Tips

Buen Dielectrico: $\beta = \frac{2\pi}{\lambda}$

$\alpha = \frac{\sigma}{2} \cdot \sqrt{\frac{\mu}{\varepsilon}}$

Buen Conductor: $\beta = \alpha = \sqrt{\frac{\omega \cdot \mu \cdot \sigma}{2}}$

(1) $\mu_r = 1$ $\varepsilon_r = 8$ $\sigma = 2{,}5 \cdot 10^{-13}$ S/m frecuencia onda $= 1{,}6$ MHz

$\gamma = ? = \alpha + j \cdot \beta$

Antes, es conductor ó dieléctrico ideal?

$$\frac{\sigma}{\omega \cdot \varepsilon} = \frac{2{,}5 \cdot 10^{-13}\ \text{S/m}}{2\pi \cdot 1{,}6\text{MHz} \cdot 8 \cdot 8{,}85 \cdot 10^{-12}} = 3{,}5 \cdot 10^{-10} \ll 1 \Rightarrow \text{Buen Dielectrico}$$

$$\alpha = \sqrt{\frac{\omega \mu \sigma}{2}} = \sqrt{\frac{2\pi \cdot 1{,}6\text{MHz} \cdot 4\pi \cdot 10^{-7} \cdot 2{,}5 \cdot 10^{-13}\ \text{S/m}}{2}} = 1{,}256 \cdot 10^{-6} \ll 1$$

$$\cancel{\Rightarrow \boxed{\gamma} = \frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}} + j \cdot \frac{2\pi \cdot F}{v}} \cong \boxed{0 + 0{,}0948 j}$$

59,6 pico

casi 0

(2) $\boxed{1\,N_p = \frac{20}{\ln(10)}\,dB}$

(3) $\sigma = 5 \cdot 10^{-3}$ S/m, $\mu_r = 1$, $\varepsilon_r = 8$

Considero dielectrico perfecto si $\frac{\sigma}{\omega \cdot \varepsilon} \leq 1\mu \approx 0$

$$\frac{5 \cdot 10^{-3}}{2\pi \cdot f \cdot \varepsilon_0 \cdot 8} = 1\mu \longrightarrow \frac{11{,}239{,}755{,}87}{f} = 1\mu \longrightarrow \boxed{11{,}2398\ \text{THz}}$$

(4) $f = 500K$ $\mu_r = 1$ $\varepsilon_r = 15$ $\sigma = 0$ Dielectrico ideal

$$\gamma = \alpha + j\beta = 0 + j \cdot \frac{2\pi \cdot c}{f \cdot \sqrt{\varepsilon_r}} = \boxed{0 + 973{,}387 j}$$

(5) $f = 400$ MHz $\varepsilon_r = 16$ $\mu_r = 4{,}5$ $\sigma = 0{,}6$ S/m

$$\frac{\sigma}{\omega \cdot \varepsilon} = \frac{0{,}6}{400M \cdot 16 \cdot \varepsilon_0} = 10{,}59 \longrightarrow \text{Tengo q usar la ecuación gral.}$$

$$\alpha = \omega \sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]} = 49{,}28\ \text{rad/m}$$

$$\beta = \omega \sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} + 1\right]} = 86{,}523\ \text{Np/m}$$

$v_p = \frac{\omega}{\beta} =$

- $\boxed{\text{en medio} \longrightarrow 29M}$
- $\boxed{\text{luz} \longrightarrow 3 \cdot 10^8}$

relación $= 9{,}\hat{6}\%$

(6) $\varepsilon_r = 18{,}5$, $\mu_r = 800$, $\sigma = 1$ S/m, $F = 1$ GHz

$\alpha, \beta, \eta, \gamma$

analizamos el medio: $\frac{\sigma}{\omega \cdot \varepsilon} = \frac{1}{8{,}85 \cdot 10^{-12} \cdot 18{,}5 \cdot 1G} = 6 \approx 1$!!

$$\alpha = \omega \sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]} = 1132{,}29\ \text{rad/m}$$

$$\boxed{\eta} = \frac{\eta_0}{\sqrt{\varepsilon_r}} = \frac{j\omega\mu}{\gamma} = \frac{6{,}316\,M}{\gamma} = \boxed{789{,}17 - j\,1944{,}03}$$

$$\beta = \omega \sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} + 1\right]} = 2789{,}27\ \text{Np/m}$$

