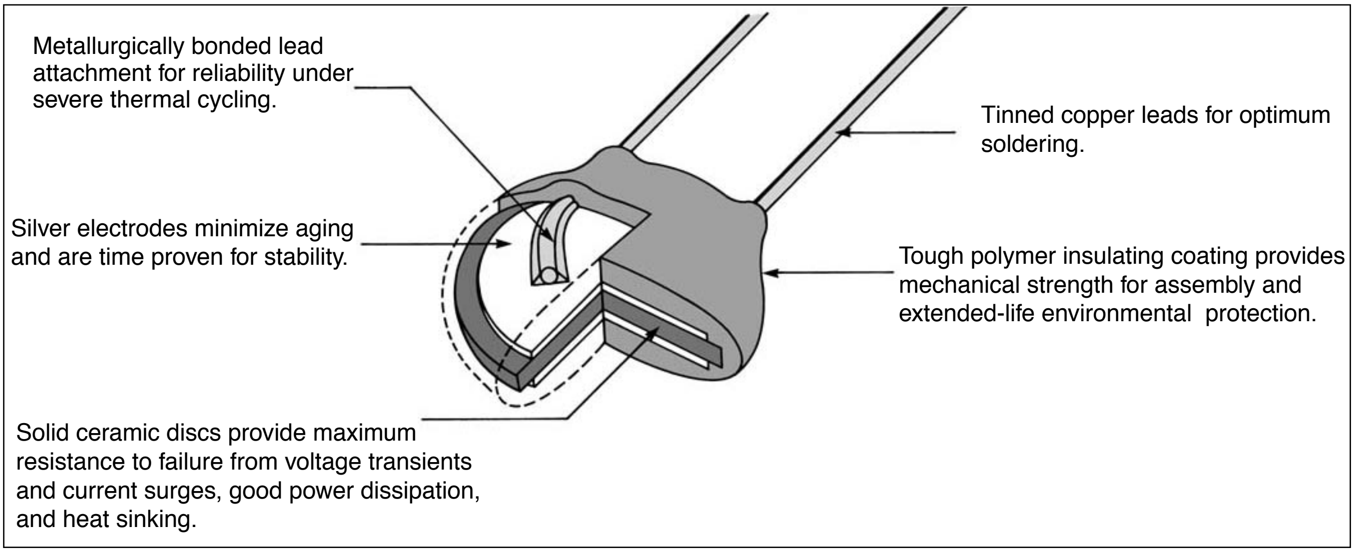
Application Data, Ceramic Disc Capacitors
1.0 Picofarad to 0.1 Microfarad

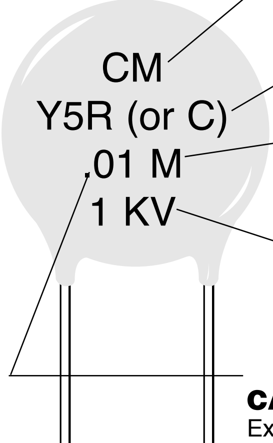
RELIABLE SOLUTIONS IN EMI/RFI, DECOUPLING, DV/DT & DI/DT, SNUBBERS, BY-PASS, ESR & ESL. EXCELLENT FOR HIGH VOLTAGE & SWITCHING POWER SUPPLIES.



MARKING INFORMATION

Wire leaded DC rated, disc capacitors are marked with a code identifying the manufacturer, capacitance, tolerance, voltage, and type of ceramic.

Specialty types such as AC rated are marked as described in those sections.



MANUFACTURER IDENTIFICATION
"Cera-Mite®" or the identification "CM."

TEMPERATURE COEFFICIENT
(See chart at right)

CAPACITANCE TOLERANCE

C = ± .25pF	M = ± 20%
D = ± .5pF	P = +100 – 0%
J = ± 5%	Y = –20 + 50%
K = ± 10%	Z = –20 + 80%

VOLTAGE
Rating normally DC volts. AC voltage rating marked AC or ~ ;. If no voltage is marked, part is 500VDC.

CAPACITANCE
Expressed in picofarads or microfarads.
Examples: 680 = 680 picofarads.
0047 = .0047 microfarads.

