SNS COLLEGE OF ENGINEERING

(Autonomous)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

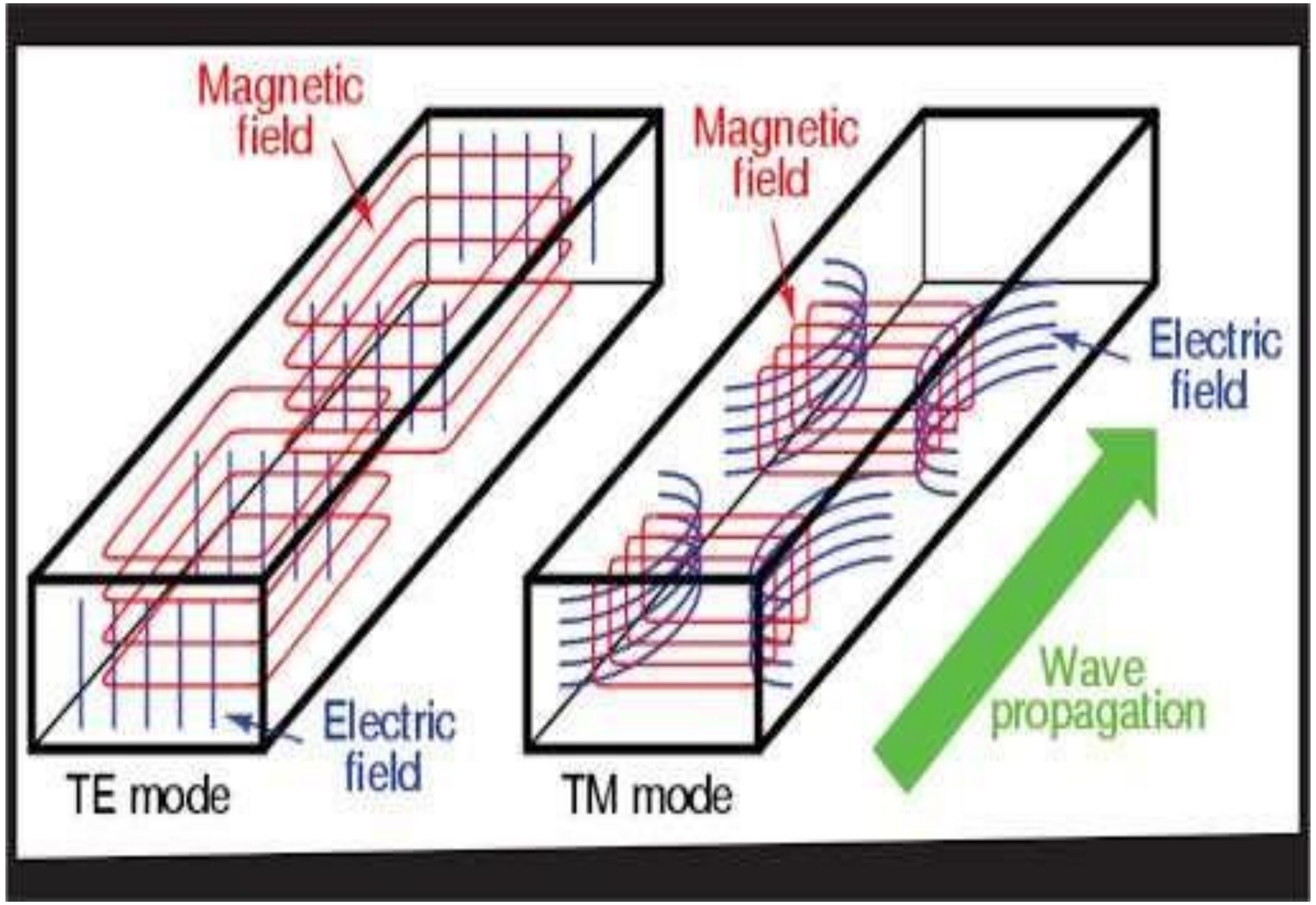
19EC502 – TRANSMISSION LINES AND ANTENNAS

III YEAR/ V SEMESTER

1

UNIT 2 – GUIDED WAVES
TE WAVES IN RECTANGULAR WAVEGUIDES

IDENTIFY THE DIFFERENCE BETWEEN TE & TM MODES



Reference : EngineeringDone.com

IDENTIFY THE DIFFERENCE BETWEEN TE & TM MODES

TE WAVES	TM WAVES
E Field is Transverse to the direction of wave propagation	H Field is Transverse to the direction of wave propagation
H field only present in the direction of wave propagation	E field only present in the direction of wave propagation
Also called H waves	Also called E waves
Hz, Hx & Ey fields exists	Ez, Ex & Hy Fields exists
Ez, Ex & Hy Fields zero	Hz, Hx & Ey fields zero

TE WAVES I RECTANGULAR WAVEGUIDES - ANALYSIS

- By Product solution method

  Hz = XY

- Where X – a function of x alone

  Y – a function of y alone

- Inserted in Wave equation for Hz and the solution was found.

