Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2007-2008 (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.** In the context of surveillance radar, explain how the beamwidth of the antenna affects the performance of the radar.

(2)

b. An antenna with azimuth and elevation beamwidths of $\Delta\phi$ and $\Delta\theta$ is required to scan a hemisphere of sky. Determine a relationship between the gain of the antenna and the number of beam positions required to fully scan the hemisphere. If an antenna has a gain of 40dB and the hemisphere of sky needs to be fully scanned every 10s, determine the dwell time per position.

(8)

c. A rotating pulsed radar system has the following parameters: frequency = 560MHz; pulse width = 1.3μS; peak power = 279kW; duty cycle = 8.3 x 10^{-4} ; antenna rotation rate = 16 RPM; vertical beamwidth = 4^{0} ; number of hits on a point target per rotation = 9.9.

Determine the following parameters:

Wavelength; pulse repetition frequency (PRF); pulse repetition time (PRT); average power; horizontal antenna beamwidth; antenna gain; maximum unambiguous range and the range resolution.

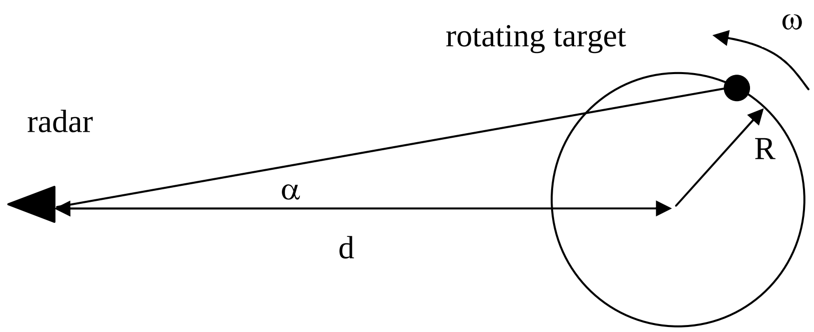
(10)

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

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 illuminates a rotating spherical target as shown in Figure1. The target rotates at an angular velocity of ω radians per second around a circular path of radius *R*. The radar operates at a frequency of f_0 Hz and is located a distance *d* away from the target. Assuming that d ? R derive an expression for the Doppler shift detected by the radar. If $f_0 = 10GHz$, $R=1m$ and the target rotates at 30rpm, sketch a graph of the variation in Doppler shift during one complete rotation of the target.

If the condition d ? R does NOT apply derive a new expression for the detected Doppler shift in terms of the parameters ω, α, R, θ and f_0



(10)

Figure 1

3. **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. A 8.8GHz communications link consists of a 1.9m diameter dish transmit antenna with an aperture efficiency of 0.7, and a receive dish antenna of 1.3m 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 500nW **(6)**

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

Plot the array factor for an element spacing of $\lambda/2$. **(8)**

4. **a.** Explain why and under what circumstances a wireless communication system is more power efficient than a cable based system **(4)**

b. Suggest an appropriate antenna type 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)

c. A resonant, lossless half-wavelength dipole antenna has a radiation pattern given by $U = \sin^3(\theta)$. The antenna has an input impedance of 73Ω and is connected to lossless 50Ω transmission line. If the antenna is illuminated by a plane-wave with a power density of 5μW/m^2 at a frequency of 10MHz calculate the power available at the end of the transmission line.

You may find the following expression useful $\int \sin^4 axdx = \frac{3x}{8} - \frac{\sin 2ax}{4a} + \frac{sin4ax}{32a}$ **(10)**

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