$$E_3 = \int_0^{\pi} \frac{P\cos^2\theta \sin\theta \, d\theta}{2\varepsilon_0}$$

$$E_3 = \frac{P}{2\varepsilon_0} \int_0^{\pi} \cos^2\theta \sin\theta \, d\theta \qquad \therefore \int_0^{\pi} \cos^2\theta \sin\theta \, d\theta = \frac{2}{3}$$

$$E_3 = \frac{P}{2\varepsilon_0} x \frac{2}{3}$$

$$E_3 = \frac{P}{3\varepsilon_0} \qquad \ldots(12)$$

Substituting equation (12) in (2), we get

$$E_{int} = E + \frac{P}{3\varepsilon_0} \qquad \ldots(13)$$

Where E_{int} is called internal field or Lorentz field.

This equation (13) shows that E_{int} is different from E. The local intensity E_{int} is larger than the macroscopic intensity E. So the molecules are more effectively polarsied.

6.1 Clausius Mosotti Equations

If N be the number of molecules per unit volume and á the molecular polarizability then total polarization

$$P = N \alpha E_{int}$$

$$E_{int} = \frac{P}{N\alpha} \qquad \ldots(14)$$

Further, we know that

$$D = \varepsilon E = \varepsilon_0 E + P$$

$$(\varepsilon - \varepsilon_0)E = P$$

$$E = \frac{P}{(\varepsilon - \varepsilon_0)} \qquad \ldots(15)$$

Lorentz field is given by

$$E_{int} = E + \frac{P}{3\varepsilon_0} \qquad \ldots(16)$$

Substituting the eqn (14) & eqn (15) in eqn. (16) we get

$$E_{int} = \frac{P}{\varepsilon - \varepsilon_0} + \frac{P}{3\varepsilon_0}$$

$$= P\left[\frac{3\varepsilon_0 + \varepsilon - \varepsilon_0}{3\varepsilon_0(\varepsilon - \varepsilon_0)}\right]$$

$$E_{int} = \frac{P}{3\varepsilon_0}\left[\frac{\varepsilon + 2\varepsilon_0}{\varepsilon - \varepsilon_0}\right] \quad \ldots(17)$$

Comparing equation (14) and (17), we get

$$\frac{P}{N\alpha} = \frac{P}{3\varepsilon_0}\left[\frac{\varepsilon + 2\varepsilon_0}{\varepsilon - \varepsilon_0}\right]$$

$$\frac{N\alpha}{3\varepsilon_0} = \frac{\varepsilon - \varepsilon_0}{\varepsilon + 2\varepsilon_0}$$

$$= \frac{(\varepsilon / \varepsilon_0) - 1}{(\varepsilon / \varepsilon_0) + 2}$$

$$\frac{N\alpha}{3\varepsilon_0} = \frac{\varepsilon_r - 1}{\varepsilon_r + 2} \quad \left[\because \varepsilon_r = \frac{\varepsilon}{\varepsilon_0}\right] \quad \ldots(14)$$

The above equation is Clausius – Mosotti relation, which relates the dielectric constant of the material and polarisability. Thus, it relates macroscopic quantity dielectric constant with microscopic quantity polarisability.

7 DIELECTRIC LOSS

When a dielectric material is subjected to an alternating electric field, some amount of energy is absorbed by the material and is dissipated in the form heat. This loss of energy is called Dielectric loss.

The dielectric loss depends on the type of dielectric medium and the following factors.

i) Temperature ii) Humidity

iii) Applied voltage iv) Frequency

Theory

In an ideal dielectric material, the current leads the voltage by 90°. (i.e. no loss of energy) i.e. = 90°

But in a commercial dielectric material, the current leads the voltage by less than 90°. (i.e., there is loss of energy), i.e., the angle = 90° **-** is known as the dielectric loss angle.