

**PRINCIPLES OF RADAR**  
**(ECEN 4224)**

**Time Allotted : 2½ hrs**

**Full Marks : 60**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 4 (four) from Group B to E, taking one from each group.*

*Candidates are required to give answer in their own words as far as practicable.*

**Group – A**

1. Answer any twelve:

**12 × 1 = 12**

*Choose the correct alternative for the following*

- (i) Which of the following best describes the term which is used when a signal is detected falsely even though it's not present?
  - (a) Uncalled echo
  - (b) False alarm
  - (c) Unambiguous signal
  - (d) Minimum detectable signal
- (ii) Which noise is generated in the ohmic region of the receiver input stage?
  - (a) Impulse noise
  - (b) Thermal noise
  - (c) Intermodulation noise
  - (d) Shot noise
- (iii) Why is it necessary to maximize the signal to noise ratio at the output of IF amplifier?
  - (a) To maximize max power transfer
  - (b) To reduce the noise components
  - (c) To maintain uniformity of signal
  - (d) To maximize the video output
- (iv) Why are pulse Doppler radars operated with a pulse repetition frequency (PRF)?
  - (a) To generate high duty cycle
  - (b) To reduce the existence of probability distribution function
  - (c) To generate false alarm
  - (d) To obtain range ambiguities
- (v) The method often employed for finding the minimum detectable signal to noise ratio when the target cross section is not constant is based on
  - (a) Probability of detection
  - (b) Probability density function
  - (c) Doppler frequency shift
  - (d) Pulse repetition frequency

- (vi) In radar range equation, the minimum detectable signal is replaced by
  - (a) Maximum unambiguous signal
  - (b) Receiver noise figure
  - (c) Maximum detectable SNR
  - (d) Minimum detectable SNR
- (vii) Which of the following are the two main characteristics of receivers?
  - (a) Gain and attenuation
  - (b) Selectivity and sensitivity
  - (c) Modulation and demodulation
  - (d) Multiplexing and demultiplexing
- (viii) For pulse radar with a maximum unambiguous range of 60km, what is the maximum allowable pulse repetition frequency
  - (a)  $4 \times 10^3$
  - (b)  $3 \times 10^3$
  - (c)  $2.5 \times 10^3$
  - (d)  $2 \times 10^3$
- (ix) What is an optimum MTI filter used for?
  - (a) To decrease the interference of clutter
  - (b) To increase the stability of oscillator
  - (c) To maximize the improvement factor
  - (d) To decrease transmitter leakage
- (x) In a phased array antenna, beam steering is achieved by
  - (a) Physically rotating the antenna
  - (b) Changing the amplitude of signals
  - (c) Adjusting the phase of signals across different antenna elements
  - (d) Increasing the transmission frequency

*Fill in the blanks with the correct word*

- (xi) The frequency shift in radar signals due to the motion of a target is known as the \_\_\_\_\_ effect.
- (xii) Water vapor and \_\_\_\_\_ are the primary atmospheric gases responsible for absorption of radar signals.
- (xiii) Radar Cross Section (RCS) is a measure of how much \_\_\_\_\_ a target reflects radar signals back to the radar receiver.
- (xiv) Military stealth technology aims to reduce a vehicle's \_\_\_\_\_ to avoid detection by radar.
- (xv) A lower detection threshold increases the probability of detecting weak signals but also increases the number of \_\_\_\_\_.

### Group - B

2. (a) Draw a block diagram to explain working function of a standard radar system.

