14	100 pcs per bag
CK15 & 16	50 pcs per bag

Tape & Reel

CK12, 13	5000 pcs per reel
CK14	3000 pcs per reel
CK15	950 pcs per reel
CK16	650 pcs per reel

SIZE SPECIFICATIONS

Dimensions: Millimeters (Inches)

Case Size	Per MIL Spec				
MIL-C-11015	CK12	CK13	CK14	CK15	CK16
Length (L)	4.07±.25 (.160±.010)	6.35±.25 (.250±.010)	9.91±.25 (.390±.010)	12.7±.51 (.500±.020)	17.53±.51 (.690±.020)
Diameter (D)	2.29±.25 (.090±.010)	2.29±.25 (.090±.010)	3.56±.25 (.140±.010)	6.35±.38 (.250±.015)	8.89±.51 (.350±.020)
Lead Diameter (L.D.)	.48±.05 (.019±.002)	.48±.05 (.019±.002)	.63±.05 (.025±.002)	.63±.05 (.025±.002)	.63±.05 (.025±.002)

MILITARY PART NUMBER IDENTIFICATION CK12 THRU CK16

Military Type Designation	Capacitance (pF)	Capacitance Tolerance	WVDC
	CK12 (BX)		
CK12BX100_	10	K, M	100
CK12BX120K	12	K	100
CK12BX150_	15	K, M	100
CK12BX180K	18	K	100
CK12BX220_	22	K, M	100
CK12BX270K	27	K	100
CK12BX330_	33	K, M	100
CK12BX390K	39	K	100
CK12BX470_	47	K, M	100
CK12BX560K	56	K	100
CK12BX680_	68	K, M	100
CK12BX820K	82	K	100
CK12BX101_	100	K, M	100
CK12BX121K	120	K	100
CK12BX151_	150	K, M	100
CK12BX181K	180	K	100
CK12BX221_	220	K, M	100
CK12BX271K	270	K	100
CK12BX331_	330	K, M	100
CK12BX391K	390	K	100
CK12BX471_	470	K, M	100
CK12BX561K	560	K	100
CK12BX681_	680	K, M	100
CK12BX821K	820	K	100
CK12BX102_	1,000	K, M	100
CK12BX122K	1,200	K	100
CK12BX152_	1,500	K, M	100
CK12BX182K	1,800	K	100
CK12BX222_	2,200	K, M	100
CK12BX272K	2,700	K	100
CK12BX332_	3,300	K, M	100
CK12BX392K	3,900	K	100
CK12BX472_	4,700	K, M	100
CK12BX562K	5,600	K	50
CK12BX682_	6,800	K, M	50
CK12BX822K	8,200	K	50
CK12BX103_	10,000	K, M	50
	CK13 (BX)		
CK13BX562K	5,600	K	100
CK13BX682_	6,800	K, M	100
CK13BX822K	8,200	K	100
CK13BX103_	10,000	K, M	100
CK13BX123K	12,000	K	50
CK13BX153_	15,000	K, M	50
CK13BX183K	18,000	K	50
CK13BX223_	22,000	K, M	50
	CK13 (BR)		
CK13BR273K	27,000	K	50
CK13BR333_	33,000	K, M	50
CK13BR393K	39,000	K	50
CK13BR473_	47,000	K, M	50

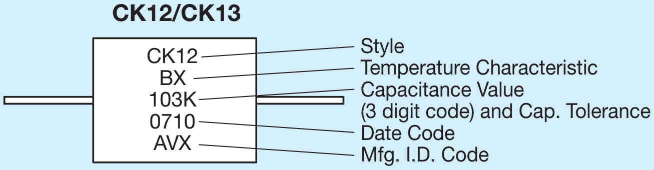
Add Capacitance Tolerance Letter K = ±10% or M = ±20%

Military Type Designation	Capacitance (pF)	Capacitance Tolerance	WVDC
	CK14 (BX)		
CK14BX123K	12,000	K	100
CK14BX153_	15,000	K, M	100
CK14BX183K	18,000	K	100
CK14BX223_	22,000	K, M	100
CK14BX273K	27,000	K	100
CK14BX333_	33,000	K, M	100
CK14BX393K	39,000	K	100
CK14BX473_	47,000	K, M	100
	CK14 (BR)		
CK14BR563K	56,000	K	100
CK14BR683_	68,000	K, M	100
CK14BR823K	82,000	K	100
CK14BR104_	100,000	K, M	100
CK14BR124K	120,000	K	50
CK14BR154_	150,000	K, M	50
CK14BR184K	180,000	K	50
CK14BR224_	220,000	K, M	50
CK14BR274K	270,000	K	50
	CK15 (BX)		
CK15BX104K	100,000	K, M	100
	CK15 (BR)		
CK15BR124K	120,000	K	100
CK15BR154_	150,000	K, M	100
CK15BR184K	180,000	K	100
CK15BR224_	220,000	K, M	100
CK15BR274K	270,000	K	100
CK15BR334_	330,000	K, M	100
CK15BR474K	470,000	K, M	50
CK15BR105_	1,000,000	K, M	50
	CK16 (BR)		
CK16BR474K	470,000	K, M	100
CK16BR105_	1,000,000	K, M	100
CK16BR225_	2,200,000	K, M	50
CK16BR335_	3,300,000	K, M	50

