Data Provided: None EEE6011

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2008-2009 (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 centre fed dipoles of lengths (i) $\lambda/2$, and (ii) λ . **(4)**

b. Using the following equations, calculate the directivity of the full-wave dipole.

$$|E_\theta| = \frac{\eta I_o}{2\pi r}\left[\frac{cos(\pi cos(\theta))+1}{sin(\theta)}\right] \qquad (1.1)$$

$$\int_0^\pi \frac{(cos(\pi cos(\theta))+1)^2}{sin(\theta)}d\theta = 3.3 \qquad (1.2)$$

(10)

c. How does this directivity compare with that of the half-wave dipole? **(2)**

d. Describe briefly how these dipoles should be fed for optimum performance. **(4)**

2. **a.** Explain briefly how a trapped dipole works. **(4)**

b. An HF trapped dipole operates at *14.2MHz* and *28.4MHz*, and is positioned *5.3m* above a level ground. Sketch the H-plane radiation pattern of this antenna at each frequency. **(4)**

c. On a particular day the electron density of the F-layer is found to be $10^{12} m^{-3}$ at a height of *300km*. Assuming this layer is responsible for 'reflection', calculate the single hop skip distances along the earth's surface at these two frequencies. Assume the radius of the earth is *6000km*. **(8)**

d. Discuss the relative merits of using either frequency to communicate with a radio station about *2900km* away. **(4)**

3. a. The radiation pattern of a reflector antenna 'dish' used for satellite TV reception with a *y* polarized aperture field can be written for small angle θ

$$\left|E_\phi(\theta,\phi=0^o)\right| \approx \frac{1}{\lambda r} F_y \qquad (3.1).$$

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

$$F_y = \frac{\pi a^2}{2} \frac{J_1(u)}{u} \qquad (3.2)$$

where

$$u = \frac{ka}{2} sin(\theta) \qquad (3.3).$$

Useful relations

$$2\pi J_o(\alpha) = \int_o^{2\pi} e^{j\alpha \cos\gamma} d\gamma \qquad (3.4),$$

$$\frac{J_1(v)}{v} = \int_0^1 J_o(v\gamma)\gamma d\gamma \qquad (3.5).$$

(10)

b. A *60cm* diameter circular dish is pointed at the *Astra* satellite at $19.2^o E$, and a *y* polarized transmission is being received at *10GHz*. A programme on the *Kopernikus* satellite at $23.5^o E$ 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.

Useful relations

$$\left|J_1(4.7)\right| = 0.28 \qquad (3.6),$$

$$\frac{J_1(0)}{0} = 0.5 \qquad (3.7).$$

(6)

c. In Scotland *80cm* diameter *Astra* dishes are required. Why? How much extra directivity do they provide over *60cm* versions? **(4)**

4 **a.** State the ICNIRP SAR restrictions for occupational and public HF exposure. **(6)**

b. Discuss the relative SAR levels within the body when standing on a perfectly conducting ground and exposed to (a) a vertically and (b) a horizontally polarized *6MHz* plane wave under the following conditions:

(i) Standing barefoot with arms down by the side

(ii) Wearing shoes and standing with arms down by the side

(iii) As in (i) but with arms outstretched

How would these values generally change as the frequency increases to *22MHz*? **(8)**

c. An engineer is working directly in front of a *250kW* BBC World Service HF curtain array, where the field strength is $E_y = 30V/m$, $E_z = 10V/m$. Calculate his induced SAR assuming a tissue conductivity and density of *1S/m* and $1000kg/m^3$ respectively. Comment on this value. **(6)**

GGC