

Capacitor Basics

Capacitor is a basic storage device to store electrical charges and release it as it is required by the circuit. In a simple form it is made of two conductive plates (Electrodes) and an insulating media (Dielectrics) which separate the electrodes.

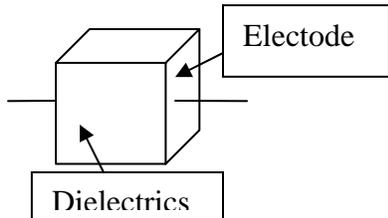


Fig 1. Basic single layer capacitor

As the voltage applies between the opposite electrode plates of a capacitor, electric field takes place between the plates and charges start accumulating on the surface of the electrodes. The charges (Q) on the capacitor plates depend on the voltage (V) and the capacitance value (C) and is as follows:

$$Q = C.V$$

Capacitors charges exponentially versus time and the charging current follows the following formula:

$$I = dQ/dt = C.dV/dt$$

The unit of capacitance measurement is in Farad (F). Due to the large value of Farad, capacitance is typically mentioned as a fraction of Farad as follows:

microFarad (uF) = 10^{-6} Farad

nanoFarad (nF) = 10^{-9} Farad

picoFarad (pF) = 10^{-12} Farad

There are so many dielectrics in industry. Each dielectric is characterized by its ability to store energy (dielectric constant K), dielectric strength, Insulation resistance, Temperature Coefficient (TC), High Frequency performance, etc...

Multilayer capacitor unlike single layer, is made of so many layers. This would allow the manufacturer to achieve higher capacitance values. (Fig 2)

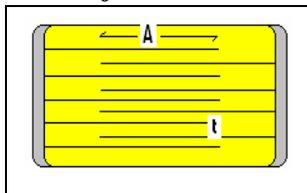


Fig 2: Multilayer Capacitor

The capacitance of a multilayer capacitor is calculated as follows:

$$C = K.A.n/4.44.t$$

C : Capacitance in uF

K : Dielectric Constant

A : Active area (in^2)

n : Number of layers

t : Active dielectric thickness (in^2)

As one can see, the higher capacitance value can be achieved by increasing the number of layers (n), decreasing the dielectric thickness (t), larger size or using higher dielectric constant (K) materials.

Typical ceramic capacitors are made with Barium Titanate ($BaTiO_3$) material. The dielectric constant of some of the common dielectrics used in the industry is as follows:

Vacuum	1.0	Mica	6.0
Air	1.004	Glass	4.0-18.0
Mylar	3.0	Barium Titanate	1500-2000
Paper	5.0	Other formulated ceramics	8000-20000