Syllabus – Capacitors

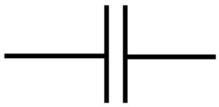
Introduction – Construction and working – Factors affecting Capacitance – Types of Capacitors – Fixed Capacitors – Non Electrolytic Capacitor – Electrolytic Capacitor – Variable Capacitors – Capacitors in Series and Parallel – Applications

Capacitors

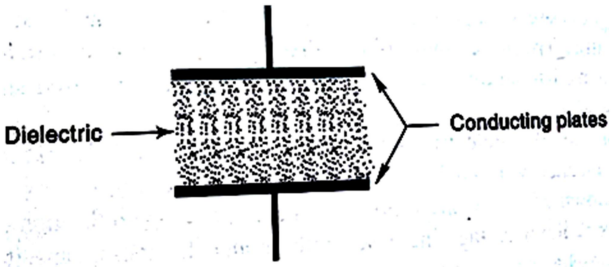
Introduction

Capacitor is a component which has the ability to store energy. It blocks dc and allows ac. The unit of capacitor is **Farads** (F)

Symbol



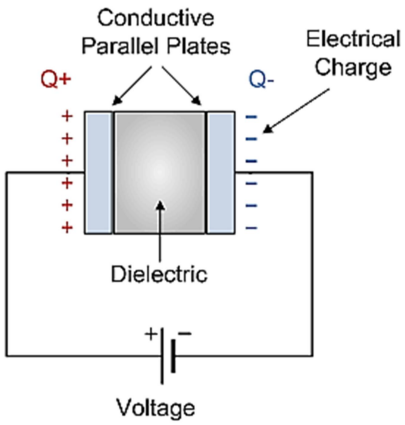
Structure



Construction

A capacitor has two parallel conducting plates which are separated by an insulator i.e. dielectric medium. The dielectric material may be air, mica, ceramic etc.

Working



Description

If a voltage source is connected across a capacitor where the positive terminal is connected to the positive terminal of a capacitor and negative terminal is connected to negative terminal of the capacitor. However, negative charge is collected on negative plate and positive charge is collected on the positive plate of capacitor. This process continues until the capacitor voltage reaches the supply voltage. When the capacitor voltage is equal to the supply voltage and capacitor is fully charged.

When the voltage source is removed, the capacitor remains charged. However, when the capacitor is connected to any load like electric bulb through a wire, it starts discharging.

Factors affecting capacitance:

The capacitance of a parallel plate capacitor is;

- directly proportional to the area (A) of each plate.
- inversely proportional to distance (d) between the plates.
- directly proportional to Permittivity of the dielectric material (ε).

Therefore,

$$C = \frac{\varepsilon A}{d} \quad \text{-------- (1)}$$

$$\varepsilon = \varepsilon_0 \varepsilon_r \text{ ------ (2)}$$

Substitute equation 2 in equation 1

The capacitance of a capacitor is given by

$$C = \varepsilon_0 \varepsilon_r A/d$$

Where A = Area of capacitor

d= Distance between plates

ε_0= Permittivity of free space

ε_r = relative permittivity of the material (or) dielectric constant of the medium between the plates.

Applications:

- The capacitor is used to store energy in the form of electricity.
- Capacitor is used in domestic as well as commercial appliances like as batteries, fans, cameras, coolers, electronic chargers, LED lights etc.,
- It is used in computers in cases of an emergency shutdown of the system.
- Capacitor is used in audio equipment and gadgets such as loudspeakers, microphones, etc.,
- It is also used in various sensors like position sensors, pressure sensors, etc.
- It is used for smoothening the voltage fluctuations in power supplies
- It is used in various communication devices like radio transmitters, receivers, wireless antennas, etc.
- It is used by Dynamic Random Access Memory (DRAM) devices to represent binary information as bits.
- Capacitor is used in tank circuits in electronic oscillators.

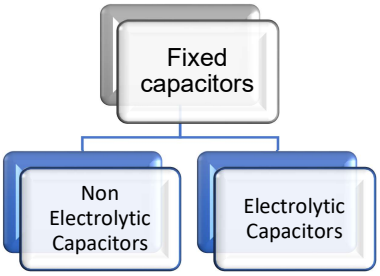
Types of Capacitors

- Fixed Capacitors
- Variable Capacitors

1. Fixed Capacitors

Fixed Capacitor is a capacitor whose capacitance value is fixed and cannot be changed.