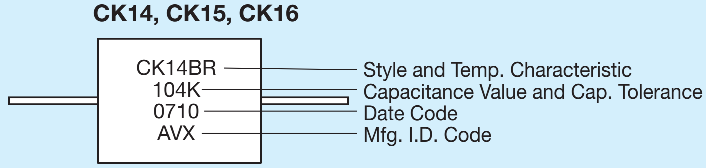
Add Capacitance Tolerance Letter K = ±10% or M = ±20%

MARKING

CK12/CK13



CK14, CK15, CK16



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:

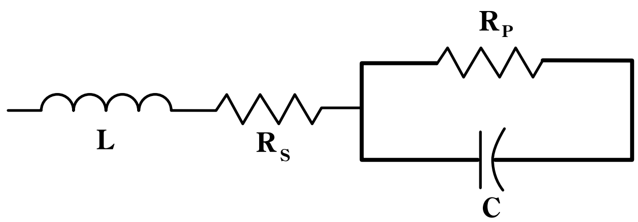
$$I_{ideal} = C\frac{dV}{dt}$$

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:

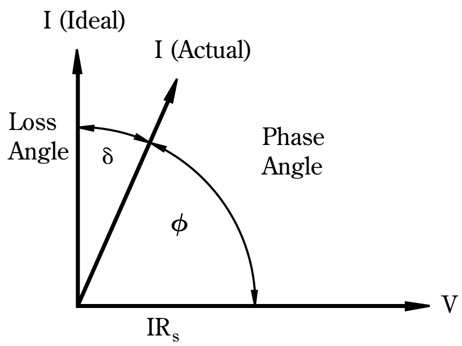
$$Z = \sqrt{R_S^2 + (X_C - X_L)^2}$$

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°.

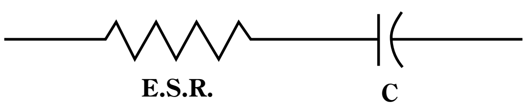


In practice the current leads the voltage by some other phase angle due to the series resistance R_s. The complement of this angle is called the loss angle and:

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.

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

The watts loss are:

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

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

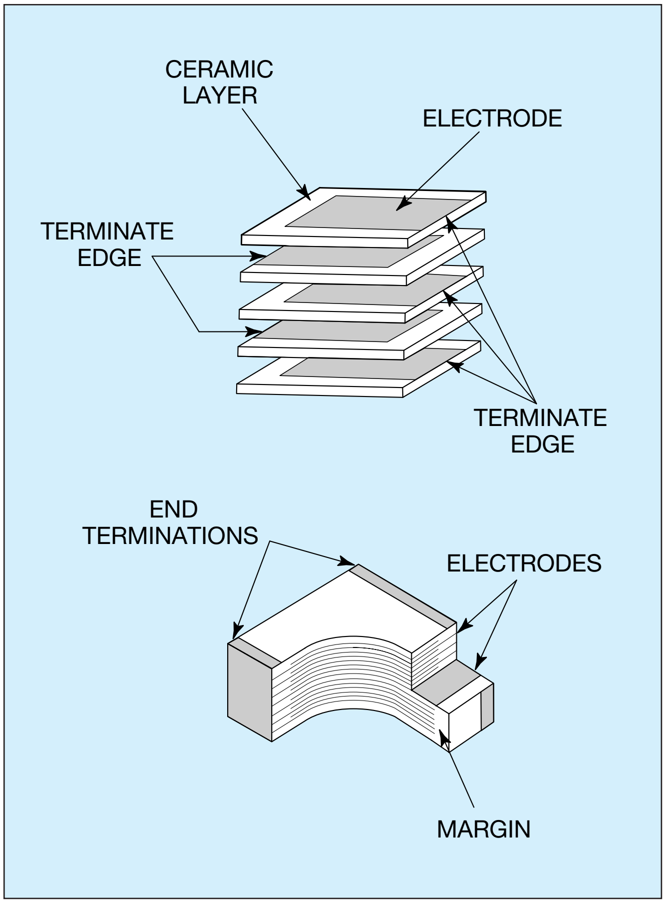


Figure 1

EIA Temperature Compensating Ceramic temperature characteristics in accordance with EIA-198.