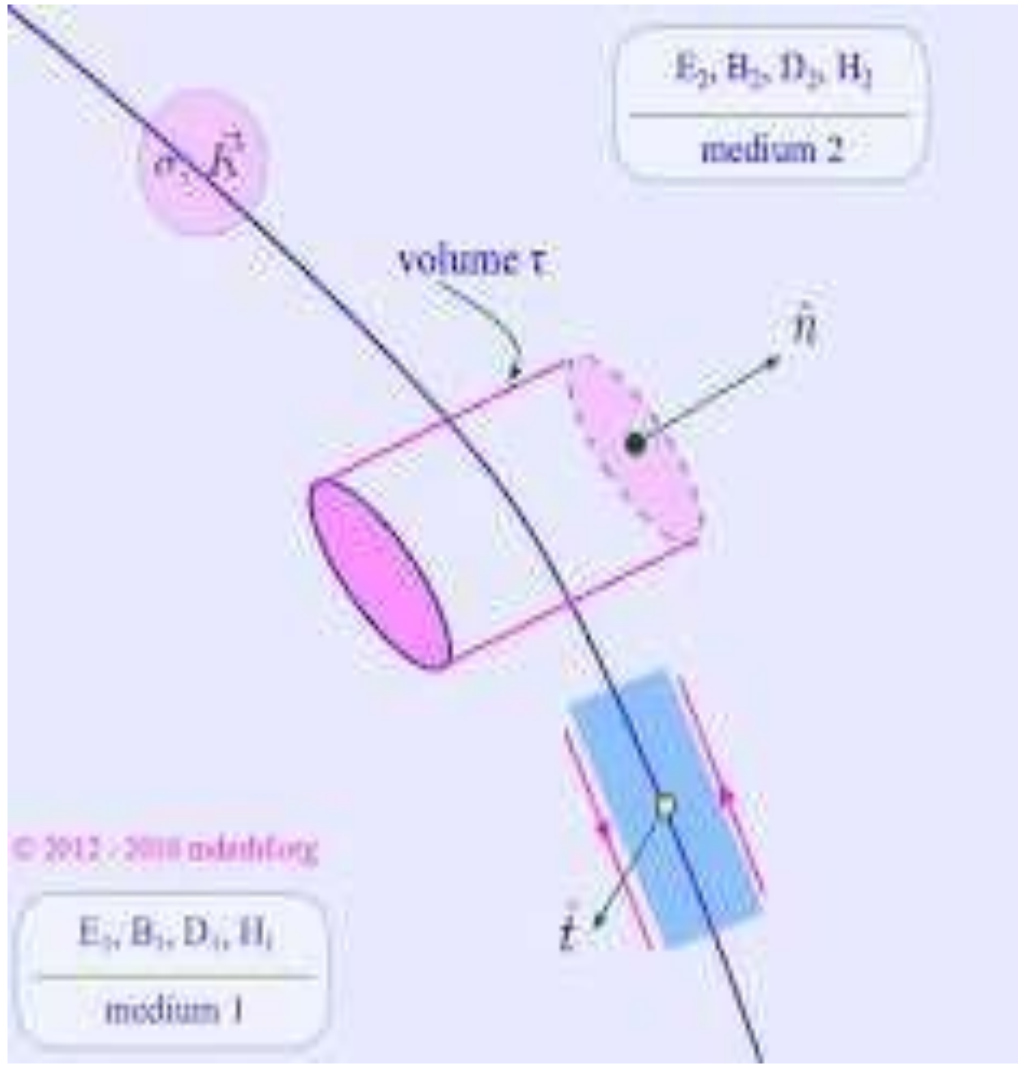
- i.e Hz = (c1 cosBx +c2 sinbx) (c3 cos Ay+c4 sin Ay)

ANALYSIS

- Boundary condition

Ey=Ez=0 at x=0 and x=a

Ex=Ez=0 at y=0 and y=b



TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

- By Product solution method

  $$Hz = XY$$

- Where X – a function of x alone
  Y – a function of y alone

- Inserted in Wave equation for Hz and the solution was found.

- i.e $Hz = (c1 \cos Bx + c2 \sin bx)(c3 \cos Ay + c4 \sin Ay)$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

The basic field equations are

$$E_x = -\frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}$$

$$E_y = \frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial x}$$

$$H_x = -\frac{\bar{\gamma}}{h^2}\frac{\partial H_z}{\partial x}$$

$$H_y = -\frac{\bar{\gamma}}{h^2}\frac{\partial H_z}{\partial y}$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

$$E_x = -\frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}$$

$$= \frac{-j\omega\mu}{h^2}\frac{\partial}{\partial y}\left[(C_1 \cos Bx + C_2 \sin Bx)(C_3 \cos Ay + C_4 \sin Ay)\right]$$

$$= -\frac{j\omega\mu}{h^2}\left[(C_1 \cos Bx + C_2 \sin Bx)(-C_3 \sin Ay + C_4 \cos Ay)\right]$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

