

2.6 DIELECTRIC CONSTANT AND STRENGTH

ELECTRIC FLUX (χ)

If the test charge is moved towards the charge Q , the test charge will experience force due to the main charge Q . The lines of force can be designated as electric flux which is equal to the charge itself. The electric flux (χ) emanates from electric charge Q .

$$\chi = Q$$

ELECTRIC FLUX DENSITY (D):

Electric flux density or Displacement density is defined as the electric flux per unit area

$$D = \frac{Q}{A} \text{ Coulomb/metre}^2$$

For sphere surface area

$$A = 4\pi r^2$$

Substitute A in D

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

But

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

Substitute D in E

$$E = \frac{D}{\epsilon}$$

$$D = \epsilon E$$

From dielectric polarization

$$D = \epsilon_0 E + P$$

$$D = \epsilon_0 E + \chi \epsilon_0 E$$

$$D = \epsilon_0 E (1 + \chi)$$

$$D = \epsilon_0 E (1 + \chi)$$

Substitute

$$\epsilon_R = 1 + \chi$$

$$D = \epsilon_0 E \epsilon_R$$

Substitute

$$\epsilon_R = \epsilon_r$$

$$\epsilon_r = 1 + \chi$$

$$D = \epsilon_0 E \epsilon_r$$

$$D = \epsilon_0 \epsilon_r E$$

$$D = \epsilon E$$

$$\epsilon = \epsilon_0 \epsilon_r$$

$$\epsilon_r = \frac{\epsilon}{\epsilon_0}$$

Equate both ϵ_r

$$\epsilon_r = \frac{\epsilon}{\epsilon_0} = 1 + \chi$$

The above equation is called as permittivity of dielectrics.

ϵ_0 is permittivity of free space.

ϵ_r is called dielectric constant or relative permittivity.

The dielectric constant or relative permittivity ϵ_r is the ratio of the permittivity of the dielectric to that of free space.

It should be noticed that ϵ_r and χ are dimensionless whereas ϵ and ϵ_0 are in farads per meter.

Dielectric breakdown is said to have occurred when a dielectric becomes conducting. Dielectric breakdown occurs in all kinds of dielectric materials and depends on the nature of the material, temperature, humidity and the amount of time that the field is applied. The minimum value of the electric field at which dielectric breakdown occurs is called the dielectric strength of the dielectric material.

The dielectric strength is the maximum electric field that a dielectric can tolerate or withstand without electrical breakdown.