$\vec{H} = ?$ $\boxed{\vec{E}} = 50 \cdot e^{-\alpha z} \cdot e^{j(\omega t - \beta z)}\ \text{V/m}\ \hat{x} = \boxed{50 \cdot e^{-\alpha z + j\omega t - j\beta z}\ \text{V/m}\ \hat{x}}$

$$\boxed{\vec{H} = j\hat{y}\,\frac{E'}{\omega\mu_0} = j\hat{y}\ \frac{50 \cdot e^{-\alpha z + j\omega t - j\beta z} \cdot (-\alpha - j\beta)}{\omega\ \mu_0}}$$

(7) (1) $\eta = \frac{\eta_0}{\sqrt{\varepsilon_r}} = 200\,\Omega$ $\longrightarrow 377\,\Omega$

$$\eta = \frac{377}{200} = \sqrt{\varepsilon_r} \longrightarrow \boxed{\varepsilon_r = 3{,}553}$$

(2)

$$10\,\text{GHz} \longrightarrow \lambda = \frac{V}{F} = 1{,}5\text{cm} \longrightarrow V = 1{,}5 \cdot 10^8 = \frac{C}{\sqrt{\varepsilon_r}}$$

$\boxed{\varepsilon_r = 4}$

(8) Frecuencia: 1,6 MHz $\sigma = 3{,}82 \cdot 10^7$ S/m $\mu_r = 1$ supongo $\varepsilon_r = 1$

chequeo si es buen algo: $\frac{\sigma}{\omega \cdot \varepsilon} = 2{,}697 \cdot 10^{12} \gg 1$

$$\beta = \alpha = \sqrt{\frac{\omega \cdot \mu \cdot \sigma}{2}} = \sqrt{\frac{1{,}6M \cdot \mu \cdot 3{,}82 \cdot 10^7}{2}} = 6197$$

$\boxed{\frac{1}{\alpha} = 1{,}613 \cdot 10^{-4} \qquad \gamma = 6197 + 6197 j}$

⑨ Buen conductor

$$\Rightarrow \beta = \alpha = \sqrt{\frac{\omega \cdot \mu \cdot \sigma}{2}} = \sqrt{\frac{100M \cdot \mu_0 \cdot 3{,}82 \cdot 10^7}{2}} = 48\,991{,}59$$

$$\eta = \sqrt{\frac{\omega\mu}{2\sigma}} + j\sqrt{\frac{\omega \cdot \mu}{2\sigma}} = \boxed{3{,}215 + j\,3{,}25}$$

$$\boxed{\gamma = 48.991 + j\,48991}$$

⑩ plata → Buen conductor

$$\frac{1}{\alpha} = 1mm = 10^{3} \longrightarrow \alpha = \sqrt{\frac{\omega \cdot \mu \cdot \sigma}{2}} \Rightarrow \frac{1}{\sqrt{\frac{2\pi \cdot f \cdot \mu_0 \cdot \sigma}{2}}} = 10^{3}$$

$$\left(\frac{1}{10^{-3}}\right)^2 = \frac{2\pi \cdot f \cdot \mu_0 \cdot \sigma}{2}$$

$$\frac{2M}{2\pi \cdot \mu_0 \cdot \sigma} = \boxed{f = 265{,}26\ kHz}$$

⑪ Cobre, Buen conductor!

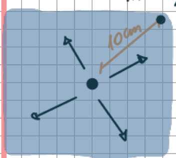
$\beta = 3{,}71 \cdot 10^{5}\ \frac{rad}{m}$ f?

$\sigma =$

$$\beta = \alpha = \sqrt{\frac{\omega \cdot \mu \cdot \sigma}{2}} = \sqrt{\frac{2\pi \cdot f \cdot \mu_0 \cdot 5{,}8 \cdot 10^7}{2}} = \beta$$

$$\boxed{f = \frac{\beta^2 \cdot 2}{2\pi \cdot \mu_0 \cdot 5{,}8 \cdot 10^7}} = 601\,MHz \xrightarrow[\text{Buen conductor?}]{\text{sigue}} \frac{\sigma}{\omega \cdot \varepsilon} >> 1 \Rightarrow \text{sí}$$

⑫ $E = 10\ V/m$ $\mu_r = 1$ $\varepsilon_r = 20$ $\sigma = 0{,}5\ S/m$



ⓐ 5 MHz, ¿E?

