Characteristics of TE and TM waves

→ Examination of field equations of TE and TM waves shows that for each component of E or H there is a sinusoidal or cosinusoidal standing wave distribution across the guide in the x-direction.

→ In y-direction, by assumption there is no variation of either magnitude or phase of any of the field components.

Thus an x-y plane is an equiphase plane for each of the field components.

→ All these equiphase surfaces progress along the guide in z direction with a velocity

$\bar{v} = \omega / \bar{\beta}$, $\bar{\beta}$ → phase constant.

imaginary part of the γ.

The propagation constant

$$\bar{\gamma} = \sqrt{h^2 - \omega^2 \mu \varepsilon} \rightarrow ①$$

$h^2 = \bar{\gamma}^2 + \omega^2 \mu \varepsilon$

$\gamma^2 = h^2 - \omega^2 \mu \varepsilon$

W.K.T $h = \frac{m\pi}{a}$

$$\therefore \bar{\gamma} = \sqrt{\left(\frac{m\pi}{a}\right)^2 - \omega^2 \mu \varepsilon} \rightarrow ②$$

$\bar{\gamma} = \bar{\alpha} + j\bar{\beta}$.

At high frequencies $\omega^2 \mu \varepsilon > \left(\frac{m\pi}{a}\right)^2$

Therefore eq ② becomes

$$\bar{\gamma} = \bar{\alpha} + j\bar{\beta} = \sqrt{-\left(\omega^2\mu\varepsilon - \left(\frac{m\pi}{a}\right)^2\right)}$$

$$\bar{\alpha} + j\bar{\beta} = j\sqrt{\omega^2\mu\varepsilon - \left(\frac{m\pi}{a}\right)^2}$$

$$\therefore \bar{\alpha} = 0$$

cut off frequency

$$\bar{\beta} = \sqrt{\omega^2\mu\varepsilon - \left(\frac{m\pi}{a}\right)^2} \rightarrow ③$$

As the frequency is decreased, a critical frequency is reached at which

$$\omega_c^2\mu\varepsilon = \left(\frac{m\pi}{a}\right)^2 \qquad \boxed{f_c = \frac{\omega_c}{2\pi}}$$

$$\omega_c^2 = \frac{1}{\mu\varepsilon}\left(\frac{m\pi}{a}\right)^2$$

$$\omega_c = \frac{1}{\sqrt{\mu\varepsilon}}\left(\frac{m\pi}{a}\right)$$

$$2\pi f_c = \frac{1}{\sqrt{\mu\varepsilon}}\left(\frac{m\pi}{a}\right)$$

$$\therefore f_c = \frac{1}{2\cancel{\pi}\sqrt{\mu\varepsilon}}\left(\frac{m\cancel{\pi}}{a}\right)$$

$$\boxed{f_c = \frac{m}{2a\sqrt{\mu\varepsilon}}} \rightarrow ④$$

For each value of m, there is a corresponding cut off frequency below which wave propagation can not occur.

wave length ($\bar{\lambda}$)

The distance required for the phase to shift through 2π radians is a wavelength.

$$\bar{\lambda} = \frac{2\pi}{\bar{\beta}}$$

$$\bar{\lambda} = \frac{2\pi}{\sqrt{\omega^2 \mu \varepsilon - \left(\frac{m\pi}{a}\right)^2}} \rightarrow (5)$$

<u>phase velocity (or) wave velocity</u>

$$\bar{V} = \bar{\lambda} f = \frac{2\pi f}{\bar{\beta}} = \frac{\omega}{\bar{\beta}} \rightarrow (6)$$

$$\therefore \bar{V} = \frac{\omega}{\sqrt{\omega^2 \mu \varepsilon - \left(\frac{m\pi}{a}\right)^2}} \rightarrow (7)$$