Transverse Electric waves:

Aim:

To study the transverse electric waves in Parallel Plates.

Objective: To find the TM wave equation

TE waves are waves in which the electric field strength E is entirely transverse.

It has a magnetic field strength H_z in the direction of propagation and no component of electric field E_z in the same direction $[E_z = 0]$.

From eq. 19 & 16

$$E_x = 0, \; H_y = 0$$

The wave equation

$$\frac{\partial^2 E_y}{\partial x^2} + \gamma^2 E_y = -\omega^2 \mu \varepsilon E_y$$

$$\frac{\partial^2 E_y}{\partial x^2} + \gamma^2 E_y + \omega^2 \mu \varepsilon E_y = 0$$

$$\frac{\partial^2 E_y}{\partial x^2} + h^2 E_y = 0$$

This is a diff. equation of simple harmonic motion.

The soln. of this equation is given by,

$$E_y = c_1 \sin hx + c_2 \cos hx$$

$c_1, c_2 \rightarrow$ arbitrary constants.

If E_y is expressed in time and direction.

$$E_y = E_y^0 e^{-\gamma z}$$

$$E_y = [c_1 \sin hx + c_2 \cos hx] e^{-\gamma z}$$

The tangential comp. of E is zero @ the surface of conductors for all values of z.

$$E_y = 0 \quad @ \quad x = 0$$

$$E_y = 0 \quad @ \quad x = a$$

Applying the first boundary condition $[x = 0]$.

$$E_y = [c_1 \sinh x + c_2 \cosh x] e^{-\gamma z}$$

$$0 = 0 + c_2 = c_2 = 0$$

$$E_y = c_1 \sinh x \, e^{-\gamma z}$$

Applying the second boundary conditions

$x = a$

$$E_y = 0 = [c_1 \sinh x + c_2 \cosh x] e^{-\gamma z}$$

$$= [c_1 \sinh a + c_2 \cosh a] e^{-\gamma z}$$

$$E_y = 0 = c_1 \sinh a$$

$$h = m\pi/a \qquad m = 1, 2, 3 \ldots$$

$$E_y = c_1 \sin\left[\frac{m\pi}{a}\right] x \, e^{-\gamma z} \rightarrow (23)$$

$$\frac{dE_y}{dx} = c_1 \cos\left[\frac{m\pi}{a} x\right] \left(\frac{m\pi}{a}\right) e^{-\gamma z}$$

$$= \frac{m\pi}{a} c_1 \cos\left[\frac{m\pi}{a} x\right] e^{-\gamma z} \rightarrow (23)$$

From eq. (9)

$$\gamma E_y = -j\omega\mu H_x$$

$$\frac{dE_y}{dx} = -j\omega\mu H_z$$

$$H_x = \frac{j\gamma E_y}{\omega\mu} \rightarrow (24)$$

Sub eq. (23) in (24)

$$H_x = \frac{-\gamma}{j\omega\mu} \left[c_1 \sin\left[\frac{m\pi}{a} x\right] e^{-\gamma z}\right]$$

From eq. (9) $H_z = \frac{-1}{j\omega\mu} \frac{dE_y}{dx}$

$$= \frac{-1}{j\omega\mu}\left[\frac{m\pi}{a} c_1 \cos\left[\frac{m\pi}{a}x\right] e^{-\gamma z}\right]$$

$$H_z = \frac{j\, m\pi}{\omega\mu a} c_1 \cos\left[\frac{m\pi}{a}x\right] e^{-\gamma z}$$

The field strength for TE waves b/w ||el plates are

$$E_y = c_1 \sin\left[\frac{m\pi}{a}x\right] e^{-\gamma z}$$

$$H_x = \frac{j\gamma}{\omega\mu} c_1 \sin\left[\frac{m\pi}{a}x\right] e^{-\gamma z}$$

$$H_z = \frac{j\, m\pi}{\omega\mu a} c_1 \cos\left[\frac{m\pi}{a}x\right] e^{-\gamma z}$$

Each values of m specifies a particular field of configuration or mode and the wave associated with integer m is designated as TE_{m0} mode.

If $m=0$ $E_y = 0$ $H_x = 0$ $H_z = 0$

Lowest order mode TE_{10}

$\gamma = \alpha + j\beta$ $(\alpha = 0)$ $\gamma = j\beta$

$$E_y = c_1 \sin\left[\frac{m\pi}{a}x\right] e^{-j\beta z}$$

$$H_x = \frac{-\beta}{\omega\mu} c_1 \sin\left[\frac{m\pi}{a}x\right] e^{-j\beta z}$$

$$H_z = \frac{j\, m\pi}{\omega\mu a} c_1 \left[\cos\left[\frac{m\pi}{a}x\right]\right] e^{-j\beta z}$$