$$\underbrace{E = E_0 \cdot e^{-\alpha z}}_{\text{Amplitud}} \quad \begin{cases} E_0 = 10\ V/m \\ z = 0{,}1 \\ \alpha = ? \end{cases}$$

Buen conductor?

$$\frac{\sigma}{\omega \cdot \varepsilon} \cong 90 >> 1 \Rightarrow \text{Buen conductor}$$

$$\Rightarrow \alpha = \sqrt{\frac{\omega\mu\sigma}{2}} = \pi \longrightarrow \boxed{10\ V/m \cdot e^{\pi \cdot 0{,}1} = 13{,}69\ V/m}$$

ⓑ 50 MHz

$$\frac{\sigma}{\omega \cdot \varepsilon} = 9 \approx 1 \Rightarrow \text{Ecuación gral.}$$

$$\text{Busco } \alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\underbrace{\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2}}_{3{,}1609} - 1\right]} = 4{,}87 \longrightarrow \boxed{10\ V/m \cdot e^{0{,}1 \cdot 4{,}87} = 16{,}27\ V/m}$$

ⓒ 500 MHz

$$\frac{\sigma}{\omega \cdot \varepsilon} = 0{,}9 \approx 1$$

ecuación gral

$$\alpha = 19{,}45 \longrightarrow \boxed{10\ V/m \cdot e^{0{,}1 \cdot 19{,}45} = 69{,}96\ V/m}$$

⑬ $f = 500\ kHz$

Parametros tierra seca: $\sigma = 10^{-3}\ S/m$, $\mu_r = 1$, $\varepsilon_r = 10$

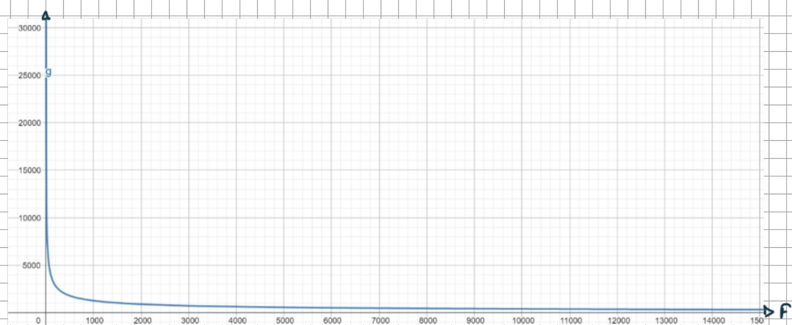
atenuación dB/Km

Para esto analizo la profundidad de penetración: $1/\alpha$

Es Buen dieléctrico? ⟶ No

$$\frac{\sigma}{\omega \cdot \varepsilon} = \frac{10^{-3}}{500000 \cdot \varepsilon_0 \cdot 10} = 22 \approx 1$$

$$\text{Ecuación gral: } \alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]} = 0{,}038$$



$$\boxed{330\ dB/Km}$$

(14) $\tan(\delta) = 0{,}02$ $\quad \varepsilon_r = 1{,}2$ $\quad$ frecuencia $= 1MHz$

atenuación dB/Km para onda plana $1MHz$

Observo q: $tg(\delta) = \dfrac{\sigma}{\omega\varepsilon} = 0{,}02 << 1 \Rightarrow$ Buen dieléctrico

$1/\alpha$ = Profundidad de penetración $\rightarrow$ atenuación de la onda

$\alpha \approx \dfrac{\sigma}{2}\sqrt{\dfrac{\mu}{\varepsilon}}$ $\qquad \dfrac{\sigma}{2\pi \cdot 1M \cdot \varepsilon_0 \cdot 1{,}2} = 0{,}02$

$\boxed{\alpha = 0{,}229\,m}$ $\qquad \boxed{\sigma = 1{,}33\mu}$ $\qquad \alpha \cdot \overbrace{\dfrac{20}{\ln(10)}}^{dB} \cdot \overbrace{1000}^{Km} = \boxed{1{,}989\ \dfrac{dB}{Km}}$

$\dfrac{Np}{m} - \dfrac{dB}{km}$

(15) $\sigma = 5$ $\quad \varepsilon_r = 80$ } agua

Señal $1kHz$, $20dB$ encima del ruido

$\Rightarrow \dfrac{\sigma}{\omega \cdot \varepsilon} = 1123975 >> 1$ Buen Conductor $\Rightarrow \alpha = \sqrt{\dfrac{\omega\mu\sigma}{2}} = 0{,}1405\ Np/m \longrightarrow 1220\ dB/Km$

