INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

TUTORIAL QUESTION BANK

Course Name	**:**	**RADAR SYSTEMS**
Course Code	**:**	**A80450**
Class	**:**	**IV B. Tech II Sem**
Branch	**:**	**ECE**
Year	**:**	**2018 – 2019**
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OBJECTIVES

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited.

In line with this, Faculty of Institute of Aeronautical Engineering, Hyderabad has taken a lead in incorporating philosophy of outcome based education in the process of problem solving and career development. So, all students of the institute should understand the depth and approach of course to be taught through this question bank, which will enhance learner's learning process.

UNIT -1
BASICS OF RADAR AND RADAR EQUATION

PART-A (Short Answer Questions)

S. No	Questions	Blooms Taxonomy Level	Course Outcome
1	Radar surface-angular measurements are referenced to true north. Define Azimuth and Elevation angles and their ranges?	Understand	1
2	Describe what is meant by Slant Range?	Understand	1
3	Explain the relation between Radar range resolution and the signal Bandwidth with relevant equation.	Remember	1
4	Explain the importance of Radar Pulse in determining the Minimum range of a radar set?	Understand	1
5	Atmospheric interference with the travel of electromagnetic energy increases with what PRF energy characteristic? Discuss	Remember	1
6	Explain the relation between Pulse Repetition period and Pulse Repetition frequency in a Radar System.	Understand	1
7	Distinguish between average power and Peak power and express the relation between the two.	Understand	1
8	Define duty cycle and state its importance in radar operation.	Remember	1
9	What type of target bearing is referenced to a war ship?	Understand	1
10	What type of radar detects range, bearing, and height? Explain	Remember	1

11	Define the term radar range resolution and write the equation ?	Understand	1
12	Describe the important function of the high voltage pulse from the modulator.	Understand	1
13	Explain the usage of a Duplexer in the Radar system.	Understand	1
14	List out some important applications of a radar system.	Remember	1
15	Write simple Radar Equation.	Understand	1
16	Describe the meaning of Antenna effective area	Understand	1
17	Discuss the importance of the position of a target in a lobe for maximum probable detection of the target?	Understand	2
18	Describe the relation between peak power of radar and the duty cycle of the pulses.	Understand	2
19	Define Unambiguous range in a radar system	Understand	2
20	Explain how the unambiguous range can be manipulated with proper design of pulse repetition frequency.	Remember	2
21	Explain the difference between the simple radar equation and modified equation.	Understand	2
22	Explain what is meant by false alarm.	Understand	2
23	Explain the difference between peak power and average power.	Understand	2
24	Write the relation between pulse repetition frequency and pulse repetition period.	Remember	2

PART-B (Long Answer Questions)

S. No	Questions	Blooms Taxonomy Level	Course Outcome
1.	Discuss the parameters on which maximum detectable range of a radar system depends.	Remember	1
2.	What are the specific bands assigned by the ITU for the radar? What the corresponding frequencies?	Understand	1
3.	What are the different range frequencies that radar can operate and give their applications?	Understand	1
4.	What are the basic functions of radar? In indicating the position of a target, what is the difference between azimuth and elevation?	Understand	1
5.	Derive fundamental radar range equation governed by minimum receivable echo power S_{min}.	Remember	1
6.	Draw the functional block diagram of simple pulse radar and explain the purpose and functioning of each block in it.	Remember	1
7.	List major applications of radar in civil and military systems.	Remember	1
8.	With the help of a suitable block diagram explain the operation of a pulse radar.	Understand	1
9.	Explain how the Radar is used to measure the range of a target?	Understand	1
10.	Write the simplifier version of radar range equation and explain how this equation does not adequately describe the performance of practical radar?	Remember	1
11.	Describe how threshold level for detection is decided in the presence of receiver noise for a specified probability of occurrence of false alarms.	Understand	2
12.	Describe the e effect of pulse repetition frequency on the estimated unambiguous range of radar.	Understand	2
13.	Obtain the SNR at the output of IF amplifier of radar receiver for a specified probability of detection without exceeding a specified probability of false alarm.	Remember	2
14.	Explain system losses will effect on the radar range?	Remember	2
15.	Discuss about the factors that influence the prediction of radar range.	Remember	2
16.	Describe the effect of (in terms of wavelength of operation) size of a spherical target on determination of radar cross section of the sphere.	Understand	2
17.	What are multiple-time-around echoes? Explain the relation between un-ambiguous range estimation and multiple-time-around echoes.	Understand	2

