Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2009-2010 (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. With the aid of a block diagram, describe the basic operation of a continuous wave Doppler radar system. **(4)**

b. A 1GHz continuous wave Doppler radar system is used to record the radar returns from a wind turbine generator (WTG) as shown in Figure 1. The blades of the WTG are 45m long and rotate at a fixed rate of 20 revolutions per minute. Assuming that the blades can be represented as flat metal plates sketch the *approximate* form of

i) the time-domain signal received by the radar system.
ii) the frequency-domain (Doppler) signal received by the radar system.

In a second experiment side **B** of each of the three blades is coated with radar absorbing material. Sketch new graphs to show the modified time-domain and frequency-domain received signals.

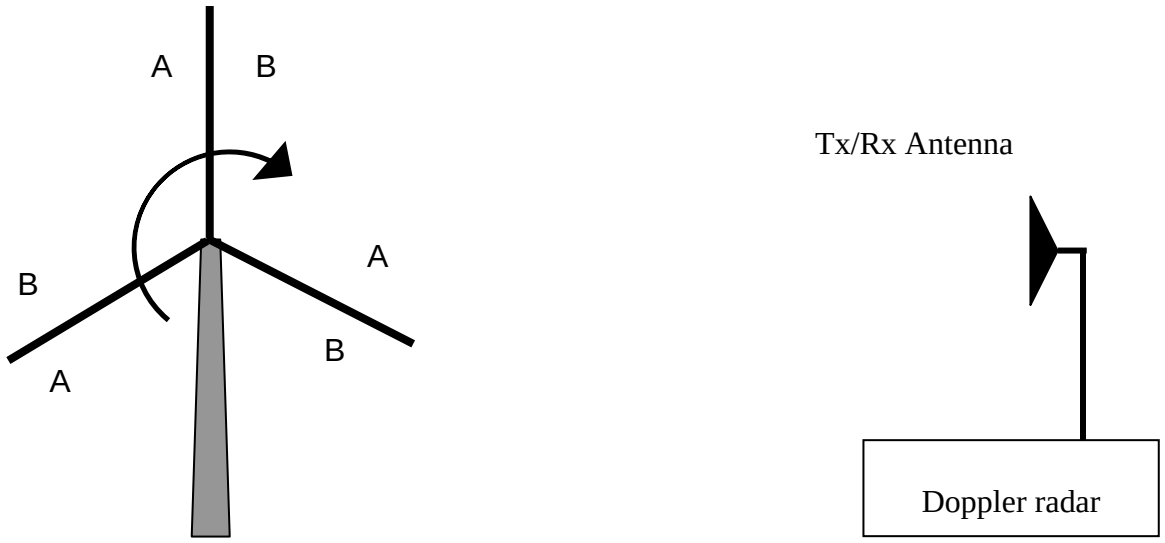


Figure 1 (Not to scale)

(10)

c. A long range surveillance radar operates at 1.3GHz and uses a common transmit/receive antenna that is 13.0m wide and 7.5m high. The antenna rotates at 6 revolutions per minute. The peak transmitter power is 80kW, the pulse duration is 150μS and the radar operates at a maximum unambiguous range of 520km.

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?

(6)

2. **a.** Derive the bi-static radar range equation. **(6)**

b. A radar system operating at 10.2GHz uses a common transmit/receive antenna with an effective aperture size of 3.2m (horizontal) by 0.8m (vertical) and a first sidelobe level of –23dB relative to the main beam. Calculate the approximate azimuth and elevation beamwidth and estimate the antenna gain. **(4)**

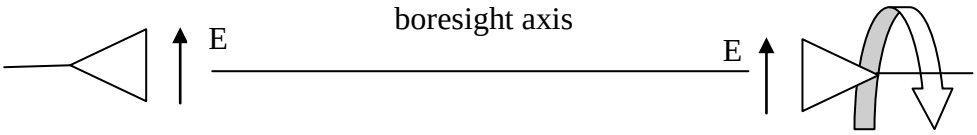
c. If the transmit power is 15kW, the noise level is –125dBW and the total losses are 4dB, calculate the maximum range at which an aircraft with an RCS of $1m^2$ could be detected with a SNR of 13dB. **(5)**

d. Calculate the RCS of a target that would produce a similar output level at half this range if detected by the antenna's first sidelobe. **(5)**

3. **a.** With the aid of a diagram, define the term *axial ratio* with regard to the polarisation of the field radiated by an antenna. What are the numerical limits on the value of axial ratio and what types of polarisation do these limits correspond to? **(4)**

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

c. A communications link consists of two antennas aligned on boresight such that they respectively transmit and receive perfect linear 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.



The linearly polarised antennas are now replaced with matched, circularly polarised antennas and the experiment is repeated. Sketch the variation of the normalised received signal as a function of rotation angle. **(6)**

d. A 10.8GHz satellite comms link consists of a 3.5m 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 0.65. If the distance between the link is 35787km and the transmit power is 100W, calculate the magnitude of the received power. **(6)**

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

i. Radio broadcast antenna
ii. Terrestrial TV reception
iii. Airport surveillance radar
iv. Airborne intercept radar
v. Mobile phone base station
vi. Simple antenna for receiving circularly polarised radiation

(6)

b. 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)**

c. A 1.2 metre long half-wavelength dipole antenna is driven at its resonant frequency by a 120 V generator with a source resistance of 50 Ohms. The input impedance of the dipole is given by $Z_A = 73 + j40$ Ohms and the antenna loss resistance is given by $R_L = 0.4$ 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)**

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