# 多层片式陶瓷电容器（MLCC）

# 技 术 交 流

## 电容器的射频电流与功率

## CAPACITOR RF CURRENT & POWER


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# 电容器的射频电流与功率 (中文译文)

这篇文章主要是讨论多层陶瓷电容器的加载电流、功率损耗、工作电压和最大额定电压之间的关系。通过电容的最大电流主要是由最大额定电压和最大功率损耗限制的。电容的容值和工作频率又决定了它们的限制是可调节。对于在固定频率下一个较低容值的电容或者是一个电容在较低的频率下工作，它们的最高电压极限一般都比最大功率损耗的极限到达快一些。

最大的额定电压决定于电容器的阻抗（Xc），就好像功率损耗决定于电阻的阻抗，或者叫做电容的等效电阻（ESR）

Xc 是由公式：Xc＝1/[2πFC] 计算出来，这里的 F 是频率，单位是 Hz；C 是容量，单位是 F。

在没有超出电容器的额定电压情况下，允许流过电容的最大电流峰值是这样计算出来的：I=Er/Xc 这里的 Er 是电容器的额定电压，电流是峰值电流，单位是 A。

流过电容的实际电流是这样计算出来：I=Ea/Xc，这里的 Ea 是应用电压或者是实际工作。

下面几个例子是讲解在固定的频率不同的电容器这些变数是怎样影响电压和电流的极限值。

例 1：0.1 pF，500V 的电容器使用在 1000MHZ 的频率上：

等效电阻：Xc=1/[2(3.14)(1000×106)(0.1x10－12)]＝1591 ohms

电流峰值：I=500/1591=0.315 Apeak 或 0.22 Arms.

如果超过这个电流，则工作电压将会超过额定电压。

例 2：1.0 pF, 500 V 的电容器使用在 1000MHZ 的频率上：

等效电阻：Xc=1/[2(3.14)(1000×106)(1.0x10－12)]＝159 ohms

电流峰值：I=500/159= 3.15 Apeak 或者 2.2 Arms

如果超过这个电流，则工作电压将会超过额定电压。

例 3：10 pF, 500 V 的电容器使用在 1000MHZ 的频率上：

等效电阻：Xc=1/[2(3.14)(1000×106)(10x10－12)]＝15.9 ohms

电流峰值：I=500/15.9= 31.5 Apeak 或者 22.2 Arms

如果超过这个电流，则工作电压将会超过额定电压。

结论：最大功率损耗值是在假设电容器的端头是一个无穷大的散热器情况下计算出来得。

这时传导到空气中的热量是忽略的。一个 10pF, 500V 的电容器工作在 1000MHZ 的频率，在功率极限下工作的电流峰值是 7A，平均电流大概是 5 Arms。在这种工作电流情况下，电容器的温度将会升到 125℃。为了稳定地工作，它的实际最大工作电流是 2 Arms，如果端头的散热效果很好可以到达 3Arms。

CAPACITOR RF CURRENT & POWER (英语原文)

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 (Xc), where as the power dissipation depends on the resistive impedance or equivalent series resistance (ESR) of the capacitor.

Xc is calculated by Xc=1/[2πFC], 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/Xc, 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/Xc, 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:

Xc=1/[2(3.14)(1000x106)(0.1x10-12)]=1591 ohms;

Ipeak=500/1591=0.315 Apeak or 0.22 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:

Xc=1/[2(3.14)(1000x106)(1.0x10-12)]=159 ohms;

Ipeak=500/159= 3.15 Apeak or 2.2 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:

Xc=1/[2(3.14)(1000x106)(10x10-12)]=15.9 ohms;

Ipeak=500/15.9=31.5 Apeak or 22.2 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 7Apeak 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.