AVX

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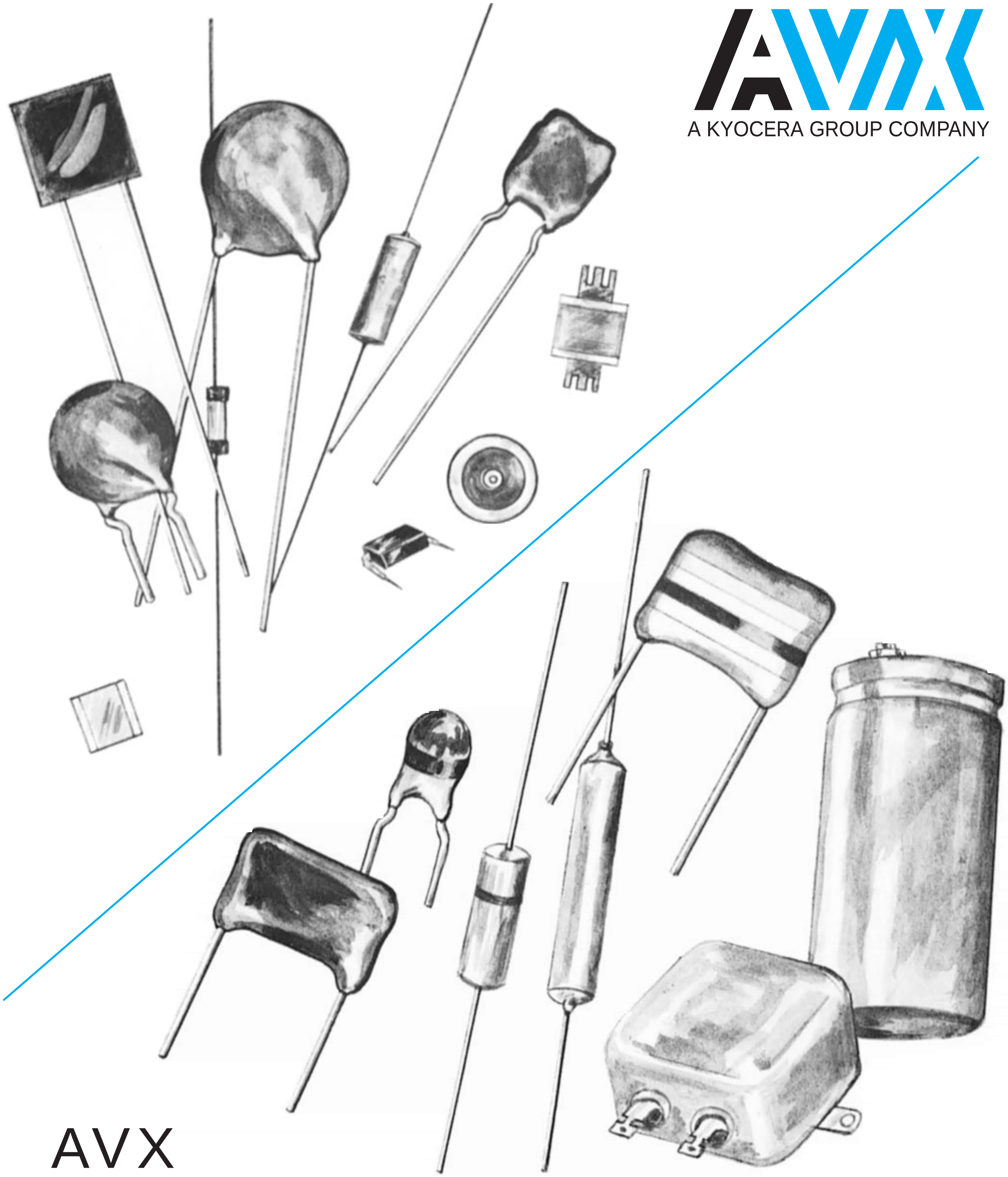