18.	Justify the requirement of integration of radar pulses to improve target detection process	Understand	2
19.	Estimate the radar cross-section of a spherical target if the wavelength of transmitting signal with reference to the target size is in Rayleigh region.	Remember	2
20.	List all the possible losses in a radar system and discuss the possible causes of each of them.	Understand	2
	PART-C (Analytical Questions)		
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1.	Compute the time required for Radar transmitted electromagnetic energy to travel 150 m and return to the source?	Understand	1
2.	Find the distance to the target if the time TR taken by the pulse to travel to the target and return is 0.2 micro seconds. (Assume that electromagnetic energy travels at the speed of light). If the Time TR is doubled, what would be the distance R to the target?	Understand	1
3.	Find the unambiguous range for a radar working with a pulse repetition frequency fP of 1000 K Hz.	Understand	1
4.	Compute the maximum detectable range of a radar system specified below: Operating wavelength = 3.2 cm Peak pulse transmitted power = 500 kW. Minimum detectable power = 10−13 W. Capture area of the antenna = 5 sq.m. Radar cross-sectional area of the target = 20 sq.m.	Remember	2
5.	For the specifications of a radar listed below, compute the power received at 50 Km distance from the radar antenna. Operating wavelength = 3.0 cm Peak pulse transmitted power = 320 kW Transmitting gain, G of the antenna = 9.6 × 104 Effective aperture area of receiving antenna = 5 sq.m Radar cross-sectional area of the target, _ = 12 sq.m.	Remember	2
6.	Use the radar range equation to determine the required transmit power for the TRACS radar given, Prmin =10-13 Watts G=2000 ë=0.23m PRF=524Hz ó=2.0m ^{2}	Remember	2
7.	Assume that 10 signal-plus-noise pulses are integrated along with 30 noise pulses arid that Pd = 0.90 and nf = 108 .If Li(40) is 3.5 dB and, Li(10) is 1.7 dB, find out the collapsing loss.	Remember	2
	UNIT – II **CW AND FREQUENCY MODULATED RADAR**		
	PART-A (Short Answer Questions)		
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1.	Describe the Doppler effect?	Understand	3
2.	Explain how the Doppler effect is used to determine velocity of targets in Radar systems?	Understand	3
3.	The beat frequency in a swept-frequency transmitter provides range Information. Explain.	Understand	3
4.	If the transmitting source is fixed and the radar target is approaching the source, What type of change the received frequency will undergo?	Remember	3

5.	If the target and the Frequency source are moving close to each other, with constant velocity, explain the change in the frequency?	Remember	3
6.	What is Doppler frequency shift?	Understand	3
7.	Explain how the multipath signals produce error in FM altimeter?	Remember	3
8.	How to find the target speed from Doppler frequency?	Remember	3
9.	Write the applications of CW Radar.	Remember	3
10.	Establish a relation between Doppler frequency shift and radial velocity of a moving target.	Understand	3
11.	What factor determines the difference between the transmitted frequency and the received frequency in an FM transmitter?	Remember	4
12.	Stationary objects are most easily detected by an FM system? Explain in detail?	Understand	4
13.	With necessary mathematical expressions, describe range and Doppler measurement if the transmitted signal of a CW radar is frequency modulated?	Understand	4
14.	Why is amplitude comparison mono pulse more likely to be preferred over the phase comparison mono pulse and conical scan tracker over sequential lobbing, or lobe switching, tracker?	Understand	4
15.	Explain the operation of the two frequencies CW Radar.	Remember	4
16.	How to select the difference between two transmitted signals of CW radar?	Understand	4
17.	Why the step error and quantization errors which occur in cycle	Remember	4
18.	Counter are used for frequency measurement in FMCW Radar? What are the effects which limit the amount of transmitter leakage power which can be tolerated at the receiver?	Understand	4

PART-B (Long Answer Questions)

