Balanis

Modos TE

$$E_z = 0$$

$$E_x = + A_{mn} \frac{\beta_y}{\varepsilon} \cos(\beta_x x) \operatorname{sen}(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$E_y = - A_{mn} \frac{\beta_x}{\varepsilon} \operatorname{sen}(\beta_x x) \cos(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$H_z = -j A_{mn} \frac{\beta_c^2}{\omega \mu \varepsilon} \cos(\beta_x x) \cos(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$H_x = A_{mn} \frac{\beta_x \beta_z}{\omega \mu \varepsilon} \operatorname{sen}(\beta_x \cdot x) \cdot \cos(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$H_y = A_{m,n} \frac{\beta_y \cdot \beta_z}{\omega \mu \varepsilon} \cos(\beta_x \cdot x) \cdot \operatorname{sen}(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

donde: $\beta_x = \frac{m\pi}{a}$ $\beta_y = \frac{n\pi}{b}$ $\beta_c^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 = 2\pi f_c \sqrt{\mu\varepsilon}$

$A_{m,n}$ es una C^{te}

$$\beta_x^2 + \beta_y^2 + \beta_z^2 = \beta^2 = \omega^2 \mu \varepsilon \rightarrow \omega^2 \mu \varepsilon - \beta^2 = K_c^2$$

$$\beta_z = \beta^2 - \beta_x^2 - \beta_y^2 = \omega^2 \mu \varepsilon - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2$$

$$\beta^2 = \omega^2 \mu \varepsilon - K_c^2 =$$

$$\beta^2 = \omega^2 \mu \varepsilon - K_x^2 - K_y^2$$

En el "Balanis" β_z es lo que el "Ramo" llama β

Balanis

Modos TM

$$H_z = 0$$

$$H_x = B_{mn} \frac{\beta_y}{\mu} \cdot \operatorname{sen}(\beta_x \cdot x) \cos(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$H_y = -B_{mn} \frac{\beta_x}{\mu} \cdot \cos(\beta_x \cdot x) \operatorname{sen}(\beta_y \cdot y) \cdot e^{-j\beta_z \cdot z}$$

$$E_z = -j\, B_{mn} \frac{\beta_c^2}{\omega \mu \varepsilon} \operatorname{sen}(\beta_x x) \operatorname{sen}(\beta_y \cdot y)\, e^{-j\beta_z \cdot z}$$

$$E_x = -B_{mn} \frac{\beta_x \beta_z}{\omega \mu \varepsilon} \cos(\beta_x x) \operatorname{sen}(\beta_y \cdot y)\, e^{-j\beta_z \cdot z}$$

$$E_y = -B_{mn} \frac{\beta_y \beta_z}{\omega \mu \varepsilon} \operatorname{sen}(\beta_x x) \cos(\beta_y y)\, e^{-j\beta_z \cdot z}$$

donde $\beta_x = \frac{m\pi}{a}$ $\quad \beta_y = \frac{n\pi}{b}$ $\quad \beta_c^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2$

$$\beta_z \Rightarrow \quad \beta_x^2 + \beta_y^2 + \beta_z^2 = \beta^2 = \omega^2 \mu \varepsilon \rightsquigarrow \beta_z^2 = \omega^2 \mu \varepsilon - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2$$

$B_{m,n}$: C^{te}

Guías de onda Rectangulares.

	$TE_{m,n}$	$TM_{m,n}$
β_c	$\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$	
f_c	$\frac{1}{2\pi\sqrt{\mu\varepsilon}} \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$	
λ_c	$\frac{2\pi}{\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}}$	
En el Balanis β_z $(f \geq f_c)$ En el Ramo es β	$\beta \sqrt{1 - \left(\frac{f_c}{f}\right)^2}$ $\sqrt{\omega^2\mu\varepsilon}$	
λ_g $(f \geq f_c)$	$\frac{\lambda}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}}$	
u_p $(f \geq f_c)$	$\frac{u}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}}$	
Z $(f \geq f_c)$	$\frac{\eta}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}}$	$\eta \sqrt{1 - \left(\frac{f_c}{f}\right)^2}$

TABLE 8-3
Summary of TE^z_{mn} and TM^z_{mn} mode characteristics of rectangular waveguide

	$TE^z_{mn}\left(\begin{array}{l} m = 0,1,2,\ldots \\ n = 0,1,2,\ldots \end{array} \; m = n \neq 0\right)$	$TM^z_{mn}\left(\begin{array}{l} m = 1,2,3,\ldots \\ n = 1,2,3,\ldots \end{array}\right)$
E_x^+	$A_{mn}\frac{n\pi}{b\varepsilon}\cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$	$-B_{mn}\frac{m\pi\beta_z}{a\omega\mu\varepsilon}\cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$
E_y^+	$-A_{mn}\frac{m\pi}{a\varepsilon}\sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$	$-B_{mn}\frac{n\pi\beta_z}{b\omega\mu\varepsilon}\sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$
E_z^+	0	$-jB_{mn}\frac{\beta_c^2}{\omega\mu\varepsilon}\sin\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$
H_x^+	$A_{mn}\frac{m\pi\beta_z}{a\omega\mu\varepsilon}\sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$	$B_{mn}\frac{n\pi}{b\mu}\sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$
H_y^+	$A_{mn}\frac{n\pi\beta_z}{b\omega\mu\varepsilon}\cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$	$-B_{mn}\frac{m\pi}{a\mu}\cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$
H_z^+	$-jA_{mn}\frac{\beta_c^2}{\omega\mu\varepsilon}\cos\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta_z z}$	0
β_c	$\sqrt{\beta_x^2+\beta_y^2} = \sqrt{\left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2}$	
f_c	$\frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2}$	
λ_c	$\frac{2\pi}{\sqrt{\left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2}}$	
$\beta_z\ (f \geq f_c)$	$\beta\sqrt{1-\left(\frac{f_c}{f}\right)^2}$	
$\lambda_g\ (f \geq f_c)$	$\frac{\lambda}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$	
$v_p\ (f \geq f_c)$	$\frac{v}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{v}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$	
$Z_w\ (f \geq f_c)$	$\frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{\eta}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$	$\eta\sqrt{1-\left(\frac{f_c}{f}\right)^2} = \eta\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$
$Z_w\ (f \leq f_c)$	$j\frac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = j\frac{\eta}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$	$-j\eta\sqrt{1-\left(\frac{f_c}{f}\right)^2} = -j\eta\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$

	$TE^z_{mn}\left(\begin{array}{l} m = 0,1,2,\ldots \\ n = 0,1,2,\ldots \end{array} \; m = n \neq 0\right)$	$TM^z_{mn}\left(\begin{array}{l} m = 1,2,3,\ldots \\ n = 1,2,3,\ldots \end{array}\right)$
$(\alpha_c)_{mn}$	$\frac{2R_s}{b\eta\sqrt{1-\left(\frac{f_{c,mn}}{f}\right)^2}}\left\{\left(\varepsilon_m+\varepsilon_n\frac{b}{a}\right)\left(\frac{f_{c,mn}}{f}\right)^2 + \frac{b}{a}\left[1-\left(\frac{f_{c,mn}}{f}\right)^2\right]\frac{m^2ab+(na)^2}{(mb)^2+(na)^2}\right\}$ where $\varepsilon_p = \begin{cases} 2 & p = 0 \\ 1 & p \neq 0 \end{cases}$	$\frac{2R_s}{ab\eta\sqrt{1-\left(\frac{f_{c,mn}}{f}\right)^2}}\frac{m^2b^3+n^2a^3}{(mb)^2+(na)^2}$