Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2011-12 (2.0 hours)

EEE6012 Antennas, Radar and Navigation

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.** 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 delete the contents of this box to begin working. **(4)**

b. Show that the normalised array factor of a 2 element array with inter-element spacing d can be expressed as

$$f(\theta) = \frac{1 + e^{jkdsin\theta}}{2}$$ **(4)**

c. Plot the array factor of the two element array for an element spacing of $\lambda/2$ **(4)**

d. A 8.4GHz communications link consists of a 1.8m diameter dish transmit antenna with an aperture efficiency of 0.75, and a receive dish antenna of 1.1m diameter with an aperture efficiency of 0.65. If the distance between the link is 100km, calculate the magnitude of the transmit power required to produce a received power level of 100nW **(6)**

e. Estimate the gain of an antenna with azimuth and elevation 3dB beamwidths of 3 degrees **(2)**

2. **a.** With the aid of a diagram explain the terms: main-beam, boresight direction, sidelobes, nulls, back-lobes and first-nulls beamwidth, as applied to an antenna's far-field radiation characteristics **(6)**

b. Sketch the equivalent circuit of an antenna in transmit mode. What is the relationship between the generator impedance Zg and the antenna impedance Za for maximum power transfer? **(4)**

c. 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 **(5)**

d. 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 **(5)**

3. **a.** In the context of radar counter measures, explain the terms: spot jamming, sweep jamming and barrage jamming. What are the three standard jamming tactics used in EW?

(3)

b. Derive the bi-static radar range equation. Ensure that you define the meaning of each variable you use and state any assumptions that you make. **(6)**

c. 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 $1m^2$. 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)**

d. A second jammer operates in conjunction with the first but at a distance of 150km from the radar. The second jammer has an antenna gain of 35dB and a transmit power level of 1.5kW and is also received by the 10 dB radar sidelobe. Calculate the new burnthrough range **(4)**

4. **a.** 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 150μS and the radar operates at a maximum unambiguous range of 470km.

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?

What is the Doppler resolution and velocity 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. In Figure 1, **A** denotes a moving police car with an onboard CW Doppler radar operating at 10GHz. The radar detects returns from each of the targets **B** to **F** simultaneously and without obstruction. Sketch a graph of the frequency spectrum of the radar receive signal indicating the features that correspond to each of the targets **B** to **F**. Assume that the *magnitude* of the received signals from each target is identical. The speed of each target (km per hour) is given in the table below and the direction of travel is indicated by the arrows in Figure

Object	Description
A	Police car with 10GHz radar travelling at 80km/hr
B	Car travelling at 130km/hr
C	Car travelling at 60km/hr
D	Car travelling at 100km/hr
E	Car travelling at 100km/hr
F	Stationary road sign

(6)

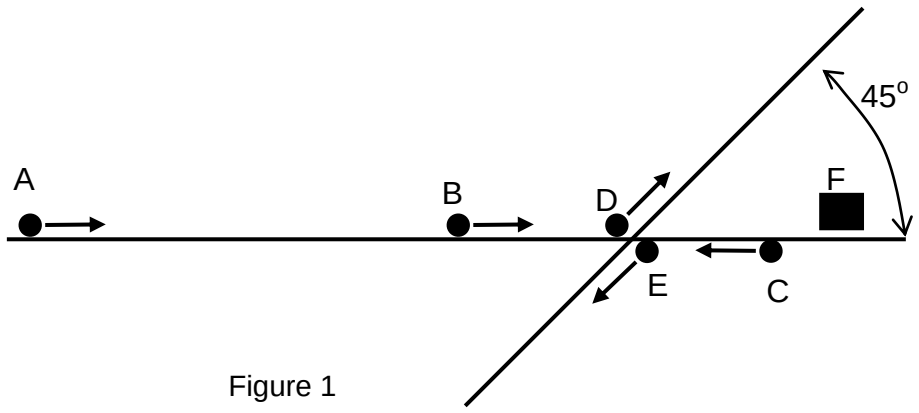

Figure 1

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