The University Of Sheffield.

Data Provided: None EEE6011

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2012-2013 (2 hours)

EEE6011 Antennas and Propagation 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. The numbers given after each section of a question indicate the relative weighting of that section. **Where a symbol or abbreviation is not defined it can be assumed to have its usual meaning, with which candidates should be familiar**.

1. a.

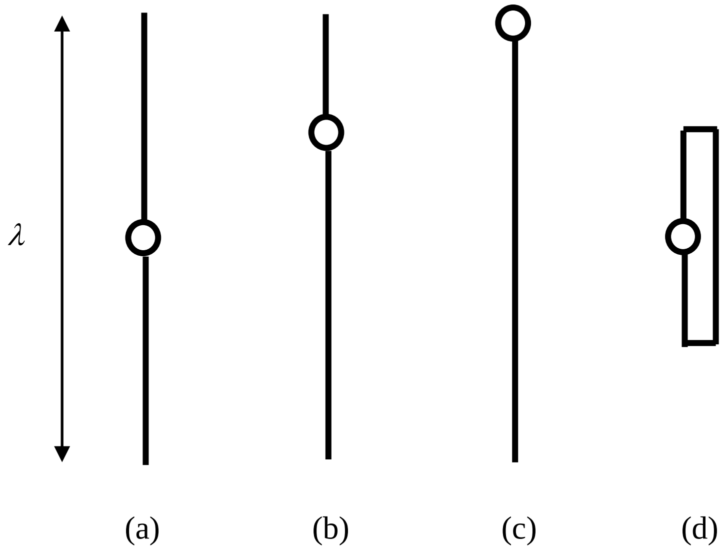

Fig. 1

Sketch the current distribution and E plane radiation pattern of a full wave dipole of length λ when it is fed

(i) At the centre as shown in Fig. 1(a)

(ii) $\lambda/4$ from one end as shown in Fig. 1(b)

(iii) At one end as shown in Fig. 1(c)

and estimate the input impedance in each case. **(9)**

b. If the radiation pattern of the centre fed full wave dipole in Fig. 1(a) is given by

$$|E_\theta| = \frac{2\eta\, I_o}{4\pi r}\left[\frac{\cos(\pi\cos(\theta)) + 1}{\sin(\theta)}\right]$$

calculate its directivity, assuming that

$$\int_0^\pi \frac{(\cos(\pi\cos(\theta)) + 1)^2}{\sin(\theta)}\, d\theta = 3.3$$

(8)

c. If the two ends of the centre fed full wave dipole are connected to make a folded dipole of length $\lambda/2$ as shown in Fig. 1(d), sketch the current distribution and radiation pattern of this new antenna and estimate the input impedance. **(3)**

2. a.

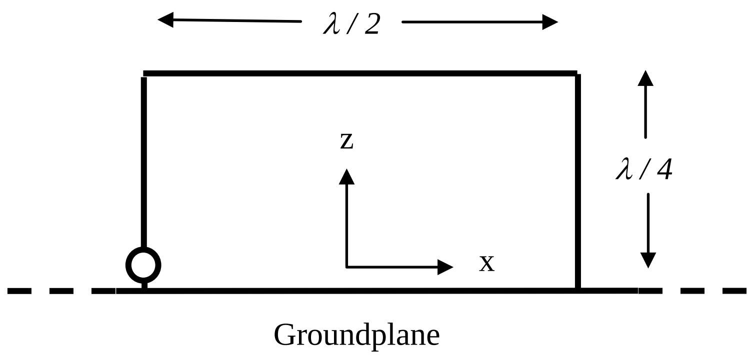

Fig. 2

A half loop antenna is counterpoised against an infinite groundplane, both perfectly conducting, and fed at the base of one of the $\lambda/4$ sections as shown in Fig. 2. Sketch the current distribution around this loop, including the image currents. **(4)**

b. Assuming the half loop is in the x-z plane, sketch the following radiation patterns of this antenna:

(i) $E_\theta(\theta, \phi = 0^o, 180^o)$

(ii) $E_\phi(\theta, \phi = 90^o, 270^o)$

(iii) $E_\theta(\theta, \phi = 90^o, 270^o)$ **(5)**

c. If the input impedance of the half loop is $118 - j53\Omega$ with directivity $5.8dBi$, find:

(i) The radiation resistance of the antenna.

