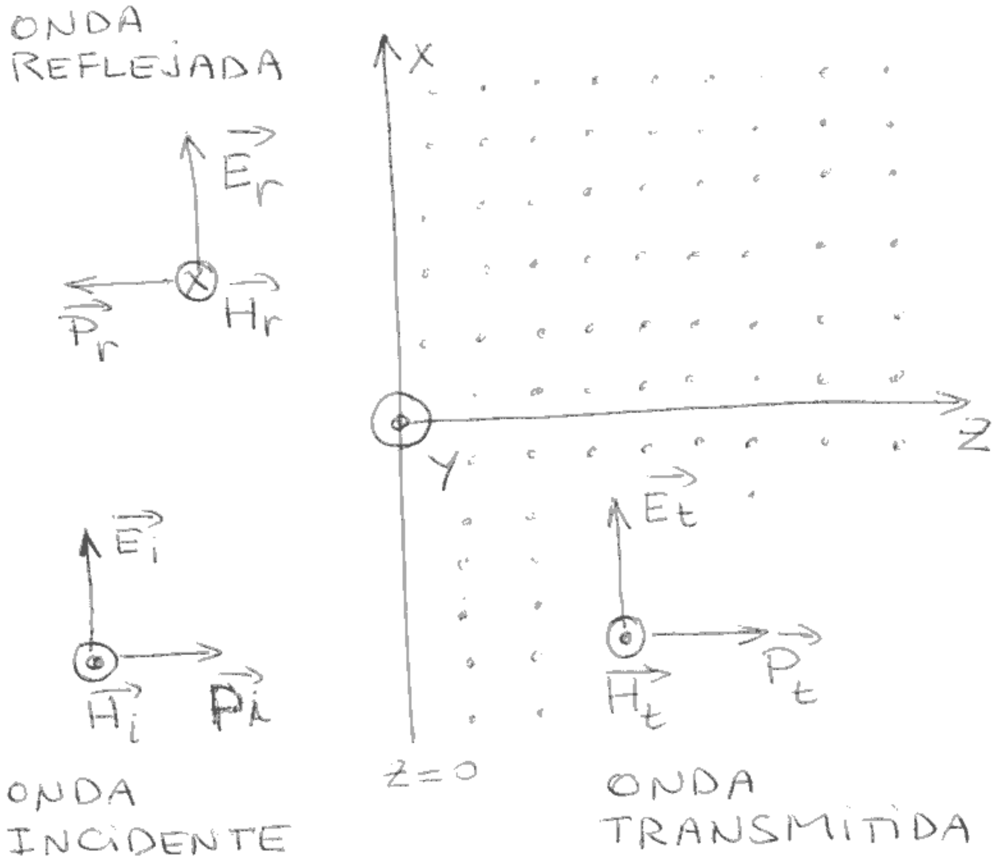
INCIDENCIA NORMAL

DIELECTRICO PERF ①
DIELECTRICO PERF ②



	MEDIO 1	MEDIO 2
$Z_1 =$	μ_1, ϵ_1	μ_2, ϵ_2
	$\sigma_1 = 0$	$\sigma_2 = 0$

$$\vec{E_i} = \hat{x} E_i e^{-j\beta_1 z}$$

$$\vec{H_i} = \hat{y} H_i e^{-j\beta_1 z} = \hat{y} \frac{E_i}{Z_1} e^{-j\beta_1 z}$$

ONDA INCIDENTE

$$Z_1 = \frac{E_i}{H_i} = \sqrt{\frac{\mu_1}{\epsilon_1}}$$

$$\vec{E_r} = \hat{x} E_r e^{j\beta_1 z}$$

$$\vec{H_r} = \frac{\nabla \times \vec{E}}{-j\omega\mu_1} = \frac{\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ E_x & 0 & 0 \end{vmatrix}}{-j\omega\mu_1} = \frac{-\hat{y}\left(-\partial E_x/\partial z\right)}{-j\omega\mu_1}$$

$$\vec{H_r} = -\hat{y} \frac{\cancel{j}\beta_1 E_r e^{j\beta_1 z}}{\cancel{j}\omega\mu_1} = -\hat{y} \frac{E_r e^{j\beta_1 z}}{Z_1} \quad y \quad Z_1 = \frac{\omega\mu_1}{\beta_1} = \sqrt{\frac{\mu_1}{\epsilon_1}}$$

LA ONDA ELECTROMAGNETICA SE PROPAGA EN EL MEDIO 1 Y LLEGA A LA INTERFAZ PLANA DE EXTEN SION $\gg \lambda$ (INFINITA). COMO EL MEDIO 2 POSEE UNA IMPEDANCIA Z_2, PARTE DE LA ENERGÍA SE TRANSMITIRÁ Y PARTE SE REFLEJARÁ

$$\vec{E_t} = \hat{x} E_t e^{-j\beta_2 z}$$

$$\vec{H_t} = \hat{k}_t \times \frac{\vec{E_t}}{Z_2} = \hat{y} \frac{E_t}{Z_2} e^{-j\beta_2 z}$$

