The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2011-2012 (2 hours)

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. Sketch the current distributions and radiation patterns of the following monopoles fed against an infinite groundplane:

(i) A $\lambda / 4$ long monopole,

(ii) A $\lambda / 2$ long monopole,

(iii) A $3\lambda / 4$ long monopole.

Assume all conductors are perfect. **(6)**

b. If the radiation pattern of the $3\lambda / 4$ monopole is given by

$$\left|E_\theta\right| = \frac{\eta I_o}{2\pi r} \frac{cos\left(\frac{3\pi}{2} cos(\theta)\right)}{sin(\theta)} \qquad (1.1)$$

in the half space above the groundplane, calculate the monopole's

(i) radiation resistance

(ii) gain over isotropic in the direction $\theta = 90^o$.

The following relation may be of use:

$$\int_0^{\pi/2} \frac{cos^2\left(\frac{3\pi}{2} cos(\theta)\right)}{sin(\theta)} d\theta = 0.88 \qquad (1.2).$$

Assume $\eta = 377\Omega$. **(10)**

c. Hence briefly compare the performances of the three monopoles in part **a.** in terms of size, gain and input impedance. **(4)**

2. a. The radiation pattern of a domestic satellite dish with an *x* polarised aperture field can be written

$$\left|E_\theta(\theta,\phi=0^o)\right| = \frac{1}{\lambda r}F_x \qquad (2.1)$$

If the aperture is perfectly circular with diameter *a* and the aperture field is uniform with $E_x = A$, show that

$$F_x = A\frac{\pi a^2}{2}\frac{J_1(u)}{u} \qquad (2.2)$$

where

$$\frac{J_1(u)}{u} = \int_0^1 J_o(u\gamma)\gamma d\gamma \qquad (2.3)$$

and

$$2\pi J_0(\alpha) = \int_0^{2\pi} e^{j\alpha\cos(\gamma)}d\gamma \qquad (2.4).$$

(10)

b. A satellite dish with an *x* polarised *45cm* diameter circular aperture has its main lobe pointed at the source of an *x* polarized *10GHz* signal in a direction of 19^o East.

(i) Calculate the gain of the antenna.

(ii) An adjacent satellite at 25.2^o East transmits on the same frequency using the same polarization and EIRP. Calculate the level of this interfering signal with respect to the 19^o East signal.

(iii) What would happen to this interfering signal if the 25.2^o East satellite transmission was circularly polarized instead?

Useful relations,

$$\left|J_1(5.1)\right| = 0.34 \qquad (2.5)$$

$$\lim_{u\to 0}\frac{J_1(u)}{u} = 0.5 \qquad (2.6)$$

Assume $c = 3\times 10^8 m/s$. **(10)**

3. a. An HF trapped antenna operates as a half wave dipole at *3.57MHz* and *7.14MHz*, and is placed horizontally at a height of *21m* above the ground. Sketch the H-plane radiation patterns of the dipole at each frequency. **(4)**

b. Assuming reflection of transmitted signals takes place at an ionospheric layer with an electron density of $10^{11} m^{-3}$ at a height of *400km*, calculate the single hop skip distances at both frequencies. Assume the radius of the earth is *6400km*. **(10)**

c. Comment on the signal strengths received at each frequency by a station at a distance of *2400km* (assume the signal can be received over a distance of approximately $\pm 60km$ on the ground at each hop). **(4)**

d. If an echo is heard on the signal by the receiving station, suggest a possible cause. **(2)**

4. a. Describe briefly the main steps involved in a Moment Method analysis of an antenna (field equations are not required). **(5)**

b. A *z*-directed centre fed thin wire dipole is to be analysed using a moment method in which it is divided into *11* equal length segments Δz. The dipole in Fig 4.1 is 11m long and operates at a frequency of *13.64MHz*.

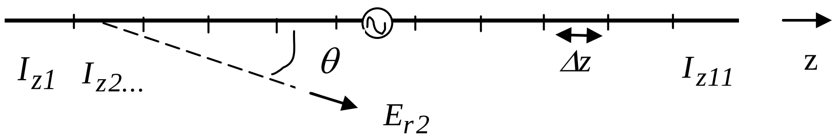

Fig 4.1

Calculate the following complex impedance matrix elements

(i) $Z_{11,2}$ (ii) $Z_{2,11}$

stating any assumptions made. Assume that the field generated by segment *n* carrying unit current at distance *r* is

$$E_{r_n} = j17\Delta z\left(\frac{1}{jkr} + \frac{1}{(jkr)^2}\right)\frac{e^{-jkr}}{r}\cos(\theta) \qquad (4.1).$$

(7)

c. Of the 121 impedance matrix elements, some have the same value. Explain why, and hence give the number of *different* impedance values in the matrix. Which matrix elements would you expect to have the largest magnitude? **(5)**

d. After completion of the moment method analysis, $I_{z6} = 1A$. Estimate the rms power radiated by the dipole and the excitation voltage amplitude. **(3)**

GGC