LARBI BEN M'HIDI OUM EL BOUAGHI UNIVERSITY
INSTITUTE OF APPLIED SCIENCES AND TECHNIQUES
NETWORKS AND TELECOMMUNICATIONS DEPARTMENT

Module: Antennas and radiation **M1 S2**

FINAL EXAM

Surname&First Name:………………………………………………………………**G:**……….

course questions: (08 pts)

0,5

1. Give the expression of the Directivity

$$D = \frac{U(\theta,\varphi)}{U_{Avg}} = \frac{U(\theta,\varphi)\,4\pi}{P_{radtot}} =$$

2. Give the expression of the Gain

0,25 0

$$P_{tot} = \oiint P_{Poy}\, ds = \iint U(\theta,\varphi)\, d\Omega \;/\; d\Omega = \sin\theta\, d\theta\, d\varphi,\; ds = R^2 d\Omega$$

3. Give the expression of the total radiated power

0,1

$$G = \eta D = \frac{4\pi\, U(\theta,\varphi)}{P_{in}} = \frac{P_P(\theta,\varphi)\, 4\pi R^2}{P_A}$$

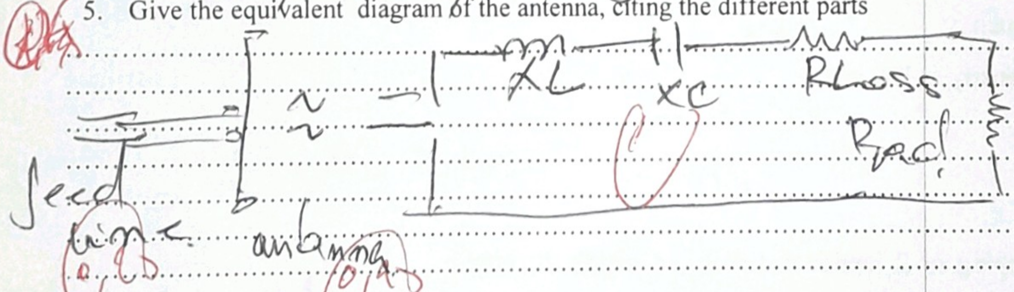
$P_{in} = P_{incident}$; $P_A = P_{antenna}$

4. Name the three modes of polarization of an electromagnetic wave

- Linear polarization (H/V)
- Circular polarization
- Elliptical polarization

0,75

5. Give the equivalent diagram of the antenna, citing the different parts



$Z_{in} = R_{in} + jX_{in}$

$R_{in} = R_{rad} + R_{Loss}$

$X_{in} = X_L + X_C$

0,25 0,25 0,25 0,25 0,25

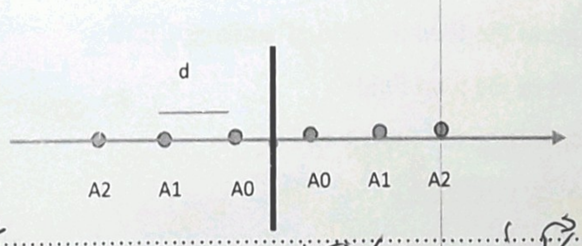
6. Give the formula of the electric and magnetic field in function of $\vec{A}$ and V

1,00

$$\vec{E} = -\frac{\partial \vec{A}}{\partial t} - \text{grad}\, V$$

$$\vec{H} = \frac{1}{\mu}\, \text{rot}\, \vec{A}$$

7. Develop the Non Uniform Grouping of antennas.



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$E_0 = A_0 e^{-j\delta/2} + A_0 e^{+j\delta/2}$ / $\delta = \beta d \sin\theta \cos\varphi$

$E_1 = A_1 e^{-3\delta/2} + A_1 e^{+j3\delta/2}$; $E_2 = A_2 e^{-j5\delta/2} + A_2 e^{+j5\delta/2}$

0,25 0,25

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$E_{tot} = A_0\left[e^{-j\psi/2} + e^{+j\psi/2}\right] + A_1\left[e^{-j3\psi/2} + e^{j3\psi/2}\right] + A_2\left[e^{-j5\psi/2} + e^{+j5\psi/2}\right]$ 0,8