S. No	Questions	Blooms Taxonomy Level	Course Outcome
1	With the help of a suitable block diagram, explain the operation of CW Doppler radar in a sideband super heterodyne receiver.	Understand	3
2	List the limitations of CW radar and explain.	Remember	3
3	What is Doppler frequency shift? Establish a relation between Doppler frequency shift and radial velocity of a moving target.	Remember	3
4	Explain how isolation between transmitter and receiver of a radar system can be achieved if single antenna is used for transmission and reception.	Understand	3
5	What is Doppler frequency shift? Discuss the effect of receiver bandwidth on the efficiency of detection and performance of a CW Doppler radar.	Understand	3
6	With the help of a suitable block diagram, explain the operation of a CW tracking illuminator application of a CW radar.	Understand	3
7	With the help of a suitable block diagram, explain the operation of a CW radar with non- zero IF in the receiver.	Understand	3
8	What are the factors that limit the amount of isolation between Transmitter and Receiver of CW Radar?	Remember	3
9	With the help of suitable block diagram, explain the operation of a FM-CW altimeter.	Understand	4
10	List out the possible errors for measurement of altitudes accurately using a FM-CW altimeter and explain.	Remember	4
11	Discuss the results of multiple frequency usage for operating FM- CW radar while mentioning the limitations of multiple frequency usage in CW radars.	Remember	4
12	Describe Range and Doppler measurement of a target using a FM-CW radar.	Understand	4
13	Why the step error and quantization errors which occur in cycle counter are used for frequency measurement in FMCW Radar?	Understand	4
14	How to select the difference between two transmitted signals of CW radar?	Remember	4
15	What are the various unwanted signals which cause errors in FM altimeter?	Understand	4

16	Explain Mono pulse tracking in two angle coordinates.	Understand	4
PART-C (Analytical Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1.	Find out the Doppler frequency shift caused by a space borne target approaching with a relative velocity of 100 m/s with respect to a CW Radar operating at a carrier frequency of 6.0 GHz. (Velocity of electromagnetic wave can be assumed as 3×10^8 m/s)	Understand	3
2.	For an ambiguous range of 81 nautical miles (1nmi=1852 meters) in a two frequency CW Radar. Determine f2 and Δf when f1=4.2 kHz.	Remember	3
3.	Determine the acceleration of a target if the received signal bandwidth is 40Hz and the operating wavelength is 9 cm.	Understand	3
4.	Determine the operating wavelength if the target is moving with acceleration as same as acceleration of gravity and the received signal bandwidth is 50 Hz.	Understand	3
5.	With a transmit (CW) frequency of 5GHz, calculate the Doppler frequency seen by stationary Radar when the target radial velocity is 100km/hr.	Understand	3
6.	A radar system operates at 3 cm with a peak pulse power of500kw. Its minimum receivable power is 10 -3 w, the capture area ofthe antenna Is 5 m^2 and the radar cross-sectional area of the target is 20m^2. Find the maximum range of the radar.	Remember	4
7.	The minimum receivable signal in a radar receiver who's IF bandwidth is1.5 MHz and which has a noise figure 9 dB will be?	Understand	4
8.	A target is moving with a velocity of 360km/hour radically towards the transmitting frequency generator of 3 GHz will be?	Remember	4
UNIT-III MTI AND PULSE DOPPLER RADAR			
PART-A (Short Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	Pulse modulation method does NOT depend on relative frequency or target motion? Discuss.	Understand	5
2	Define MTI radars.	Remember	5
3	Define pulse Doppler radars.	Remember	5
4	What is a delay line canceller?	Understand	5
5	What are blind speeds?	Remember	5
6	How does MTI radar differ from CW radar?	Understand	5
7	Write about Doppler Effect.	Understand	5
8	List out the advantages of Non coherent MTI radar.	Understand	5
9	Differentiate MTI and pulse Doppler Radar.	Remember	5
10	List out the limitations of CW Radar.	Remember	5
11	Compare and contrast the situations with a power amplifier and a power oscillator in the transmitter of an MTI system.	Understand	5
12	Explain about equipment instabilities.	Remember	5
13	Explain Scanning modulation.	Remember	5
14	Explain Internal fluctuation of clutter.	Remember	5
15	Write the description of Range gate Doppler filters.	Understand	5
16	Differentiate blind phases from blind speeds.	Understand	5
17	How does MTI radar differ from Pulse Doppler radar.	Understand	5
18	A simple MTI delay line canceller an example of time domain filter. Why?	Understand	5