ESTA ES UNA MANERA SIMPLIFICADA DE CALCULAR $\vec{H_t}$. LA OTRA MANERA SE VIO ANTES:

$$\vec{H_t} = \frac{\nabla \times \vec{E_t}}{-j\omega\mu_2} = \frac{\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ E_x & 0 & 0 \end{vmatrix}}{-j\omega\mu_2} = \frac{-\hat{y}(-\partial E_x/\partial z)}{-j\omega\mu_2}$$

$$\vec{H_t} = +\hat{y} \frac{(\cancel{-j}\beta_2)}{\cancel{-j}\omega\mu_2} E_t e^{-j\beta_2 z} = \hat{y} \frac{E_t e^{-j\beta_2 z}}{\frac{\omega\mu_2}{\beta_2}} = \hat{y} \frac{E_t e^{-j\beta_2 z}}{\underbrace{\frac{\omega\mu_2}{\beta_2}}_{Z_2}}$$

$$Z_2 = \frac{\omega\mu_2}{\beta_2} = \frac{\cancel{\omega}\mu_2}{\cancel{\omega}\sqrt{\mu_2\epsilon_2}} = \sqrt{\frac{\mu_2}{\epsilon_2}}$$

SE APLICAN LAS CONDICIONES DE CONTORNO EN $z=0$:

$$E_{tangencial_1} = E_{tangencial_2}$$

$$H_{tangencial_1} = H_{tangencial_2}$$

$$\begin{cases} E_i + E_r = E_t \\ H_i + H_r = H_t \end{cases} \quad \text{PARA } z=0$$

REEMP H_i, H_r Y H_t

$$\begin{cases} E_i + E_r = E_t & (1) \\ \dfrac{E_i}{Z_1} - \dfrac{E_r}{Z_1} = \dfrac{E_t}{Z_2} & (2) \end{cases}$$

$$\begin{cases} E_i + E_r = E_t \\ E_i - E_r = E_t \dfrac{Z_1}{Z_2} \end{cases}$$

SUMANDO SE OBTIENE

$$2E_i = E_t\left(1 + \frac{Z_1}{Z_2}\right)$$

$$\frac{E_t}{E_i} = \frac{2}{1 + \dfrac{Z_1}{Z_2}} = \frac{2 . Z_2}{Z_2 + Z_1}$$

COEFICIENTE DE TRANSMISIÓN

EC. (2) $\times Z_2$

$$\begin{cases} E_i + E_r = E_t \\ (E_i - E_r)\dfrac{Z_2}{Z_1} = E_t \end{cases}$$

RESTANDO

$$E_i + E_r - (E_i - E_r)\frac{Z_2}{Z_1} = 0$$

$$E_i\left(1 - \frac{Z_2}{Z_1}\right) + E_r\left(1 + \frac{Z_2}{Z_1}\right) = 0$$

COEF. DE REFLEXIÓN

$$\frac{E_r}{E_i} = \frac{-(1 - Z_2/Z_1)}{(1 + Z_2/Z_1)} = \frac{-(Z_1 - Z_2)}{(Z_1 + Z_2)} = \frac{Z_2 - Z_1}{Z_1 + Z_2}$$

$$\boxed{\begin{array}{l} T_E = \dfrac{E_t}{E_i} = \dfrac{2Z_2}{Z_2+Z_1} \\[2ex] \Gamma_E = \dfrac{E_r}{E_i} = \dfrac{Z_2-Z_1}{Z_1+Z_2} \end{array}}$$

PARA INCIDENCIA NORMAL SE CUMPLE LA SIGUIENTE PROPIEDAD:

$$1 + \Gamma_E = T_E$$

PARA EL CAMPO MAGNETICO, SE PARTE DE:

$$\left\{ \begin{array}{l} E_i + E_r = E_t \qquad \text{PARA } z=0 \\ H_i + H_r = H_t \end{array} \right.$$

COMO $E_i = H_i Z_1$ Y $E_r = -H_r Z_1$ Y $E_t = H_t Z_2$

$$\left\{ \begin{array}{ll} H_i Z_1 - H_r Z_1 = H_t Z_2 & (3) \\ H_i + H_r = H_t & (4) \end{array} \right.$$

$(3) \times 1/Z_1$

$$\left\{ \begin{array}{l} H_i - H_r = H_t \dfrac{Z_2}{Z_1} \\ H_i + H_r = H_t \end{array} \right.$$

SUMANDO:

$$2H_i = H_t\left(1 + \frac{Z_2}{Z_1}\right) = H_t\left(\frac{Z_1+Z_2}{Z_1}\right)$$

$$\frac{H_t}{H_i} = \frac{2Z_1}{(Z_1+Z_2)} = T_H$$

④ $\times Z_2$

$$\begin{cases} H_i Z_1 - H_r Z_1 = H_t Z_2 \\ H_i Z_2 + H_r Z_2 = H_t Z_2 \end{cases}$$

RESTANDO.

$$H_i Z_1 - H_r Z_1 - H_i Z_2 - H_r Z_2 = 0.$$

$$H_i (Z_1 - Z_2) - H_r (Z_1 + Z_2) = 0.$$

$$\frac{H_r}{H_i} = \frac{Z_1 - Z_2}{Z_1 + Z_2} = \Gamma_H$$

$$\boxed{\begin{array}{l} T_H = \dfrac{H_t}{H_i} = \dfrac{2 Z_1}{Z_1 + Z_2} \\ \Gamma_H = \dfrac{H_r}{H_i} = \dfrac{Z_1 - Z_2}{Z_1 + Z_2} \end{array}}$$

COEF. DE TRANSMISIÓN DE H

COEF. DE REFLEXIÓN DE H

LAS PROPIEDADES SON

$$T_H = \frac{Z_1}{Z_2} T_E \quad \text{Y} \quad \Gamma_H = -\Gamma_E.$$

INCIDENCIA NORMAL

PARA EL CASO DIELÉCTRICO - DIELÉCTRICO
PERF. PERF.

$$\Gamma = \frac{Z_2 - Z_1}{Z_1 + Z_2} \qquad \text{DONDE: } Z_1 = \sqrt{\frac{\mu_1}{\epsilon_1}} = \sqrt{\frac{\mu_0}{\epsilon_1}}$$

$$Z_2 = \sqrt{\frac{\mu_2}{\epsilon_2}} = \sqrt{\frac{\mu_0}{\epsilon_2}}$$

COMO Z_1 Y $Z_2 \in \mathbb{R}e \Rightarrow \Gamma \in \mathbb{R}e$.

