Universidad
Carlos III de Madrid
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Escuela Politécnica Superior

Asignatura P y T Prueba 1 27/10/16.

Nombre del Alumno

Fecha Curso Grupo

(1) $s = \frac{1+|\rho|}{1-|\rho|}$ $|\rho| = \frac{s-1}{s+1} = \frac{1}{3}$ $1 - \left|\frac{1}{3}\right|^2 = \frac{8}{9}$

$\int \cos^2\theta \sin\theta \, d\theta \, d\phi = -\frac{\cos^3\theta}{3}\Big|_0^{\pi/2} \phi\Big|_0^{\pi} = \frac{1}{3}\pi = \frac{\pi}{3}$

$D = \frac{4\pi}{\Omega_A} = \frac{4\pi}{\frac{\pi}{3}} = 12$ $G = 0{,}9 \cdot \frac{8}{9} \cdot 12 = \frac{48}{5} = 9{,}6$

$10 \log_{10} 9{,}6 = 9{,}82 \text{ dB}$.

(2) $\lambda_0 = \frac{c}{f} = \frac{3\cdot 10^8}{100 \cdot 10^6} = 3 \text{ m}$ $A_{e\,max} = \frac{3^2}{4\pi} \cdot 1{,}5 \simeq 1{,}074 \text{ m}^2$

$P_{rec} = P_{in} \cdot A_e$ $P_{in} = \frac{3 \mu W}{1{,}074 \text{ m}^2} \simeq 2{,}79 \mu W/m^2$

$P_{in} = \frac{|E|^2}{2\eta}$ $|E| = \sqrt{2{,}79 \cdot 10^{-6} \cdot 120\pi \cdot 2} =$ ~~$0{,}0324$~~ $0{,}04586$ V/m.

$|H| = \frac{|E|}{\eta} \simeq$ ~~$8{,}6 \cdot 10^{-5}$~~ $1{,}216 \cdot 10^{-4}$ A/m.

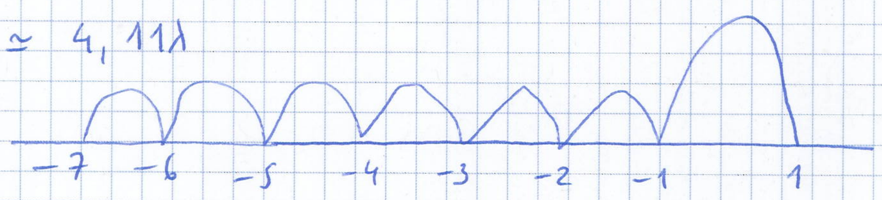
(3) $\cos 45° = \frac{\sqrt{2}}{2}$ $u = k\frac{L}{2}\left(\cos\theta - \frac{\sqrt{2}}{2}\right)$

$\theta \in [0, \pi]$ $u = \frac{2\pi}{\lambda} \frac{L}{2}\left(\cos\theta - \frac{\sqrt{2}}{2}\right)$

$\left[-1{,}7 \frac{L}{\lambda}\pi, \ldots \pi \frac{L}{\lambda} 0{,}3\right]$

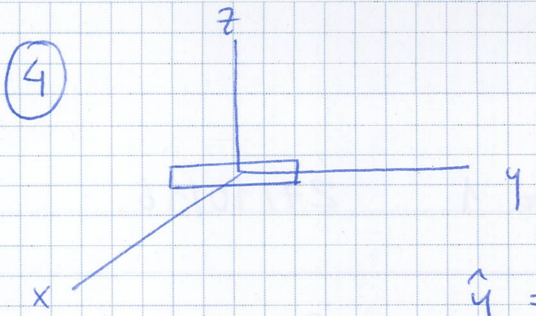
$L = 4\lambda$ $[-6{,}8\pi, \ldots 1{,}2\pi]$

$L \simeq 4{,}11\lambda$



Papel ecológico.