(ii) The power radiated by the antenna assuming an excitation of 100V rms.

(iii) The value of inductance required to tune the half loop to resonance at 14MHz.

(iv) The antenna efficiency if the groundplane now has finite conductivity producing an effective loss resistance of 118Ω.

(v) The radiation resistance and directivity of a perfectly conducting full loop antenna of side lengths equal to $\lambda/2$ in free space with no groundplane and fed in the middle of one of the sides?

(9)

d. Discuss the usefulness of such a half loop antenna when used for

(i) HF communication using the real earth as a groundplane

(ii) GPS reception using a car roof as a groundplane. **(2)**

3. a.

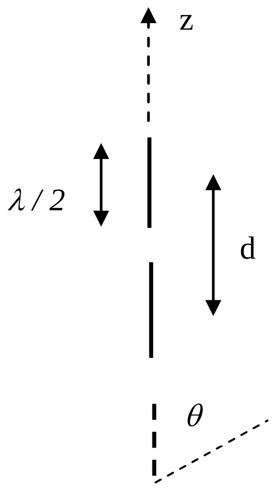

Fig. 3

The E plane radiation pattern of a co-linear array of N centre fed perfectly conducting $\lambda/2$ dipoles each with input impedance R_r and positioned co-axially and symmetrically along the z axis and separated by a distance d as shown in Fig. 3 is given by

$$E_\theta = C\left[\frac{\cos\left(\frac{\pi}{2}\cos(\theta)\right)}{\sin(\theta)}\right] I_o \frac{\sin\left(N\frac{\Psi}{2}\right)}{\sin\left(\frac{\Psi}{2}\right)}$$

where $\Psi = kd\cos(\theta) + \gamma$

Give expressions for

(i) The individual dipole radiation pattern

(ii) The array factor

(iii) The excitation current I_o of each dipole in terms of the total transmitter current I, where the supplied transmitter power is $I^2 R_r / 2$.

(iv) The approximate input impedance of the array assuming all dipoles are fed in parallel (before any matching and ignoring mutual coupling)

(5)

b. For an $N = 17$ element array with $d = 0.6\lambda$ calculate the following parameters of the E plane radiation pattern (assuming $\gamma = 0^o$)

(i) The antenna gain in dBi

(ii) The position and height (with respect to the main lobe) of the first sidelobes

(iii) The 3dB beamwidth of the main lobe

Hint: $\frac{sin(Nx)}{N\,sin(x)}$ (for $N = 17, x = 0.082) = 0.71$

(9)

c. What is the value of γ required to move the main lobe to $\theta = 30^o$? Comment on the directivity of this main lobe. **(4)**

d. If two of these arrays were placed side by side separated by $\lambda / 2$, what would be the new antenna directivity? **(2)**

4. a. By equating the forces due to the electric field $e\underline{E}$ and inertia $m\frac{dV}{dt}$ acting on an electron in a plasma through which a radio wave propagates, show that the critical frequency of the plasma is given by

$$f_c = \frac{1}{2\pi}\sqrt{\frac{Ne^2}{m\varepsilon_o}}$$

(9)

b. An ionosonde transmits signals vertically upwards at 3 frequencies:

(i) 2.8MHz, with echo time 0.8ms

(ii) 6.3MHz, with echo time 1.3ms

(iii) 8.9MHz, with echo time 2ms

(9)

Estimate the reflection layer electron densities and heights, and identify each layer.

Hint: $\sqrt{\frac{e^2}{m\varepsilon_o}} = 56$, $c = 3\times10^8 m/s$.

c. How do these layers change between day and night? **(2)**

GGC