Types of Fixed capacitor:

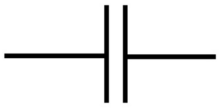


1.1 Non Electrolytic Capacitors

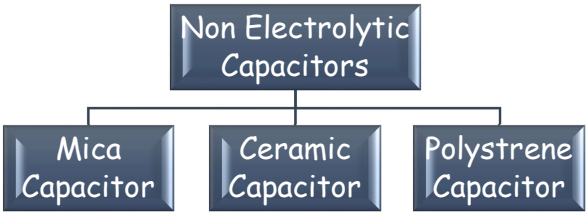
Introduction:

Non Electrolytic Capacitors have no Polarity. It can be connected in either direction.

Symbol



Types of Non Electrolytic capacitor

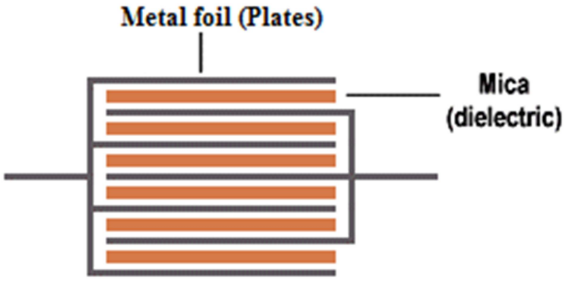


Mica Capacitor:

Introduction:

A Mica capacitor is a capacitor which uses mica as the dielectric.

Circuit Diagram:



Construction:

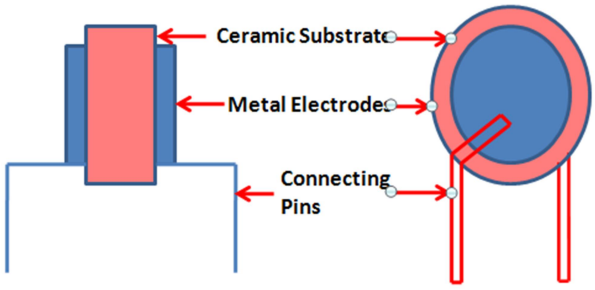
Mica capacitor is a sandwich of metal plates is separated by mica sheets. The alternate plates are connected together and leads are fixed at both ends of the plates. The entire assembly is covered with plastic. Its range is from 50 to 500 picofarads. It is used in radio & telecommunication applications.

Ceramic Capacitor

Introduction:

A Ceramic capacitor is a capacitor which uses ceramic as the dielectric.

Circuit Diagram:



Construction:

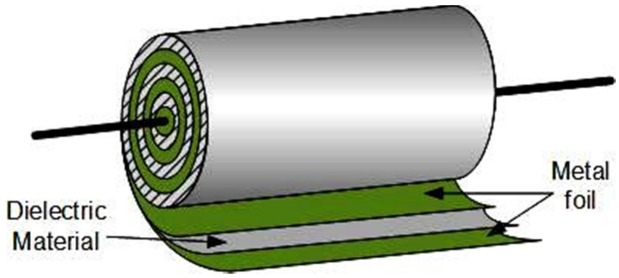
Ceramic capacitor is a sandwich of thin film of silver plates is separated by ceramic. Leads are fixed at both side of the disc and the entire assembly is covered with Plastic. Ceramic capacitors are available in disc & tubular form. Its range is from 10pf to 1μf. It is used as bypass & coupling capacitor.

Polystyrene capacitor

Introduction:

A Polystyrene capacitor is a capacitor which uses polystyrene as the dielectric.

Circuit Diagram:



Description:

In Polystyrene capacitors, the Aluminium foils are separated by polystyrene film. The leads are fixed at both ends. The entire assembly is covered with Plastic and heated carefully so that the plastic softens and makes good contact with the aluminium foils. Its range is from 10pf to 47nf. It is used in coupling & filter circuits

1.2 Electrolytic Capacitors

Electrolytic capacitor is a Polarized capacitor which uses an electrolyte to achieve a larger capacitance. Electrolytic capacitors have polarities.

