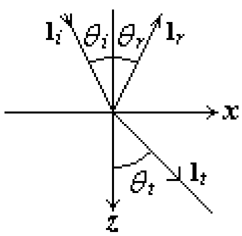
FORMULARIO TEORIA DE ONDAS GUIADAS

$$\mathbf{E}(\boldsymbol{r},t)=\Re\left\{\hat{\boldsymbol{e}}_{\mathrm{T}}^{\pm}(u_1,u_2)\mathrm{e}^{\mp\hat{\gamma}\mathbf{1}_n\cdot\boldsymbol{r}}\mathrm{e}^{j\omega t}\right\}\ ;\ \mathbf{H}(\boldsymbol{r},t)=\Re\left\{\hat{\boldsymbol{h}}_{\mathrm{T}}^{\pm}(u_1,u_2)\mathrm{e}^{\mp\hat{\gamma}\mathbf{1}_n\cdot\boldsymbol{r}}\mathrm{e}^{j\omega t}\right\}$$

$$\hat{\boldsymbol{e}}_{\mathrm{T}}^{\pm}=-\nabla\hat{\phi}_e^{\pm}\ \text{donde}\ \nabla^2\hat{\phi}_e^{\pm}=0;\hat{\boldsymbol{h}}_{\mathrm{T}}^{\pm}=\pm\mathbf{1}_{\boldsymbol{n}}\times\frac{\hat{\boldsymbol{e}}_{\mathrm{T}}^{\pm}}{\hat{\eta}}\ ;\ \hat{\gamma}=j\omega\sqrt{\mu\hat{\epsilon}}=\alpha+j\beta\ ;\ \hat{\eta}=\sqrt{\frac{\mu}{\hat{\epsilon}}}$$

$$\beta=2\pi/\lambda\ ;\ v=\omega/\beta=f\lambda\ ;\ \boldsymbol{P}_{\mathrm{av}}^{\pm}=\pm\frac{|\hat{\boldsymbol{e}}_{\mathrm{T}}^{\pm}|^2}{2|\hat{\eta}|}\mathrm{e}^{\mp2\alpha\mathbf{1}_n\cdot\boldsymbol{r}}\cos\theta_\eta\mathbf{1}_{\boldsymbol{n}}$$

		Buenos conductores	Dieléctricos con pocas pérdidas
α	$\frac{\omega\sqrt{\mu\epsilon}}{\sqrt{2}}\left(\sqrt{\sqrt{1+(\sigma/\omega\epsilon)^2}-1}\right)$	$\sqrt{\mu\omega\sigma_c/2}$	$\frac{\omega\sqrt{\mu\epsilon}}{2}\sigma/\omega\epsilon$
β	$\frac{\omega\sqrt{\mu\epsilon}}{\sqrt{2}}\left(\sqrt{\sqrt{1+(\sigma/\omega\epsilon)^2}+1}\right)$	$\sqrt{\mu\omega\sigma_c/2}$	$\omega\sqrt{\mu\epsilon}\left(1+1/8(\sigma/\omega\epsilon)^2\right)$
$\hat{\eta}$	$\frac{\sqrt{\mu/\epsilon}\,\mathrm{e}^{j1/2\tan^{-1}(\sigma/\omega\epsilon)}}{\sqrt[4]{1+(\sigma/\omega\epsilon)^2}}$	$\sqrt{\omega\mu/2\sigma_c}(1+j)$	$\sqrt{\mu/\epsilon}\left(1-3/8(\sigma/\omega\epsilon)^2+j\sigma/2\omega\epsilon\right)$



$$\theta_i=\theta_r\ ;\ \mathrm{sen}\,\theta_t=\frac{\hat{\gamma}_1}{\hat{\gamma}_2}\mathrm{sen}\,\theta_i$$

