THE PNG UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & COMMUNICATIONS ENGINEERING DEPARTMENT

SECOND (2nd) SEMESTER (2023)

EE427 ANTENNAS AND RADAR

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

1. You have **TEN (10) MINUTES to** read this paper. Do not write during this allocated time

2. There are **Four (4) Questions** in this Exam Booklet**. Answer all Questions**

3. **Total marks available is 100 marks.**

4. All answers must be written in the **Answer Booklet**

5. **COMPLETE STUDENT DETAILS ARE TO BE FILLED ON THE ANSWER BOOKLET-DO THIS NOW**

6. Only drawing instruments and calculators are allowed on your desk. Textbooks and notebooks are **NOT** allowed

7. If you are found **Cheating** in this Exam, penalties specified by the **University** shall be applied.

8. TURN OFF all your mobile phones and place them on the floor under your seat before you start the examination

QUESTION 1 [Total Marks 25]

(a) With an appropriate diagram, and using the signal-to-noise ratio (SNR) equation, define the following terms (a) false alarm (b) detected target (c) missed target.

[7 Marks]

(b) An airborne radar has peak power of 15 kW and uses pulse repetitive frequencies (PRFs) of f_1 and f_2. The average power for both PRFs is 2 kW. If the required energy in the pulses are 0.2 Joules and 0.1 Joule, determine the frequencies f_1 and f_2.

[8 Marks]

(c) Write down the radar equation.

(i) Discuss the variables of the radar equations that are constant for a given radar, and the variables that are dependent on the target and the operating environment.

[5 Marks]

(ii) Using the antenna gain in the radar equation, explain how you would choose an appropriate antenna for a given radar application.

[5 Marks]

QUESTION 2 [Total Marks 25]

(a) With appropriate diagrams and equation, show how unambiguous range measurement depends on the pulse repetitive frequency (PRF).

[8 Marks]

(b) From the basic equation for the power density of the signals radiated from an omnidirectional antenna, $P_T/4\pi R^2$ W/m^{2,} derive the radar equation. P_T is the total power transmitted from the antenna and R is the distance of the target from the transmitting antenna. Assume that that the target radar cross sectional area is σ m^2.

[10 Marks]

(c) Write down the radar equation, and show how the selection of the antenna determines the range of operation and the size of the target that may be detected and tracked.

[7 Marks]

QUESTION 3 [Total Marks 25]

(a) Write down the Doppler frequency equation for a bistatic radar. How does the Doppler frequency changes as the target moves with respect to the radar? Show how the Doppler frequency may become zero, positive and negative.

[10 Marks]

(b) Two aircraft are moving towards each other and on collision course. The radar on one of the aircraft moving at 250 m/s operates at a wavelength of 0.3 m. The radar of the other aircraft moving at 175 m/s operates at a wavelength of 0.01 m. Determine the Doppler frequency shifts shown in both aircraft. Which of the two radars give better range resolution? If one of the aircraft swerves out an angle of 30^{o} what will be the new Doppler frequencies registered on the two radars? How is it that the Doppler frequency alone cannot be used for collision avoidance?

[10 Marks]

(c) How is the polarization of the reflected signal affected by different geometrical shapes of (I) the radome and (ii) the wings of the aircraft?

[5 Marks]

QUESTION 4 [Total Marks 25]

(a) Write down the S/N ratio of a radar system, and distinguish between design parameters and performance parameters. Using this distinction between parameters, briefly describe how you will design radar system to track birds.

[7 Marks]

(b) Given that the power density radiated from an isotropic radiator of transmitter power P_t is $P_t/4\pi R^2$, derive (i) the radar equation and (ii) the S/N ratio equation.

[8 Marks]

(c) A radar system has the following parameters: Determine its S/N ratio at 120 nmi.

Radar Parameters

Range	60 nmi
Aircraft cross section	1 m^2
Peak Power	1.4 Megawatts
Duty Cycle	0.000525
Pulsewidth	.6 microseconds
Bandwidth	1.67 MHz
Frequency	2800 MHz
Antenna Rotation Rare	12.8 RPM
Pulse Repetition Rate	1200 Hz
Antenna Size	4.9 m wide by 2.7 m high
Azimuth Beamwidth	1.35 °
System Noise Temp.	950 ° K

$\lambda = c / f = .103$ m

$G = 4 \pi A / \lambda^2 = 15670\ m^2$
$= 42$ dB, (actually 33 dB with beam shaping losses)

Number of pulses per beamwidth = 21

Assume Losses = 8dB

[10 Marks]