(4)



$$\bar{I} = I_0 \hat{y}$$

$$\bar{A} = \frac{\mu_0}{4\pi} \int_{-L/2}^{L/2} I_0 \hat{y} \, \frac{e^{-jkr}}{r}$$

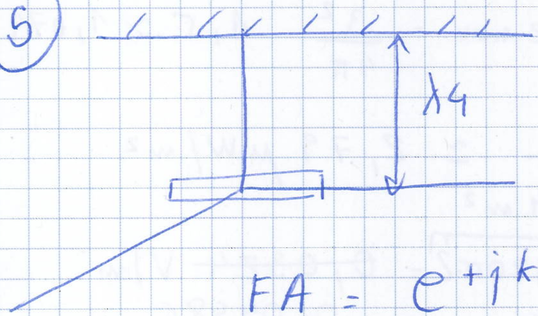
$$\hat{y} = \hat{\theta} \cos\theta \operatorname{sen}\phi + \hat{\phi} \cos\phi$$

$$\bar{E} = -j\omega \bar{A} = -\frac{j\omega \mu L I_0}{4\pi} \frac{e^{-jkr}}{r} \left[\cos\theta \operatorname{sen}\phi \, \hat{\theta} + \cos\phi \, \hat{\phi} \right] \text{ V/m.}$$

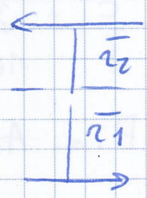
$$\bar{H}_{rad} = \frac{\hat{r} \times \bar{E}}{\eta_0} \qquad \begin{vmatrix} \hat{r} & \hat{\theta} & \hat{\phi} \\ 1 & 0 & 0 \\ 0 & E_\theta & E_\phi \end{vmatrix} = -E_\phi \hat{\theta} + E_\theta \hat{\phi}$$

$$\bar{H}_{rad} = \frac{1}{\eta_0} \frac{\omega \mu L I_0}{4\pi} \frac{e^{-jkr}}{r} \left[\cos\phi \, \hat{\theta} - \cos\theta \operatorname{sen}\phi \, \hat{\phi} \right] \frac{\text{A}}{\text{m}}.$$

(5)



Tª Imágenes ⟹



$$\bar{r}_2 = \frac{\lambda}{4} \hat{z}$$

$$\bar{r}_1 = \frac{\lambda}{4} (-\hat{z})$$

$$FA = e^{+jk\bar{r}_1 \cdot \hat{r}} - e^{jk\bar{r}_2 \cdot \hat{r}}$$

$$= e^{-j\frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} \hat{z} \cdot \hat{r}} - e^{jk\frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} \hat{z} \cdot \hat{r}}$$

$$= e^{-j\frac{\pi}{2}\cos\theta} - e^{j\frac{\pi}{2}\cos\theta} = 2j \operatorname{sen}\left(\frac{\pi}{2}\cos\theta\right)$$

$$\bar{E}_{total} = -\frac{j\omega\mu L I_0}{4\pi} \frac{e^{-jkr}}{r} 2j \operatorname{sen}\left(\frac{\pi}{2}\cos\theta\right) \left[\cos\theta \operatorname{sen}\phi \, \hat{\theta} + \cos\phi \, \hat{\phi} \right]$$

V/m.

(6) $f_0 = 12\ GHz$ $\quad \lambda_0 = \frac{c}{f} = \frac{3 \cdot 10^8}{12 \cdot 10^9} = \frac{1}{40} = 0{,}025\ m.$

$G_s = 26\ dB$ $\quad \hat{e}_s = \frac{\hat{\theta} + j\hat{\phi}}{\sqrt{2}}$ $\quad |\hat{e}_s \cdot \hat{\theta}|^2 = \frac{1}{2}$

$-3\ dB$ por pol

$P_2 = -75\ dBm$ $\quad D_2 = 37\ dBi$

$\Gamma = \frac{67-50}{67+50} = \frac{17}{117} \simeq 0{,}1453$ $\quad (1 - |\Gamma|^2) = 0{,}9788$

$10 \log_{10} 0{,}9788 = -0{,}092\ dB.$

$R = \sqrt{250^2 + 298^2} = 388{,}98\ km.$

Per. esp libre $\quad 20 \log_{10} \frac{\lambda}{4\pi R} = -165{,}823\ dB.$

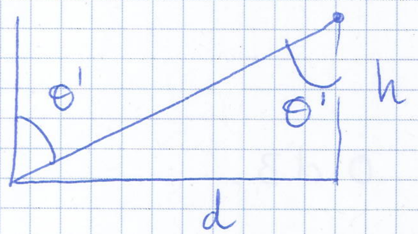
Balance

$-75\ dBm = P_t + 26 + 37 - 0{,}092 - 165{,}823 - 3$

$-75\ dBm = P_t - 105{,}917$ $\quad P_t = 30{,}915\ dBm \simeq 31\ dBm$

$1234{,}52\ mW \simeq 1{,}23\ W$

(7) Ahora las antenas no están apuntadas.



