## Capacitor Dielectric Comparison Chart

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Multi-Layer Ceramics</th>
<th>Multi-Layer Glass-K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPO</td>
<td>Stable</td>
</tr>
<tr>
<td>Range, mfd</td>
<td>1pF</td>
<td>1pF</td>
</tr>
<tr>
<td>Min. Tol. %</td>
<td>±0.5%</td>
<td>±5%</td>
</tr>
<tr>
<td>T.C. % ± C</td>
<td>±0.3%</td>
<td>±15%</td>
</tr>
<tr>
<td>I.R.</td>
<td>&lt;1.0 mfd</td>
<td>10 MΩ</td>
</tr>
<tr>
<td></td>
<td>&gt;1.0 mfd</td>
<td>MΩ - mfd</td>
</tr>
<tr>
<td>Dissipation Factor</td>
<td>Percent</td>
<td>0.1%</td>
</tr>
<tr>
<td></td>
<td>Typical, %</td>
<td>0.6%</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>Freq. Response</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Max. Freq. (MHz)</td>
<td>For Δ C = ±10%</td>
</tr>
<tr>
<td>Stability (1000 Hrs.)</td>
<td>Typical Life Test, % Δ C</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

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Basic Capacitor Formulas

I. Capacitance (farads)
   English: $C = \frac{.224 \text{ K A}}{T_D}$
   Metric: $C = \frac{.0884 \text{ K A}}{T_D}$

II. Energy stored in capacitors (Joules, watt - sec)
   $E = \frac{1}{2} CV^2$

III. Linear charge of a capacitor (Amperes)
   $I = CV \frac{dV}{dt}$

IV. Total Impedance of a capacitor (ohms)
   $Z = \sqrt{R_S^2 + (XC - X_L)^2}$

V. Capacitive Reactance (ohms)
   $XC = \frac{1}{2\pi fC}$

VI. Inductive Reactance (ohms)
   $X_L = \frac{2\pi fL}{\text{V}}$

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) = $(2\pi f)(E.S.R.)$

IX. Power Factor (%)
   $P.F. = \sin \delta$ (loss angle) = $\cos \phi$ (phase angle)
   $P.F. = (\text{when less than 10%}) = DF$

X. Quality Factor (dimensionless)
   $Q = \cotan \delta$ (loss angle) = $1 / D.F.$

XI. Equivalent Series Resistance (ohms)
   $E.S.R. = (D.F.) \frac{X_C}{C}$

XII. Power Loss (watts)
   $\text{Power Loss} = 2\pi fCV^2 \times D.F.$

XIII. KVA (Kilowatts)
   $KVA = 2\pi fCV^2 \times 10^{-3}$

XIV. Temperature Characteristic (ppm/°C)
   $T.C. = \frac{C_{t} - C_{25} \times 10^6}{C_{25}(T_{t} - 25)}$

XV. Capac Drift (%)
   $C.D. = \frac{C_{1} - C_{2}}{C_{1}} \times 100$

XVI. Reliability of Ceramic Capacitors
   $D.F. = \frac{E.S.R.}{(2\pi fC)}$

XVII. Capacitors in Series (current the same)
   Any Number: $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}$

XVIII. Capacitors in Parallel (voltage the same)
   $C_T = C_1 + C_2 + \cdots + C_N$

XIX. Aging Rate
   $A.R. = \% \Delta C/$decade of time

XX. Decibels
   $db = 20 \log \frac{V_1}{V_2}$

METRIC PREFIXES

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Prefix</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Pico</td>
<td>$10^{-12}$</td>
<td>X</td>
</tr>
<tr>
<td>Nano</td>
<td>$10^{-9}$</td>
<td>P</td>
</tr>
<tr>
<td>Micro</td>
<td>$10^{-6}$</td>
<td>n</td>
</tr>
<tr>
<td>Milli</td>
<td>$10^{-3}$</td>
<td>m</td>
</tr>
<tr>
<td>Deci</td>
<td>$10^{-1}$</td>
<td>d</td>
</tr>
<tr>
<td>Kilo</td>
<td>$10^{3}$</td>
<td>k</td>
</tr>
<tr>
<td>Mega</td>
<td>$10^{6}$</td>
<td>M</td>
</tr>
<tr>
<td>Giga</td>
<td>$10^{9}$</td>
<td>G</td>
</tr>
<tr>
<td>Tera</td>
<td>$10^{12}$</td>
<td>T</td>
</tr>
</tbody>
</table>

SYMBOLS

- $K$ = Dielectric Constant
- $A$ = Area
- $T_D$ = Dielectric thickness
- $V$ = Voltage
- $t$ = time
- $L_o$ = Operating life
- $f$ = frequency
- $L$ = Inductance
- $\delta$ = Loss angle
- $\phi$ = Phase angle
- $X$ & $Y$ = exponent effect of voltage and temp.
- $R_s$ = Series Resistance

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