OPTIONAL MARKINGS
Lot Date Code and/or Customer Part Number are available options which may also be imprinted on the capacitor

TYPE OF CERAMIC (Temperature Coefficient)

CAPACITANCE CHANGE OVER TEMP. RANGE PPM PER DEGREE C	MARKING CODE FOR TEMP. RANGE –55˚ TO +125˚C				ALTERNATE MARKING CODE	DIELECTRIC CLASS
0 ± 30 (NPO)	C0G				A	I
–750 ± 120 (N750)	U2J				U	I
–1000 ± 250 (N1000)	M3K				V	I
–1500 ± 250 (N1500)	P3K				W	I
–2200 ± 500 (N2200)	R3L				X	I
–3300 ± 500 (N3300)	S3L				Y	I
–4700 ± 1000 (N4700)	T3M				Z	I & II*
MAX. % CHANGE	**+ 10˚ + 85˚C**	**– 30˚ + 85˚C**	**– 55˚ + 85˚C**	**– 55˚ + 125˚C**	**–**	**–**
± 4.7%	Z5E	Y5E	X5E	X7E	B	II
± 7.5%	Z5F	Y5F	X5F	X7F	B	II
± 10%	Z5P	Y5P	X5P	X7P	C	II
± 15%	Z5R	Y5R	X5R	X7R	C	II or IV**
± 22%	Z5S	Y5S	X5S	X7S	C	II or IV
+22 – 56%	Z5U	Y5U	X5U	X7U	E	III
+22 – 82%	Z5V	Y5V	X5V	X7V	F	III

* N4700 is a transition material between Class I and II, and has characteristics of both. It is used for larger cap values: capacitance and DF measured at 1 kHz.

** Class IV uses same material as Class II, but is processed differently.

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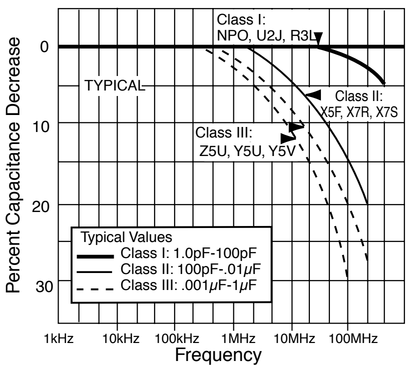
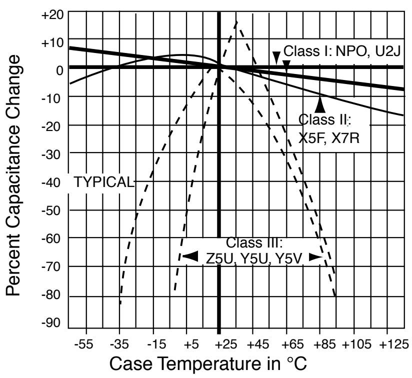
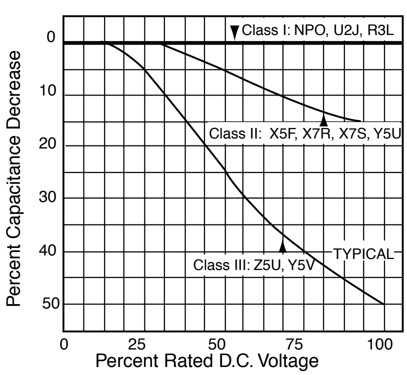
Capacitance Change vs. Frequency



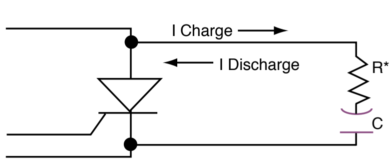
Capacitance Change vs. Temperature



Capacitance Decrease vs. D-C Voltage Bias



Ceramic Disc Capacitors as Snubbers



*Select R to limit dv/dt and di/dt to capacitor and semiconductor ratings. "Lossless" low dissipation factor discs are especially well suited for snubber service due to low self heating. See types 10TCU, 1DF0, 2DF0, and 3DF0.