$\mu_1 = \mu_2 = \mu_0$.

SI $Z_2 > Z_1$

$\Gamma > 0$. E_r NO CAMBIA LA FASE

SI $Z_2 < Z_1$

$\Gamma < 0$. E_r CAMBIA LA FASE

EN EL MEDIO 1 SE TENDRÁ:

$$\vec{E_1}(z) = \vec{E_i}(z) + \vec{E_r}(z)$$

$$\vec{E_1}(z) = \hat{x} E_i e^{-j\beta_1 z} + \hat{x} E_r e^{j\beta_1 z}$$

$$\vec{E_1}(z) = \hat{x} E_i e^{-j\beta_1 z} + \hat{x} E_i \Gamma e^{j\beta_1 z}$$

$$\boxed{\vec{E_1}(z) = \hat{x} E_i . e^{-j\beta_1 z}(1 + \Gamma e^{2j\beta_1 z})}$$

SI $\Gamma > 0$ $(Z_2 > Z_1)$

MAXIMO $|\vec{E_1}(z)|$ $\quad 2\beta_1 z = -2m\pi \quad m = 0, 1, 2 \ldots$

$$z_{MAX} = -\frac{m\pi}{\beta_1}$$

MINIMOS $|\vec{E_1}(z)|$ $\quad 2\beta_1 z = -(2m+1)\pi \quad m = 0, 1, 2 \ldots$

$$z_{MIN} = -(2m+1)\frac{\pi}{2}\frac{1}{\beta_1}$$

Si $\Gamma < 0$ $(Z_2 < Z_1)$

MAXIMO $|\vec{E}_1(z)|$ $\quad 2\beta_1 z = -(2m+1)\pi \quad m = 0, 1, 2 \ldots$

$$Z_{MAX} = -(2m+1)\frac{\pi}{2\beta_1}$$

MÍNIMO $|\vec{E}_1(z)|$ $\quad 2\beta_1 Z = -2m\pi \quad m = 0, 1, 2 \ldots$

$$Z_{MIN} = -\frac{m\pi}{\beta_1}$$

RELACION DE ONDA ESTAGONARIA

SWR o ROE

$$ROE = \frac{|E|_{max}}{|E|_{MIN}} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

TAMBIÉN $\quad |\Gamma| = \dfrac{ROE - 1}{ROE + 1}$

LOS VALORES DE Γ Y ROE ESTARÁN ENTRE:

$-1 \leq \Gamma \leq 1$

$1 \leq ROE \leq \infty$

MUCHAS VECES EL ROE SE EXPRESA EN dB

$$ROE|_{dB} = 20 \log_{10} ROE$$

ANALOGAMENTE $\vec{H}(z)$ EN EL MEDIO 1 ES:

$$\vec{H}_1(z) = \vec{H}_i(z) + \vec{H}_r(z)$$

$$\vec{H}_1(z) = \hat{y} H_i e^{-j\beta_1 z} - \hat{y} \frac{E_r}{Z_1} e^{j\beta_1 z} = \hat{y} \frac{E_i}{Z_1} e^{-j\beta_1 z} - \hat{y} \frac{E_r}{Z_1} e^{j\beta_1 z}$$

$$\boxed{\vec{H}_1(z) = \hat{y} \frac{E_i}{Z_1} e^{-j\beta_1 z}\left(1 - \Gamma \cdot e^{2j\beta_1 z}\right)}$$

EL VECTOR DE POYNTING PROMEDIO TEMPORAL

$$\langle \vec{P} \rangle = \frac{1}{2} \mathrm{Re}(\vec{E} \times \vec{H}^*)$$

EN EL MEDIO 1:

$$\langle \vec{P_1} \rangle = \frac{1}{2} \mathrm{Re}\left[\hat{x} E_i e^{-j\beta_1 z}(1+\Gamma e^{2j\beta_1 z}) \times \hat{y} \frac{E_i}{Z_1} e^{j\beta_1 z}(1-\Gamma e^{-2j\beta_1 z})\right]$$

$$\langle \vec{P_1} \rangle = \frac{\hat{z} E_i^2}{2Z_1} \mathrm{Re}\left[(1+\Gamma e^{2j\beta_1 z}) \cdot (1-\Gamma e^{-2j\beta_1 z})\right]$$

$$\langle \vec{P_1} \rangle = \frac{\hat{z} E_i^2}{2Z_1} \mathrm{Re}\left[1 - \Gamma e^{-2j\beta_1 z} + \Gamma e^{2j\beta_1 z} - \Gamma^2\right]$$

$$\boxed{\langle \vec{P_1} \rangle = \hat{z} \frac{E_i^2}{2Z_1} \cdot \left[1-\Gamma^2\right]}$$

EN EL MEDIO 2:

$$\langle \vec{P_2} \rangle = \frac{1}{2} \mathrm{Re}(\vec{E_2} \times \vec{H_2}^*)$$

$$\langle \vec{P_2} \rangle = \frac{1}{2} \mathrm{Re}\left[\hat{x} E_t e^{-j\beta_2 z} \times \frac{E_t}{Z_2} e^{j\beta_2 z}\right]$$

