INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION FORM

Course Title	:	**RADAR SYSTEMS**			
Course Code	:	**A80450**			
Academic Year	:	**2018 – 2019**			
Branch/Sem	:	**IV - B. Tech – II SEM**			
Course Structure	:	**Lectures**	**Tutorials**	**Practical**	**Credits**
		4	**---**	**---**	**4**
Course Faculty	:	**Mrs. V. Bindusree, Assistant Professor** **Mrs. J. Swetha, Assistant Professor** **Mr. M. Bhargav Kumar, Assistant Professor**			

I. COURSE OVERVIEW

This subject course imparts fundamental concepts on Radar Systems. Course begins with a description of how a simple Radar Equation can be formulated, discusses on the improvement factors in arriving at the final Radar equation. The course goes on to educate the students on design aspects of various sub systems, performance, limitations and application aspects of Radar systems using block diagram. The course probes into the functioning details of CW, FM-CW, Doppler, Pulsed, MTI radar systems, bandwidth requirements for receivers, isolation details. The course describes methods of determination of radar Cross section of targets, system losses. The course covers the theory on acquisition Radars, tracking radars and their applications, functioning of radar receiver subsystems under noisy conditions.

II. PREREQUISITE(S)

Level	Credits	Periods/Week	Prerequisite
UG	4	4	Analog & Digital communications
UG	4	4	Antenna and wave propagation

III. MARKS DISTRIBUTION:

Sessional Marks (25 Marks)	University End Exam Marks	Total Marks
There shall be 2 midterm examinations. Each midterm examination consists of subjective type and Objective type tests. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each midterm exam shall contain 4 questions. The student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks with duration of 20minutes. It consists of 10 Multiple choice and 10 objective type questions. The student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first 2 ½ units of syllabus and second midterm examination shall be conducted for the remaining 2 ½ units. Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course reason whatsoever, will get zero marks(s).	75	100

IV. EVALUATION SCHEME

S.No	Component	Duration(Hrs)	Marks
1	I Mid Examination	1 hr 20 min	20
2	I Assignment	--	05
3	II Mid Examination	1 hr 20 min	20
4	Ii Assignment	--	05
5	End Semester Examination	3 hrs	75

V. COURSE OBJECTIVES

At the end of the course, the students will be able to:

I. Understand the block diagram of RADAR, Radar frequencies and applications
II. Analyze the Doppler Effect, CW and Frequency Modulated Radar and understand the concept of FM-CW Radar, Multiple Frequency CW Radar.
III. Demonstrate MTI and Pulse Doppler radar, Parameters.
IV. Understand the concept of Tracking Radar, Types and Comparison of Trackers, Detection of Radar Signals in Noise, Filter designing.
V. Familiarize with Radar Receivers, Duplexers, Beam Steering and Beam Width changes.

VI. COURSE OUTCOMES

After completing this course the student must demonstrate the knowledge and ability to:

1. Understand about radar fundamentals.
2. Remember the radar ranges and parameters of general radar equation.
3. Demonstrate the Doppler Effect and the concepts of continuous wave radars.
4. Analyze the FM-CW Altimeter.
5. Discuss the operation of MTI and pulse Doppler radar.
6. Remember the tracking radar systems and mono pulse radar.
7. Analyze the detection of radar signals in noise.
8. Demonstrate the noise figure and radar receiver, Beam steering.

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiency assessed by
PO1	**Engineering Knowledge** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems	S	Assignments
PO2	**Problem Analysis** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	S	Design Exercises and assignments
PO3	**Design/Development of Solutions** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	H	Practice Sessions Assignments
PO4	**Conduct Investigations of Complex Problems** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	H	Practice Sessions Assignments

PO5	**Modern Tool Usage** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations	**S**	Lectures and Exercises
PO6	**The Engineer And Society** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	**N**	-----
PO7	**Environment and sustainability** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	**N**	---
PO8	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	**N**	--
PO9	**Individual and Team Work** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	**S**	Seminars, Discussions
PO10	**Communication** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**N**	--
PO11	**Project management and finance** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	**S**	Assignments
PO12	**Life-long learning** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	**S**	Assignments, Development of Mini Projects

