Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2012-13 (2.0 hours)

EEE334 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. The antenna of an air-traffic control radar system rotates at 6 revolutions per minute (RPM) and has a beamwidth $\Delta\theta$ of 1.2°. The pulse repetition frequency (PRF) is 480Hz, the pulse length is $1.5\mu s$ 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

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

iii. Calculate the range resolution, Doppler resolution and unambiguous range of the system

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(10)

b. With the aid of a block diagram, describe the basic operation of a continuous wave Doppler radar system. **(4)**

c.

A CW Doppler radar speed trap is set up on one side of a valley road, at position A as shown in Figure 1. The curve of the road is described by the equation $y = x^2/1000\,\text{m}$. If the radar is horizontally focused on point B and is designed to trigger at boresight velocities exceeding 65mph, what road velocity of a car at point B will trigger the detector?

(6)

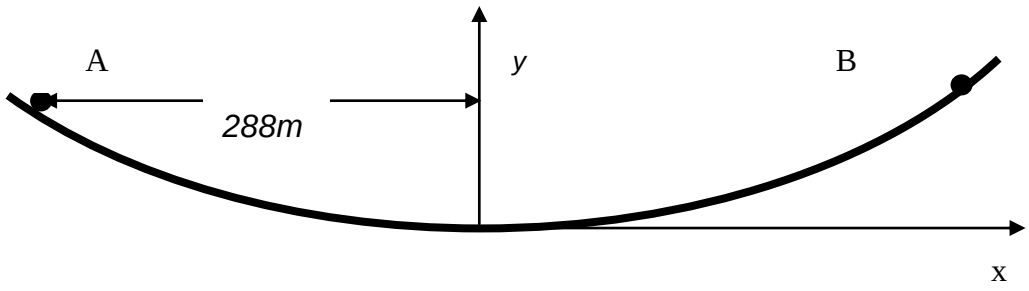


Figure 1

2. **a.** Derive the *bi-static* radar range equation. Ensure that you explain each step and define the variables that you introduce. **(6)**

b. The bi-static radar system in Figure 2 operates at 10.0GHz and has transmit and receive antennas with gains of 35dB and 10dB respectively. If the RCS of the target is 2.0m^2 and the antenna transmit power is 1.0kW and the total system loss is 2dB, calculate the magnitude of the scattered power at the receive antenna.

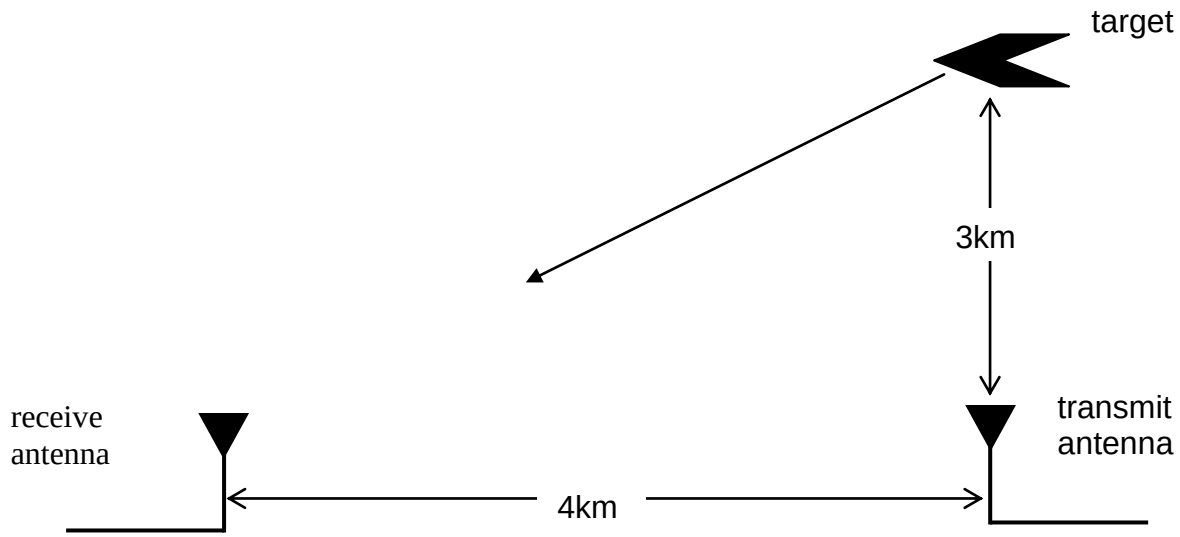


Figure 2

(6)

c. A 8GHz radar with a boresight gain of 40dB and a peak transmit power of 200kW is used to track a target with an RCS of 1.4m^2. The radar antenna also receives a jamming signal in a sidelobe which has a gain of 15dB. The jammer operates at a distance of 100km from the radar and has an antenna gain of 30dB and a transmit power level of 1.5kW. Calculate the burnthrough range. **(8)**

3. **a.** Suggest an appropriate antenna type for use in each of the following applications:

i. Point-to-point high data rate link
ii. In car radio reception
iii. Terrestrial TV reception
iv. Missile defence radar
v. Mobile base station **(5)**

b. A 1 metre long 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 $73 + j42.5$ Ohms and the antenna loss resistance is given by $R_L = 0.75$ 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

In a similar experiment, a 1 metre long monopole antenna is driven at its resonant frequency by a 100 V generator with a source resistance of 50 Ohms. The antenna loss resistance is still given by $R_L = 0.5$ Ohms. Determine the new values of the parameters calculated in i) to v)

(10)

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

$U(\theta) = 1;\ 0^o \leq \theta \leq 30^o$

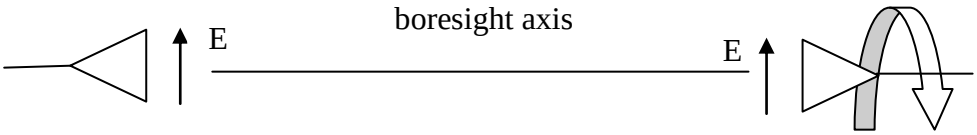
$U(\theta) = 0.2;\ < \theta \leq 90^o$

The pattern is independent of ϕ. Calculate the maximum directivity **(5)**

4. **a.** Describe the two common operating modes of a helical antenna and give approximate design conditions for each mode. **(5)**

b. Explain how polarisation diversity may be used to increase the capacity of a communications link. **(4)**

c. i) A communications link consists of two antennas aligned on boresight such that they respectively transmit and receive perfect circular polarisation. One of the antennas is now rotated through 360 degrees about the boresight axis; sketch the variation of the normalised received signal as a function of rotation angle.



ii) One of the circularly polarised antennas is now replaced with linearly polarised antenna and the experiment is repeated. Sketch the variation of the magnitude received signal as a function of rotation angle. **(6)**

d. A 11.8GHz satellite comms link consists of a 4.5m diameter dish transmit antenna with an aperture efficiency of 0.75, and a receive dish antenna of 1.8m diameter with an aperture efficiency of 0.5. If the distance between the link is 35787km and the transmit power is 80W, calculate the magnitude of the received power. **(5)**

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