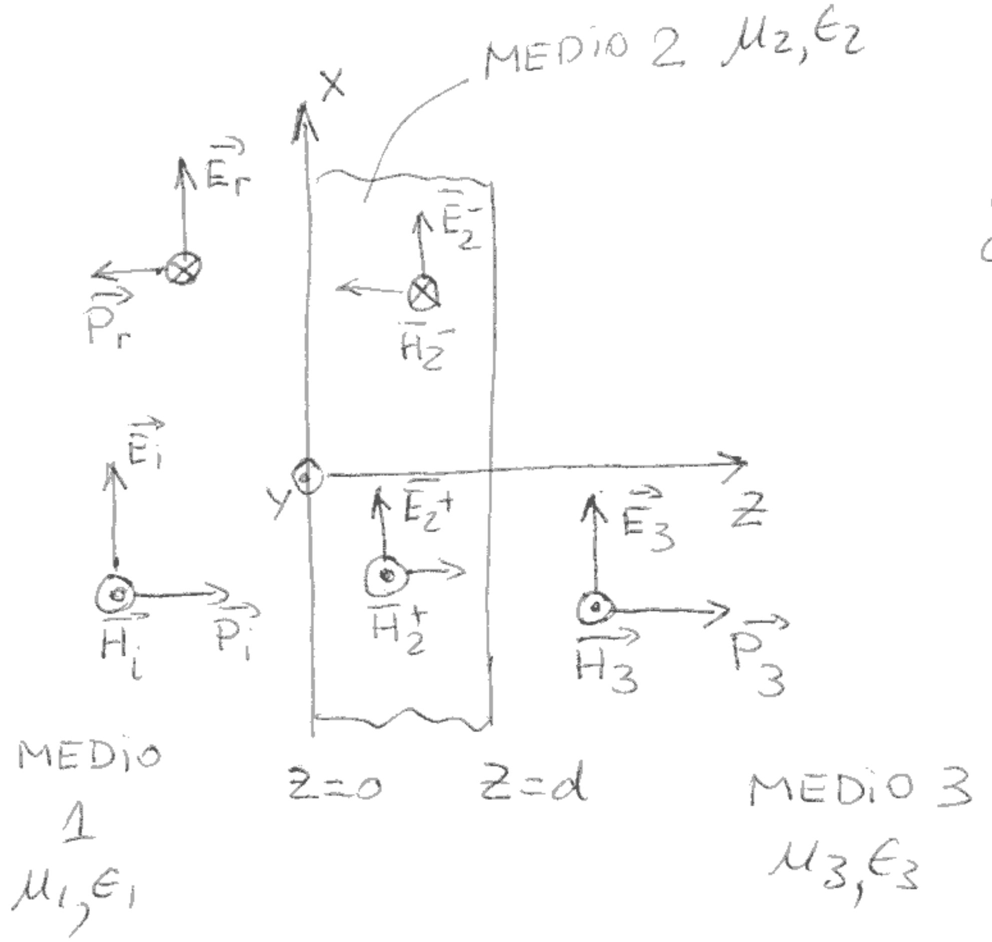
$$\boxed{\langle \vec{P_2} \rangle = \hat{z} \frac{E_t^2}{2Z_2} = \hat{z} \frac{E_i^2 . T^2}{2Z_2}}$$

COMO NO HAY PÉRDIDAS EN MEDIOS 1 Y 2

$$\langle P_1 \rangle = \langle P_2 \rangle$$

$$\frac{\cancel{E_i^2}}{\cancel{2}Z_1}(1-\Gamma^2) = \frac{\cancel{E_i^2} T^2}{\cancel{2}Z_2}$$

$$\boxed{1-\Gamma^2 = T^2 \cdot \frac{Z_1}{Z_2}}$$



LAMINA DE CARAS PLANAS PARALELAS.

EL CAMPO ELÉCTRICO EN EL MEDIO 1

$$E_1 = \hat{x}\left(E_i e^{-j\beta_1 z} + E_r e^{j\beta_1 z}\right)$$

LA IMPEDANCIA DE ONDA EN ① SE DEFINE:

$$E_{1x}(z) = E_i\left(e^{-j\beta_1 z} + \Gamma e^{j\beta_1 z}\right)$$

$$H_{1y}(z) = \frac{E_i}{Z_1}\left(e^{-j\beta_1 z} - \Gamma e^{j\beta_1 z}\right)$$

CON UNA SOLA INTERFAZ EN $z=0$.

$$Z_1(z) = \frac{E_{1x}}{H_{1y}} = \frac{Z_1\left(e^{-j\beta_1 z} + \Gamma e^{j\beta_1 z}\right)}{\left(e^{-j\beta_1 z} - \Gamma e^{j\beta_1 z}\right)}$$

$$Z_1(z)\Big|_{z=-l} = Z_1\left(\frac{e^{j\beta_1 l} + \Gamma e^{-j\beta_1 l}}{e^{j\beta_1 l} - \Gamma e^{-j\beta_1 l}}\right) \qquad \Gamma = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

$$= Z_1 \frac{\cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l + \Gamma\cos\beta_1 l - j\Gamma\,\mathrm{sen}\,\beta_1 l}{\cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l - \Gamma\cos\beta_1 l + j\Gamma\,\mathrm{sen}\,\beta_1 l}$$

$$= Z_1 \cdot \frac{(\cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l)(Z_2+Z_1) + (\cos\beta_1 l - j\,\mathrm{sen}\,\beta_1 l)(Z_2-Z_1)}{(\cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l)(Z_2+Z_1) + (-\cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l)(Z_2-Z_1)}$$

$$= Z_1 \cdot \frac{2 Z_2 \cos\beta_1 l + j\,\mathrm{sen}\,\beta_1 l \cdot 2 Z_1}{2 Z_1 \cos\beta_1 l + j\,2 Z_2\,\mathrm{sen}\,\beta_1 l}$$

$$Z_1(z)\Big|_{z=-l} = Z_1 \cdot \left[\frac{Z_2 \cos\beta_1 l + j Z_1\,\mathrm{sen}\,\beta_1 l}{Z_1 \cos\beta_1 l + j Z_2\,\mathrm{sen}\,\beta_1 l}\right]$$

