Matière : Radiocommunication
Master : M1. Systèmes des Télécommunication
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Corrigé type

Exercice 1 (8 Points)

1- $\vec{\nabla} \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$ (1) $\rightarrow \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \partial/\partial x & 0 & 0 \\ 0 & 0 & E_z \end{vmatrix} = -\dfrac{d}{dt}\left(B_x \hat{a}_x + B_y \hat{a}_y + B_z \hat{a}_z\right)$.

$$\begin{cases} 0 = -\dfrac{dB_x}{dt} \\ -\dfrac{\partial E_z}{\partial x} = -\dfrac{dB_y}{dt} \\ 0 = -\dfrac{dB_z}{dt} \end{cases} \rightarrow \begin{cases} B_x = 0 \\ B_y = \displaystyle\int \dfrac{\partial E_z}{\partial x}\, dt \\ B_z = 0 \end{cases} \rightarrow \begin{cases} B_x = 0 \text{ (1)} \\ B_y = -\dfrac{E_0}{C}\cos(\omega t - Kx) \text{ (1)} \\ B_z = 0. \text{ (1)} \end{cases}$$

2- $\vec{R} = \vec{E} \times \vec{H}$ (1) $= \dfrac{\vec{E} \times \vec{B}}{\mu_0} = \dfrac{1}{\mu_0} \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 0 & 0 & E_z \\ 0 & B_y & 0 \end{vmatrix} \rightarrow \vec{R} = \dfrac{E_0^2}{\mu_0 C}\cos^2(\omega t - kx)\,\hat{a}_x$ (1)

3- $P = \displaystyle\iint_S \vec{R}\cdot\vec{ds} = \iint_S \|\vec{R}\|\cdot\hat{a}_x\cdot ds\,\hat{a}_x = \|\vec{R}\|\cdot S$ (1) $\quad \langle P \rangle = \dfrac{1}{T}\displaystyle\int_0^T P \cdot dt \rightarrow$

$\langle P \rangle = \dfrac{1}{T}\displaystyle\int_0^T \|\vec{R}\|\cdot S\, dt = \dfrac{E_0^2 \cdot S}{\mu_0 C}\cdot \underbrace{\dfrac{1}{T}\int_0^T \cos^2(\omega t - kx)\cdot dt}_{=1/2} \rightarrow \langle P \rangle = \dfrac{E_0^2 \cdot S}{2\mu_0 C}$ (1)

Exercice 2 (8 Points)

1- $\lambda = \dfrac{c}{f} = \dfrac{3\cdot 10^8}{5{,}8\cdot 10^9} = 0{,}052\,m$. $\quad (P_R)_{dB} = (P_R)_{dBm} - 30 = -85 - 30 = -115\,dB$

$P_R = P_T + G_T + G_R - L_S$ (1) $\rightarrow L_S = P_T + G_T + G_R - P_R = -10 + 16 + 16 + 115 = 137\,dB$ (1)

$(L_s)_{dB} = 20\,\mathrm{Log}\left(\dfrac{4\pi d}{\lambda}\right) \rightarrow d_{max} = \dfrac{\lambda}{4\pi}\cdot 10^{\frac{L_{s\,dB}}{20}}$ (1). $\quad$ A.N $\rightarrow d_{max} = \dfrac{0.052}{4\times 3.14}\cdot 10^{\frac{137}{20}} \rightarrow$

$d_{max} \approx 29\,km$. (1)

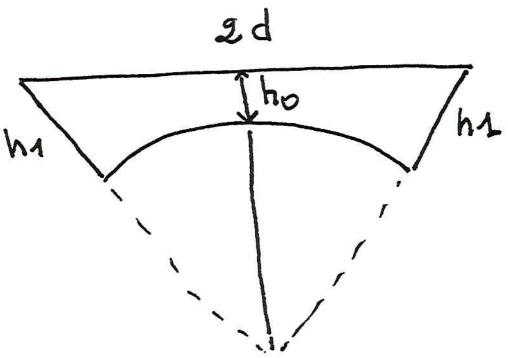
2- $r = \sqrt{\dfrac{\lambda d_1 d_2}{d_1 + d_2}}$ (0,5) à mi-portée $d_1 = d_2 = \dfrac{d}{2} \rightarrow r = \dfrac{1}{2}\sqrt{\lambda d}$. (0,5)

A.N. $\rightarrow r = \dfrac{1}{2}\sqrt{0.05 \times 29 \times 10^3} \rightarrow r \approx 19\,m$. (0,5)

- La hauteur des antennes $h = h_0 + r$ (0,5) avec $h_0 = \dfrac{d^2}{8R}$ (0,5) et $r = \dfrac{1}{2}\sqrt{\lambda d} = 19\,m$ (0,5)

$h_0 = \dfrac{29^2 \times 10^6}{8 \times 6.4 \times 10^6} \rightarrow h_0 = 16.4\,m$ (0,5) $\rightarrow h = h_0 + r \approx 16 + 19 = 35\,m$. (0,5)

Exercice 3 (4 Points)



1- Il faut que $h_p \geq h_1 + r$

h_1 : hauteur des antennes quand l'axe radioélectrique est tangent à l'obstacle.

r : rayon du 1^{er} ellipsoïde de Fresnel dans le plan de l'obstacle.

$(h_1+R)^2 = (h_0+R)^2 + d^2$ où $R = \frac{4}{3} R_0$ (atmosphère standard)

$2h_1 R \simeq 2h_0 R + d^2 \rightarrow h_1 = h_0 + \frac{d^2}{2R}$. ①

$r = \sqrt{\frac{\lambda d_1 d_2}{d_1+d_2}}$; ici $d_1 = d_2 = d \rightarrow r = \sqrt{\frac{\lambda d}{2}}$ → il faut que

$h_p \geqslant h_1 + \sqrt{\frac{\lambda d}{2}}$ ①

2 – $d = 15 \times 10^3 \, m$. $R = \frac{4}{3} \times 6400 \times 10^3 \, m$; $h_0 = 40m$;

$\frac{d^2}{2R} = 13{,}2 \, m$. $h_p = 90m$.

$h_p \geqslant h_1 + \sqrt{\frac{\lambda d}{2}} \rightarrow \sqrt{\frac{\lambda d}{2}} \leqslant h_p - h_1 \rightarrow \frac{\lambda d}{2} \leqslant (h_p - h_1)^2 \rightarrow$

$\lambda = \frac{c}{f} \leqslant (h_p - h_1)^2 \times \frac{2}{d} \rightarrow f \geqslant \frac{c.d}{2(h_p-h_1)^2}$ ①

Soit : $f_{min} = \frac{c.d}{2(h_p-h_1)^2}$. A.N. → $f_{min} = \frac{3.10^8 \times 15 \times 10^3}{2.(90-40-13{,}2)^2} \rightarrow$

$f_{min} \simeq 1{,}66$ GHz. ①