$1220\,dB$ ——— $1000\,m$

$20\,dB$ ——— $\boxed{16{,}39\,m}$

(2) $\lambda = \dfrac{2\pi}{\beta} \rightarrow \dfrac{\lambda}{2} = \dfrac{\pi}{\beta}$

$\beta = \alpha$ por buen conductor

$\boxed{\lambda = 22{,}36}$

(16) $\dfrac{5}{\alpha} \cdot \alpha = \alpha \cdot z$

$z = 5 \longrightarrow E_0 \cdot e^{-5\alpha} \xrightarrow{\text{a dB}} \boxed{20 \cdot \log\left(E_0 \cdot e^{-5\alpha}\right) dB}$

(17) $\dfrac{\sigma}{\omega\,\varepsilon} = 0{,}05 <<$ Buen dieléctrico

$\varepsilon_r = 2{,}5$ $\qquad$ Frec $= 3GHz$

Amplitud de onda $= E_0 \cdot e^{-\alpha z}$ → distancia

$\dfrac{\sigma}{2{,}5 \cdot \varepsilon_0 \cdot 3G \cdot 2\pi} = 0{,}05 \longrightarrow \sigma = 0{,}02085$

$\alpha = \dfrac{\sigma}{2}\sqrt{\dfrac{\mu}{\varepsilon}} = 2{,}48$

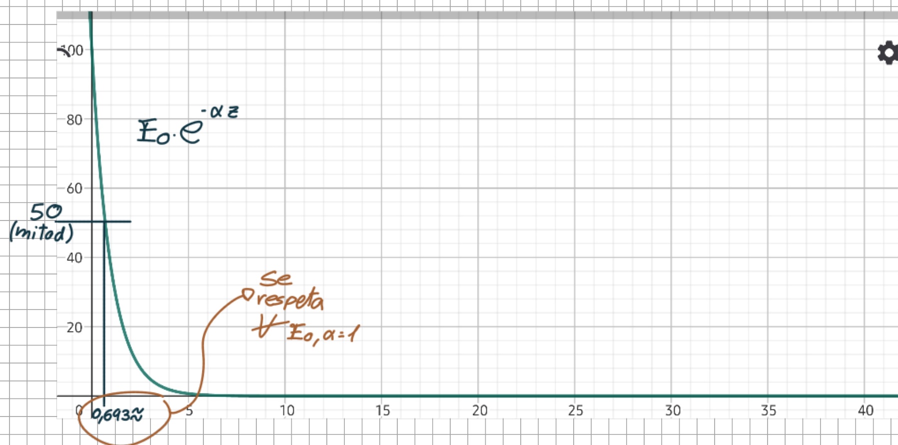
$\Rightarrow E_0$ ——— 100%

$\dfrac{E_0}{2}$ ——— 50%

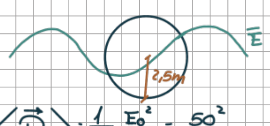
$\hookrightarrow \cancel{E_0} \cdot \frac{1}{2} = e^{-2{,}48z} \cdot \cancel{E_0}$

$\ln(1/2) = -2{,}48\,z$

$\boxed{z = 0{,}2795\,m}$



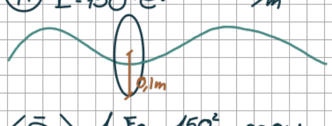
(18) $\vec{E} = 50 \cdot e^{j(\omega t - \beta z)}\ V/m\ \hat{x}$



Ahora, para esto uso Vector de Pointing promedio → densidad superficial de potencia en f(t)

$\langle \vec{P} \rangle = \dfrac{1}{2}\dfrac{E_0^2}{Z_m} = \dfrac{50^2}{377 \cdot 2} = 3{,}32\ W/m^2 \xrightarrow{\pi r^2} 65{,}18\ W$

(19) $E = 150 \cdot e^{j(\omega t - \beta z)}\ V/m$

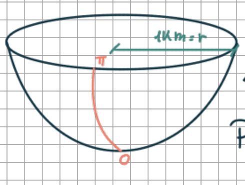


Si estamos en espacio libre, $\sigma = 0 \Rightarrow \alpha = 0$

$\beta = \dfrac{2\pi}{\lambda}$

$\langle \bar{P} \rangle = \dfrac{1}{2}\dfrac{E_0}{Z_m} = \dfrac{150^2}{377 \cdot 2} = 29{,}841\ W/m^2 \xrightarrow{\pi \cdot r^2} 0{,}937\ W \approx 1W$