19	What is the distinctive feature that makes the MTI radar and Pulse Doppler to differ?	Understand	5
20	What is matched filter? Why it is needed in pulse Radar?	Remember	5
PART-B (Long Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	What is a delay line canceller? Illustrate the concept of blind speeds based on the frequency response of a single delay line canceller.	Understand	5
2	Discuss the factors limiting the performance of an MTI system.	Remember	5
3	What are blind speeds? Suggest a method to reduce the effect of blind speeds for unambiguous detection of a moving target.	Understand	5
4	Explore the possibility of broadening the clutter rejection null using a second delay line canceller in the MTI radar system.	Remember	5
5	Describe automatic tracking of a target through range gating technique for unambiguous detection of a moving target.	Understand	5
6	With the help of necessary block diagram explain the operation of an MTI radar system with a power amplifier in the transmitter.	Understand	5
7	Compare and contrast the situations with a power amplifier and a power oscillator in the transmitter of an MTI system.	Understand	5
8	Draw and Explain frequency response characteristics of a MTI using range gates and filters.	Understand	5
9	Enumerate the advantage of the delay line canceller as compared to conventional frequency domain filter.	Understand	5
11	Describe the method of staggering pulse repetition frequency to reduce the effect of blind speeds in an MTI system.	Understand	5
12	Explain the following limitations of MTI radar. (a) Equipment instabilities. (b) Scanning modulation. (c) Internal fluctuation of clutter.	Understand	5
13	Discuss the limitations of non-coherent MTI Radar systems.	Remember	5
14	Write the description of Range gate Doppler filters.	Remember	5
15	Explain the operation of MTI radar with 2 pulse repetition frequencies.	Understand	5
16	Explain the function of time domain filter with an example.	Understand	5
17	Describe Briefly about the analog MTI radars.	Understand	5
18	What is the method of overcoming the problem of blind speed in analog Radars?	Understand	5
19	Derive an expression for blind speed of an MTI radars.	Understand	5
20	Discuss about the internal Fluctuation of clutter which limits the performance of MTI radar.	Understand	5
PART-C (Analytical Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	What is the highest frequency that a radar can be operated if it is required to have a maximum unambiguous range of 350 km and no blind speeds less than 100 m/s.	Understand	5
2	A s-band air surveillance radar utilizes a staggered waveform with four different PRFs which are 1222,1031,1138,1000 HZ. What is the first blind speed if a constant PRF is used which has the pulse repetition period equal to the average of the four periods of the staggered wave form.	Understand	5

3	A s-band air surveillance radar utilizes a staggered waveform with four different PRFs which are 1222,1031,1138,1000 HZ. What is first blind speed of the staggered PRF wave form. Note the ni for these four frequencies are : 27,32,29,33 respectively	Understand	5
UNIT-IV TRACKING RADAR			
PART-A (Short Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	Explain the characteristic(s) of radiated energy that need to be altered to achieve electronic scanning?	Remember	6
2	Describe the single lobe scanning?	Understand	6
3	The reflected signals decrease in strength. Discuss the significance of this Statement with reference to target motion off the lobe axis?	Remember	6
4	List out and describe the basic methods of scanning?	Understand	6
5	Define scan and its importance in a Radar system.	Remember	6
6	Explain Split-range-gate tracking.	Remember	6
7	Limitation of automatic detection and tracking.	Remember	6
8	Discuss in detail about the Echo pulse with respect to Tracking in range.	Remember	6
9	Describe the Early-late range gates with respect to Tracking in range.	Understand	6
10	Explain the Difference signal between early and late range gates.	Remember	6
PART-B (Long Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	Discuss the effect of surface quality and reaction characteristics of a target on the angular tracking accuracy of tracking radar.	Remember	6
2	Describe the phase comparison mono pulse tracking technique in a radar system with the help of necessary block diagram.	Understand	6
3	With the help of a suitable block diagram, discuss the Sequential lobbing type of tracking technique in a tracking radar system.	Remember	6
4	Compare and contrast conical scan and sequential lobbing type tracking techniques.	Remember	6
5	Describe the process of acquiring a moving target prior to tracking it along with the patterns used for acquisition.	Understand	6
6	Describe automatic tracking of a target through range gating technique	Understand	6
7	Describe sequential lobbing type of error signal generation to track a target automatically.	Understand	6
8	List the merits and demerits of Monopulse tracker over conical scan type tracker.	Remember	6
9	Draw the block diagram of an amplitude comparison mono pulse tracking radar in azimuth and elevation directions. Explain the functioning of this two dimensional tracking radar.	Understand	6
10	Why does tracking radar have poor accuracy at low elevation angles?	Remember	6
11	Explain with diagrams explain Split-range-gate tracking.	Understand	6
12	Limitation of automatic detection and tracking radar.	Remember	6
13	Explain the block diagram of amplitude comparison mono pulse for extracting error signals in both elevation and azimuth.	Understand	6
14	Draw and explain the following with respect to Tracking in range: i. Echo pulse ii. Early-late range gates iii. Difference signal between early and late range gates.	Remember	6
15	Draw and explain block diagram of Conical-scan tracking radar.	Understand	6