N-None **S–Supportive** **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO 1	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.	**H**	Lectures and Assignments
PSO 2	**Problem-solving skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	**S**	Tutorials
PSO 3	**Successful career and Entrepreneurship:** An understanding of social- awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	**S**	Seminars and Projects

N-None **S–Supportive** **H – Highly Related**

IX. SYLLABUS:

UNIT–I:

BASICS OF RADAR: Introduction, Maximum unambiguous Range, Simple form of Radar Equation Radar Block diagram and Operation Radar Frequencies and Applications, Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise, Modified Radar Range Equation, Illustrative problems

RADAR EQUATION: SNR, Envelope Detector, False Alarm Time and Probability, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment), Illustrative Problems.

UNIT–II:

CW AND FREQUENCY MODULATED RADAR: Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar, Illustrative Problems.

FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Multiple Frequency CW Radar.

UNIT–III:

MTI AND PULSE DOPPLER RADAR: Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, And Staggered PRFs. Range Gated Doppler Filters, MTI Radar Parameters, Limitations to MTI Performance,MTI versus Pulse Doppler radar.

UNIT–IV:

TRACKING RADAR: Tracking with Radar, Sequential Lobing, Conical Scan, Monopulse Tracking Radar– Amplitude Comparison Monopulse (one- and two coordinates), Phase Comparison Monopulse, Tracking in Range, Acquisition and Scanning Patterns, Comparison of Trackers.

UNIT–V:

DETECTION OF RADAR SIGNALS IN NOISE: Introduction, Matched Filter Receiver – Response Characteristics and Derivation, Correlation Function and Cross-correlation Receiver, Efficiency of Nonmatched Filters, Matched Filter with Non-white Noise.

RADAR RECEIVERS: Noise Figure and Noise Temperature, Displays – types. Duplexers – Branch type and Balanced type, Circulators as Duplexers. Introduction to Phased Array Antennas – Basic Concepts, Radiation Pattern, Beam Steering and Beam Width changes, Series versus Parallel Feeds, Applications, Advantages and Limitations.

TEXT BOOKS:

1. Introduction to Radar Systems Merrill I Skolnik, TMH Special Indian Edition, 2nd edition, 2007

REFERENCES:

1. Merrill I.Skolnik,"Introduction to radar systems", 3rd Edition., TMH, 2001
2. Byron Edde "Radar: Principles, Technology, Applications", Pearson Education, 2004
3. Peebles, Jr. P.Z Wiley, "Radar Principles", New York, 1998

X. COURSE PLAN:

The course plan is meant as a guideline. There may be probably be changes.

