كلية التقنية الالكترونية College of Electronic Technology - Tripoli	القســـم: الاتصالات	أسئلة الامتحان النهائي	لمادة: الهوائيات
	لطلبة الفصل: السابع	رمز المادة: CM423	التاريخ 2020/09/23
للفصل الدراسي : خريف 2019-2020	اسم الأستاذ: أ. مبروكة العاقل		الزمن: ساعتان
اسم الطالب:..............................	رقم القيد		المجموعة :

Section One

Answer one of the following questions (Each question carries 10 marks)

Question 1:

Choose the right answer: **[1 mark each]**

a. The beam width of an antenna tells us about:

1. Signal strength	2. Signal power
3. Directivity	4. Signal attenuation

b. The radiation pattern of a half-wave dipole has the shape of a ______

1. Doughnut	2. Sphere
3. Circle	4. Triangle

c. The radiation pattern of an isotropic antenna has the shape of a ______

1. Doughnut	2. Sphere
3. Circle	4. Triangle

d. Sterdian is a measurement unit of

1. Point angle	2. Linear angle
3. Plane angle	4. Solid angle

e. The ability of an antenna to radiate more energy in one direction than in other directions is called:

1. Directivity	2. Selectivity
3. Reactance	4. Resonance

f. Which one is not a typical antenna parameter?

1. Gain	2. Conductivity
3. Directivity	4. Radiation Pattern

g. ------ of an antenna is a plot of the magnitude of the far field strength versus position around the antenna.

1. Radiation pattern	2. Directivity
3. Beam width	4. None of the mentioned

h. According to the geometry, how many Sterdians are present in a full sphere?

1. $\pi/2$	2. π
3. 2π	4. 4π

i. Directivity is inversely proportional to.........

1. Beam area	2. Gain
3. Distance from the source	4. FNBW

j. Practically gain is always ------ than directivity

1. Lesser	2. Greater
3. Equal to	4. None of the above

Question 2:

Calculate the D_{approx} from the HPBW of a unidirectional antenna if the power pattern is given by: $E(\theta,\emptyset)=\begin{cases}10\cos^2\theta\,\sin^{\frac{1}{2}}\emptyset, & 0\le\theta\le\pi, 0\le\emptyset\le\pi\\ zero, & othewise\end{cases}$

Then repeat by calculating D_{exact} for the previous pattern. **[10]**

Section Two

Answer all questions in this section (Total of 50 marks)

Question 3:

i. The normalized radiation intensity of an antenna is given by

$$U(\theta,\emptyset)=\begin{cases}\sin\theta\,\sin\emptyset, & 0\le\theta\le\pi, 0\le\emptyset\le\pi\\ zero, & elsewhere\end{cases}$$ Find

1. The exact directivity. **[4]**
2. Azimuthal and elevation plane half-power beam widths (in degrees). **[4]**
3. The approximate directivity. **[3]**
4. Effective aperture Assuming the efficiency of the antenna is equal to 0.6 and operating frequency is 1 GHz. **[3]**

ii. Compare the amplitudes of currents and Radiation Resistance R_r that would be required in dipole antennas of length 0.05 λ and 0.03 λ to produce 100W of radiated power from each. **[6]**

Question 4:

i. For two elements uniform array of isotropic sources with same amplitude and phase in a distance of λ/2 apart, find:

1. Directions in which maximum, nulls and half power points occur. **[9]**
2. Draw the radiation pattern of the array factor. **[3]**

ii. Calculate the dimensions of a Yagi–Uda array that has a directivity of 10 dB at 10 MHz **[8]**

Question 5:

A log-periodic dipole antenna operates over the frequency range of 54 MHz to 216 MHz has a directivity of 6.5 dB and a scale factor of 0.822 and spacing factor of 0.149
Find:

1. Array angle, α **[2]**
2. The number of elements **[3]**
3. The lengths of the shortest and the longest dipoles **[5]**