Subs B.C I $E_x = 0$ at $y = 0$

$$E_x = \frac{-j\omega\mu}{h^2}\left[(C_1 \cos Bx + C_2 \sin Bx)\,(C\,0 + C_4\,A)\right]$$

To satisfy the B.C

$$\boxed{C_4 = 0}$$

Therefore H_z becomes

$$H_z = (C_1 \cos Bx + C_2 \sin Bx)(C_3 \cos Ay)$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

Subs B.C II $E_y = 0$ at $x = 0$

$$E_y = \frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial x}$$

$$E_y = \frac{j\omega\mu}{h^2}\frac{\partial}{\partial x}\left[(C_1 \cos Bx + C_2 \sin Bx)(C_3 \cos Ay)\right]$$

$$= \frac{j\omega\mu}{h^2}\frac{\partial}{\partial x}\left[(-C_1 B \sin Bx + C_2 B \cos Bx)(C_3 \cos Ay)\right]$$

ACTIVITY

Logic Puzzle: You're at a fork in the road in which one direction leads to the City of Lies (where everyone always lies) and the other to the City of Truth (where everyone always tells the truth). There's a person at the fork who lives in one of the cities, but you're not sure which one. What question could you ask the person to find out which road leads to the City of Truth?

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

At $x = 0$

$$E_y = \frac{j\omega\mu}{h^2}\left[(C_2 B)(C_3 \cos Ay) \right)$$

To satisfy the B.C, either C_2 (or) C_3 in the above equation is zero.

→ But $C_3 = 0$ make the field vanish.

→ So instead C_2 put equal to zero.

∴ $\boxed{C_2 = 0}$

H_z equation becomes

$$H_z = C_1 C_3 \cos Bx \cos Ay \, e^{-\bar{\gamma} z}.$$

$$C_1 C_3 = C$$

$$H_z = C \cos Bx \cos Ay \, e^{-\bar{\gamma} z}.$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

OTHER FIELDS

$$E_x = \frac{-j\omega\mu}{h^2} \frac{\partial}{\partial y}\left[C \cos Bx \cos Ay \, e^{-\bar{\gamma} z}\right]$$

$$E_z = \frac{j\omega\mu}{h^2} CA \cos Bx \sin Ay \, e^{-\bar{\gamma} z}$$

$$E_y = \frac{j\omega\mu}{h^2} \frac{\partial H_z}{\partial x}$$

$$= \frac{j\omega\mu}{h^2} \frac{\partial}{\partial x}\left[C \cos Bx \cos Ay \, e^{-\bar{\gamma} z}\right]$$

$$E_y = -\frac{j\omega\mu}{h^2} CB \sin Bx \cos Ay \, e^{-\bar{\gamma} z}$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

$$H_x = \frac{j\omega\varepsilon}{h^2}\frac{\partial}{\partial y}\left[C\cos Bx\cos Ay\, e^{-\bar{\gamma} z}\right]$$

$$= \frac{j\omega\varepsilon}{h^2} C\cos Bx\,(-A\sin Ay)\, e^{-\bar{\gamma} z}$$

$$\therefore H_x = \frac{-j\omega\varepsilon CA}{h^2}\cos Bx\sin Ay\, e^{-\bar{\gamma} z}$$

$$H_y = \frac{-j\omega\varepsilon}{h^2}\frac{\partial}{\partial x}(E_z)$$

$$= \frac{-j\omega\varepsilon}{h^2}\frac{\partial}{\partial x}\left[C\cos Bx\cos Ay\, e^{-\bar{\gamma} z}\right]$$

$$= \frac{-j\omega\varepsilon C}{h^2}(-\sin Bx)\,B\cos Ay\, e^{-\bar{\gamma} z}$$

$$H_y = \frac{j\omega\varepsilon CB}{h^2}\sin Bx\cos Ay\, e^{-\bar{\gamma} z}.$$

TE WAVES IN RECTANGULAR WAVEGUIDES -ANALYSIS

By subs $\bar{\gamma} = j\bar{\beta}$, where $A = \frac{m\pi}{a}$, $B = \frac{n\pi}{b}$

The fields are

$$H_z = C \cos Bx \cos Ay \, e^{-j\bar{\beta} z}$$

$$H_x = \frac{j\bar{\beta}}{h^2} CB \sin Bx \cos Ay \, e^{-j\bar{\beta} z}$$

$$E_x = \frac{j\omega\mu}{h^2} CA \cos Bx \sin Ay \, e^{-j\bar{\beta} z}$$

$$H_y = \frac{j\bar{\beta}}{h^2} CA \cos Bx \sin Ay \, e^{-j\bar{\beta} z}$$

$$E_y = \frac{-j\omega\mu}{h^2} CB \sin Bx \cos Ay \, e^{-j\bar{\beta} z}$$

ASSESSMENT

1.The wave in which the electric field is perpendicular to the direction of wave propagation is --------

2.The wave in which the magnetic field is perpendicular to the direction of wave propagation is --------

3.The TE wave is also called as -----------

4.State the boundary conditions of TE waves in Rectangular waveguides.

5.For waveguide propagation the value of propagation constant must be equal to -----------

THANK YOU