Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2006-2007 (2 hours)

Antennas, Radar and Navigation 3

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.**

1. a. If the power radiated by a half-wave dipole is given by $36.6I_0^2$ and the peak radiation density at a distance R from the antenna by $\frac{15I_0^2}{\pi R^2}$, where I_0 is the driving current, calculate the peak directivity and show that the radiation resistance is approximately 73Ω

(6)

b. A 1m long dipole antenna is driven with a current of 2A. Calculate the radiated power when the operating frequency is

i) 150MHz

ii) 500kHz

The following information may be useful: Radiation resistance of a small (Hertzian) dipole is given by $R_{rad} = 80\pi^2\left(\frac{l}{\lambda}\right)^2$

(6)

c. An electrically large aperture antenna has 3dB far-field principal plane beamwidths of β_x and β_y respectively. Derive an approximate expression for the gain of the antenna, stating any assumptions you make

(6)

d. Estimate the gain of an antenna with an azimuth 3dB beamwidth of 4 degrees and an elevation 3dB beamwidth of 2 degrees

(2)

2. a. With the aid of simple sketches, explain how the radiation pattern of an array can be expressed in terms of the element pattern and an array factor **(4)**

b. Derive an expression for the normalised array factor of a simple 2-element array with element spacing d and uniform, equal phase excitation **(8)**

c. A 9GHz satellite comms link consists of a 3.2m diameter dish transmit antenna with an aperture efficiency of 0.65, and a receive dish antenna of 1.5m diameter with an aperture efficiency of 0.55. If the distance between the link is 37000km and the transmit power is 120W, calculate the magnitude of the received power.

(8)

3. a. Explain the terms: spot jamming, sweep jamming and barrage jamming.

What are the three standard jamming tactics used in EW?

(6)

b. Derive the radar range equation.

(6)

c. A 10GHz radar with a boresight gain of 42dB and a peak transmit power of 110kW is used to track a target with an RCS of $1.2m^2$. The radar antenna also receives a jamming signal in a sidelobe which has a gain of -32dB relative to the main beam gain. The jammer operates at a distance of 100km from the radar and has an antenna gain of 30dB and a transmit power level of 1kW. Calculate the burnthrough range.

(8)

4. **a.** The antenna of an air-traffic control radar system rotates at 8 revolutions per minute (RPM) and has a beamwidth $\Delta\theta$ of 1.6^{o}. The pulse repetition frequency (PRF) is 460Hz, the pulse length is 1.4μS and the peak transmit power is 1.4MW.

i) What is the duty cycle and mean transmit power?
ii) Show that the number of pulses that hit a target each time the antenna scans past is

$$n = \frac{\Delta\theta \times (PRF)}{6 \times (RPM)}$$

and calculate n for this system

iii) Calculate the range resolution and unambiguous range of the system.
iv) Calculate the Doppler resolution each time the target is illuminated.

(10)

b. With the aid of a block diagram, describe the basic operation of a continuous wave Doppler radar system.

(4)

c. A stationary 10GHz Doppler radar detects a target moving at 10m/s and at an angle of 60^{0} to the boresight direction of the main beam of the radar antenna, as shown in Figure 1. If the beamwidth of the antenna main beam is 4^{0} calculate the Doppler shift produced at the centre of the main beam and at each edge of main the beam.

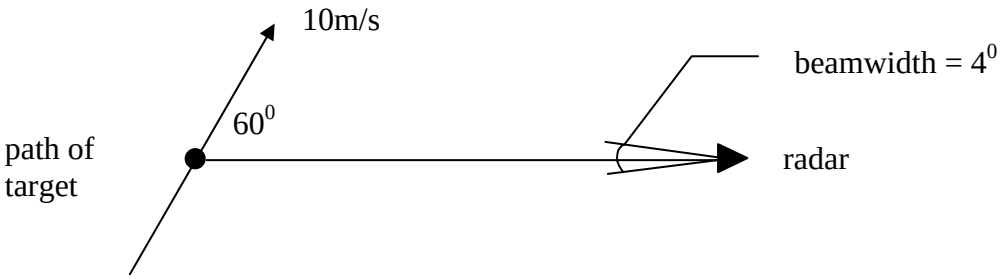

Figure 1

(6)

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