Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2008-2009 (2 hours)

Antennas, Radar and Navigation 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.**

1. **a.** Sketch the equivalent circuit of an antenna in transmit mode. What is the relationship between the generator impedance Z_A and the antenna impedance Z_G for maximum power transfer? **(4)**

b. A 1 metre long half-wavelength dipole antenna is driven at its resonant frequency by a 100 V generator with a source resistance of 50 Ohms. The input impedance of the dipole is given by $Z_A = 73 + j42.5$ Ohms and the antenna loss resistance is given by $R_L = 0.5$ Ohms. Determine

i) The frequency of the generator

ii) The current flowing into the antenna

iii) The average power dissipated by the antenna

iv) The average power radiated by the antenna

v) The radiation efficiency of the antenna **(10)**

c. An antenna has a radiation pattern with normalised intensity given by

$U(\theta) = 1;\ \ 0^0 \le \theta \le 45^0$

$U(\theta) = 0.25;\ \ \theta > 45^0$

The pattern is independent of ϕ. Calculate the maximum directivity **(6)**

2. **a.** In the context of antenna design define the terms: gain, directivity, efficiency and effective area. **(4)**

b. 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.

Estimate the gain of an antenna with azimuth and elevation 3dB beamwidths of 3 degrees **(6)**

c. A 10GHz satellite comms link consists of a 3.0m diameter dish transmit antenna with an aperture efficiency of 0.7, and a receive dish antenna of 1.4m diameter with an aperture efficiency of 0.55. The transmit and receive antennas are both linearly polarised and polarisation matched. If the distance between the link is 35787km and the transmit power is 100W, calculate the magnitude of the received power. If the transmit antenna is modified to transmit a circularly polarised signal what will be the change in received power? **(10)**

3. **a.** Briefly describe techniques that can be employed to reduce the RCS of an aircraft **(4)**

b. Derive the radar range equation **(6)**

c. A radar system operating at 10.0GHz uses a common transmit/receive antenna with an effective aperture size of $2m^2$. The radar is used to detect a square plate of side length 1m at a distance of 10km. The plate is illuminated at normal incidence. If the transmit power is 1kW calculate the magnitude of the received power at the radar.

A second identical plate is placed adjacent to the first but at a distance 7.5mm behind it. Calculate the change in received power. (*hint: use superposition and consider the phase of each scattered signal*)

Note the RCS of a flat plate of area A at normal incidence is given by $\sigma = \frac{4\pi A^2}{\lambda^2}$ **(10)**

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

What are the three standard jamming tactics used in EW? **(3)**

b. A 10GHz radar with a boresight gain of 40dB and a peak transmit power of 100kW 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 10dB. 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. **(7)**

c. A long-range surveillance radar operates at 1.3GHz and uses a common transmit/receive antenna that is 11.9m wide and 6.9m high with a linear efficiency factor of 0.707. The antenna rotates at 5 revolutions per minute. The peak transmitter power is 56kW, the pulse duration is 140μS and the radar operates at a maximum unambiguous range of 490km.

i) What is the transmitter duty cycle and mean transmitter power? What is the power gain of the antenna?

ii) For how long is a point target illuminated each antenna revolution and how many 'hits' are there on a point target each revolution?

iii) What is the Doppler resolution and velocity resolution each time the target is illuminated?

(10)

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