(20)



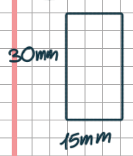
$\bar{E} = \dfrac{100V}{r}\,\mathrm{sen}(\theta)\, e^{j(\omega t - \beta z)}\,\hat{\theta}$ $\qquad \bar{H} = \dfrac{0{,}265A}{r}\,\mathrm{sen}(\theta)\, e^{j(\omega t - \beta z)}\,\hat{\phi}$

$\langle \bar{s} \rangle = \dfrac{1}{2}\mathrm{Re}\{\bar{E} \times \bar{H}^*\} = \dfrac{1}{2}\dfrac{100V}{r}\mathrm{sen}(\theta)\,\dfrac{0{,}265A}{r}\,\mathrm{sen}(\theta)\,\hat{r} = \langle \bar{s} \rangle = \dfrac{13{,}25V}{r^2}\,\mathrm{sen}^2(\theta)\,\hat{r}$

$P = \iint \langle \bar{s} \rangle\, d\bar{s}$ $\qquad d\bar{s} = r^2\,\mathrm{sen}(\theta)\, d\theta\, d\phi\, \hat{r}$

$P = \displaystyle\int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi/2} \dfrac{13{,}25W}{r^2}\, r^2\,\mathrm{sen}^3(\theta)\, d\theta\, d\phi \Rightarrow \boxed{P = 13{,}25W\, 2\pi \int_{0}^{\pi/2} \mathrm{sen}^3(\theta)\, d\theta = 55{,}5W}$

(21) $\vec{E} = 150 \cdot e^{j(\omega t - \beta z)}$



$\langle \bar{P} \rangle = \frac{1}{2}\frac{E_0^2}{Z_m} = \frac{1}{2}\frac{150^2}{377} = 29{,}841\ \frac{W}{m^2} \xrightarrow{b \times h} \boxed{14{,}77\,mW}$

Vector de Poynting

(22) $E_0 = 10\ V/m$

① **Valor máximo:** $E_0 \cdot H_0 = \frac{E_0 \cdot E_0}{Z_m} = \frac{100}{377} = \boxed{0{,}265\ W/m^2}$

② **Valor medio: $0{,}1326\ W/m^2$** $\left(\frac{max}{2}\right)$

③ $H_0? \longrightarrow E_0 = H_0 \cdot Z_m \longrightarrow \frac{10\,V/m}{377\,\Omega} = \boxed{H_0 = 26\ \frac{mA}{m}}$

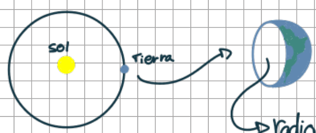
(23) $f = 10\,MHz \quad \langle \bar{P} \rangle = 2\ \frac{W}{m^2}$

ⓐ Longitud de onda $= \boxed{\lambda} = \frac{V}{f} = \frac{C}{f \cdot \sqrt{\varepsilon_r}} = \frac{3 \cdot 10^8}{10M} = \boxed{30\,m}$

ⓑ E_0: $\langle \bar{P} \rangle = \frac{1}{2}\frac{E_0^2}{Z_m} \longrightarrow \boxed{E_0} = \sqrt{2\,\frac{W}{m^2} \cdot 2 \cdot Z_m} = \boxed{38{,}83\ V/m}$

$H_0 = \frac{E_0}{Z_m} = 0{,}103\ \frac{A}{m}$

(24)



radiación electromagnético $= 1400\ \frac{W}{m^2}$

Suponemos onda plana

$\langle \bar{P} \rangle = 1400\ \frac{W}{m} = \frac{1}{2}\frac{E_0^2}{Z_m} \longrightarrow E_0^2 = 1.055.600\ \frac{V^2}{m^2}$

Potencia sol: $\langle \bar{P} \rangle \cdot$ distancia $= 1400\ \frac{W}{m^2} \cdot 4\pi \cdot (1{,}49 \cdot 10^8\,Km)^2 = \boxed{3{,}906 \cdot 10^{20}\ W}$

Potencia recibida: $\langle \bar{P} \rangle \cdot$ sup. tierra $= \boxed{1{,}785 \cdot 10^{11}\ W}$