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-PRF-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-PRF-39014. The new high reliability military specification, MIL-PRF-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 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.

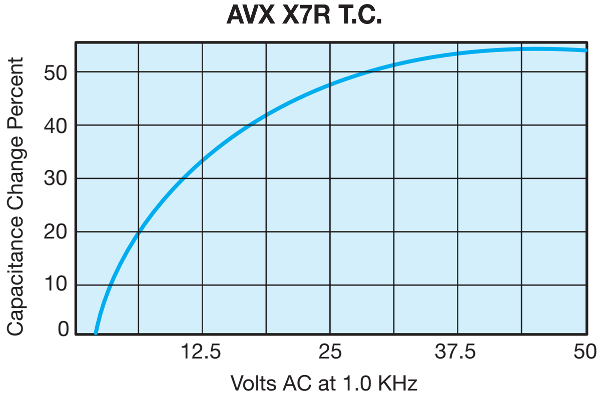


Figure 2

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

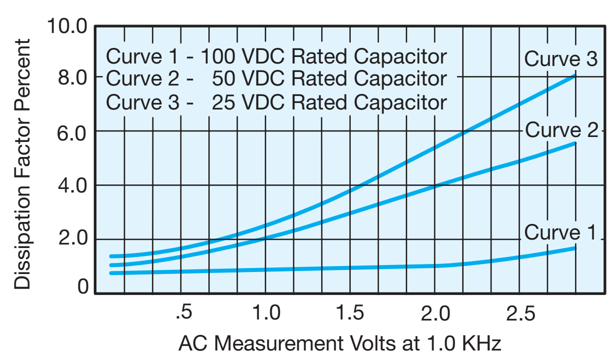


Figure 3

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.