CERAMIC DISC CAPACITOR APPLICATION NOTES

- **HIGH K:** For small size and higher values of capacitance, EIA 198D Class III, Z5U, Y5U, Y5V. This type is usually broad tolerance: ± 20% or + 80 – 20%.
- **MODERATELY HIGH K:** Materials are formulated to provide better capacitance stability against change in temperature and voltage, but may be larger in size than the HIGH K types, especially in the higher capacitance values, EIA 198D Class II, X5F, X7R, X7S. Usually tighter tolerance. ±10%at 25˚C. Higher dv/dt rating.
- **LOW K FORMULATIONS FOR PRECISION CAPACITORS:** Ultra stable capacitance over broadest temperature, frequency and voltage variation, EIA Class I, NP0, U2J, R3L and S3L. Usually ±5% tolerance. Highest dv/dt rating.
- **HYPERCON** construction gives highest capacitance density. Made by forming a thin dielectric barrier layer at each electrode surface. They exhibit very high capacitance and good temperature stability. Improvements have extended range to 100 VDC. EIA 198D Class IV.
- **CAPACITANCE MEASUREMENTS:** Class IV dielectric are conducted at 50 to 100 millivolts, 1000Hz. All others are measured at 1.0 volts, Class II & III at 1 kHz. Class I at 1 MHz.

FREQUENCY:

- Operating frequency range is determined primarily by capacitor value and self resonance due to lead inductance. This typically occurs at 500 MHz for 100 pF, decreasing to 50 MHz at .01 µF and 10 MHz at 0.1 µF.
- Class III and IV, typical applications are power and logic bus coupling and decoupling, and broad-band bypass filtering. Class I and II are chosen for frequency discriminating filters, d-c blocking, reference circuits, and similar circuits requiring close tolerance and stability.

TEMPERATURE:

- Capacitors are designed for service temperatures of –55˚C to +105˚C or greater. The limiting factor is the life of the polymer coating. Ceramic discs are not injured by short time exposure up to 125˚C.
- In applications where there is continuous heat dissipation in the capacitor, such as in snubber networks for power semiconductors, the case temperature rise should be limited to 30˚C. Class I, II and III may be used for snubber service. Low Dissipation Factor capacitors are especially well suited.

VOLTAGE:

- The extensive range of d-c voltage ratings available allows selection of the appropriate device to minimize d-c voltage effects in the circuit.
- A-C voltage ratings for capacitors up to 1000 volts applies to applications where energy and current are limited by circuit impedance. 1000 ohms impedance at the maximum a-c voltage rating is adequate.
- Ratings apply to 50 kHz. Above 50 kHz derate a-c voltage by $(freq./50kHz)^2$.

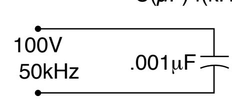
CURRENT:

- **For sinusoidal applied voltages:** I_{RMS}= 7VfC where V = rms Voltage; f =frequency; C = farads. Power dissipation may be approximated by Watts = $(I_{RMS})^2$ x Effective Series Resistance (ESR).

Approximate ESR values:

Class I, ESR = $\frac{100}{C(pF)\ f(MHz)}$ Ex.: 10pF ESR = 10 ohms at 1 MHz

Class II or III, ESR = $\frac{1}{C(\mu F)\ f(kHz)}$ Ex.: .001 µF ESR = 100 ohms at 10kHz

Ex.:


$I_{RMS} = 7 \times 100 \times (50 \times 10^3) \times (.001 \times 10^{-6}) = 35$ mA
Power Dissipation = $(35 \times 10^{-3})^2 \times 20 = .024$ watts

- **For nonsinusoidal applied voltage** (repetitive transient pulses) limit on peak current is: $Ip = \frac{dv}{dt} \times C$ where V = volts; T = seconds; C = farads; approximate $\frac{dv}{dt}$ limits:

≤ 100pF = 10,000V/µs, Class I	100pF - 1,000pF =2,000V/µs, Class II & III
>100pF = 5,000V/µs, Class I	1000pF - 10,000pF = 1,000V/µs, Class II & III
<100pF = 5,000V/µs, Class II	>10,000pF = 500V/µs, Class II & III
	>10,000pF = 100V/µs, Class IV

Example: .001 µF, Class II; $Ip = \frac{1000}{10^{-6}} \times (.001 \times 10^{-6}) = 1$ ampere peak

Note: Above calculations are typical. Actual circuit conditions may allow more or less current and voltage. Actual circuit test is recommended.