Symbol:

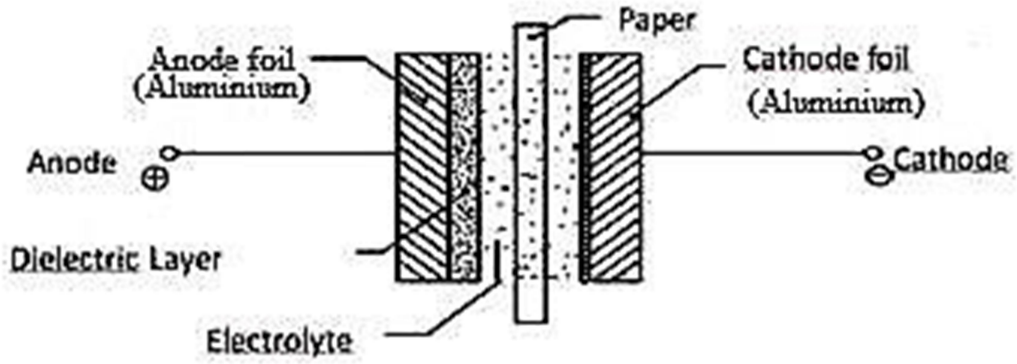
Types of Electrolytic Capacitors:

- Aluminium Electrolytic capacitor
- Tantalum Electrolytic Capacitor

Aluminium Electrolytic capacitors

Aluminium is used to form anode & cathode foils. Its shape is roller type.

Circuit Diagram:



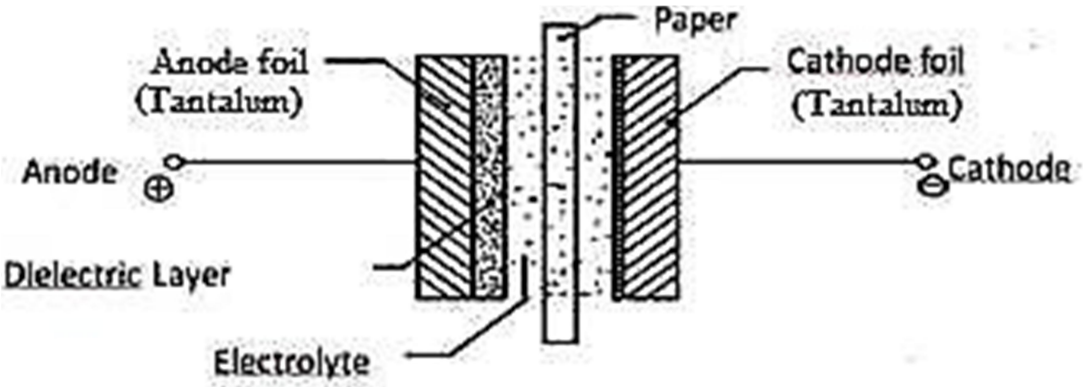
Description:

- Anode foil is made up of Aluminium
- The Aluminium oxide acts as dielectric which is deposited in the Anode.
- The cathode is also an Aluminium foil
- The cathode & oxide coated anode is separated by a paper spacer which is soaked in an electrolytic solution
- The paper spacer is used to prevent short circuit between anode & cathode foils

Tantalum Electrolytic capacitors

Tantalum is used to form anode & cathode foils. Its shape is roller type.

Circuit Diagram:



Description:

- Anode foil is made up of Tantalum
- The Tantalum oxide acts as dielectric which is deposited in the anode.
- The cathode is also an Tantalum foil
- The cathode & oxide coated anode is separated by a paper spacer which is soaked in an electrolytic solution
- The paper spacer is used to prevent short circuit between anode & cathode foils

Uses:

Electrolytic capacitors are used in filters, bypass capacitor & coupling capacitor

2. Variable Capacitors

The Variable capacitor is a capacitor whose capacitance value is varied. The capacitance value can be varied by rotating a shaft attached to the capacitor. It is made by using air, mica, ceramic or plastic as dielectric.