*[[CO1] (Remember /LOCQ)]*

- (b) Calculate the maximum range of Radar for the following specifications, operating frequency  $f=10\text{GHz}$ , peak power transmitted by the radar  $P_t=400\text{KW}$ , effective aperture of antenna  $A_e = 5\text{m}^2$ , radar cross section of target  $\sigma=30\text{ m}^2$ , power of minimum detectable signal  $S_{\min}=10^{-10}\text{ W}$ . [[CO1](Analyse/IOCQ)]
- (c) Define noise figure of a receiver and show how it changes with temperature. [[CO2](Remember/LOCQ)]
- 5 + 4 + 3 = 12**
3. (a) Discuss what is false alarm and how its chances can be reduced in target detection. [[CO1](Remember/LOCQ)]
- (b) Calculate the maximum range of Radar for peak power transmitted by the radar  $P_t=250\text{KW}$ , gain of transmitting antenna  $G=4000$ , effective aperture of antenna  $A_e = 4\text{m}^2$ , radar cross section of target  $\sigma=25\text{ m}^2$ , power of minimum detectable signal  $S_{\min}=10^{-12}\text{ W}$ . [[CO1](Analyse/IOCQ)]
- (c) A pulsed radar has bandwidth  $B = 1\text{ MHz}$  and probability of false alarm is  $12.95\text{ dB}$ . Find the average false alarm time. [[CO2](Analyse/LOCQ)]
- (d) Discuss about different Radar frequencies. [[CO2](Analyse/LOCQ)]
- 4 + 4 + 2 + 2 = 12**

### Group - C

4. (a) Discuss with a block diagram about CW Doppler radar system. [[CO3](Remember/LOCQ)]
- (b) If the Radar operates at a frequency of  $5\text{GHz}$ , then find the Doppler frequency of an aircraft moving with a speed of  $100\text{KMph}$ . [[CO3](Remember/LOCQ)]
- (c) Mention different Radar Cross Section prediction technique. [[CO3](Understand/LOCQ)]
- 5 + 4 + 3 = 12**
5. (a) Draw a block diagram of IF Doppler filter bank and explain how it controls received bandwidth. [[CO3](Analyse/IOCQ)]
- (b) Explain the effects of atmospheric absorption and back scattering on radar signals. [[CO3](Understand/LOCQ)]
- (c) A radar emits a wave at a frequency of  $10\text{ GHz}$  and detects a reflected wave at  $10.02\text{GHz}$ . If the speed of the radar wave is  $3 \times 10^8\text{ m/s}$ , what is the speed of the target object? [[CO3](Apply/IOCQ)]
- 5 + 4 + 3 = 12**

### Group - D

6. (a) Explain the relation between Pulse Repetition period and Pulse Repetition frequency in a Radar System. [[CO4](Understand/LOCQ)]
- (b) Define Beam, rotation and target axis in conical scanning. [[CO4](Remember/LOCQ)]
- (c) Derive frequency response function of a matched filter. [[CO3](Analyse/IOCQ)]
- 4 + 3 + 5 = 12**
7. (a) How to find the number of pulses that returned from a point target as the radar antenna scans through its beam width? [[CO4](Apply/IOCQ)]

- (b) Why most of the radar receivers are considered as envelop detectors while calculating the SNR. [[C04](Understand/LOCQ)]
- (c) Explain in detail various system losses involved in Radar system. [[C04](Understand/LOCQ)]
- 4 + 4 + 4 = 12**

### Group - E

8. (a) Distinguish between MTI and Pulse Doppler Radar. [[C05](Remember/LOCQ)]
- (b) Draw the block diagram of MTI Radar with power amplifier Transmitter. [[C05](Apply/IOCQ)]
- (c) Explain the tracking radar and search radar system? [[C05](Remember/LOCQ)]
- 3 + 6 + 3 = 12**
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9. (a) An MTI radar operates at 10GHz with a pulse repetition frequency of 1800 Hz. Evaluate the lowest three blind speeds of this radar. [[C05](Evaluate/HOCQ)]
- (b) Compare and contrast the situations with a power amplifier and a power oscillator in the transmitter of an MTI system. [[C05](Remember/LOCQ)]
- (c) Draw the block diagram of MTI radar using range gates and filters and explain each block. [[C05](Remember/LOCQ)]
- 4 + 4 + 4 = 12**

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	63.55	32.29	4.17