LA IMPEDANCIA EN EL MEDIO 2, SE PUEDE CALCULAR EN $z=0$, SE TRANSFORMAN LAS VARIABLES:

$l \rightarrow d$

$Z_2 \rightarrow Z_3$

$Z_1 \rightarrow Z_2$

$$Z_2(z)\Big|_{z=0} = Z_2 \cdot \left[\frac{Z_3 \cos\beta_2 d + j Z_2\,\mathrm{sen}\,\beta_2 d}{Z_2 \cos\beta_2 d + j Z_3\,\mathrm{sen}\,\beta_2 d}\right]$$

CONSIDERE EL COEF. DE REF. A LA ENTRADA:

$$\Gamma_0 = \frac{E_r}{E_i} = \frac{Z_2(0) - Z_1}{Z_2(0) + Z_1}$$

SI SE BUSCA $\Gamma_0 = 0 \Rightarrow Z_2(0) - Z_1 = 0$

$$Z_2\left(Z_3 \cos\beta_2 d + j Z_2\,\mathrm{sen}\,\beta_2 d\right) = Z_1\left(Z_2 \cos\beta_2 d + j Z_3\,\mathrm{sen}\,\beta_2 d\right)$$

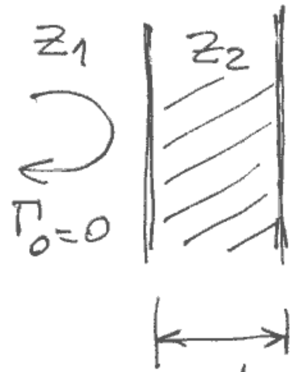
$$\begin{cases} Z_3 \cos\beta_2 d = Z_1 \cos\beta_2 d & (1) \\ Z_2^2\,\mathrm{sen}\,\beta_2 d = Z_1 Z_3\,\mathrm{sen}\,\beta_2 d & (2) \end{cases}$$

SEPARANDO PARTES REALES E IMAGINARIAS

SE DEBEN CUMPLIR SIMULTANEAMENTE 1 Y 2:

DE 1	DE 2
$Z_3 = Z_1$	$Z_2 = \sqrt{Z_1 Z_3}$
o	o
$\cos \beta_2 d = 0$	$\operatorname{sen} \beta_2 d = 0$
$\beta_2 d = (2m+1)\frac{\pi}{2} \quad m = 0,1,2\ldots$	$\beta_2 d = m\pi \quad m = 0,1,2,\ldots$
$d = (2m+1)\frac{\lambda_2}{4}$	$d = \frac{\lambda_2}{2} m$

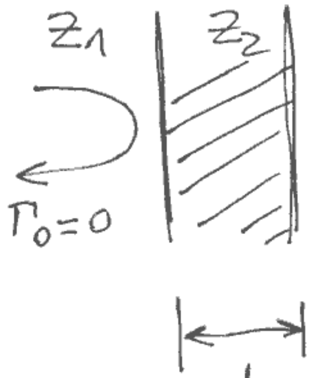
POR LO TANTO SE VA A TENER DOS SOLUCIONES



