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)

1. Define the power intensity U:

We call radiation intensity (steric power), it is the power radiated per unit of solid angle. $U(\theta,\varphi) = \frac{dP_{RAD}}{d\Omega}\ (W\ ou\ {}^{W}/_{sr})$

2. Define power density Ppoy

We call radiation density (surface power), it is the power radiated per unit surface.[W /m ^{2}]

$$P(\theta,\varphi)_{Poyting} = \frac{dP_{RAD}}{dS} = \frac{dP_{RAD}}{R^2 d\Omega} = \frac{U(\theta,\varphi)}{R^2} \ldots\ldots\ldots$$

3. Give the formula of the total power radiated Ptot.

$$p_{tot} = \int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi} P_{POY}(\theta,\varphi) R^2 sin\theta d\theta d\varphi$$

$$p_{tot} = \int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi} U(\theta,\varphi) sin\theta d\theta d\varphi \ldots\ldots\ldots$$

4. Give the formula of the electric field of vertical antenna

- $dE(\theta) = j\frac{Z_0}{2\lambda R} I\ dl\ sin\theta\ e^{-j\beta R}$

Z0: impedance of the medium; λ: wave length; R: the distance between the source and the destination; I: the feed current; $\beta = \frac{2\pi}{\lambda}$: wave vector; dl : antenna length; θ: elevation angle.

5. Define the Uniforme Grouping (alignment) of antennas.

In this case, the antennas are identical, regularly spaced, and powered by current sources with equal amplitudes ....

6. Define the Polarization of antenna

The polarization of an antenna describes the direction in space of the electric field vector of the electromagnetic wave produced and radiated by this antenna in the far field. More precisely, it describes the direction in which the field intensity is maximum ....

7. There are three types of polarization:

- Rectilinear polarization (horizontal or vertical)
- Circular polarization
- Elliptical polarization

Exercise 01

Consider an antenna with a radiated power density ($Ppoy$) of the form

$$Ppoy(r,\theta,\varphi) = \begin{cases} W_0 \frac{cos^4\theta}{r^2} & \text{for } 0 < \theta < \frac{\pi}{2} \\ 0 & \text{for } \frac{\pi}{2} < \theta < \pi \end{cases}$$

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Module: Antennas and radiation **M1 S2** (2)

GOOD LUCK

Ex 4) 1/ $U(\theta,\varphi) = P_{rad}\, r^2 = \begin{cases} W_0 \cos^4\theta & 0 < \theta < \frac{\pi}{2} \\ 0 & \frac{\pi}{2} < \theta < \pi \end{cases}$ (0,5) (0,5)

$U_{max} = W_0 \;/\; \cos^4\theta = 1$ (0,5)

2/ $D = \frac{U(\theta,\varphi)}{\frac{1}{4\pi} P_{rad}}$ (0,5) ; $D = \frac{U_{max} \cdot 4\pi}{P_{rad}}$ (0,5)

$P_{rad} = \int_\theta \int_\varphi U(\theta,\varphi) \cdot \sin\theta \, d\theta \, d\varphi$ (0,5)

$= \int_0^{2\pi} d\varphi \int_0^{\frac{\pi}{2}} W_0 \cos^4\theta \sin\theta \, d\theta$

$= 2\pi (W_0) \left[-\frac{1}{5} \cos^5\theta \right]_0^{\frac{\pi}{2}}$

$= 2\pi W_0 \left[0 + \frac{1}{5} \right]$

(0,5) $P_{rad} = \frac{2}{5} \pi W_0$

$\Rightarrow D = 4\pi \cdot \frac{W_0}{\frac{2}{5}\pi W_0} = \boxed{10}$ (0,25)

$D_{dB} = 10\log(10) = \boxed{10}$ (0,25)

3/ $\eta = 0{,}7$; $G = \eta D = 0{,}7 * 10 = \boxed{7}$ (0,5) (0,25) ; $G_{dB} = 10\log(7) = \boxed{8{,}45}$ (0,25)

Ex 2 :

1/ $P_e = 8\,KW = 8.10^3\,W$; $G = 5\,dB$; $R = 100\,Km$.

$$P_{poy}(x) = \frac{P_A . G_e}{4\pi R^2} = \frac{8.10^3 . 3,16}{4\pi 100^2 . 10^6} = 2,013 . 10^{-5}\,W = 20,13\,\mu W$$ (0,5) (0,5)

$G_{dB} = 5\,dB = 10 \log G \Rightarrow G = 10^{0,5} = 3,16$.

2/ $P_{poy} = \frac{1}{2} E . H = \frac{1}{2} \frac{E^2}{Z_0} \Rightarrow E = \sqrt{2 Z_0 P_{poy}} = \sqrt{2 . 120\pi . 2,013 . 10^{-5}}$ (0,25) (0,25)

$E = 123,1 . 10^{-3}\,V/m$ (0,5)

3/ $H = \frac{E}{Z_0} = 0,33 . 10^{-3}\,A/m$. (0,5) (0,5)

Ex 3 :

1/ $dE_1 = dE_{(0)} \left[e^{j\beta z(\cos\theta - 1)} + e^{-j\beta z(\cos\theta - 1)} \right]$ (0,5)

$dE_1 = 2dE_0 \cos\left[\beta z (\cos\theta - 1)\right] \Rightarrow E_1 = 2E_0 \left| \frac{\sin(\beta L(\cos\theta - 1))}{\beta L(\cos\theta - 1)} \right|$ (0,5)

2/ $E_2 = E_1 . e^{j\delta}$ / $\delta = \beta d \sin\theta \sin\varphi$. (0,5) (0,5)

3/ $E_{tot} = E_1 + E_2 = E_1 (1 + e^{j\delta})$ (0,5)

$= E_1 e^{j\delta/2} \left(e^{j\delta/2} + e^{-j\delta/2} \right)$

$E_{tot} = 2E_1 e^{j\delta/2} \cos(\delta/2)$ (0,5)

4/ $F(\theta,\varphi) = F_1(\theta) . 2\cos(\delta/2) = \frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta} 2\cos\left(\beta d \frac{\sin\theta \sin\varphi}{2}\right)$ (0,5) (0,5)