三巨電子
SANJV ELECTRONIC

多层片式陶瓷电容器（MLCC）

技术交流

如何理解电容器的静电容量

HOW TO UNDERSTAND THE CAPACITANCE

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如何理解电容器的静电容量

A.电容量

电容器的基本特性是能够储存电荷（Q），而 Q 值与电容量（C）和外加电压（V）成正比。

$$Q = CV$$

因此充电电流被定义为：

$$= dQ/dt = CdV/dt$$

当外加在电容器上的电压为 1 伏特，充电电流为 1 安培，充电时间为 1 秒时，我们将电容量定义为 1 法拉。

C = Q/V = 库仑/伏特 = 法拉

由于法拉是一个很大的测量单位，在实际使用中很难达到，因此通常采用的是法拉的分数，即：

皮法（pF） = 10^{-12}F

纳法（nF） = 10^{-9}F

微法（mF）= 10^{-6}F

B.电容量影响因素

对于任何给定的电压，单层电容器的电容量正比于器件的几何尺寸和介电常数：

C = KA/f(t)
K = 介电常数
A = 电极面积
t = 介质层厚度
f = 换算因子

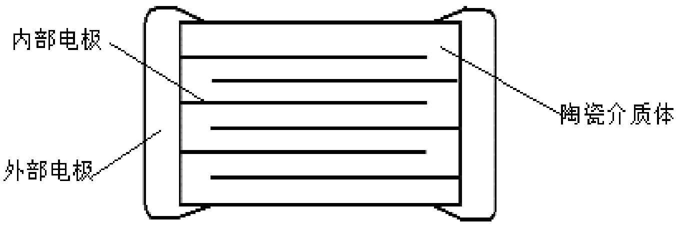
在英制单位体系中，f = 4.452，尺寸 A 和 t 的单位用英寸，电容量用皮法表示。单层电容器为例，电极面积 1.0×1.0″，介质层厚度 0.56″，介电常数 2500，

C = 2500（1.0）（1.0）/4.452（0.56）= 10027 pF

如果采用公制体系，换算因子 f = 11.31，尺寸单位改为 cm，

C = 2500（2.54）（2.54）/11.31（0.1422）= 10028 pF

正如前面讨论的电容量与几何尺寸关系，增大电极面积和减小介质层厚度均可获得更大的电容量。然而，对于单层电容器来说，无休止地增大电极面积或减小介质层厚度是不切实际的。因此，平行列阵迭片电容器的概念被提出，用以制造具有更大比体积电容的完整器件，如下图所示。



在这种“多层”结构中，由于多层电极的平行排列以及在相对电极间的介质层非常薄，电极面积 A 得以大大增加，因此电容量 C 会随着因子 N（介质层数）的增加和介质层厚度 t’的减小而增大。这里 A’指的是交迭电极的重合面积。

C = KA’N/4.452（t’）

以前在 1.0×1.0×0.56″的单片电容器上所获得的容量，现在如果采用相同的介质材料，以厚度为 0.001″的 30 层介质相迭加成尺寸仅为 0.050×0.040×0.040″的多层元件即可获得（这里重合电极面积 A’为 0.030×0.020″）。

C = 2500（0.030）（0.020）30/4.452（0.01）= 10107 pF

上面的实例表明在多层结构电容器尺寸相对于单层电容器小 700 倍的情况下仍能提供相同的电容量。因此通过优化几何尺寸，选择有很高介电常数和良好电性能（能在形成薄层结构后保持良好的绝缘电阻和介质强度）的介质材料即可设计和制造出具有最大电容量体积系数的元件。

HOW TO UNDERSTAND THE CAPACITANCE

A. CAPACITANCE

The principal characteristic of a capacitor is that it can store an electric charge (Q), which is directly proportional to the capacitance value (C) and the voltage applied (V).

Q = CV

The charging current I is therefore defined as

I = dQ/dt = CdV/dt.

The value of capacitance is defined as one Farad when the voltage across the capacitor is one volt, and a charging current of one ampere flows for one second.

C = Q/V = Coulomb/Volt = Farad

Because the Farad is a very large unit of measurement, and is not encountered in practical applications, fractions of the Farad are commonly used, namely:

picofarad (pF) = 10-12 Farad

nanofarad (nF) = 10-9 Farad

microfarad (mF) = 10-6 Farad

B.FACTORS AFFECTING CAPACITANCE

For any given voltage the capacitance value of the single plate device is directly proportional to the geometry and dielectric constant of the device:

C = KA/f(t)

K = dielectric constant

A = area of electrode

t = thickness of dielectric

f = conversion factor

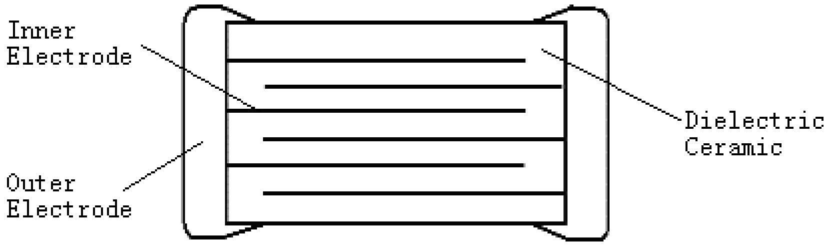
In the English system of units, f=4.452, and using dimensions in inches for A and t, the capacitance value is expressed in picofarads (pF). For example: for a single plate device, with a 1.0 X 1.0" area, .056" dielectric thickness, and a dielectric constant of 2500,

C = 2500 (1.0)(1.0)/4.452 (.056) = 10,027 pF

utilizing the Metric System, the conversion factor is f= 11.31, and dimensions are in centimeters.

C = 2500 (2.54)(2.54)/11.31 (.1422) = 10,028 pF.

As is evident from the above relationship of capacitance to geometry, greater capacitance can be achieved by increasing the electrode area while decreasing the dielectric thickness. As it is physically impractical to increase area in a single plate device with thinner dielectric, the concept of stacking capacitors in a parallel array was conceived to produce a physically sound device with more capacitance per unit volume, as illustrated in below Figure.



In this “multilayer” configuration, the area A is increased by virtue of many electrodes in parallel arrangement, in a construction permitting very thin dielectric thickness between opposing electrodes, such that the capacitance C is enlarged by the factor N (number of dielectric layers) and reduced dielectric thickness t’, where A’ is now the area of overlap of opposing electrodes。