Balanis

Modos TE

\[ E_z = 0 \]
\[ E_x = + A_{mn} \frac{\beta_x}{\varepsilon} \cos(\beta_x x) \sin(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ E_y = - A_{mn} \frac{\beta_y}{\varepsilon} \sin(\beta_x x) \cos(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ H_z = -j A_{mn} \frac{\beta_c^2}{\omega \mu \varepsilon} \cos(\beta_x x) \cos(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ H_x = A_{mn} \frac{\beta_x \beta_c}{\omega \mu \varepsilon} \sin(\beta_x x) \cos(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ H_y = A_{mn} \frac{\beta_y \beta_c}{\omega \mu \varepsilon} \cos(\beta_x x) \sin(\beta_y y) \cdot e^{-j\beta_z z} \]

donde:
\[ \beta_x = \frac{\omega n_x}{a} \quad \beta_y = \frac{n_y}{b} \quad \beta_c = \sqrt{\left(\frac{\omega n_x}{a}\right)^2 + \left(\frac{n_y}{b}\right)^2} = \frac{n_c \omega}{\sqrt{\mu \varepsilon}} \]

\[ A_{mn} \text{ es una constante} \]

\[ (\beta_x^2 + \beta_y^2 + \beta_c^2) = \beta^2 = \varepsilon \frac{w^2}{k^2} \]
\[ w^2 \varepsilon - \beta^2 = k_c^2 \]
\[ \beta_c = w^2 \varepsilon - k_c^2 = \frac{w^2}{k_c^2} \]

En el "Balanis" (\( \beta_0 \)) es lo que el "Ramo" llama \( \beta_0 \)
\[ H_z = 0 \]
\[ H_x = B_{mn} \frac{\beta_y}{\mu} \cdot \text{sen}(\beta_x x) \cos(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ H_y = -B_{mn} \frac{\beta_x}{\mu} \cdot \cos(\beta_x x) \text{sen}(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ E_z = -j B_{mn} \frac{\beta_c}{w \mu \varepsilon} \cdot \text{sen}(\beta_x x) \text{sen}(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ E_x = -B_{mn} \frac{\beta_x \beta_c}{w \mu \varepsilon} \cdot \cos(\beta_x x) \text{sen}(\beta_y y) \cdot e^{-j\beta_z z} \]
\[ E_y = -B_{mn} \frac{\beta_y \beta_c}{w \mu \varepsilon} \cdot \text{sen}(\beta_x x) \cos(\beta_y y) \cdot e^{-j\beta_z z} \]

Dado:
\[ \beta_x = \frac{n \pi}{a} \]
\[ \beta_y = \frac{n \pi}{b} \]
\[ \beta_c = \left(\frac{n \pi}{a}\right)^2 + \left(\frac{n \pi}{b}\right)^2 \]
\[ \beta^2 = \beta_x^2 + \beta_y^2 + \beta_c^2 = \frac{w^2 \mu \varepsilon}{\mu} \quad \Rightarrow \quad \beta^2 = \frac{w^2 \mu \varepsilon}{\mu} - \left(\frac{n \pi}{a}\right)^2 - \left(\frac{n \pi}{b}\right)^2 \]

\[ B_{m,n} : C^\infty \]
Guías de onda Rectangulares

$TE_{m,n}$

$TM_{m,n}$

$\beta_c$

$f_c$

$\lambda_c$

$\beta \left( \frac{1}{\beta} \right)$

$\mu \left( \frac{1}{\mu} \right)$

$z \left( \frac{1}{z} \right)$

$\sqrt{\left( \frac{m \pi}{a} \right)^2 + \left( \frac{n \pi}{b} \right)^2}$

$\frac{1}{\sqrt{\pi \nu \varepsilon}} \sqrt{\left( \frac{m \pi}{a} \right)^2 + \left( \frac{n \pi}{b} \right)^2}$

$\frac{2 \pi}{\sqrt{(m \pi)^2 + (n \pi)^2}}$

$\sqrt{1 - \left( \frac{f_c}{\nu} \right)^2}$

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<table>
<thead>
<tr>
<th>(TE_{mn}^z) (m = 0, 1, 2, \ldots ) (n = 0, 1, 2, \ldots) (m \neq 0)</th>
<th>(TM_{mn}^z) (m = 1, 2, 3, \ldots) (n = 1, 2, 3, \ldots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E_x^z)</td>
<td>(A_{mn}^{\frac{m\pi}{b\varepsilon}} \cdot \frac{m\pi}{a\varepsilon} \cdot \frac{m\pi}{(a-x)\sin \left(\frac{n\pi}{b}\right)} \cdot e^{-\beta z})</td>
</tr>
<tr>
<td>(-B_{mn}^{\frac{m\pi}{a\varepsilon}} \cdot \frac{n\pi}{b\mu} \cdot \frac{n\pi}{b\varepsilon} \cdot \sin \left(\frac{n\pi}{b}\right) \cdot e^{-\beta z})</td>
<td></td>
</tr>
<tr>
<td>(E_y^z)</td>
<td>(-A_{mn}^{\frac{n\pi}{b\varepsilon}} \cdot \frac{n\pi}{a\varepsilon} \cdot \frac{n\pi}{b\mu} \cdot \cos \left(\frac{n\pi}{b}\right) \cdot e^{-\beta z})</td>
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</tr>
<tr>
<td>(E_z^z)</td>
<td>0</td>
</tr>
<tr>
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<td>(H_x^z)</td>
<td>(A_{mn}^{\frac{m\pi}{b\varepsilon}} \cdot \frac{m\pi}{a\varepsilon} \cdot \frac{m\pi}{b\mu} \cdot \sin \left(\frac{n\pi}{b}\right) \cdot e^{-\beta z})</td>
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\(\beta_c\) \(\sqrt{\beta_x^2 + \beta_y^2} = \sqrt{\left[\frac{m\pi}{a}\right]^2 + \left[\frac{n\pi}{b}\right]^2}\)

\(f_c\) \(\frac{1}{2\pi\sqrt{\varepsilon}} \sqrt{\left[\frac{m\pi}{a}\right]^2 + \left[\frac{n\pi}{b}\right]^2}\)

\(\lambda_c\) \(\frac{2\pi}{\sqrt{\left[\frac{m\pi}{a}\right]^2 + \left[\frac{n\pi}{b}\right]^2}}\)

\(\beta_e\) \(\beta \sqrt{1 - \left(\frac{f}{f_c}\right)^2}\)

\(\lambda_e\) \(\frac{\lambda}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}}\)

\(v_e\) \(\frac{v}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}}\)

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

\(Z_{e1}\) \(\frac{j\eta}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}} = \frac{j\eta}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}} = \frac{j\eta}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}}\)

\(\epsilon_{mn}\) \(\frac{2R_e}{b\eta} \sqrt{1 - \left(\frac{f_{e, mn}}{f_c}\right)^2} \left(\frac{\epsilon_m + \epsilon_n}{a} \cdot \frac{f_{e, mn}}{f_c}\right)^2\)

\(\alpha_{e, mn}\) \(\frac{2R_e}{a\eta} \sqrt{1 - \left(\frac{f_{e, mn}}{f_c}\right)^2} \left[\frac{m^2 b^3 + n^2 a^3}{(mb)^2 + (na)^2}\right]\)

where \(\epsilon_p\) \(\begin{cases} 2 & p = 0 \\ 1 & p \neq 0 \end{cases}\)