

## CAPACITOR RF CURRENT & POWER

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This note discusses the relationship of current handling, power dissipation, applied voltage and the maximum rated voltage of a multi-layer ceramic capacitor. Either the maximum voltage rating or the maximum power dissipation of the part limits the maximum current through a capacitor. The capacitance value and the operating frequency determine which of the two becomes the governing limit. For lower values of capacitance at a given frequency, or lower frequencies at a given capacitance, the voltage limitation is generally reached before the power dissipation limitation.

The voltage limitation depends on the capacitors reactive impedance ( $X_c$ ), where as the power dissipation depends on the resistive impedance or equivalent series resistance (ESR) of the capacitor.

$X_c$  is calculated by  $X_c=1/[2\pi FC]$ , where  $F$ = frequency in hertz and  $C$  = Capacitance in farads.

The maximum allowable peak current flow through a capacitor (without exceeding the capacitors rated voltage) is calculated by  $I=Er/X_c$ , where  $Er$  is the capacitors rated voltage, and  $I$  = the peak current flow in amperes.

The actual current flow through a capacitor is calculated by  $I=Ea/X_c$ , where  $Ea$  is the applied or working voltage.

The following examples illustrate how these variables effect the voltage/current limitation for some specific capacitors at a given frequency.

EXAMPLE 1: A 0.1 pF, 500 Volt capacitor is to be used at 1000 MHz:

$$X_c=1/[2(3.14)(1000 \times 10^6)(0.1 \times 10^{-12})]=1591 \text{ ohms};$$

$$I_{\text{peak}}=500/1591=0.315 \text{ A}_{\text{peak}} \text{ or } 0.22 \text{ Arms.}$$

If you exceed this current, you will exceed the voltage rating of the capacitor.

EXAMPLE 2: A 1.0 pF, 500 Volt capacitor is to be used at 1000 MHz:

$$X_c=1/[2(3.14)(1000 \times 10^6)(1.0 \times 10^{-12})]=159 \text{ ohms};$$

$$I_{\text{peak}}=500/159= 3.15 \text{ A}_{\text{peak}} \text{ or } 2.2 \text{ Arms.}$$

If you exceed this current, you will exceed the voltage rating of the capacitor.

EXAMPLE 3: A 10 pF, 500 Volt capacitor is to be used at 1000 MHz:

$$X_c=1/[2(3.14)(1000 \times 10^6)(10 \times 10^{-12})]=15.9 \text{ ohms};$$

$$I_{\text{peak}}=500/15.9=31.5 \text{ A}_{\text{peak}} \text{ or } 22.2 \text{ Arms.}$$

This current level is actually never reached because at this frequency, values over approximately 1.5 pF are limited by the power dissipation of the capacitor.

**IMPORTANT NOTE:** The power dissipation limited data assumes an infinite heat sink at the capacitor terminations. The heat transferred to the air is ignored.

The 10pF, 500V capacitor at 1000 MHz would actually be power limited to about  $7A_{\text{peak}}$  which is about 5 Arms. At this current level the temperature of the capacitor would rise to about 125 degrees C. For reliable operation, it would be practical to limit the current to 2 Arms with a decent heat sink, or even 3Arms if there is a very good heat sink at the terminations.