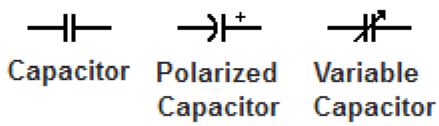
Capacitor

A **Capacitor** is a passive component that resists voltage changes. A capacitor consists of two conductive surface areas separated by a non-conductive medium called dielectric. The measurement of capacitance is in Farads. There are a variety of capacitor components, fixed, variable, or dependent on electrical or mechanical influences.

Capacitor Symbols



Capacitance

A capacitor is a device that stores electric charge. The voltage across the capacitor results in a charge stored within the capacitor. If the voltage applied to the capacitor changes, the capacitor will initially resist the change. It would resist by either charging or discharging, depending on the direction of changing voltage.

$$C = \frac{Q}{V} = \varepsilon \times \frac{A}{d}$$

Where ϵ is the permittivity of the capacitor's dielectric
A is the area of the capacitors plate
d is the distance between the plates
Q is electric charge
V is the voltage between the plates

Capacitor Impedance

The impedance of a capacitor is in reactance.

$$X_C = \frac{V_o}{I_o} = -\frac{V_o}{\omega C V_o} = -\frac{1}{\omega C}$$

$$X_C = -\frac{1}{2\pi f C}$$

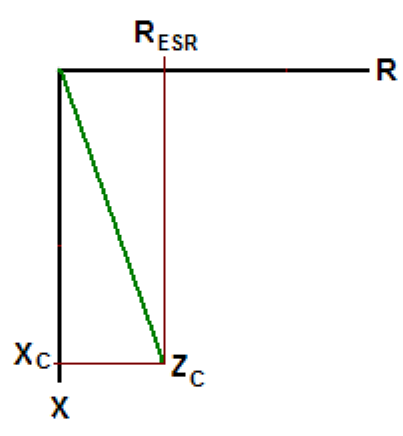
Here, we can see that the higher the frequency, the lower the reactance. Reactance decreases with increasing frequency. At DC voltage, the reactance is extremely high.

Ideal capacitors will store and release electrical energy without dissipation. Real capacitors will have imperfections that may be a factor at very high frequencies where the reactance of the capacitor becomes so low that the resistive component becomes significant. This resistance is known as ESR (Equivalent Series Resistor).

$$Z_C = R_{ESR} + jX_C$$

Where Z is impedance, R is the series equivalent resistance, and X is reactance. For the capacitor, the impedance is:

$$Z_C = jX_C = -j\frac{1}{\omega C}$$



Capacitor Circuits

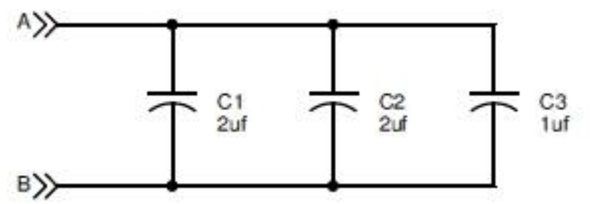
Capacitors in Parallel

Unlike resistors and capacitors, parallel capacitors increases capacitance. This can be seen as increasing capacitor plate surface with each parallel capacitor.

$$C_{Total} = C_1 + C_2 + \ ... + C_N$$

$$C_{Total} = 2uf + 2uf + 1uf$$

$$C_{Total} = 5uf$$



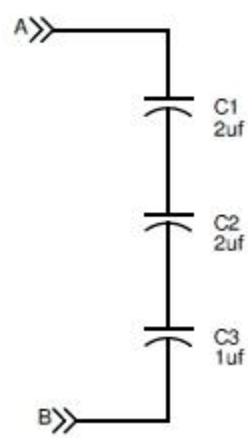
Capacitors in series

$$\frac{1}{C_{Total}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}$$

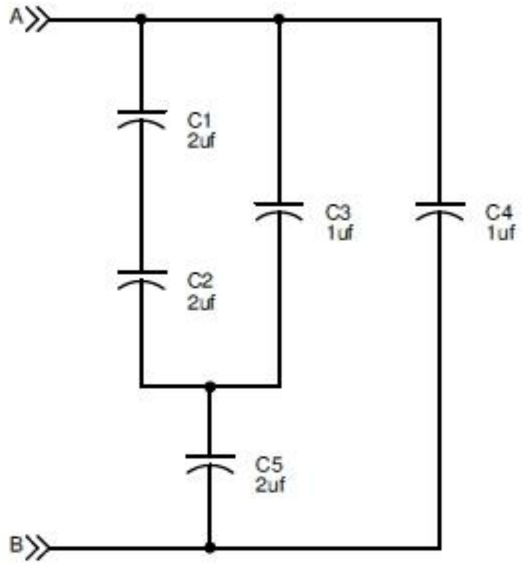
$$\frac{1}{C_{Total}} = \frac{1}{2uf} + \frac{1}{2uf} + \frac{1}{1uf}$$

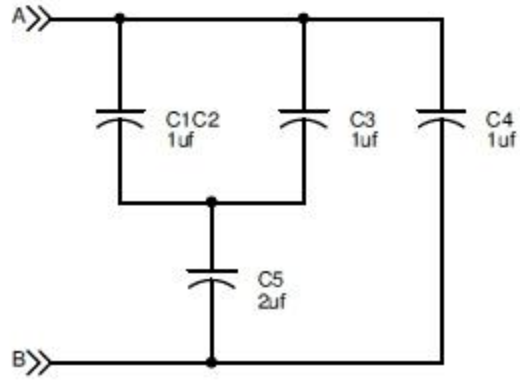
$$C_{Total} = \frac{1}{\frac{1}{2uf} + \frac{1}{2uf} + \frac{1}{1uf}}$$

$$C_{Total} = 0.5uf = 500nf$$



Mixed Series and Parallel Capacitors





First complete the series capacitors, then parallel. Here, C1 and C2 are added together, then with C3