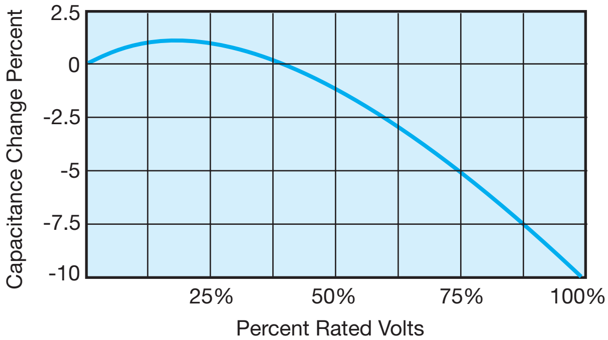


Figure 4

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

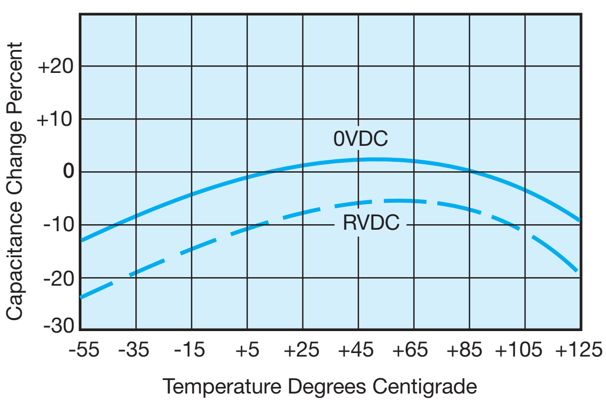


Figure 5

Cap. Change vs. Frequency

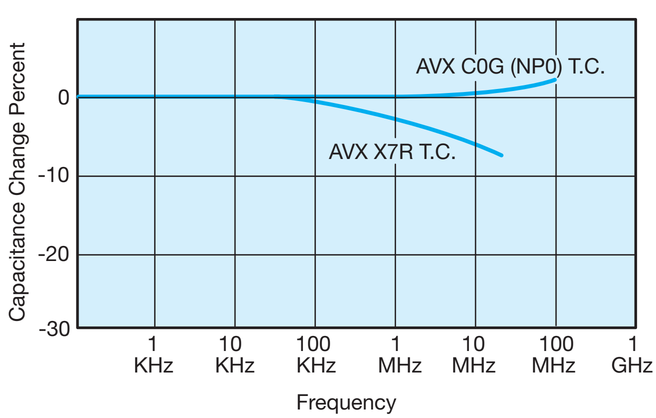


Figure 6

"Q" vs. Frequency

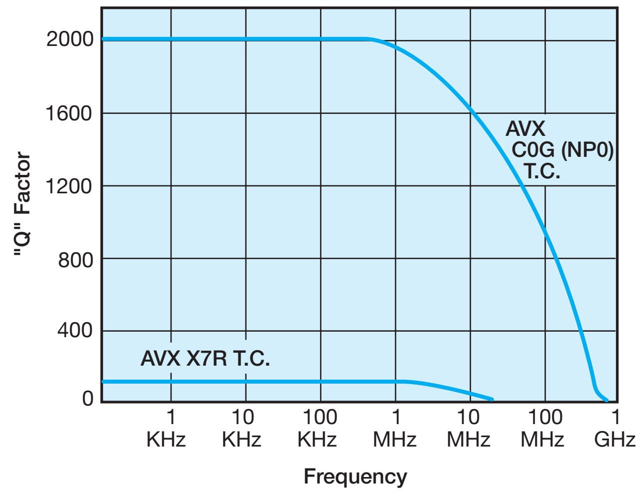


Figure 7

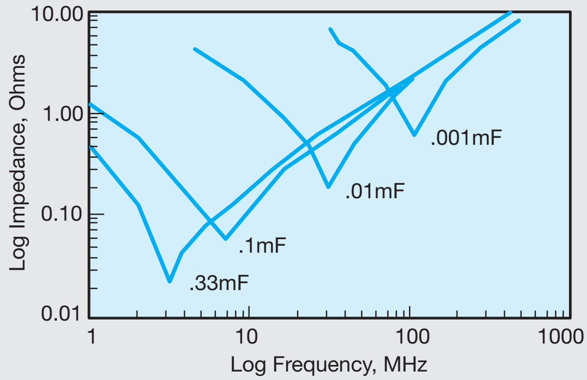
Effects of Frequency – Frequency affects capacitance and dissipation factor as shown in Figures 6 and 7.

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)

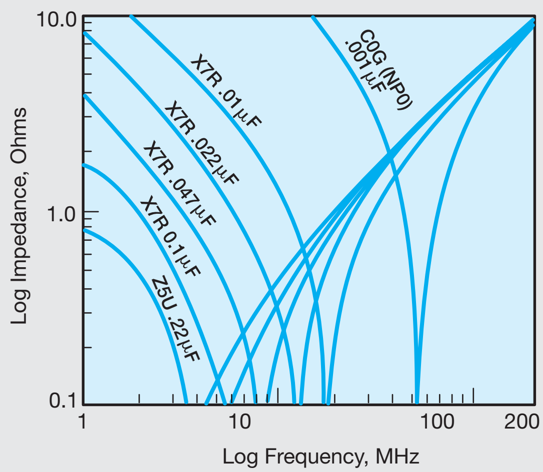
Effects of Time – Class 2 ceramic capacitors change capacitance and dissipation factor with time as well as temperature, voltage and frequency. This change with time is known as aging. Aging is caused by a gradual re-alignment of the crystalline structure of the ceramic and produces an exponential loss 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

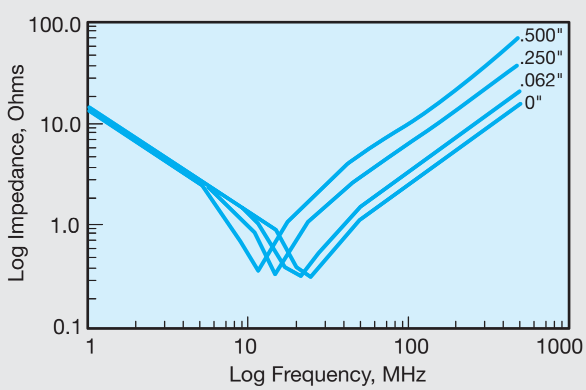
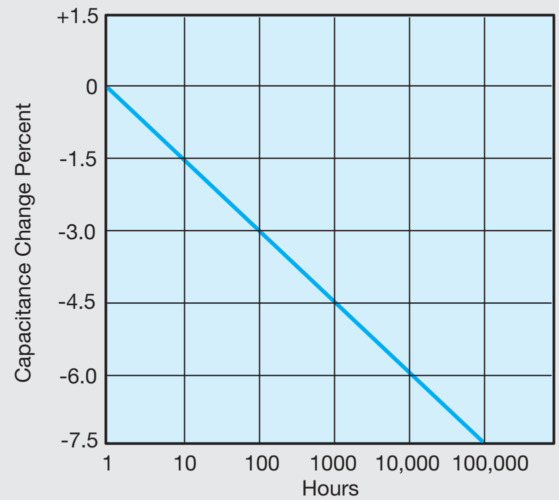


Figure 8

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.

The Capacitor

General Electrical and Environmental Specifications

Many AVX ceramic capacitors are purchased in accordance with Military Specifications, MIL-PRF-39014, MIL-C-11015, MIL-PRF-20, MIL-PRF-55681, and MIL-PRF-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.= $\tan \delta$ (loss angle) = $\frac{E.S.R.}{X_C}$ = $(2 \pi fC)$ (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.) / $(2 \pi fC)$

XII. Power Loss (watts)

Power Loss = $(2 \pi fCV^2)$ (D.F.)

