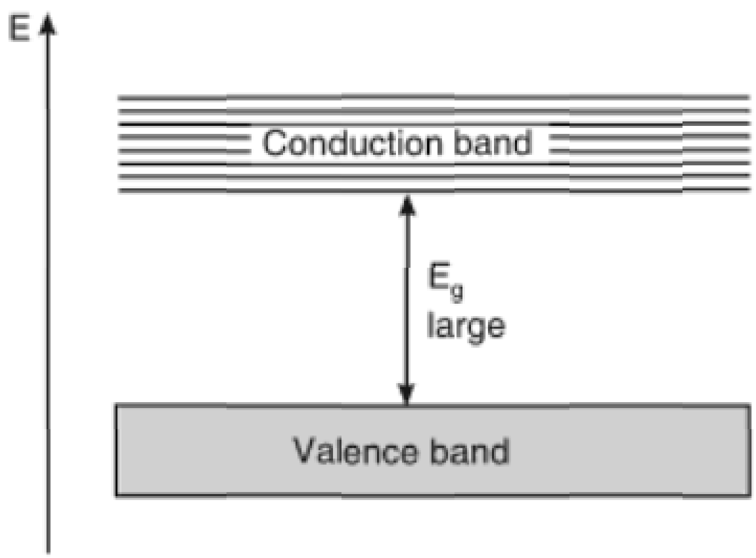
Dielectrics

- Dielectric materials are insulators.
- Insulating materials are used to resist the flow of current through it when a difference of potential is applied across its ends.
- **Dielectric materials** are used to store electrical energy.
- Dielectric materials are characterized **by dielectric constant**, **dielectric loss**, **dielectric strength** and **high resisitivity**.
- Eg. Ferroelectric materials exhibit very high dielectric constant and low dielectric loss.
- Dielectric materials have resisitivity range from 10^{10} to 10^{20} ohm-m



DIELECTRIC CONSTANT

$$\boxed{\boldsymbol{\varepsilon_r = \frac{C}{C_0}}}$$

where C_0 is the capacitance with air as the medium between the plates and C is the capacitance with dielectric as medium.

$\boldsymbol{\varepsilon}_r$ is called dielectric constant or relative permittivity. It is a dimensionless quantity, which is always greater than unity in case of dielectrics, and it is independent of the size or shape of the dielectric.

- $\boldsymbol{\varepsilon}_r$ describes the ability of the dielectric material to store electric charges.

$$\boxed{\boldsymbol{\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}}}$$

Where permitivity of the medium (ε) to the permitivity of free space (ε_0)

Electric Field Intensity or Electric Field Strength

Consider a point charge dq in the region of an electric field. Let F be the force acting on the point charge dq. The force per unit test charge dq is known as electric field strength (E), given by

$$E = \frac{F}{dq} = \frac{Q}{4\pi\varepsilon r^2}$$

From Coulomb's law, when two point charges Q_1 and Q_2 are separated by a distance r, the force of attraction or repulsion between the two charges is

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon r^2}\hat{n}$$

where ε is the permitivity or dielectric constant of the medium in which the charge is placed. For vacuum, $\varepsilon = \varepsilon_0 = 8.854 \times 10^{-12}$ F m^{-1}

Electric Flux Density or Electric Displacement Vector

The electric flux density or electric displacement vector D is the number of flux lines crossing a surface normal to the lines, divided by the surface area.
The electric flux density at a distance r from the point charge Q can be written as,

$$D = \frac{Q}{4\pi r^2}$$

where, $4\pi r^2$ is the surface area of a sphere of radius r.

We know that

$$E = Q/4\pi \varepsilon r^2$$

So,

$$\mathbf{D = \varepsilon E = \varepsilon_0 E + P}$$

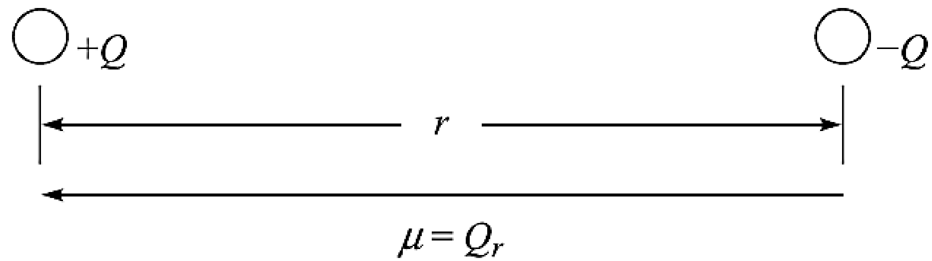
where P is the polarisation and it has the same unit as D, i.e., coulomb per square metre (Cm^{-2}).

Here D, E and P are three filed vectors

Dielectric Parameters

a. Dielectric constant (ε_r)
b. Electric dipole moment (μ)
c. Polarisation (P)
d. Polarisability (α).

Electric Dipole Moment



The arrangement of two equal and opposite charges + Q and – Q, separated by a distance r is known as **electric dipole**.
The product of magnitude of the charge and the distance of separation is known as **electric dipole moment (μ)**.

$$\boldsymbol{\mu = \text{charge x distance} = Qr}$$

The total dipole moment of a system constituting of point charges Q_1, Q_2, Q_3, ..,Q_n and the distances of separation r_1, r_2,.., r_n is

$$\mu_{\text{total}} = \sum_{i=1}^{n} Q_i \, r_i$$

Polarisation

polarisation: the induced dipole moment per unit volume.

$$\mathbf{P = \mu / \text{volume}}$$

Polarisability

$$\mathbf{P \propto E}$$

$$\mathbf{P = \alpha E}$$

where $\boldsymbol{\alpha}$ is a proportionality constant known as **polarisability**. The unit of α is F m^2.

- If the solid material contains N number of particles per unit volume, then the polarisation can be

$$\mathbf{P = N \alpha E}$$

where $\alpha = \alpha_e + \alpha_i + \alpha_0$. Here α_e, α_i and α_0 are the **electronic, ionic and orientation polarisability**