Parameter	Formula	Parameter	Formula
Infinitesimal area of sphere	$ds = r^2 \sin\theta \, d\theta \, d\phi$	Elemental solid angle of sphere	$d\Omega = \sin\theta \, d\theta \, d\phi$
Average power density	$\mathbf{W}_{av} = \frac{1}{2}\mathrm{Re}[\mathbf{E} \times \mathbf{H}^*]$	Radiated power/average radiated power	$P_{rad} = \oint\!\!\oint_S \mathbf{W}_{av} \cdot ds = \frac{1}{2}\oint\!\!\oint_S \mathrm{Re}[\mathbf{E}\times\mathbf{H}^*] \, ds = \int_0^{2\pi}\int_0^{\pi} U_n(\theta,\phi)\sin\theta \, d\theta \, d\phi$
Radiation density of isotropic radiator	$W_0 = \frac{P_{rad}}{4\pi r^2}$	Radiation intensity (far field)	$U = r^2 W_{rad}$
Directivity $D(\theta,\phi)$	$D = \frac{U}{U_0} = \frac{4\pi U}{P_{rad}} = \frac{4\pi}{\Omega_A}$	Beam solid angle Ω_A	$\Omega_A = \int_0^{2\pi}\int_0^{\pi} F_n(\theta,\phi)\sin\theta \, d\theta \, d\phi$ $F_n(\theta,\phi) = \frac{F(\theta,\phi)}{\lvert F(\theta,\phi)\rvert_{max}}$
Maximum directivity D_0	$D_{max} = D_0 = \frac{U_{max}}{U_0} = \frac{4\pi U_{max}}{P_{rad}}$	Approximate maximum directivity (*one main lobe pattern*)	$D_0 \simeq \frac{4\pi}{\Theta_{\theta r}\Theta_{\varphi r}} = \frac{41\,253}{\Theta_{\theta d}\Theta_{\varphi d}}$ (Kraus)
Gain $G(\theta,\phi)$	$G = \frac{4\pi U(\theta,\phi)}{P_{in}} = e_{cd}\left[\frac{4\pi U(\theta,\phi)}{P_{rad}}\right] = e_{cd} D(\theta,\phi)$	Antenna radiation efficiency e_{cd}	$P_{rad} = e_{cd} P_{in}$ $\quad e_{cd} = \frac{R_r}{R_r + R_L}$
Maximum effective aperture A_{em}	$A_{em} = e_{cd}\left(\frac{\lambda^2}{4\pi}\right) D = \left(\frac{\lambda^2}{4\pi}\right) G$	Friis transmission equation	$\frac{P_r}{P} = \left(\frac{\lambda}{4\pi R}\right)^2 G_t G_r$
Aperture efficiency ε_{ap}	$\varepsilon_{ap} = \frac{A_{em}}{A_p} = \frac{\text{maximum effective area}}{\text{physical area}}$	Wave impedance Z_w	$Z_w = \frac{E_\theta}{H_\phi} \simeq \eta = 377$ ohms

Parameter	Formula	Parameter	Formula
	Infinitesimal Dipole $(l \le \lambda/50)$		***Small Dipole*** $(\lambda/50 < \ell \le \lambda/10)$
Radiation resistance R_r	$R_r = \eta\left(\frac{2\pi}{3}\right)\left(\frac{l}{\lambda}\right)^2 = 80\pi^2\left(\frac{l}{\lambda}\right)^2$	Radiation resistance R_r	$R_r = 20\pi^2\left(\frac{l}{\lambda}\right)^2$
Half-power beamwidth	$\mathrm{HPBW} = 90^\circ$	Half-power beamwidth	$\mathrm{HPBW} = 90^\circ$
	Half Wavelength Dipole $(l = \lambda/2)$		***Finite length Dipole*** $(l > \lambda/10)$
Radiation resistance R_r	$R_r = \frac{\eta}{4\pi} C_{in}(2\pi) \simeq 73$ ohms	Electric field intensity E_θ	$E_\theta \simeq j\eta \frac{I_0 e^{-jkr}}{2\pi r}\left[\frac{\cos\left(\frac{kl}{2}\cos\theta\right) - \cos\left(\frac{kl}{2}\right)}{\sin\theta}\right]$
Half-power beamwidth	$\mathrm{HPBW} = 78^\circ$		