# AVX
# Dielectric Comparison Chart

# Capacitor Dielectric Comparison Chart

| Characteristics | | Multi-Layer Ceramics: NP0 | Multi-Layer Ceramics: Stable | Multi-Layer Ceramics: HiK | Ceramic Discs | Internal Barrier Layer | Reduced Titanates | Multi-Layer Glass | Multi-Layer Glass-K: "T" Characteristic | Multi-Layer Glass-K: "U" Characteristic | Multi-Layer Glass-K: "V" Characteristic | Mica | Polyester | Poly-carbonate | Poly-propylene | Poly-styrene | Solid Tantalums | Aluminum Electrolytics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacitance | Range, mfd | 1pF – .01µF | 1pF – 2.2µF | .001 – 10µF | 1pF 0.1µF | .01 – .22µF | .01 – 1.0µF | 0.5pF – .01µF | 270pF – .02µF | .012 – .039µF | .022 – .1µF | 1pF – .09µF | .001 – 10µF | .001 – 10µF | 47 – .047µF | 100pF – .027µF | .01 – 1000µF | 0.5 – $10^6$µF |
| | Min. Tol. Avail. % | ±0.5% | ±5% | ±20% | Same as Multi-layers | ±20% | ±20% | ±0.5% | ±5% | ±10% | ±10% | ±0.5% | ±5% | ±1% | ±0.5% | ±0.5% | ±5% | ±20% |
| | Std. Tol. % | ±5%, ±10% | ±10% | +80%, -20% | Same as Multi-layers | +80%, -20% | +80%, -20% | ±1%, ±5% | ±5%, ±10% | ±5%, ±10% | ±5%, ±10% | ±1%, ±5% | ±10% | ±10% | ±5% | ±5% | ±20% | +100%, -10% |
| Voltage Range | Typical, VDC | 50 – 200 | 50 – 200 | 25 – 100 | 50 – 10,000 | 50 | 3 – 50 | 50 – 2000 | 25 – 50 | 25 – 50 | 25 – 50 | 50 – 500 | 100 – 600 | 100 – 600 | 100 – 600 | 30 – 600 | 6 – 125 | 3 – 500 |
| Temperature | Range, °C | -55°C, +125°C | -55°C, +125°C | +10°C, +85°C and -55°C, +85°C | -55°C, +85°C | -55°C, +85°C | -55°C, +85°C | -75°C, +200°C | -75°C, +200°C | -75°C, +200°C | -75°C, +200°C | -55°C, +125°C | -55°C, +125°C | -55°C, +125°C | -55°C, +85°C | -55°C, +70°C | -55°C, +125°C | -40°C, +85°C |
| | T.C. %Δ C | ±0.3% | ±15% | +22%, –56% and –22%, –80% | Same as Multi-layers | ±30% | ±10%, ±30% | ±1.65% | +2%, –10% | –2%, –15% | +20%, –45% | -.4%, +1.8% | ±12% | ±2% | ±2.5% | ±1% | ±8% | ±10% |
| I.R. | <1.0 mfd | $10^5$ MΩ | $10^5$ MΩ | $10^4$ MΩ | Same as Multi-layers | $10^4$ MΩ | 10 MΩ | $10^5$ MΩ | $10^4$ MΩ | $10^4$ MΩ | $10^4$ MΩ | $10^2$ MΩ | $10^4$ MΩ | $10^5$ MΩ | $10^5$ MΩ | $10^6$ MΩ | $10^2$ MΩ | N.A. |
| | >1.0 mfd MΩ –mfd | N.A. | 2,500 | 1,000 | N.A. | N.A. | 0.1 | N.A. | N.A. | N.A. | N.A. | N.A. | $10^3$ | $10^4$ | N.A. | N.A. | 10 | 100 |
| Dissipation Factor | Percent At 1KHz, % | 0.1% | 2.5% | 3.0% | 0.1% to 4.0% | 5.0% | 5% to 10% | 0.2% | 1.0% | 1.5% | 3.0% | 0.1% | 2% | 1.0% | 0.35% | .1% | 8% to 24% | 8% (at 120 Hz) |
| Dielectric Absorption | Percent Typical, % | 0.6% | 2.5% | N.A. | Same as Multi-layers | N.A. | N.A. | .05% | 0.1% | 0.1% | 1.3% | 0.3% – 0.7% | 0.5% | 0.35% | .05% | .05% | N.A. | N.A. |
| Frequency Response | Freq. Response 10 = Best, 1 = Poorest | 9 | 8 | 8 | 8 | 3 | 2 | 9 | 8 | 8 | 8 | 7 | 6 | 6 | 6 | 6 | 5 | 2 |
| | Max. Freq. (MHz) For Δ C = ±10% | 100 | 10 | 10 | Same as Multi-layers | 10 | 1 | 100 | 100 | 75 | 10 | 100 | N.A. | N.A. | N.A. | N.A. | .002 | N.A. |
| Stability (1000 Hrs.) | Typical Life Test, %Δ C | 0.1% | 10% | 20% | Same as Multi-layers | 20% | 20% | 0.5% | 5% | 10% | 20% | 0.1% | 10% | 5% | 3% | 2% | 10% | 10% |
| Polarity | Single Cap | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | N.P. | P | P |

# 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) $= \frac{E.S.R.}{Xc} = (2 \pi fC)(E.S.R.)$

**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 π 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**

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

**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 | $X\ 10^{-12}$ | Deca | $X\ 10^{+1}$ |
| Nano | $X\ 10^{-9}$ | Kilo | $X\ 10^{+3}$ |
| Micro | $X\ 10^{-6}$ | Mega | $X\ 10^{+6}$ |
| Milli | $X\ 10^{-3}$ | Giga | $X\ 10^{+9}$ |
| Deci | $X\ 10^{-1}$ | 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 |
| $L_o$ | = Operating life | | | $R_S$ | = Series Resistance |


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