TM mode

- TM modes in rectangular wave guide
- TM11
- TM12
- TM21

$$\lambda_{cm} = \frac{2ab}{\sqrt{m^2 b^2 + n^2 a^2}}$$

Propagation Of TE wave

$$E_x = -\frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y} \qquad E_x = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right) C\cos\left(\frac{m\pi}{a}\right)x\sin\left(\frac{n\pi}{b}\right)ye^{(j\omega t-\gamma z)}$$

$$E_y = -\frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial x} \qquad E_y = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)C\sin\left(\frac{m\pi}{a}\right)x\cos\left(\frac{n\pi}{b}\right)ye^{(j\omega t-\gamma z)}$$

$$H_x = -\frac{\gamma}{h^2}\frac{\partial H_z}{\partial x} \qquad H_x = \frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)C\sin\left(\frac{m\pi}{a}\right)x\cos\left(\frac{n\pi}{b}\right)ye^{(j\omega t-\gamma z)}$$

$$H_y = -\frac{\gamma}{h^2}\frac{\partial H_z}{\partial y} \qquad H_y = \frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)C\cos\left(\frac{m\pi}{a}\right)x\sin\left(\frac{n\pi}{b}\right)ye^{(j\omega t-\gamma z)}$$

- TE00
- TE01
- TE10
- TE11

- DOMINANT MODE : CUT OFF WAVELENGTH ASSUMES MAXIMUM VALUE
- $\lambda C01=2b$
- $\lambda C10=2a$
- $\lambda C11=2ab/\sqrt{a^2+b^2}$
- $Vp=c/ \sqrt{1-(\lambda 0/\lambda c)^2}$

Wave impedance

- Ratio of electric field in one transverse direction to the strength of magnetic field in other transverse direction
- $Z_z = E_x/H_y = -E_y/H_x$

$TM wave$

$$Z_z = \frac{\sqrt{E_x^2 + E_y^2}}{\sqrt{H_x^2 + H_y^2}}$$

$$Z_{TM} = \frac{E_x}{H_y} = \frac{-\frac{\gamma}{h^2}\frac{\partial E_z}{\partial x} - \frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}}{\frac{-\gamma}{h^2}\frac{\partial H_z}{\partial y} - \frac{j\omega\varepsilon}{h^2}\frac{\partial E_z}{\partial x}}$$

$for TM wave Hz = 0, and \gamma = j\beta$

$$Z_{TM} = \frac{E_x}{H_y} = \frac{\frac{\gamma}{h^2}\frac{\partial E_z}{\partial x}}{-\frac{j\omega\varepsilon}{h^2}\frac{\partial E_z}{\partial x}} = \frac{\gamma}{j\omega\varepsilon} = \frac{j\beta}{j\omega\varepsilon} = \frac{\beta}{\omega\varepsilon}$$

$$\beta = \sqrt{\omega^2\mu\varepsilon - \omega_c^2\mu\varepsilon}$$

$$Z_{TM} = \frac{\sqrt{\omega^2\mu\varepsilon - \omega_c^2\mu\varepsilon}}{\omega\varepsilon}$$

$$= \sqrt{\frac{\mu}{\varepsilon}} . \sqrt{1-\left(\frac{\omega_c}{\omega}\right)^2} = \sqrt{\frac{\mu}{\varepsilon}} . \sqrt{1-\left(\frac{f_c}{f}\right)^2} = \sqrt{\frac{\mu}{\varepsilon}} . \sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}$$

$for air \sqrt{\frac{\mu}{\varepsilon}} = 377\Omega = \eta$ (intrinsic impedance of free space)

$\lambda_0 < \lambda_c, Z_{TM}$ is always less than free space impedance

$TE wave$

$$Z_z = \frac{\sqrt{E_x^2 + E_y^2}}{\sqrt{H_x^2 + H_y^2}}$$

$$Z_{TM} = \frac{E_x}{H_y} = \frac{\frac{-\gamma}{h^2}\frac{\partial E_z}{\partial x} - \frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}}{\frac{-\gamma}{h^2}\frac{\partial H_z}{\partial y} - \frac{j\omega\varepsilon}{h^2}\frac{\partial E_z}{\partial x}}$$

$$= \frac{j\beta}{j\omega\varepsilon} = \sqrt{\frac{\mu\varepsilon}{\varepsilon.\varepsilon}}\sqrt{1-\left(\frac{\omega_c}{\omega}\right)^2} = \eta\sqrt{1-\left(\frac{\lambda_O}{\lambda_c}\right)^2}$$

$$for TM wave Ez = 0, and \gamma = j\beta$$

$$Z_{TE} = \frac{E_x}{H_y} = \frac{\frac{j\omega\mu}{h^2}\frac{\partial H_z}{\partial y}}{-\frac{\gamma}{h^2}\frac{\partial H_z}{\partial y}} = \frac{j\omega\mu}{\gamma} = \frac{\omega\mu}{\beta}$$

$$\beta = \sqrt{\omega^2\mu\varepsilon - \omega_c^2\mu\varepsilon}$$

$$Z_{TE} = \frac{\omega\mu}{\sqrt{\omega^2\mu\varepsilon - \omega_c^2\mu\varepsilon}} = \frac{\eta}{\sqrt{1-\left(\frac{\omega_c}{\omega}\right)^2}}$$

$$= .\frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{\eta}{\sqrt{1-\left(\frac{\lambda_c}{\lambda_c}\right)^2}}$$

$\lambda_0 < \lambda_c, Z_{TE}$ is always greater than free space impedance