$Z_3 = Z_1$

a

$$d = \frac{m\lambda_2}{2} \quad m = 0,1,2,\ldots$$



$Z_3 \neq Z_1 \qquad Z_2 = \sqrt{Z_1 Z_3}$

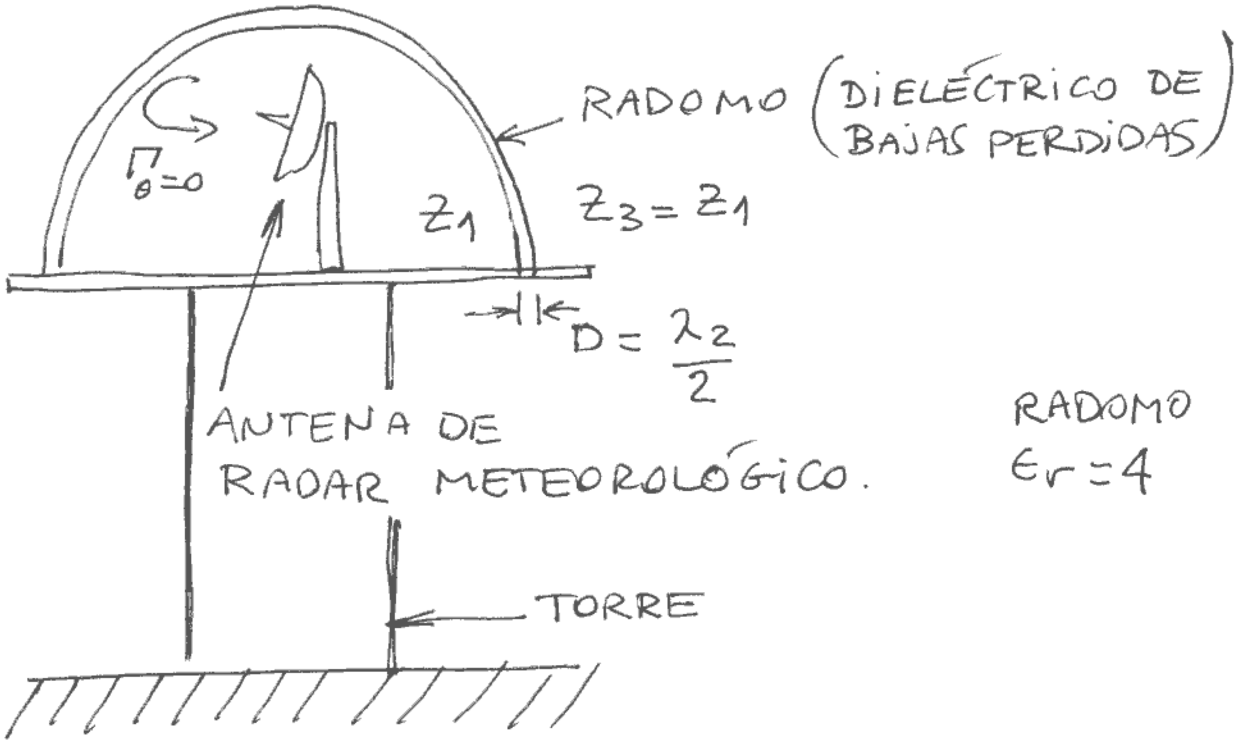
b

$$d = (2m+1)\frac{\lambda_2}{4} \quad m = 0,1,2,\ldots$$

LAS LÁMINAS DE CARAS PARALELAS TIENEN APLICACIONES EN ÓPTICA, DONDE SE APLICA UN RECUBRIMIENTO ANTIREFLECTANTE A LARGAVISTAS POR EJEMPLO.

TAMBIEN SE UTILIZAN EN RADOMOS, PARA PROTEGER ANTENAS DE RADAR METEOROLÓGICO O ANTENAS DE TELEFONÍA DE LAS INCLEMENCIAS DEL TIEMPO.

EJEMPLO



RADOMO
$\epsilon_r=4$

SI EL RADAR METEOROLOGICO TIENE UNA SEÑAL DE $f=5600\ MHz$

$$\lambda_0=\frac{c}{f}=\frac{3.10^8\ m/s}{5600.10^6\ 1/s}=5.35\ cm \qquad \lambda_2=\frac{\lambda_0}{\sqrt{\epsilon_r}}=\frac{\lambda_0}{2}$$

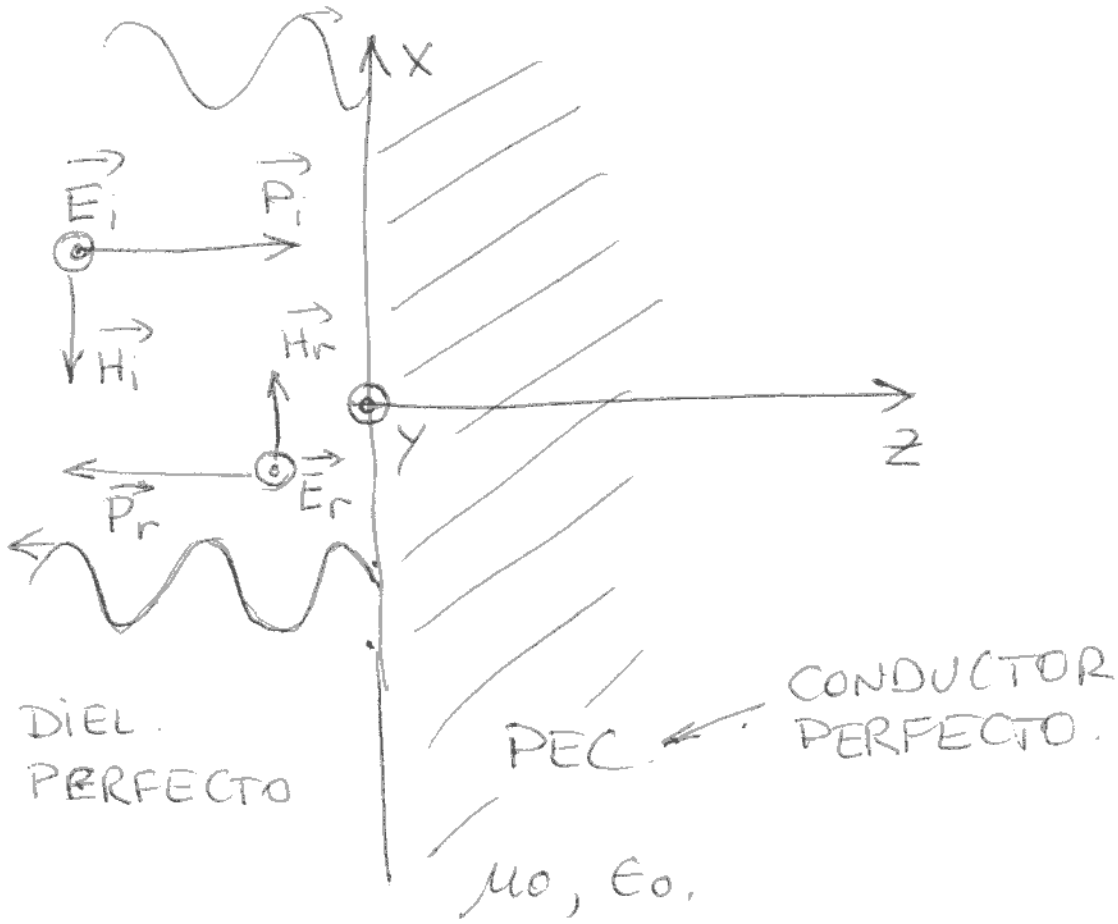
$$D=\frac{\lambda_2}{2}=\frac{5,35}{2.2}\ cm=1,33\ cm$$

$\lambda_0=\lambda$ EN EL AIRE

$\lambda_2=\lambda$ EN EL DIELECTRICO.

