University of Al-Mustaqbal
College of Science
Department of Medical Physics

Electrical Material

First Stage

Lecture name : Capacitance

Lecture number : 5

Name of lecturer

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Introduction to Capacitance

1. What is Capacitance?

Capacitance is the ability of a system to **store electric charge** when a potential difference (voltage) is applied across it.
A device designed to store charge is called a **capacitor**.

A capacitor typically consists of:

- Two conducting plates
- Separated by an insulating material called a **dielectric**

❖ When a voltage is applied, positive charge accumulates on one plate and negative charge on the other.

2. Definition of Capacitance

Capacitance is defined as the ratio of the magnitude of the charge on one plate to the potential difference between the plates:

$C = Q/V$

Where:

- (C) = capacitance (Farads, F)
- (Q) = charge (Coulombs)
- (V) = potential difference (Volts)

3. Unit of Capacitance

The SI unit of capacitance is the **Farad (F)**:

1 F = 1 (Coulomb /Volt)

In practice, capacitors are usually measured in:

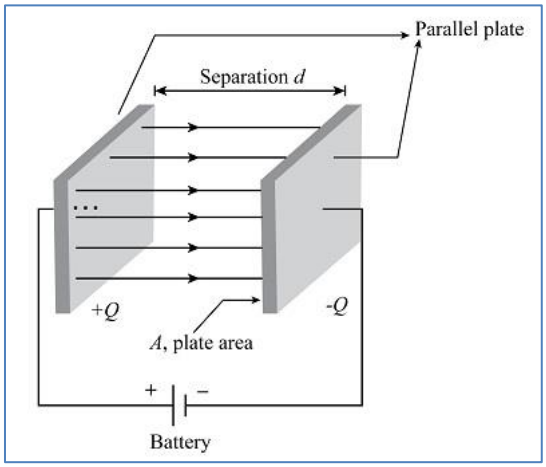
- microfarads (μF)
- nanofarads (nF)
- picofarads (pF)

Parallel-Plate Capacitor

1. Structure of a Parallel-Plate Capacitor

A parallel-plate capacitor consists of two large conducting plates of area (A), separated by a distance (d).

Diagram: Parallel-Plate Capacitor



2. Capacitance Formula

For a capacitor in vacuum or air:

$C = \varepsilon_0 (A / d)$

Where:

- ($\varepsilon_0 = 8.85 \times 10 - 12$ F/m)
- (A) = area of plates
- (d) = separation distance

❖ Capacitance increases when:

- Plate area increases
- Distance between plates decreases

3. Electric Field Between Plates

The electric field between the plates is uniform and given by:

$E = V/d$

Dielectrics and Capacitance

1. What is a Dielectric?

A **dielectric** is an insulating material placed between capacitor plates to increase capacitance.

Examples:

- Air
- Glass
- Plastic
- Ceramic

2. Effect of Dielectric

When a dielectric is inserted:

- The electric field decreases
- Capacitance increases

3. Capacitance with Dielectric

$C = K \varepsilon_0 (A / d)$

Where:

- K = dielectric constant (relative permittivity)

4. Polarization of Dielectric

Dielectric molecules become polarized in an electric field, reducing the effective field and allowing more charge to be stored.

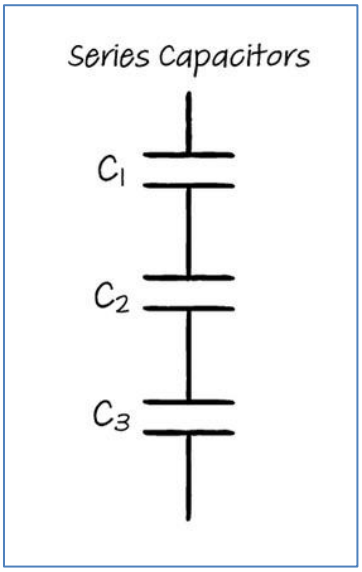
Capacitors in Circuits and Applications

1. Capacitors in Series

$1/C_{eq} = 1/C_1 + 1/C_2 + ...$

- Same charge on each capacitor
- Total capacitance decreases

Diagram: Series Capacitors



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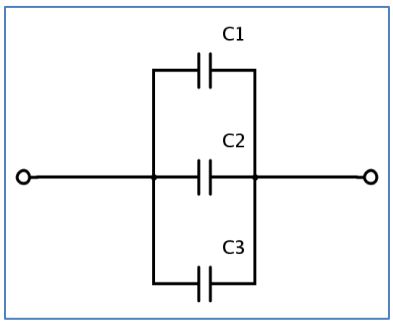
2. Capacitors in Parallel

$C_{eq} = C_1 + C_2 + C_3 + ...$

- Same voltage across each capacitor
- Total capacitance increases

Diagram: Parallel Capacitors



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3. Practical Applications

- Signal filtering
- Energy storage
- Timing circuits
- Medical equipment (ECG, MRI, defibrillators)