مع تمنياتي للجميع بالتوفيق والنجاح

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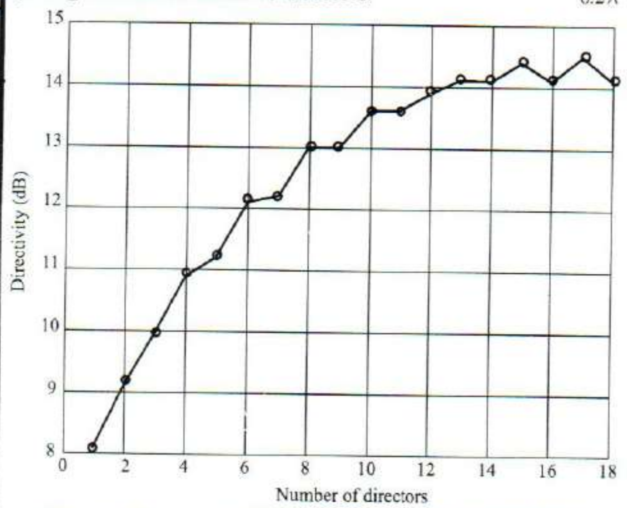
Parameter	Formula
	2 Isotropic Sources with Same amplitude and phase
ARRAY FACTOR	$(E)_n = \cos[\frac{1}{2}(kd\cos\theta)]$
	2 Isotropic Sources with Same amplitude and opposite phase
ARRAY FACTOR	$(E)_n = \sin[\frac{1}{2}(kd\cos\theta)]$
	2 Isotropic Sources with Same amplitude and phase quadrant
ARRAY FACTOR	$(E)_n = \cos[\frac{1}{2}(kd\cos\theta + \frac{\pi}{2}]$
	2 Isotropic Sources with Same amplitude with any phase difference
ARRAY FACTOR	$(E)_n = \cos[\frac{1}{2}(kd\cos\theta + \beta)]$
	N-ELEMENT LINEAR ARRAY: UNIFORM AMPLITUDE AND SPACING
ARRAY FACTOR	$(E)_n = \sum_{n=1}^{N} e^{j(n-1)\psi}$ where $\psi = kd\cos\theta + \beta$ $(E)_n \simeq \frac{\sin\left(\frac{N}{2}\psi\right)}{\frac{N}{2}\psi}$ **Nulls** $\sin\left(\frac{N}{2}\psi\right) = 0 \Rightarrow \frac{N}{2}\psi\vert_{\theta=\theta_n} = \pm n\pi$ $n = 1, 2, 3, \ldots$ $n \neq N, 2N, 3N, \ldots$ **Maximum** $\frac{\psi}{2} = \frac{1}{2}(kd\cos\theta + \beta)\vert_{\theta=\theta_m} = \pm m\pi$ $m = 0\ \ 1, 2\ldots$ **3- dB point** $\frac{N}{2}\psi = \frac{N}{2}(kd\cos\theta + \beta)\vert_{\theta=\theta_h} = \pm 1.391$

Yagi–Uda array

length of the reflector:	0.482λ
length of the driven element:	0.45λ
length of each of the directors:	0.40λ
spacing between the driven element and the reflector:	0.2λ
spacing between the driven element and the first director:	0.2λ
spacing between consecutive directors:	0.2λ



Log-periodic Dipole Array

$$\frac{R_n}{R_{n+1}} = \frac{g_n}{g_{n+1}} = \frac{l_n}{l_{n+1}} = \frac{d_n}{d_{n+1}} = \tau \qquad R_n = \frac{l_n}{2\tan(\alpha)}$$

$$\log(f_U) - \log(f_L) = (N-1)\log\left(\frac{1}{\tau}\right) \qquad \sigma = \frac{R_{n+1} - R_n}{2l_{n+1}}$$

$$\tan\alpha = \frac{(1-\tau)}{4\sigma} \qquad l_N = \frac{1}{2}\frac{c}{f_L} \qquad l_1 = \frac{1}{2}\frac{c}{f_U}$$

In this array the n th dipole has a length l_n, diameter d_n a feed gap g_n and is kept at a distance R_n from the origin where $\tau < 1$ and is known as the scale factor.and spacing factor σ andthe array angle, α