REFLEXION DE ONDAS. INCIDENCIA NORMAL

DIELECTRICO PERFECTO – COND. PERFECTO.



$$\vec{E}_i = \hat{y}\, E_i\, e^{-j\beta_1 z}$$
$$\vec{H}_i = -\hat{x}\, H_i\, e^{-j\beta_1 z}$$

$$Z_1 = \frac{E_i}{H_i}$$
$$\beta_1 = \omega\sqrt{\mu_0 \epsilon_1}$$

$$\vec{E}_r = \hat{y}\, E_r\, e^{+j\beta_1 z}$$
$$\vec{H}_r = \hat{x}\, H_r\, e^{+j\beta_1 z}$$

COMO

$$\nabla \times \vec{E_r} = -j\omega\mu_1 \vec{H_r}$$

$$\vec{H_r} = \frac{\nabla \times \vec{E_r}}{-j\omega\mu_1} = \frac{\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 0 & Ere^{j\beta_1 z} & 0 \end{vmatrix}}{-j\omega\mu_1} = \frac{\hat{x}(-\partial Er/\partial z)}{-j\omega\mu_1}$$

$$\vec{H_r} = \hat{x}\frac{-j\beta_1 Ere^{j\beta_1 z}}{-j\omega\mu_1} = +\hat{x}\frac{\beta_1}{\omega\mu_1} Ere^{j\beta_1 z}$$

$$\beta_1 = \omega\sqrt{\mu_1\epsilon_1}$$

$$\vec{H_r} = +\hat{x}\frac{\cancel{\omega}\sqrt{\mu_1\epsilon_1}}{\cancel{\omega}\mu_1} Ere^{j\beta_1 z}$$

$$\vec{H_r} = +\hat{x}\sqrt{\frac{\epsilon_1}{\mu_1}} Ere^{j\beta_1 z}$$

$$\boxed{\vec{H_r} = +\hat{x}\frac{Ere^{j\beta_1 z}}{Z_1}}$$

EN EL MEDIO 2 NO EXISTIRÁ CAMPO ELÉCTRICO.
POR SER PEC.

EN LA INTERFAZ $(z=0)$

$$E_{tang_1} = E_{tang_2} = 0$$

LA CONDICION DE BORDE DE CAMPO ELECTRICO TANGENCIAL.

$$E_{tang_1} = E_i\Big|_{z=0} + E_r\Big|_{z=0}$$

$$E_{tang_1} = E_i + E_r = 0$$

ENTONCES:

$$E_i + E_r = 0 \Rightarrow \boxed{E_r = -E_i}$$

POR LO TANTO:

$$\boxed{E_r = -\hat{y} E_i e^{+j\beta_1 z}}$$

EL CAMPO TOTAL EN EL MEDIO 1 SERÁ:

$$E_{TOT} = \hat{y} E_i e^{-j\beta_1 z} - \hat{y} E_i e^{j\beta_1 z}$$

$$E_{TOT} = \hat{y} E_i (\cos\beta_1 z - j\,\mathrm{sen}\,\beta_1 z) - \hat{y} E_i (\cos\beta_1 z + j\,\mathrm{sen}\,\beta_1 z)$$

$$E_{TOT} = \hat{y} E_i (-2j\,\mathrm{sen}\,\beta_1 z)$$

APLICANDO $e^{j\omega t}$

$$E_{TOT} = -2j\,\hat{y} E_i\,\mathrm{sen}\,\beta z\, e^{j\omega t}$$

$$\boxed{\vec{E}_{TOT} = 2\ \hat{y} E_i \operatorname{sen} \beta z \operatorname{sen} \omega t}$$

ESTO REPRESENTA UNA ONDA ESTACIONARIA PURA PORQUE EL CAMPO ELECTRICO SE ANULA PARA DETERMINADAS DISTANCIAS Z.

$$\beta z = -m\pi \qquad m = 0, 1, 2 \ldots$$

$$z = -m\frac{\pi}{\beta} = -m\frac{\cancel{\pi}}{2\cancel{\pi}/\lambda} = -m\frac{\lambda}{2}$$

EL CAMPO MAGNETICO REFLEJADO:

$$\vec{H}_r = \hat{x} H_r e^{j\beta_1 z}$$

$$H_r = +\hat{x}\frac{E_r}{Z_1}e^{j\beta_1 z} = -\hat{x}\frac{E_i}{Z_1}e^{j\beta_1 z} \quad (E_r = -E_i)$$

POR LO TANTO

$$\vec{H}_{TOT} = \vec{H}_i + \vec{H}_r$$

E_i/Z_1

$$\vec{H}_{TOT} = -\hat{x} H_i e^{-j\beta_1 z} - \hat{x}\frac{E_i}{Z_1}e^{j\beta_1 z} = -\hat{x}\frac{E_i}{Z_1}\left(e^{-j\beta_1 z} + e^{j\beta_1 z}\right)$$

$$\boxed{\vec{H}_{TOT} = -2\hat{x}\overset{H_i}{\frac{E_i}{Z_1}}\cos\beta_1 z \cos\omega t}$$

EL CAMPO MAGNETICO SE VA A ANULAR EN:

$$\beta z = -\frac{\pi}{2}, -\frac{3\pi}{2}, -\frac{5\pi}{2}$$

$$\beta z = -(2m+1)\frac{\pi}{2} \qquad m = 0, 1, 2 \ldots \qquad \text{con } \beta = \frac{2\pi}{\lambda}$$