XIII. KVA (Kilowatts)

KVA = $2 \pi fCV^2 \times 10^{-3}$

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		

C0G (NP0) Dielectric "A"

GENERAL SPECIFICATIONS

Capacitance Range
See Individual Parts Specifications

Capacitance Test at 25°C
Measured at 1 VRMS max. at 1 KHz
(1 MHz for 1,000 pF or less)

Capacitance Tolerances
C = ±.25 pF, D = ±.50 pF, E = ±0.5%, F = ±1.0%,
G = ±2%, H = ±3%, J = ±5%, K = ±10%, M = ±20%
For values less than 10 pF tightest tolerance available is ±.25 pF

Operating Temperature Range
-55°C to +125°C

Temperature Characteristic
0 ± 30 ppm/°C

Voltage Ratings
200,100 & 50 Vdc

Dissipation Factor
.15% max. (+25°C and +125°C) for values greater than 30 pF or Q = 20 x C + 400 for values of 30 pF and below.
1.0 VRMS, 1 MHz for values ≦ 1,000 pF, and
1 KHz for values > 1,000 pF

Insulation Resistance 25°C (MIL-STD-202-Method 302)
100 K megohms or 1000 megohms - µF minimum, whichever is less

Dielectric Strength
250% of rated Vdc

Life Test (1,000 hours)
200% rated voltage at +125°C

Moisture Resistance (MIL-STD-202-Method 106)

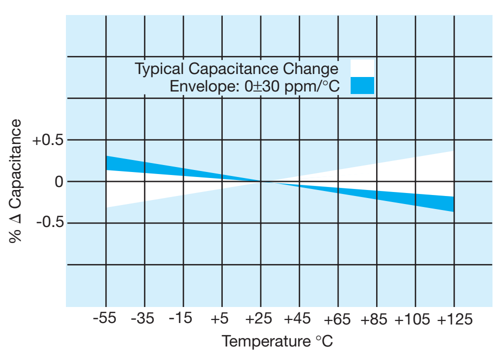
Thermal Shock (MIL-STD-202-Method 107, condition A, at rated elevated temperature)
-55°C to +125°C

Immersion Cycling (MIL-STD-202-Method 104, condition B)

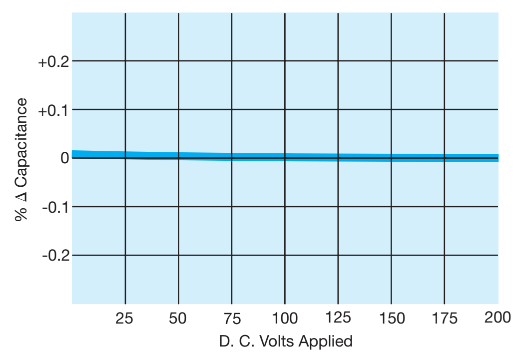
For current reliability information, consult factory.

TYPICAL CHARACTERISTICS

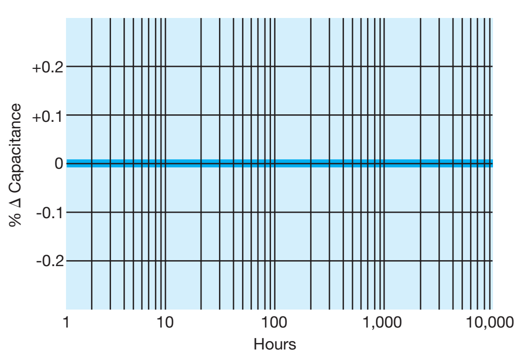
Temperature Coefficient



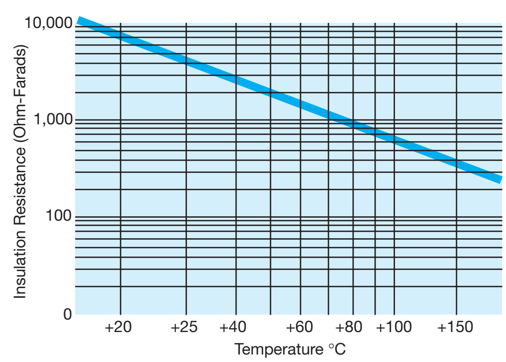
Voltage Coefficient



Aging Rate



Insulation Resistance vs. Temp.



X7R Dielectric “C”

GENERAL SPECIFICATIONS

Capacitance Range
See Individual Parts Specifications

Capacitance Test at 25°C
Measured at 1 VRMS max. at 1 KHz

Capacitance Tolerances
J = ±5%, K = ±10%, M = ±20%

Operating Temperature Range
-55°C to +125°C

Temperature Characteristic
± 15% (0 Vdc)

Voltage Ratings
200,100 & 50 Vdc

Dissipation Factor
2.5% max. at 1 KHz, 1 VRMS max.