REFLEXION TOTAL:

$$\theta_{ic}=\mathrm{sen}^{-1}(v_1/v_2)\ ;\ \theta_t=(\pi/2+2n\pi)+j\theta_{ti}$$

$$\theta_{ti}=\cosh^{-1}\left((v_2/v_1)\mathrm{sen}\,\theta_i\right)$$

$$\hat{\boldsymbol{E}}_{\boldsymbol{t}}=\hat{\boldsymbol{E}}_{\boldsymbol{0t}}\mathrm{e}^{-jx\beta_2\cosh\theta_{ti}}\mathrm{e}^{-jz\beta_2\mathrm{senh}\,\theta_{ti}}$$

$$\hat{\Gamma}_{\perp}=\frac{\hat{\eta}_2\cos\theta_1-\hat{\eta}_1\cos\theta_2}{\hat{\eta}_2\cos\theta_1+\hat{\eta}_1\cos\theta_2}\qquad\hat{\Gamma}_{//}=\frac{\hat{\eta}_1\cos\theta_1-\hat{\eta}_2\cos\theta_2}{\hat{\eta}_1\cos\theta_1+\hat{\eta}_2\cos\theta_2}$$

$$\hat{T}_{\perp}=\frac{2\hat{\eta}_2\cos\theta_1}{\hat{\eta}_2\cos\theta_1+\hat{\eta}_1\cos\theta_2}\qquad\hat{T}_{//}=\frac{2\hat{\eta}_2\cos\theta_1}{\hat{\eta}_1\cos\theta_1+\hat{\eta}_2\cos\theta_2}$$

BREWSTER:

$$\tan\theta_{iB//}=\sqrt{\frac{\epsilon_2}{\epsilon_1}}\sqrt{\left(\frac{\epsilon_1\mu_2-\epsilon_2\mu_1}{\epsilon_1\mu_1-\epsilon_2\mu_2}\right)}$$

$$\tan\theta_{iB\perp}=\sqrt{\frac{\mu_2}{\mu_1}}\sqrt{\left(\frac{\epsilon_1\mu_2-\epsilon_2\mu_1}{\epsilon_2\mu_2-\epsilon_1\mu_1}\right)}$$

INCIDENCIA NORMAL EN MULTIPLE MEDIOS

$$\hat{\Gamma}(z)=\frac{\hat{Z}(z)-\hat{\eta}}{\hat{Z}(z)+\hat{\eta}}\quad;\quad\hat{Z}(z)=\hat{\eta}\frac{1+\hat{\Gamma}(z)}{1-\hat{\Gamma}(z)}\quad;\quad\hat{\Gamma}(z')=\hat{\Gamma}(z)e^{+2\hat{\gamma}(z'-z)}$$

$$\hat{\boldsymbol{E}}=(\hat{E}^+\mathrm{e}^{-\hat{\gamma}z}+\hat{E}^-\mathrm{e}^{+\hat{\gamma}z})\mathbf{1}_{\boldsymbol{x}}=\hat{E}^+\mathrm{e}^{-\hat{\gamma}z}(1+\hat{\Gamma}(z))\mathbf{1}_{\boldsymbol{x}}\ ;\ \hat{\boldsymbol{H}}=\left(\frac{\hat{E}^+}{\hat{\eta}}\mathrm{e}^{-\hat{\gamma}z}-\frac{\hat{E}^-}{\hat{\eta}}\mathrm{e}^{+\hat{\gamma}z}\right)\mathbf{1}_{\boldsymbol{y}}=\frac{\hat{E}^+}{\hat{\eta}}\mathrm{e}^{-\hat{\gamma}z}(1-\hat{\Gamma}(z))\mathbf{1}_{\boldsymbol{y}}$$

$$\text{R. O. E.}=\frac{|\hat{\boldsymbol{E}}|_{max}}{|\hat{\boldsymbol{E}}|_{min}}=\frac{|\hat{\boldsymbol{H}}|_{max}}{|\hat{\boldsymbol{H}}|_{min}}=\frac{1+|\hat{\Gamma}|}{1-|\hat{\Gamma}|}\ ;\ |\hat{\Gamma}|=\frac{\text{R. O. E.}-1}{\text{R. O. E.}+1}$$