$E_{tot} = 2\left[A_0 \cos(\psi/2) + A_1 \cos(3\psi/2) + A_2 \cos(5\psi/2)\right]$ 0,1

Exercise 01

An antenna emits a signal with a total power of 10 watts. We measure a radiation intensity which follows the following expression:

$$U(\theta,\varphi) = \begin{cases} B.\cos^2(\theta)\ [w/sr]\ pour\ 0 \le \theta \le \frac{\pi}{2};\ et\ -\pi \le \varphi \le +\pi \\ 0 \qquad\qquad over \end{cases}$$

1. Find the correct value of B
2. Determine the surface power density.
3. Find the maximum directivity in value and dB

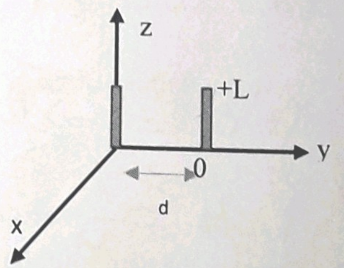
Exercise 02

An isotropic antenna radiates a power of 20W at 5cm wavelength. Determine :

1. The transmission frequency.
2. The radiated power density at 100 km.
3. Radiation intensity

Exercise 03:

We consider a uniform grouping of 2 identical dipoles of length 2L (same amplitude of the supply current), regularly spaced by a distance d. Knowing that these dipoles are parallel and are contained in the same yoz plane, the current



$I(z) = I_M e^{-j\beta|z|}$

1. Give the expression of Electric field of antenna 1 E1?
2. Give the expression of the Electric field of antenna 2 E2?
3. Give the expression of the total field?
4. Deduce the total characteristic function?

- knowing that $F_i(\theta) = \frac{cos[n\pi cos\theta]}{sin\theta}$

GOOD LUCK

Exo1 : $P_{rad} = 10\,W$; $U(\theta,\varphi) \begin{cases} B\cos^2(\theta)\ W/sr & \text{for } 0 \leq \theta \leq \frac{\pi}{2},\ -\pi \leq \varphi \leq \pi \\ 0 & \text{ailleurs.} \end{cases}$

1/ B = ?

$P_{rad} = \iint U(\theta,\varphi)\cdot d\Omega = \iint B\cos^2\theta \sin\theta\, d\theta\, d\varphi$ 0,5

$P_{rad} = B \int_{-\pi}^{\pi} d\varphi \int_0^{\frac{\pi}{2}} \cos^2\theta \sin\theta\, d\theta$. 0,25

$= B[2\pi]\cdot\left(-\frac{1}{3}\right)\int_0^{\pi/2} (-3\sin\theta)\cos^2\theta\, d\theta$

$= B[2\pi]\left[-\frac{1}{3}\right]\left[\cos^3\theta\right]_0^{\pi/2} = B(2\pi)\left(\frac{-1}{3}\right)(-1)$

$P_{rad} = 10 = \frac{B\cdot 2\pi}{3}$ 0,5 $\Rightarrow B = \frac{30}{2\pi} = 4{,}77$

2/ $P_{Poy} = \frac{U}{R^2} = \begin{cases} \frac{4{,}77\cos^2\theta}{R^2}\ W/m^2 ; & 0 \leq \theta \leq \frac{\pi}{2} ;\ -\pi \leq \varphi \leq +\pi \\ 0 & \text{ailleurs} \end{cases}$ 0,5 0,5

3/ $D_{max} = \frac{U_{max}}{P_{rad}}\cdot 4\pi$ 0,5

$U_{max}\big|_{\theta=0} = B = 4{,}77\ W/sr.$ 0,25

$\Rightarrow D_{max} = \frac{4{,}77}{10}\cdot 4\pi = 6$ 0,5

$\Rightarrow D_{dB} = 10\log(6) = 7{,}78$ 0,5

①

Exo2 :