Insulation Resistance 25°C (MIL-STD-202-Method 302)
100 K megohms or 1000 megohms - µF minimum, whichever is less

Dielectric Strength
250% of rated Vdc

Life Test (1,000 hours)
200% rated voltage at +125°C

Moisture Resistance (MIL-STD-202-Method 106)

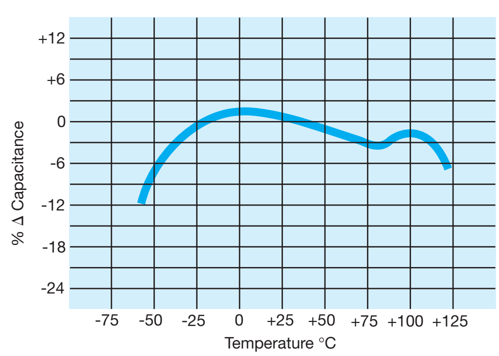
Thermal Shock (MIL-STD-202-Method 107, condition A, at rated elevated temperature)
-55°C to +125°C

Immersion Cycling (MIL-STD-202-Method 104, condition B)

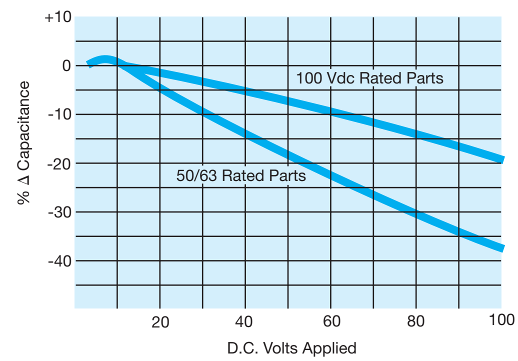
For current reliability information, consult factory.

TYPICAL CHARACTERISTICS

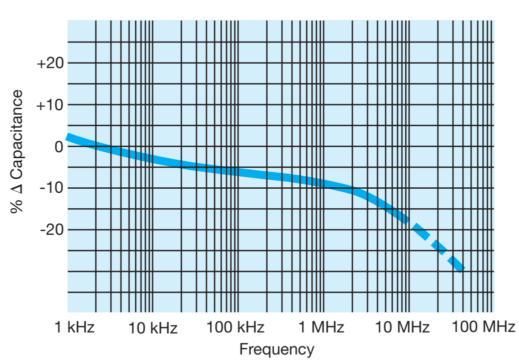
Temperature Coefficient



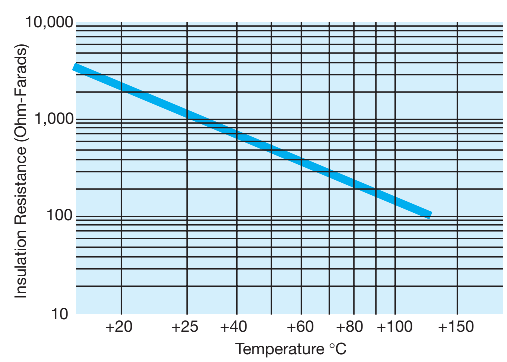
Voltage Coefficient



Δ Capacitance vs. Frequency



Insulation Resistance vs. Temp.



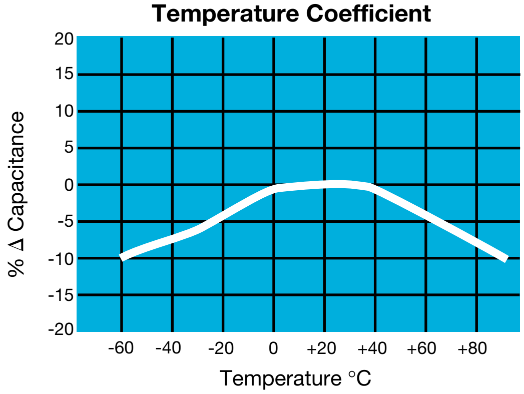
X5R Dielectric “D”

GENERAL DESCRIPTION

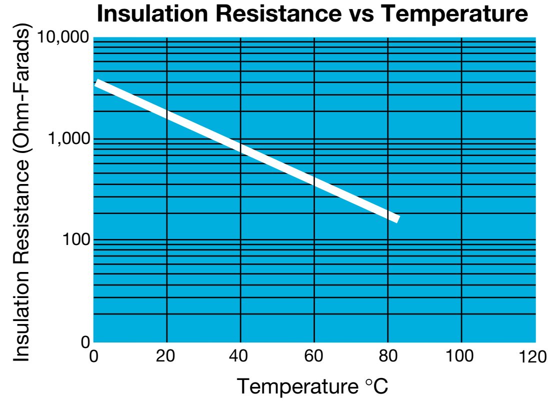
- General Purpose Dielectric for Ceramic Capacitors
- EIA Class II Dielectric
- Temperature variation of capacitance is within ±15% from -55ºC to +85ºC
- Well suited for decoupling and filtering applications
- Available in High Capacitance values (up to 100μF)