Symbol

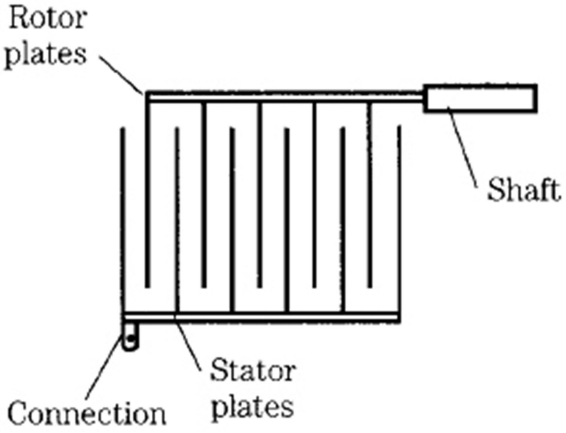
Types of Variable Capacitors:

- Variable capacitors with air as a dielectric
- Trimmers

2.1 Variable capacitors with air as a dielectric

The Variable capacitor uses air as a dielectric.

Circuit diagram



Description

The capacitors consist of two sets of metal plates separated from each other by air. One set of plate is fixed while other is rotatable & is connected to shaft. As the plates are moved in or out of fixed plates, the capacitance value varies.

2.2 Trimmer

Circuit Diagram:

Description:

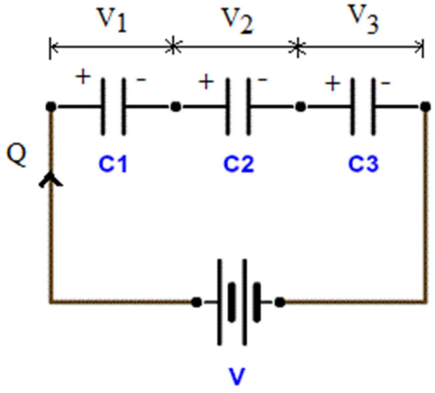
A trimmer has two small flexible metal plates are separated by dielectric like ceramic, mica or plastic. The spacing between the plates can be changed by a screw adjustment.

Capacitors in Series and Parallel

Capacitors in Series

Consider the capacitors C_1, C_2, C_3 are connected in Series

Circuit Diagram:



Analysis:

The charge on each capacitor is same while voltage across each Capacitor is different.

Voltage across each Capacitor C_1, C_2, C_3 is V_1, V_2, V_3 respectively.

Voltage across each capacitor $V = V_1 + V_2 + V_3$

Voltage across each capacitor $V = Q/C$, $V_1 = Q/C_1$, $V_2 = Q/C_2$, $V_3 = Q/C_3$

$$Q/C = Q/C_1 + Q/C_2 + Q/C_3$$

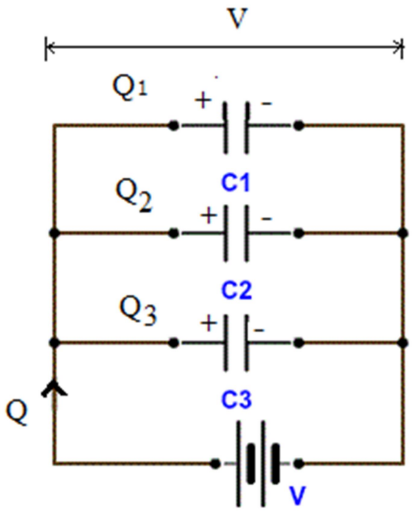
$$Q/C = Q\,(1/C_1 + 1/C_2 + 1/C_3)$$

$$\boxed{1/C = 1/C_1 + 1/C_2 + 1/C_3}$$

Capacitors in Parallel

Consider the capacitors C_1, C_2, C_3 are connected in Parallel.

Circuit Diagram:



Analysis:

Voltage across each capacitor is same while charge on the capacitor is different.

The charge on the capacitor C_1, C_2, C_3 is Q_1, Q_2, Q_3 respectively.

The charge on the capacitor $Q = Q_1+Q_2+Q_3$

$Q = CV$, $Q_1 = C_1V$, $Q_2 = C_2V$, $Q_3 = C_3V$

$CV = C_1V+C_2V+C_3V$

$CV = V(C_1+C_2+C_3)$

$$C = C_1+C_2+C_3$$