PART-C (Analytical Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	For ground-based search radar with a beam width of 1.5 deg, the pulse repetition frequency is 300 Hz, and the antenna scan rate is 5 rpm (30deg /sec). Find the number of pulses returned from a point target as the radar scans through the beam width.	Understand	6
2	If the one way antenna power pattern of a conical scan tracking antenna is described by the Gaussian function, what is the loss I received signal when the target is directly at the beam cross over? The antenna half power beam width is 2 deg and the squint angle is 0.75 digress?	Remember	6
3	Why does tracking radar have poor accuracy at low elevation angles? Summarize the two methods that may be worth considering when it is necessary to avoid poor tracking of target at low altitudes?	Understand	6
UNIT-V DETECTION OF RADAR SIGNALS IN NOISE			
PART-A (Short Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1.	Explain the ground clutter in radar systems.	Understand	7
2.	Discuss the efficiency of non-matched filters.	Remember	7
3.	What is the difference between matched filter and non-matched filter?	Remember	7
4.	Describe any two types of duplexers used in radar receivers	Understand	7
6.	Define noise figure and equivalent noise temperature of a radar receiver.	Remember	7
7.	Explain the function of time domain filter with an example.	Understand	7
8.	Explain how a threshold level is selected in threshold detection?	Understand	7
9.	Distinguish the difference between a mono static and bi static radar systems	Remember	8
10.	Describe the function of an Envelop detector in Radar receivers.	Understand	8
11.	List out and explain the three fundamental quantities involved in radar displays?	Understand	8
12.	Explain a Radar Display system.	Understand	8
13.	Describe the coordinates are presented on a PPI scope?	Remember	8
PART-B(Long Answer Questions)			
S. No	**Questions**	**Blooms Taxonomy Level**	**Course Outcome**
1	Explain the principle behind the operation of duplexers and receiver protectors	Understand	7
2	Explain how a circulator can be utilized for a radar receiver protection	Understand	7
3	Define noise figure and noise temperature of a receiver system	Remember	7
4	Describe the principle behind the operation of a phased array antenna in a radar system.	Understand	7
5	Derive the impulse response of a matched filter that is commonly used in a radar system.	Remember	7
6	Substantiate the requirement of duplexers in efficient radar systems Describe the operation of branch and balanced type duplexers with necessary diagrams.	Understand	7
7	Describe any of two types duplexers used in radar receivers.	Understand	7
8	Define noise figure and equivalent noise temperature of a radar receiver.	Remember	7
9	Discuss in detail about Matched-filter Receiver with necessary expressions.	Remember	7
10	Explain the function of time domain filter with an example.	Understand	7

11	Derive the impulse response of a matched filter that is commonly used in a radar receiver.	Remember	7
12	Explain how a threshold level is selected in threshold detection?	Remember	7
13	How to find the number of pulses that returned from a point target as the radar antenna scans through its beam width?	Understand	7
14	Why most of the radar receivers are considered as envelop detectors while calculating the SNR?	Remember	7
15	Discuss the relation between the matched filter characteristics and correlation detection.	Remember	7
16	What is the difference between matched filter and non-matched filter?	Understand	7
17	List out the general characteristics and bring out requirements for a radar receiver.	Remember	8
18	Define noise figure and noise temperature of a receiver system.	Understand	8
19	Derive the expression for the noise figure of two networks that are in cascade.	Remember	8
20	What is low noise front end? What are its applications?	Understand	8
21	Describe briefly various visual displays to view radar echo signals in radar systems.	Understand	8

PART-C (Analytical Questions)

S.No	Questions	Blooms Taxonomy Level	Course Outcome
1.	Explain how you will design application to create a Smart Card in detail.	Remember	7
2.	Analyze and design application for Adaptive Cruise Control System in Car in detail.	Understand	7
3.	Develop and design a application for sending Application Layer Byte Stream on a TCP/IP Network in detail. (Write with design and code.)	Understand	7
4.	Explain how will you design a application for Automatic Chocolate Vending Machine in detail. (Write with design and code.)	Remember	7
5.	If the target's relative velocity is not constant, a further widening of the received signal spectrum can occur. If ar is the acceleration of the target	Understand	8
6.	With respect to the radar, the signal will occupy a bandwidth. If it is the twice the acceleration due to gravity, what should be the receiver bandwidth when the radar wavelength is 10 cm Estimate the system noise figure if the antenna is at 300deg Kelvin and the transmission line loss is 1.5 dB and the receiver noise figure is 2.6 dB ?	Remember	8
7.	A receiver with a mixer front end has noise figure of 6.6 DB. A LNA with a noise figure of 1.2dB and gain of 10 dB is inserted ahead of mixer to reduce the overall receiver noise figure. A) How much of the new noise figure is due to mixer noise, and by how much has the dynamic range of the receiver been reduced? B) The gain of LNA was increased to 20 dB, what would be the receiver noise figure and the decrease in dynamic range.	Remember	8

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