TYPICAL ELECTRICAL CHARACTERISTICS

Temperature Coefficient



Insulation Resistance vs Temperature



GENERAL INFORMATION

AVX AR Series

Conformally Coated Radial Leaded MLC

Temperature Coefficients: C0G (NP0), X7R, X8R

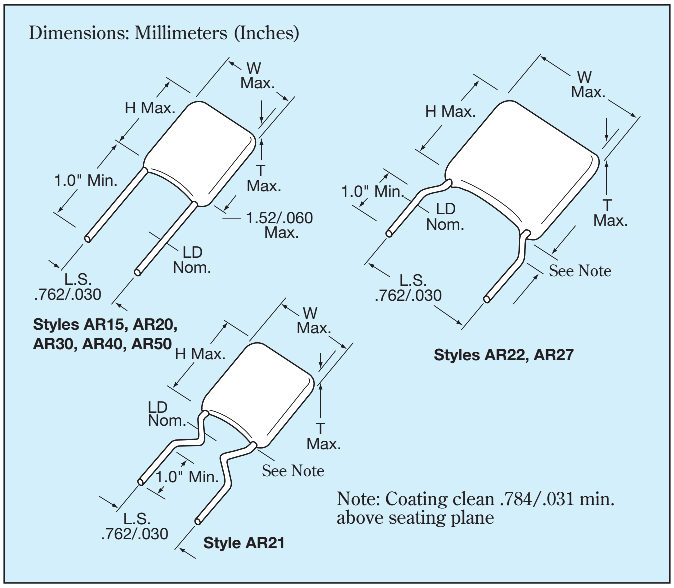
200, 100, 50 Volts

Case Material: Epoxy

Lead Material: Solderable

Qualified: to AEC-Q200

Temperature Range: up to 150ºC

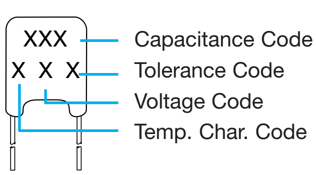


HOW TO ORDER

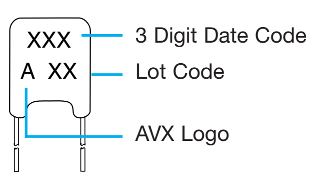
AR21	5	F	104	M	4	R
AVX Style	**Voltage** 5 = 50V 1 = 100V 2 = 200V	**Temperature Coefficient** A = C0G (NP0) C = X7R F = X8R	**Capacitance** First two digits are the significant figures of capacitance. Third digit indicates the additional number of zeros. For example, order 100,000 pF as 104. (For values below 10pF use "R" in place of decimal point, e.g., 1R4 = 1.4pF.)	**Capacitance Tolerance** C0G (NP0): C = ±.25pF D = ±.5pF F = ±1% (>50pF only) G = ±2% (>25pF only) J = ±5% K = ±10% X7R: J = ±5% K = ±10% M = ±20% X8R: J = ±5% K = ±10% M = ±20%	**Failure Rate** 4 = AEC-Q200	**Leads** T = Trimmed Leads .230" ± .030" A = Long Leads 1.0" minimum (Other lead lengths are available, contact AVX) R = RoHS Long Lead 1.0" minimum

MARKING

FRONT



BACK



PACKAGING REQUIREMENTS

	Quantity per Bag
AR15, 20, 21, 30	1000 Pieces
SR40	500 Pieces

Note: AR15, AR20, AR21, AR30, and AR40 available on tape and reel per EIA specifications RS-468. See pages 29 and 30.

Z5U Dielectric “E”

GENERAL SPECIFICATIONS

Capacitance Range
See Individual Parts Specifications

Capacitance Test at 25°C
Measured at 0.5 VRMS max. at 1 KHz

Capacitance Tolerances
M = ±20%, Z = +80%, -20%, P = GMV*

Operating Temperature Range
+10°C to +85°C

Temperature Characteristic
+22%, -56%

Voltage Ratings
100 & 50 Vdc

Dissipation Factor
4.0% max. at 1 KHz, .5 VRMS max.

