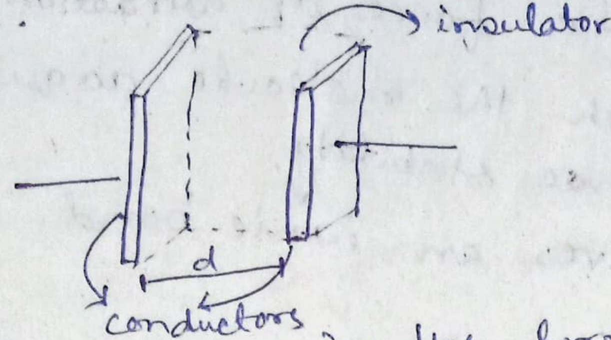
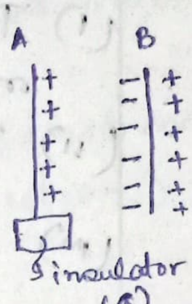
Capacitors:-

(1) **Definition**:- A capacitor is a system of two conductors separated by an insulator. It is arrangement for storing large amounts of electric charge and hence electrical energy in a small place.



(ii) They store energy in the form electrostatic potential energy during charging.

(iii) This energy can be used in electrical circuits when required.



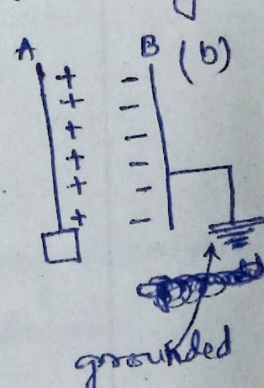
(2) **Principle of capacitor**:-

Let us consider an insulated metal plate A. Let some positive charge be given to this plate, till its potential becomes maximum. Assume, a attempt is made to store more positive charge, so that it can store more electrostatic potential energy.

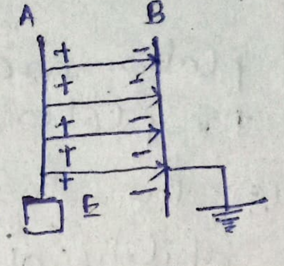
The way to achieve this, is to decrease the potential of the metal plate.

Let us assume, an uncharge metal B is brought near the metal plate A. Metal B has free electrons, so the positively charge A plate will attract them. So left surface of B will induce '-ve' charge and right side '+ve' charge. But the net charge on B is zero.

Now metal B is connected to ground. The +ve charge metal B will go to ground due to repulsion from metal A. But the '-ve' charge on metal B due to attraction from metal A



will not go to ground. Due to '+ve' and '-ve' charge existance, there is the appearance of electric field. Thus there occurs electrostatic potential energy and function as a energy storage device.



Due to the existance of metal plate B, there exist a '-ve' potential, which decreases the potential of metal A. Thus metal plate A can store more '+ve' charge. This is the basic principle of capacitor.

Conclusion:- The capacitance of an insulated conductor is increased considerably by bringing near it an uncharged earthed conductor. ⇒ this is the pricipal of capacitor.

☐ Electrical Capacitance:-

The ability of a conductor to store electric charge is called electrical capacitance.

$Q \propto V$

$Q = CV$

$\therefore C = \frac{Q}{V}$.

Q = charge provided to the capacitor

V = electrostatic potential energy or voltage.

C = electrical capacitance (const.)

SI unit of capacitance – Farad. voltage increase by $V = 1$ volt ⇒ measured electrical capacitance $Q = 1$ Cb and is called Farad.

☐ The capacitance of a capacitor is affected by the area of the plates, the distance between the plates, and the ability of the dielectrics to support electrostatic forces.

(a) As the area of plates increases, capacitance increases.

(b) Capacitance is directly proportional to the electrostatic force between the plates. This field is stronger when plates are closer. Therefore, as the distance between the plates decreases, capacitance increases.

(e) The higher the dielectric constant the greater the ability of dielectric to support electrostatic forces. Thus, as the dielectric constant increases, capacitance increases.

Supercapacitor

Supercapacitors:

a) Supercapacitors are electronic devices which are used to store extremely large amounts of electrical charge.
b) The charge is stored physically, with no chemical or phase changes taking place, the process is highly reversible and the discharge cycle can be repeated over and over again, virtually without limit.
c) They are also known as double-layer capacitors or ultracapacitors.
d) Instead of using a conventional dielectric, supercapacitors use two mechanisms to store electrical energy: double-layer capacitance and pseudocapacitance.

Types of Supercapacitors:

Supercapacitors are classified into three types:

1. Electrostatic double-layer capacitors
2. Pseudo-capacitors
3. Hybrid capacitors

○ Electrostatic Double Layer Capacitors:

a) These types of capacitor include two electrodes, a separator, and an electrolyte.
b) The electrolyte is the mixture that constitutes positive and negative ions dissolved in water.
c) The two electrodes are separated by a separator.
d) They store electrical charge in an electric double layer at the interface between a high-surface-area carbon electrode and a liquid electrolyte.
e) These supercapacitors use carbon electrodes or derivatives with much higher electrostatic double-layer capacitance.
f) The separation of charge in electrostatic double-layer capacitors is less than in a conventional capacitor; it ranges from 0.3–0.8 nm.

○ Pseudo Capacitors

a) Pseudo capacitors are also referred to as electrochemical pseudo-capacitors.
b) These capacitors make use of metal oxide or conducting polymer electrodes with a high amount of electrochemical pseudocapacitance.
c) These types of components store electrical energy by electron charge transfer between electrode and electrolyte. This can be done by a reduction-oxidation reaction commonly known as a redox reaction.

Capacitance Functionality

Applying a voltage at the capacitor terminals moves the polarized ions or charged atoms in the electrolyte to the opposite polarized electrode. Between the surfaces of the electrodes and the adjacent electrolyte an electric double-layer forms. One layer of ions on the electrode surface and the second layer of adjacent polarized and solvated ions in the electrolyte move to the opposite polarized electrode. The two ion layers are separated by a single layer of electrolyte molecules. Between the two layers, a static electric field forms that results in double-layer capacitance. Accompanied by the electric double-layer, some de-solvated electrolyte ions pervade the separating solvent layer and are adsorbed by the electrode's surface atoms. They are specifically adsorbed and deliver their charge to the electrode. In other words, the ions in the electrolyte layer also act as electron donors and transfer electrons to the electrode atoms, resulting in a faradaic current. This faradaic charge transfer, originated by a fast sequence of reversible redox reactions, electrosorptions or intercalation processes between electrolyte and the electrode surface is called pseudocapacitance.

- ### Hybrid capacitors

a) The hybrid capacitors are developed by using the techniques of double-layer capacitors and pseudo-capacitors.
b) In these components, electrodes with different characteristics are used. One electrode with the capacity to display electrostatic capacitance, and the other electrode with electrochemical capacitance.
c) Examples of hybrid capacitors: the lithium-ion capacitor.

Specifications of Supercapacitor:

1. Supercapacitors have high capacitances up to 2 kF.
2. These capacitors store large amounts of energy.
3. Supercapacitors bridge the gap between conventional capacitors and rechargeable batteries.
4. The charge time of a supercapacitor is 1–10 seconds.
5. These components can store electricity through either electrostatic charge absorption/desorption.

Applications of Supercapacitors:

Supercapacitors are used in the following:

1. Electric cars
2. Wind turbines
3. Photographic flash
4. Flywheel in machines
5. MP3 players
6. Regenerative braking in the automotive industry
7. Static memories (SRAM)
8. Industrial electrical motors