THE PNG UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & COMMUNICATIONS ENGINEERING DEPARTMENT

SECOND (2nd) SEMESTER (2022)

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. The paper is worth 100 Marks.**

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

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

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

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

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

QUESTION 1

(a) With an appropriate sketch, describe the basic structure of a radar. How does a bistatic radar differ from a monostatic radar?

[5 Marks]

(b) A certain pulsed radar has a peak power of 10 kW. It uses two pulse repetitive frequencies of 10 kHz and 30 kHz. What are the required pulse widths of the two waveforms if the required average power is 1500 Watts? Compare the pulse energy in each case and the maximum range for each waveform.

[8 Marks]

(c) A radar has an unambiguous range of 100 km and a bandwidth of 0.5 MHz Calculate the required pulse repetitive frequency, pulse repetitive interval, range resolution and pulse width.

[4 Marks]

(d) Determine the range if the bandwidth is changed to 1 MHz, comment on the results and the importance of bandwidth with regards to:
(i) range resolution and
(ii) identification of the target.

Give appropriate sketches to illustrate your answers.

[8 Marks]

[TOTAL 25 Marks]

QUESTION 2

(a) With appropriate sketches 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 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]

[TOTAL 25 Marks]

QUESTION 3

(a) Write down the Doppler frequency equation for a bistatic radar. How does the Doppler frequency change 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]

[TOTAL 25 Marks]

QUESTION 4

(a) What are the different applications of radar? Sketch the radiation beams of three different types of antennas, including omnidirectional and narrow beam antennas, and how each may be used for a specific application of radars.

[10 Marks]

(b) Given a C-band radar with the following parameters: peak power of 1.5 kW, operating frequency of 5.6 GHz, antenna gain of 46 dB, effective temperature of 290 K, noise figure of 3 dB, pulse width of 0.2 μs. The radar threshold signal-to-noise ratio is 20 dB. For target cross section of 0.1 m^2, determine the maximum range.

[10 Marks]

(c) Using an appropriate sketch, show how the radiation safety in the vicinity of a radar needs to be strictly implemented.

[5 Marks]

[TOTAL 25 Marks]