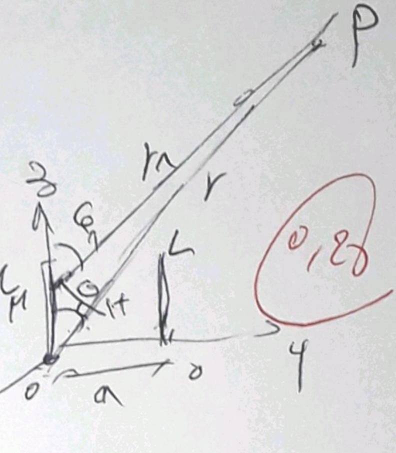
$P_{rad} = 20W$, $G = 1$; $\lambda = 5cm = 0,05m$

1/ $d = \frac{\ell}{\lambda} = 8GHz$ (0,1)

2/ $G = \frac{P_{poy}}{P_A} \cdot 4\pi R^2 \rightarrow P_{poy} = \frac{G \cdot P_A}{4\pi R^2} = 1,6 \cdot 10^{-10} \, W/m^2$ (0,1) (0,1)

3/ $U = P_{poy} \cdot R^2 = \frac{G \cdot P_A}{4\pi} = 1,6 \, W/sr$ (0,1) (0,1)

Exo3 : $I(z) = I_M e^{-j\beta|z|}$



1/ $dE_{1/o} = j \frac{Z_0}{2\lambda r} I(z) \sin\theta \, dl \, e^{-j\beta r}$ (0,25)

$dE_{1/M} = j \frac{Z_0}{2\lambda r_1} I(z) \sin\theta_1 \, dl \, e^{-j\beta r_1}$ (0,25)

$r_1 = r - oH \, / \, oH = z\cos\theta$, (0,25) $\Big/ \; r \simeq r_1$, $\theta \simeq \theta_1$, $e^{r_1} \neq e^{r}$

$dE_{1/M} = j \frac{Z_0}{2\lambda r} I(z) \sin\theta \, dl \, e^{-j\beta(r - z\cos\theta)}$ (0,25)

$dE_{1/M} = j \frac{Z_0}{2\lambda r} I_M \sin\theta \cdot e^{-j\beta r} \cdot e^{-j\beta|z|} \cdot e^{+j\beta z\cos\theta} \, dl$

$E_{1\,tot} = j \frac{Z_0}{2\lambda r} I_M \sin\theta \, e^{-j\beta r} \int_0^L e^{j\beta(z\cos\theta - z)} \, dz$

$= j \frac{Z_0}{2\lambda r} I_M \sin\theta \, e^{-j\beta r} \int_0^L e^{j\beta z(\cos\theta - 1)} \, dz$

$= j \frac{Z_0}{2\lambda r} I_M \sin\theta \, e^{-j\beta r} \left[\frac{e^{j\beta(\cos\theta - 1)L} - 1}{j\beta(\cos\theta - 1)} \right]$

2

$$E_{1/tot} = j \frac{Z_0}{2\lambda r} I_M e^{-j\beta r} \left[\frac{\sin\theta \left[2 \sin \left[\beta (\cos\theta - 1) \frac{L}{2} \right] \right]}{\beta (\cos\theta - 1)} \right] e^{j\beta(\cos\theta - 1) L/2}$$

0,1

2/ $E_2 = E_1 \cdot e^{j\delta}$ / $\delta = \beta d \sin\theta \cdot \sin\varphi$.

0,2

0,1

3/ $E_{tot} = E_1 + E_2 = E_1 + E_1 e^{j\delta} = E_1 (1 + e^{j\delta}) = E_1 \cdot e^{j\delta/2} (e^{-j\delta/2} + e^{j\delta/2})$.

0,2

$E_{tot} = E_1 e^{j(\delta/2)} (2 \cos(\delta/2))$ 1

4/ $F(\theta,\varphi) = F_i(\theta) \cdot C(\theta,\varphi)$ 0,5

$F_i(\theta) = \left[\frac{\cos[n \pi \cos\theta]}{\sin\theta} \right]$; $C(\theta,\varphi) = (\cos(\delta/2))$.

0,5

③