Lecture no.	Course Learning objectives	Topics to be covered	Reference
1	Basic idea on Radar fundamentals	Basics of Radar: Introduction	T1: chapter1.1
2-3	Identify detectable ranges and parameters of general Radar Equation.	Maximum unambiguous Range, Simple form of Radar Equation	T1: chapter1.2
4-6	Discuss Radar Subsystems and their inter connectivity	Radar Block diagram and Operation	T1: chapter1.3
7-8	Describe the selective frequency bands, their importance and range	Radar Frequencies and applications, Prediction of Range Frequencies	T1: chapter1.4,2.1
9	Determine and compute minimum detectable signal	Minimum Detectable Signal	T1: chapter2.2
10-11	Derive the receiver noise and formulate improved radar equation with illustrative problems	Receiver Noise, Modified Radar Range Equation, Illustrative problems	T1: chapter2.3
12	Derive Signal to noise ratio and envelop detector	Radar Equation SNR, Envelop Detector	T1: chapter2.5
13-14	Describe about spurious alarms and probability of false alarms	False Alarm Time and Probability Integration of Radar Pulses	T1: chapter2.4,10.8
15-16	Examine and compute radar cross section for various targets	Radar cross section of targets (simple targets, sphere, cone sphere)	T1: chapter2.7
17-18	Basics of Transmitter Power, pulse repetition. Frequency and Range Ambiguities	Transmitter Power, PRF and Range Ambiguities	T1: chapter2.9-2.10
19-20	Discuss system losses	System losses (qualitative treatment),Illustrative problems	T1: chapter2.12
21-22	Describe the importance of Doppler effect and the concepts of Continuous wave radars	CW and Frequency modulated Radar: Doppler effect, CW Radar Block Diagram	T1: chapter3.1-3.2
23-24	Identify the need for Isolation between transmitter and receiver	Isolation Between transmitter and receiver	T1: chapter3.2
25-26	Discuss the receiver bandwidth requirements	Non zero IF receiver, Receiver bandwidth requirements	T1: chapter3.2
27	Explain the applications of CW radars and work on illustrative problems	Applications of CW Radars, Illustrative problems	T1: chapter3.4
28	Describe the Range and Doppler measurements of FM CW radar	FM CW Radar: Range and Doppler Measurement	T1: chapter3.3
29	Classify FMCW radar sub systems and their interconnectivity	Block diagram and characteristics Approaching receiving targets)	T1: chapter3.3
30	Describe FMCW Altimeter	FM CW Altimeter	T1: chapter3.3
31	Explain the limitations of FM CW and know about Multiple frequency CW radar	Multiple frequency CW radar	T1: chapter3.5
32	Basic idea of MTI and pulse Doppler Radar	MTI and Pulse Doppler Radar: Introduction, Principle	T1: chapter4.1
33-34	Describe MTI Radar variants	MTI Radar with Power amplifier transmitter & power oscillator transmitter	T1: chapter4.1
35-36	Discuss the delay line cancellers	Delay line cancellers-filter characteristics	T1: chapter4.2
37-38	Distinguish the blind speeds and double cancellation concepts	Blind speeds, double cancellation, Staggered PRFs	T1: chapter4.3
39	Describe the range gated Doppler filters	Range gated Doppler filters	T1: chapter4.4

40-41	Derive the MTI Radar parameters, Limitations To MTI performance and comparisons	MTI Radar parameters, Limitations to MTI performance, MTI verses Pulse Doppler radar	T1: chapter4.8
42-43	Describe the tracking radar systems	Tracking Radar: Tracking with Radar, Sequential lobbing, Conical scan	T1: chapter5.1-5.3
44-45	Describe mono pulse radar	Mono Pulse Tracking Radar, Amplitude comparison mono Pulse (one and two coordinates)	T1: chapter5.4
46-47	Differentiate phase Comparison mono pulse and tracking in range	Phase comparison mono pulse, Tracking in range,	T1: chapter5.9
48	Describe acquisition and scanning patterns, Comparison of trackers	Acquisition and scanning patterns, Comparison of trackers	T1:chapter5.7,5.9
49-50	Explain how to handle radar signals under noisy situations	Detection of Radar signals in Noise: Introduction, Matched filter receiver, Response characteristics and derivation,	T1: chapter10.1-10.2
51-52	Explain about cross correlation receiver	Correlation function and cross correlation receiver	T1: chapter10.3
53-54	Describe matched filters	Efficiency of non matched filters, Matched filter and non white noise noise	T1: chapter10.2
55-57	Estimate noise figure and understand the effect of noise	Radar Receivers: Noise figure and noise temperature	T1: chapter9.2
58	Describe the display types	Displays types	T1: chapter9.5
59-60	Differentiate the duplexers and circulators	Duplexers – Branch type and balanced type, Circulators and duplexers,	T1: chapter9.6
61-62	Discuss phased array systems	Introduction to phased array antennas-Basic concepts ,radiation patterns	T1: chapter8.9
63	Describe the beam orientation and radar beam width changes	Beam steering and beam width changes, Applications, advantage and limitations	T1: chapter8.11-8.12

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
I.		S	H	H					S	S			H	S	
II.	S		S								S		S		S
III.	S	S		S					S	S	S			S	S
IV.			H	H									H		
V.	S		S		S						S	S	S		S

N-None **S–Supportive** **H – Highly Related**

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1.	S			S	S				S	S	S				S
2.	S	S		H					S	S	S			S	S
3.			H	S	S							S	H		
4.	S		S						S	S	S		S		S
5.		S		S								S		S	
6.		S		H	S									S	
7.	S		S		S				S	S	S			S	S
8.			S	S					S	S			H		S

N-None **S–Supportive** **H – Highly Related**

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