SNS COLLEGE OF ENGINEERING

(Autonomous)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19EC502 – TRANSMISSION LINES AND ANTENNAS

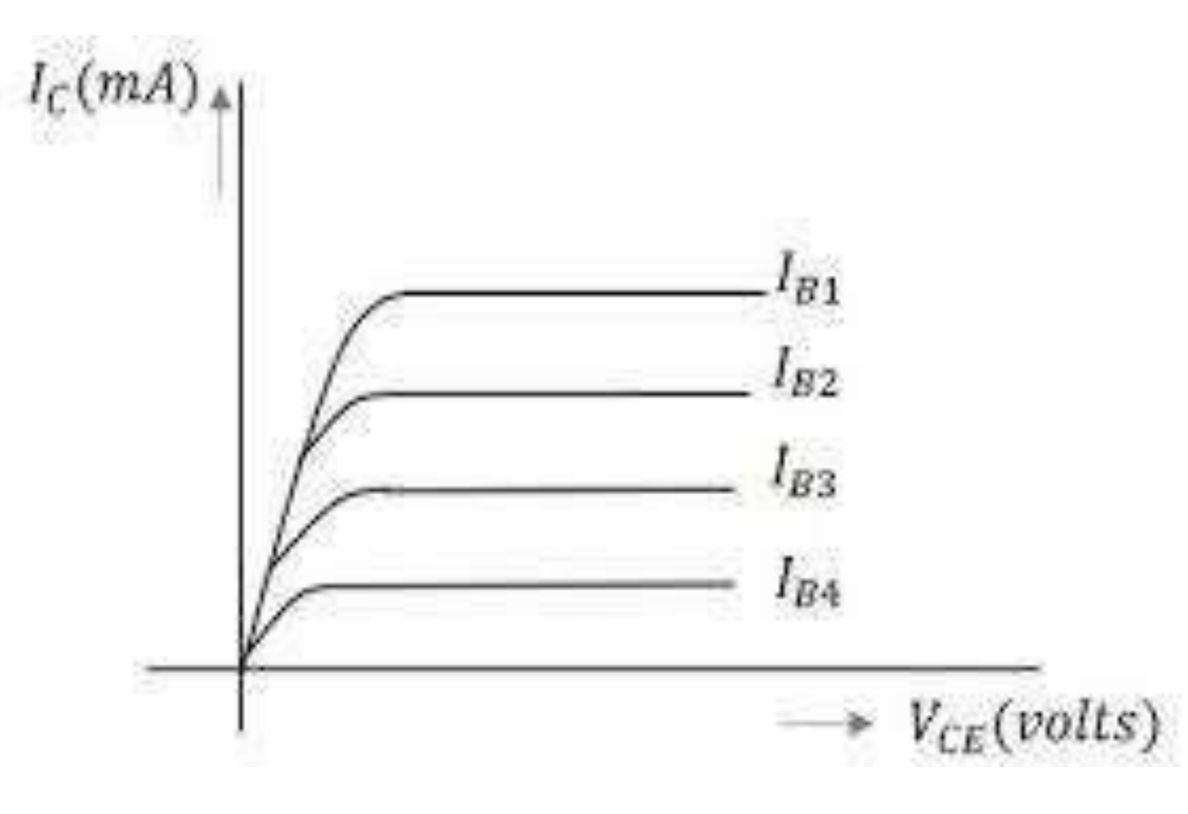
III YEAR/ V SEMESTER

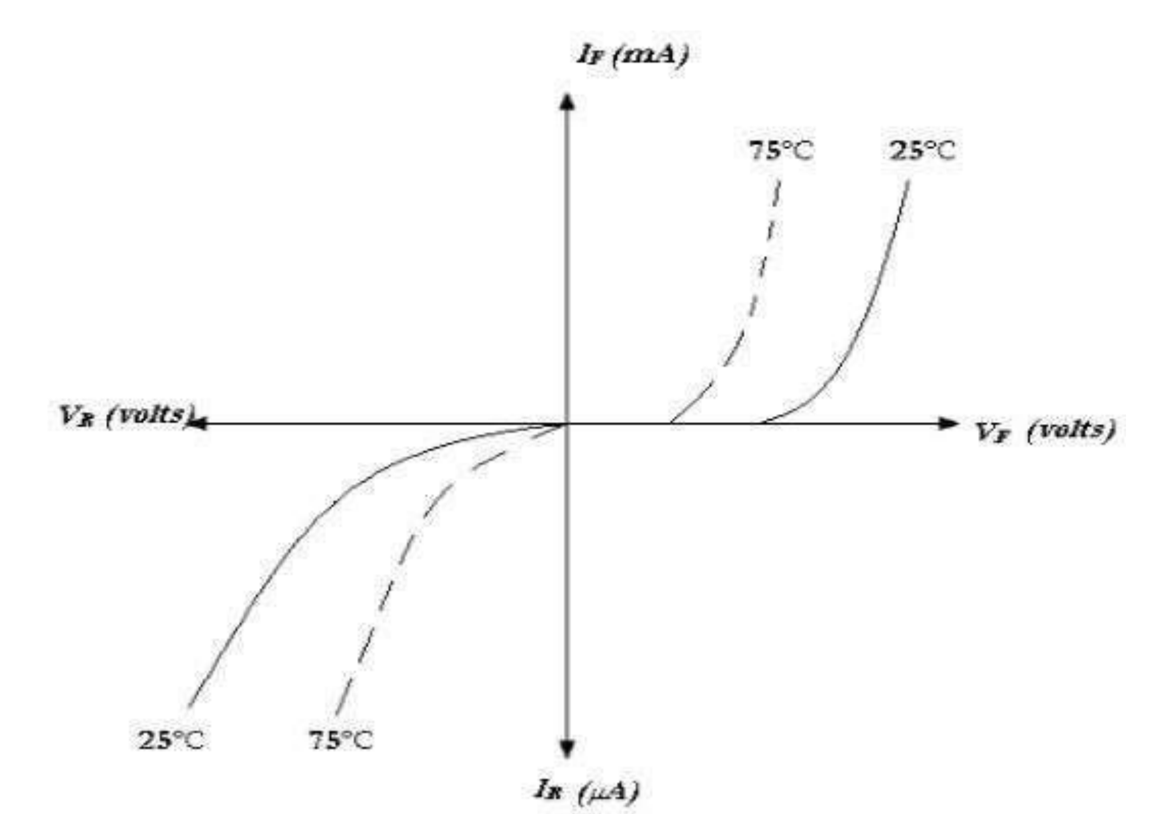
1

UNIT 2 – GUIDED WAVES

TOPIC 5 – CHARACTERISTICS OF TE AND TM WAVES

WHAT DO YOU INFER FROM THESE DIAGRAMS ?





TE & TM WAVE CHARACTERISTICS

→ 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.

TE & TM WAVE CHARACTERISTICS

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

TE & TM WAVE CHARACTERISTICS

Therefore eq (3) becomes

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

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

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

off frequency

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

TE & TM WAVE CHARACTERISTICS

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

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

$$f_c = \frac{\omega_c}{2\pi}$$

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

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

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

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

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

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

TE & TM WAVE CHARACTERISTICS

Wavelength ($\bar{\lambda}$)

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

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

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

TE & TM WAVE CHARACTERISTICS

Phase velocity (or) wave velocity

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

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