$\mu_0 = 4\pi\times10^{-7}$ H m^{-1} ; $\epsilon_0 = \frac{1}{36\pi}\times10^{-9}$ F m^{-1} ; $c = 3\times10^{8}$ m s^{-1} ; 1" = 2.54 cm

$$\hat{f}_z = \begin{Bmatrix} \hat{e}_z^{\pm}(u_1,u_2) \\ \hat{h}_z^{\pm}(u_1,u_2) \end{Bmatrix} \qquad \hat{k}_c^2 = \frac{\iint_{\text{S.T.}} |\nabla \hat{f}_z|^2 da}{\iint_{\text{S.T.}} |\hat{f}_z|^2 da} \quad ; \quad \nabla_{\mathrm{T}}^2(\hat{f}_z) + \hat{k}_c^2 \hat{f}_z = 0$$

$\hat{e}_z^{\pm}(u_1,u_2) = \frac{\partial \hat{h}_z^{\pm}(u_1,u_2)}{\partial n} = 0$ en la interfaz: conductor/dieléctrico con $\sigma_c = \infty$

Modo TE (Modo H)	Modo TM (Modo E)	
$\hat{h}_z^{\pm} \neq 0$; $\hat{e}_z^{\pm} = 0$ $\hat{h}_{\mathrm{T}}^{\pm} = \mp \frac{\hat{\gamma}}{\hat{k}_c^2} \nabla \hat{h}_{\mathrm{z}}^{\pm}$ $\hat{e}_{\mathrm{T}}^{\pm} = \mp \mathbf{1}_z \times \hat{\eta}_{\mathrm{TE}} \hat{h}_{\mathrm{T}}^{\pm}$ $\hat{\eta}_{\mathrm{TE}} = j\omega\mu/\hat{\gamma}$	$\hat{e}_z^{\pm} \neq 0$; $\hat{h}_z^{\pm} = 0$ $\hat{e}_{\mathrm{T}}^{\pm} = \mp \frac{\hat{\gamma}}{\hat{k}_c^2} \nabla \hat{e}_{\mathrm{z}}^{\pm}$ $\hat{h}_{\mathrm{T}}^{\pm} = \pm \mathbf{1}_z \times \hat{e}_{\mathrm{T}}^{\pm} / \hat{\eta}_{\mathrm{TM}}$ $\hat{\eta}_{\mathrm{TM}} = \hat{\gamma} / j\omega\hat{\epsilon}$	$\hat{\gamma} = \omega\sqrt{\mu\epsilon}\sqrt{(f_c/f)^2 - 1}$ $f_c = \hat{k}_c / (2\pi\sqrt{\mu\epsilon})$ $\beta_z = 2\pi/\lambda_z$

$$\mathbf{E}(u_1,u_2,z,t) = \Re\left\{\hat{\boldsymbol{e}}^{\pm}(u_1,u_2)\,\mathrm{e}^{\mp\hat{\gamma}z}\,\mathrm{e}^{j\omega t}\right\} \;;\; \mathbf{H}(u_1,u_2,z,t) = \Re\left\{\hat{\boldsymbol{h}}_{\mathrm{T}}^{\pm}(u_1,u_2)\,\mathrm{e}^{\mp\hat{\gamma}z}\,\mathrm{e}^{j\omega t}\right\}$$

GUIAS DE ONDA RECTANGULARES: ($a > b$)

$k_{cmn} = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$; TE: $\begin{Bmatrix} m \\ n \end{Bmatrix} = 0,1,2,3...$ pero no pueden ser ambos nulos. ; TM: $\begin{Bmatrix} m \\ n \end{Bmatrix} = 1,2,3...$

Para $f > f_{cmn}$

$$\mathrm{TE}_{mn}: \alpha_c = \frac{2\sqrt{\frac{\omega\mu_c}{2\sigma_c}}}{b\sqrt{\frac{\mu}{\epsilon}}\sqrt{1-\left(\frac{f_{cmn}}{f}\right)^2}}\left[(1+\frac{b}{a})\left(\frac{f_{cmn}}{f}\right)^2 + \frac{b}{a}\left(\frac{\epsilon_{0n}}{2} - \left(\frac{f_{cmn}}{f}\right)^2\right)\left(\frac{m^2ab + n^2a^2}{m^2b^2 + n^2a^2}\right)\right] \text{ Np m}^{-1} \qquad \epsilon_{0n} = \begin{Bmatrix} 1 \text{ si } n=0 \\ 2 \text{ si } n>0 \end{Bmatrix}$$