$tg\,\theta' = \frac{d}{h}$ $\quad arctg \frac{d}{h} = arctg \frac{298}{250} = 50°$

En la figura para $\theta = 50°$ el diagrama cae $-15\ dB$.

$D_2(\theta') = D_{2\,max} - 15\ dB = 37 - 15 = 22\ dBi$

la potencia deberá ser mayor ahora

$P_t' = 31\ dBm + 15\ dB = 46\ dBm$

$\simeq 39\ W$

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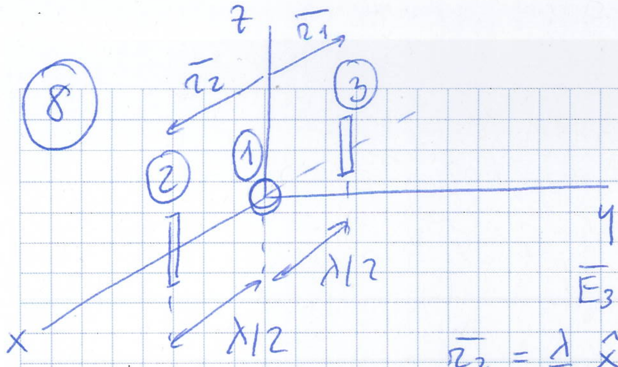

$$\bar{E}_1 = -E_0 \frac{e^{-jkr}}{r}\hat{\theta}$$

$$\bar{E}_2 = E_0 \operatorname{sen}\theta \, e^{jk\bar{r}_2\cdot\hat{r}} \frac{e^{-jkr}}{r}\hat{\theta}$$

$$\bar{E}_3 = E_0 \operatorname{sen}\theta \, e^{jk\bar{r}_3\cdot\hat{r}} \frac{e^{-jkr}}{r}\hat{\theta}$$

$$\bar{r}_2 = \frac{\lambda}{2}\hat{x} \qquad \bar{r}_1 = -\frac{\lambda}{2}\hat{x}$$

Aplicando superposición

$$\bar{E}^1_{tot} = E_0\left(-1 + \operatorname{sen}\theta\left(e^{jk\frac{\lambda}{2}\hat{x}\cdot\hat{r}} + e^{-jk\frac{\lambda}{2}\hat{x}\cdot\hat{r}}\right)\right)\hat{\theta}\,\frac{e^{-jkr}}{r}$$

$$\hat{x}\cdot\hat{r} = \operatorname{sen}\theta\cos\phi$$

$$= E_0\left(-1+\operatorname{sen}\theta\left(2\cos(\pi \operatorname{sen}\theta\cos\phi)\right)\right)\frac{e^{-jkr}}{r}\hat{\theta}$$

$$r_1(\theta,\phi) = \left(-1 + 2\operatorname{sen}\theta\cos(\pi\operatorname{sen}\theta\cos\phi)\right)^2$$

Ahora $\bar{E}_1 = -E_0 \frac{e^{-jkr}}{r}\hat{\phi}$

$$\bar{E}^2_{tot} = E_0\left(-\hat{\phi} + \operatorname{sen}\theta\, 2\cos(\pi\operatorname{sen}\theta\cos\phi)\hat{\theta}\right)\frac{e^{-jkr}}{r}$$

$$r_2(\theta,\phi) = \frac{1 + \operatorname{sen}^2\theta\, 4\cos^2(\pi\operatorname{sen}\theta\cos\phi)}{5}$$

9 dipolo según $\hat{z}$ (sobre el eje y) eje y $\begin{cases}\theta = 90^\circ & \pi/2\\ \phi = 90^\circ & \pi/2\end{cases}$

$$\bar{E}^1_{tot} = E_0(-1+2)\frac{e^{-jkr}}{r}\hat{\theta} \Rightarrow \hat{e}_1 = \hat{\theta}$$

$$\bar{E}^2_{tot} = E_0(-\hat{\phi}+2\hat{\theta})\frac{e^{-jkr}}{r} \Rightarrow \hat{e}_2 = \frac{-\hat{\phi}+2\hat{\theta}}{\sqrt{5}}$$

$$\hat{e}_{dipolo} = \hat{\theta}$$

Pérdidas por pol.

Caso 1 $\quad |\hat{e}_d\cdot\hat{e}_1^*|^2 = 1 \quad$ 0 dB.

Caso 2 $\quad |\hat{e}_d\cdot\hat{e}_2^*|^2 = \frac{4}{5} \quad$ −0,96 dB