Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2013-2014 (2 hours)

EEE6011 Antennas and Propagation

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 centre fed dipoles of lengths (i) $\lambda/2$, (ii) λ and (iii) $3\lambda/2$. **(6)**

b. Using the following equations, calculate the radiation resistance of the $3\lambda/2$ dipole.

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

$$\int_0^\pi \frac{\cos^2\left(\frac{3\pi}{2}\cos(\theta)\right)}{\sin(\theta)}\,d\theta = 1.76$$

(10)

c. Estimate the input impedance of the $3\lambda/2$ dipole, and compare it with the input impedance of the $\lambda/2$ dipole. **(4)**

2. **a.** An *HF* trapped dipole antenna is electrically $\lambda/2$ long at two resonant frequencies, *15MHz* and *22.5MHz* and is mounted horizontal to the ground at a height of *10m*. Sketch the *H-plane* elevation radiation patterns at these two frequencies. Assume the ground is perfectly conducting. **(6)**

b. On a particular day at 12 noon the electron density of an ionospheric layer is found to be $7.9\times10^{11}m^{-3}$ at a height of *300km*. Assuming this layer is responsible for ‘reflection’, calculate the single hop skip distances along the earth’s surface at the two frequencies of part **a**. Assume the radius of the earth is *6000km*. **(10)**

c. Discuss the relative merits of using each of the two frequencies of part **a** for an *HF* radio link over several thousand km. **(4)**

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

$$\left|E_\theta(\theta,\phi=0^o)\right| \approx \frac{1+\cos(\theta)}{2\lambda r}F_x$$

If the aperture is perfectly circular with diameter *a* and the aperture field is uniform with $E_x=1$, show that

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

where

$$u = \frac{ka}{2}\sin(\theta)$$

Useful formulae:

$$2\pi J_o(\alpha) = \int_o^{2\pi} e^{j\alpha\cos\gamma}d\gamma$$

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

(12)

b. A *60cm* diameter dish is pointed at the *Astra* satellite in the direction $(\theta=0^o,\phi=0^o)$, and an *x* polarized transmission is being received at *11.55GHz*.

A programme on the *Kopernikus* satellite in the direction $(\theta=4.3^o,\phi=0^o)$, is also transmitted using the same frequency and polarization. Assuming both transmissions have the same *EIRP*, calculate the level of the interfering *Kopernikus* signal with respect to the *Astra* signal. The following formulae may be of use:

$$|J_1(5.4)| = 0.35$$

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

(8)

4. **a.** Explain the terms:

(i) *Linear polarization,*

(ii) *Circular polarization,*

(iii) *Elliptical polarization,*

and give examples of antennas that produce these. **(8)**

b. Show that the *Axial Ratio* is given by

$$\Psi = \frac{\sqrt{\frac{E_x{}^2}{2} + \frac{E_y{}^2}{2} + \frac{1}{2}K}}{\sqrt{\frac{E_x{}^2}{2} + \frac{E_y{}^2}{2} - \frac{1}{2}K}}$$

where

$$K = \sqrt{E_x{}^4 + E_y{}^4 + 2E_x{}^2 E_y{}^2 \cos 2\Delta\varphi}$$

(8)

c. An electric field propagates in the *z* direction and is elliptically polarized in the *x*-*y* plane with Cartesian field components related by $E_x = 2E_y$ and with a 90^o phase shift between them. Calculate the *Axial Ratio* of the field. **(4)**

GGC