$$\mathrm{TM}_{mn}: \alpha_c = \frac{2\sqrt{\frac{\omega\mu_c}{2\sigma_c}}}{b\sqrt{\frac{\mu}{\epsilon}}\sqrt{1-\left(\frac{f_{cmn}}{f}\right)^2}}\left[\left(\frac{m^2b^3 + n^2a^3}{m^2b^2a + n^2a^3}\right)\right] \text{ Np m}^{-1}$$

GUIAS DE ONDAS CIRCULARES: (Radio = R)

n	p_{n1}	p_{n2}	p_{n3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620

n	p'_{n1}	p'_{n2}	p'_{n3}
0	3.832	7.016	10.174
1	1.841	5.331	8.536
2	3.054	6.706	9.970

$$k_{cTEnm}=\frac{p'_{nm}}{R}\ ;\ k_{cTMnm}=\frac{p_{nm}}{R}$$

Para $f > f_{cnm}$

$$\mathrm{TE}_{nm}:\alpha_c=\sqrt{\frac{\omega\mu_c}{2\sigma_c}}\frac{\left(\frac{f_{cnm}}{f}\right)^2+\frac{n^2}{(p'_{nm})^2-n^2}}{R\sqrt{\frac{\mu}{\epsilon}}\sqrt{1-\left(\frac{f_{cnm}}{f}\right)^2}}\ \mathrm{Np\ m^{-1}}$$

$$\mathrm{TM}_{nm}:\alpha_c=\sqrt{\frac{\omega\mu_c}{2\sigma_c}}\frac{1}{R\sqrt{\frac{\mu}{\epsilon}}\sqrt{1-\left(\frac{f_{cnm}}{f}\right)^2}}\ \mathrm{Np\ m^{-1}}$$

$$P(dBm)=10\log\left(\frac{P(mW)}{1\,mW}\right)$$

$$\hat{\bar{\mathrm{E}}}_{\mathrm{T1}}(u_1,u_2,z)=\frac{\hat{\bar{e}}_{T1}^{N}(u_1,u_2)}{K_1}[\hat{V}(z)]\ ;\ \hat{\bar{\mathrm{H}}}_{\mathrm{T1}}(u_1,u_2,z)=\frac{\mathbf{1}_z\times\hat{\bar{e}}_{T1}^{N}(u_1,u_2)}{K_2}[\hat{I}(z)]$$

$$\hat{V}^{\pm}=K_1\hat{E}_{01\mathrm{T}}^{\pm}\ ;\ \hat{I}^{\pm}=K_2\hat{H}_{01\mathrm{T}}^{\pm}\ ;\ K_D^2=\iint_{\text{Secc. Transv.}}|\hat{\bar{e}}_{\mathrm{T1}}^{N}(u_1,u_2)|^2\,da$$

$$\hat{V}(z)=\hat{V}^{+}\mathrm{e}^{-\hat{\gamma}z}+\hat{V}^{-}\mathrm{e}^{+\hat{\gamma}z}=\hat{V}^{+}\mathrm{e}^{-\hat{\gamma}z}\left(1+\hat{\Gamma}(z)\right)$$

$$\hat{I}(z)=\hat{I}^{+}\mathrm{e}^{-\hat{\gamma}z}+\hat{I}^{-}\mathrm{e}^{+\hat{\gamma}z}=\hat{I}^{+}\mathrm{e}^{-\hat{\gamma}z}\left(1-\hat{\Gamma}(z)\right)$$

$$\hat{Z}(z)=Z_0\frac{1+\hat{\Gamma}(z)}{1-\hat{\Gamma}(z)}\ ;\ Z_0=\frac{\hat{V}^{+}}{\hat{I}^{+}}=-\frac{\hat{V}^{-}}{\hat{I}^{-}}=\frac{K_1}{K_2}\eta_1$$