Insulation Resistance 25°C (MIL-STD-202-Method 302)
10 K megohms or 100 megohms - μF minimum, whichever is less

Dielectric Strength
200% of rated Vdc

Life Test (1,000 hours)
150% rated voltage at +85°C

Moisture Resistance (MIL-STD-202-Method 106)

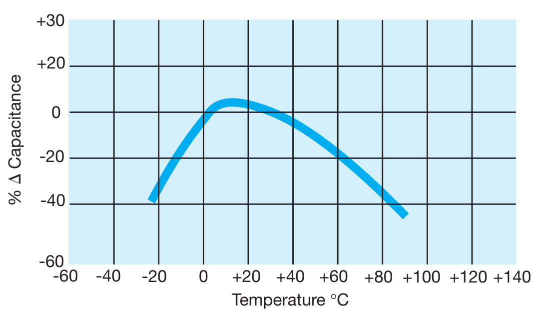
Immersion Cycling (MIL-STD-202-Method 104, condition B)

For current reliability information, consult factory.

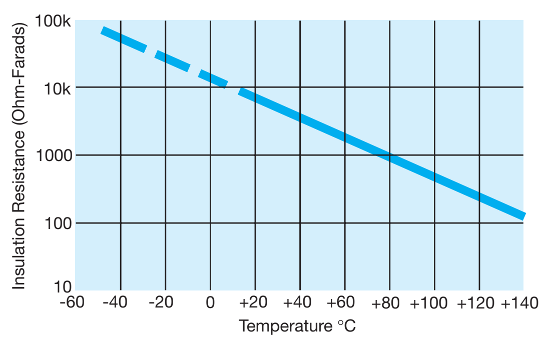
*Guaranteed Minimum Value

TYPICAL CHARACTERISTICS

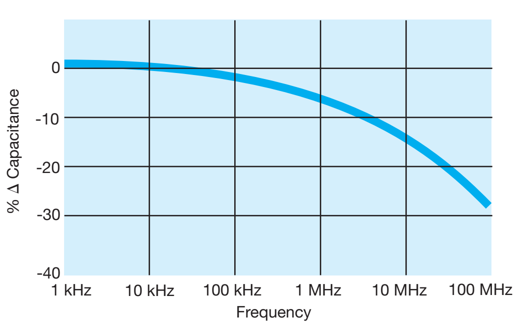
Temperature Coefficient



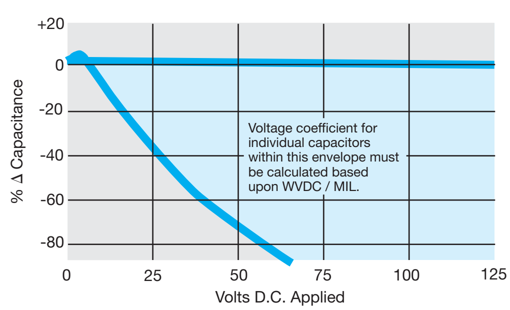
Insulation Resistance vs. Temp.



Δ Capacitance vs. Frequency



Voltage Coefficient



European Detail Specifications

CECC 30-601 & 30-701

SkyCap and Ceralam capacitors are available to European CECC specifications covering three standard dielectric materials: 1B/C0G, 2C1/X7R and 2F4/Y5V. The latter is available only with SkyCap capacitors.

To order use AVX part number with the Failure Rate code of "T" for CECC.

Molded Radial – CECC

	1B/A CECC 30 601 009 Issue 1			2C1/C CECC 30 701 007 Issue 1		
	50V	**100V**	**200V**	**50V**	**100V**	**200V**
B/MR05	1R0-682	1R0-472	1R0-332	221-224	221-154	221-393
C/MR06	1R0-223	1R0-153	1R0-123	122-105	122-474	122-124

SkyCap – CECC

SR15 = D2	SR20 = D6	SR21 = D7	SR30 = D11	SR40 = D15	SR50 = D14	SR65 = D16

	1B/A CECC 30 601 801 Issue 2				2C1/C CECC 30 701 801 Issue 2				2F4/E CECC 30 701 802 Issue 1	
	50V	**100V**	**200V**	**500V**	**50V**	**100V**	**200V**	**500V**	**50V**	**100V**
SR15	1R0-122	1R0-681	1R0-471	—	221-333	221-273	221-562	—	103-154	103-393
SR20	1R0-682	1R0-392	1R0-392	1R0-152	102-184	102-124	102-333	102-103	103-824	103-224
SR21	1R0-682	1R0-392	1R0-392	1R0-152	102-184	102-124	102-333	102-153	103-824	103-224
SR30	102-273	102-223	102-223	101-472	333-105	333-334	333-124	103-473	104-225	104-684
SR40	103-563	103-393	103-393	—	334-155	334-105	124-274	—	105-156	105-335
SR50	103-104	103-823	103-563	—	104-155	104-185	104-564	—	225-276	225-685
SR65	102-273	102-223	102-103	101-472	333-105	333-334	333-124	103-473	104-225	104-684