The University Of Sheffield.

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DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2010-2011 (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.** Calculate the input impedance of a perfectly conducting, resonant, centre-fed half wave ($\lambda/2$ long) wire dipole antenna. The following equations should be of use:

$$|E_\theta| = \frac{2\eta I_o}{4\pi r}\left[\frac{\cos\left(\frac{\pi}{2}\cos(\theta)\right)}{\sin(\theta)}\right] \qquad (1.1)$$

$$\int_0^\pi \frac{\cos^2\left(\frac{\pi}{2}\cos(\theta)\right)}{\sin(\theta)} d\theta = 1.22 \qquad (1.2).$$

(10)

b. Explain how traps could be used to resonate a centre fed wire as a half wave dipole at frequencies of *3.55MHz* and *7.1MHz*, including a brief description of how the traps could be constructed using coaxial cable. Give typical antenna dimensions. **(6)**

c. If the inductance of a trap is $17.5\mu H$, calculate its capacitance. What is the input impedance of the wire at *3.55MHz* and *7.1MHz*? **(4)**

2. a.

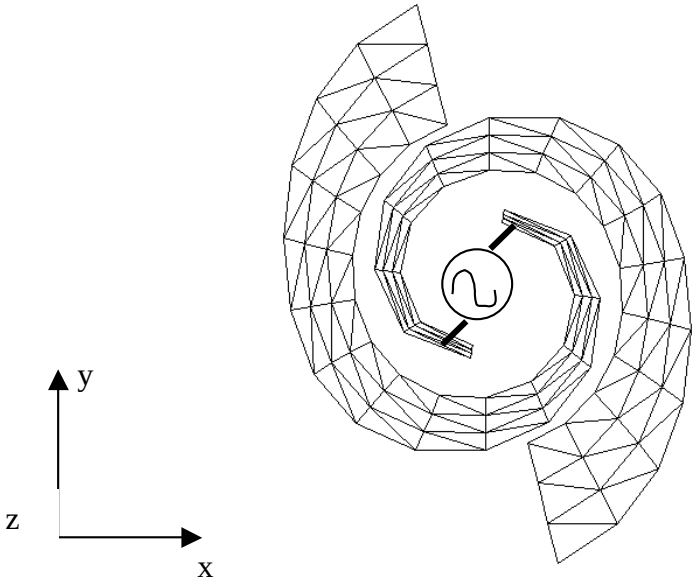

Fig. 2.1

The antenna in Fig. 2 has been designed in the geometry editor of a moment method analysis program, and shows the segmentation used for computation. The antenna consists of a two arm spiral made from planar conductor which is printed on a planar dielectric substrate and fed at the centre. Give brief reasoned answers to the following:

(i) What type of far field polarization would you expect from this antenna?

(ii) If the antenna is resonant, what can be said about the input impedance?

(iii) Why are the arms flared?

(iv) What is the purpose of the triangular patch segmentation of the spiral arms?

(v) What is the effect of the dielectric substrate?

The exact antenna dimensions are not required to answer (i) – (v). **(10)**

b. The axial ratio of the radiation field at $x = 0, y = 0, z \to \infty$ is given by:

$$\Psi = \frac{\sqrt{E_x{}^2 + E_y{}^2 + K}}{\sqrt{E_x{}^2 + E_y{}^2 - K}} \qquad (2.1)$$

where $K = \sqrt{E_x{}^4 + E_y{}^4 + 2E_x{}^2 E_y{}^2 \cos 2\Delta\varphi}$ (2.2).

Calculate the axial ratio in the following cases, and name the type of field polarization:

(i) $\underline{E} = \cos(\omega t)\,\hat{x}$

(ii) $\underline{E} = cos(\omega t + 90^o)\hat{x},\ cos(\omega t)\hat{y}$

(iii) $\underline{E} = cos(\omega t + 90^o)\hat{x},\ 0.5\,cos(\omega t)\hat{y}$

(iv) $\underline{E} = 0.5\,cos(\omega t - 45^o)\hat{x},\ 0.5\,cos(\omega t)\hat{y}$

(8)

c. Why might circular polarization, rather than linear, be used in a radio frequency communications link? **(2)**

3. a. Assuming the forces acting on an electron in a plasma through which a radio wave propagates can be represented by

$$e\underline{E} = m\frac{d\underline{V}}{dt} \qquad (3.1),$$

obtain expressions for the plasma

(i) conduction current

(ii) displacement current

(iii) cut off frequency

(iv) relative permittivity. **(12)**

b. If the electron density is $10^{12}\,m^{-3}$ calculate the critical frequency and the relative permittivity at this frequency and explain their significance. Assume $\sqrt{\frac{e^2}{m\varepsilon_o}} = 56$. **(6)**

c. Briefly describe a plasma antenna. **(2)**

4. a. Show that the rate of change of refractive index with height in the troposphere is related to that assuming a planar earth as follows:

$$\frac{\partial n^*}{\partial h} = \frac{\partial n}{\partial h} + \frac{1}{a} \qquad (4.1).$$

(10)

b. A mobile phone communicates with a base station *2km* away over level ground. Assuming both handset and base station are *10m* above the ground, and that the signal is transmitted parallel to the ground, calculate the minimum height of the signal path between the two stations. Assume the radius of the earth is *6370km*, and that $\partial n / \partial h = -39 \times 10^{-6}\, km^{-1}$. **(6)**

c. Explain the effects that a high pressure weather system might have on the signal propagation. **(4)**

GGC