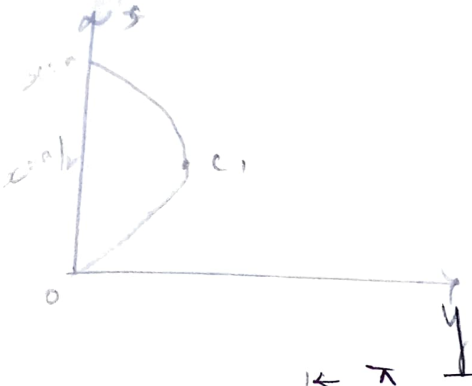
E_y as a fn. of x for TE_{10} mode @ $\beta z = 0$

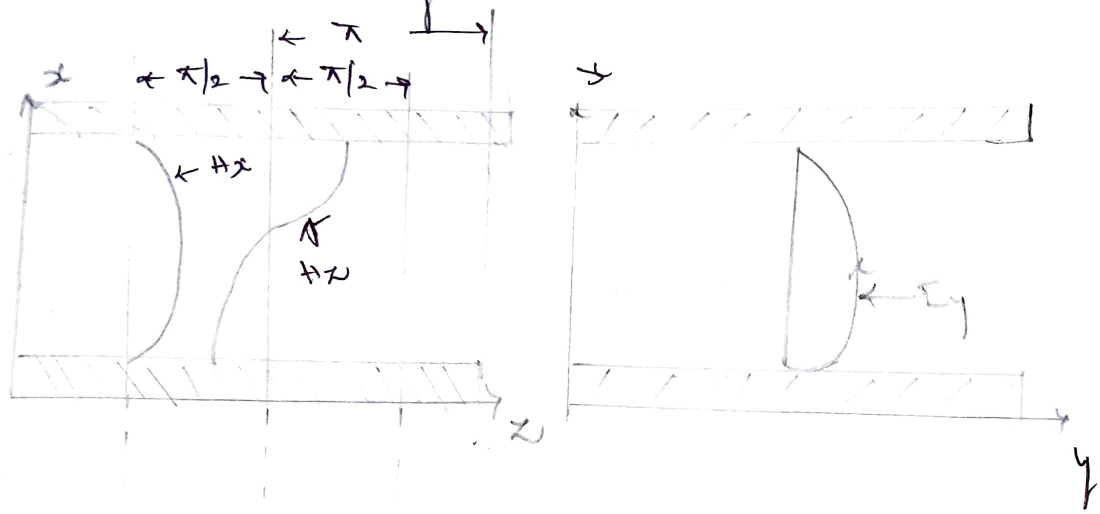
$$E_{y(x,y,t)} = c_1 \sin\left(\frac{\pi}{a}x\right)\cos(\omega t - \beta z)$$

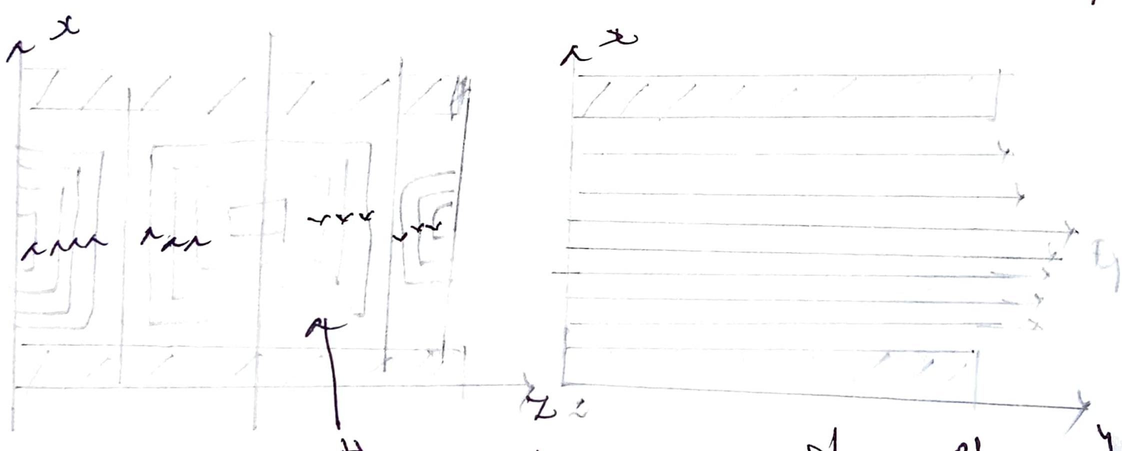
$$= c_1 \sin(\pi/a\, x) \cos\omega t$$

put $x = 0$ $x = a/2$ $x = a$

$E_y = 0$ $E_y = c_1 \cos\omega t$ $E_y = 0$







Electric and magnetic waves b/w ||el plates

outcome:

studied about the EM wave propagation b/w ||el plates.

Transverse magnetic waves:

Aim:

To learn TM wave propagation in Parallel plates.

objective: To know the TM wave equation