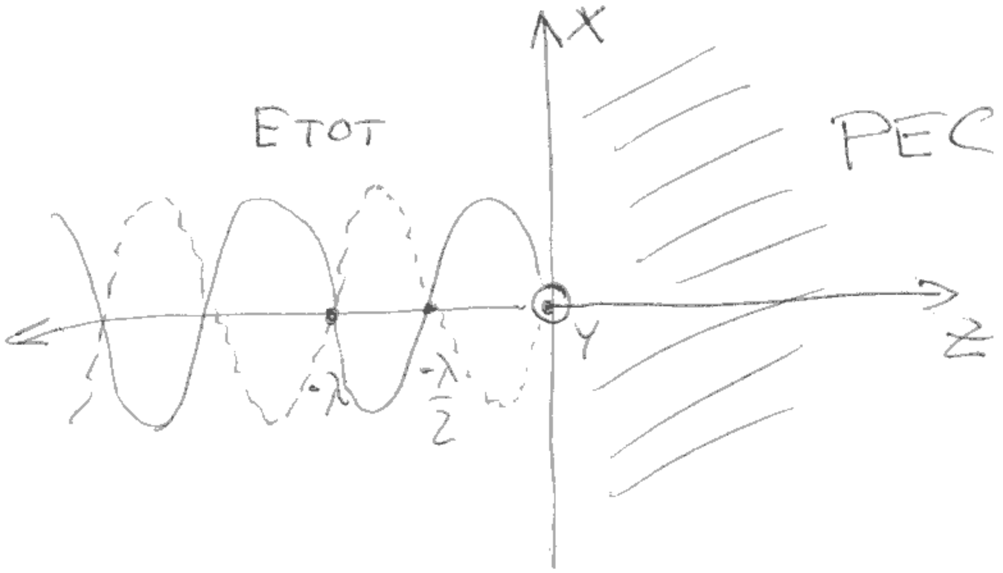
$$z = -(2m+1)\frac{\cancel{\pi}}{2\,\frac{2\cancel{\pi}}{\lambda}} = -(2m+1)\frac{\lambda}{4}$$

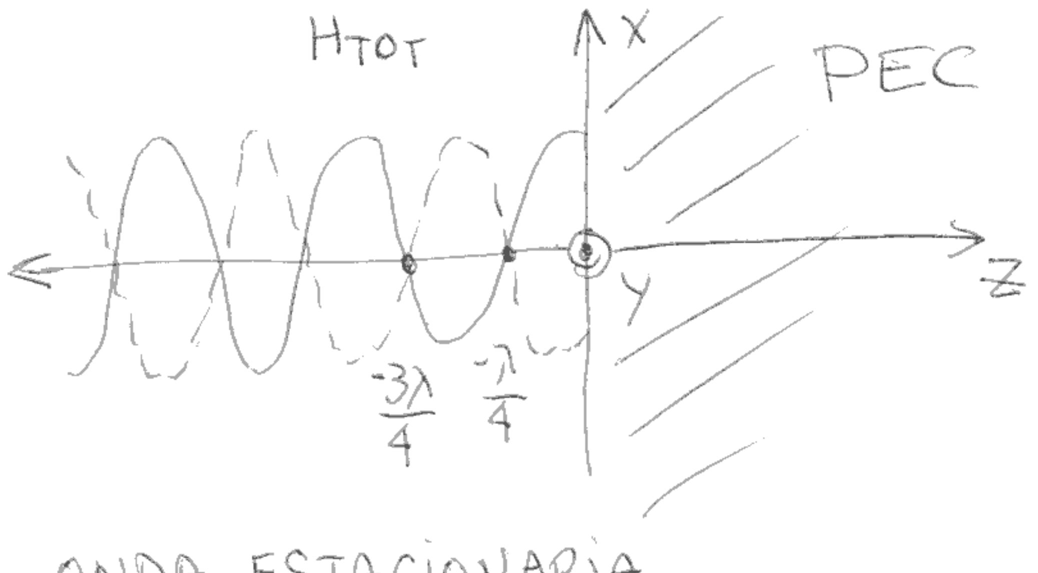
POR LAS CONDICIONES DE CONTORNO DEL CAMPO MAGNETICO

$$\vec{J}_{su}\Big|_{z=0} = \hat{n} \times \vec{H}_{tot}\Big|_{z=0} \qquad \hat{n} = \hat{z}$$

$$\vec{J}_{su}\Big|_{z=0} = (-\hat{z}) \times (-\hat{x})\, 2H_i = \hat{y}\, 2H_i e^{j\omega t}$$

LA DENSIDAD DE CORRIENTE DE CONDUCCIÓN TIENE LA DIRECCION $\hat{y}$





ONDA ESTACIONARIA

$$\Gamma_E = \frac{E_r}{E_i} = \frac{-E_i}{E_i} = -1$$

$$\Gamma_H = \frac{H_r}{H_i} = \frac{E_i/Z_1}{E_i/Z_1} = \frac{+E_i}{E_i} = +1$$

COEFICIENTE DE REFLEXIÓN DE $\vec{E}$ Y DE $\vec{H}$

RESUMEN

$$\vec{E_i} = \hat{y} E_i e^{-j\beta_1 z} \qquad Z_1 = \frac{E_i}{H_i}$$

$$\vec{H_i} = -\hat{x} H_i e^{-j\beta_1 z}$$

$$\vec{E_r} = -\hat{y} E_i e^{j\beta_1 z}$$

$$\vec{H_r} = -\hat{x} \frac{E_i}{Z_1} e^{j\beta_1 z}$$