INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATIONENGINEERING

COURSE DESCRIPTOR

Course Title	**MICROWAVE ENGINEERING**				
Course Code	**AEC015**				
Programme	B.Tech				
Semester	VII	ECE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Dr. V Siva Nagaraju, Professor				
Course Faculty	Mr. S Annapurna, Assistant Professor Ms. P Saritha, Assistant Professor Mr. U Somanaidu, Assistant Professor				

I. COURSE OVERVIEW:

The subject microwave engineering may be also referred to as applied electromagnetic. The importance of microwaves started way back in World War II period and later expanded its ways out to domestic (microwave oven), military, commercial, satellite and etc. This subject starts with the definition of microwave frequency range, its applications and its importance in modern era. The microwave transmission lines like waveguides (rectangular, circular), micro-strips etc. and the various microwave components like T-junctions, circulator, isolator etc. are discussed in detail to enable the student to design microwave systems and sub- systems. They will learn to understand the behavior of microwave power generators and their operation.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEC007	IV	Electromagnetic Theory and Transmission Lines	4
UG	AEC011	V	Antennas and Propagation	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Microwave Engineering	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for continuous internal assessment (CIA) and 70 marks for semester end examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lectures, Assignments, Exercises
PO 2	**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	1	Problem related exercises
PO 4	**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.	2	Design Exercises
PO 12	**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.	2	Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	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.	2	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.	-	-
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.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Develop the knowledge on transmission lines for microwaves, cavity resonators and Wave guide components and applications.
II	Enable the students to understand and analyze the operation of microwave tubes like klystron, magnetron, travelling wave tube, etc.,
III	Familiarize with microwave solid state devices
IV	Introduce the student the microwave test bench for measure different parameters like attenuation, VSWR, impedance etc.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the types of waveguides, rectangular waveguides and field equations.	CLO 1	Understand the microwave spectrum and applications of microwaves.
		CLO 2	Analyze the types of waveguides, rectangular waveguides and field equations in rectangular waveguide.
		CLO 3	Determine the wave impedance for a TM and TE wave in rectangular waveguide
		CLO 4	Understand the types of cavity resonators and

COs	Course Outcome	CLOs	Course Learning Outcome
			determine the dominant mode.
CO 2	Understand the coupling mechanisms in waveguides and analyze the waveguide multiport junctions	CLO 5	Explore the coupling mechanisms for a cavity resonator.
		CLO 6	Understand the waveguide discontinuities: waveguide irises, tuning screws, posts and matched loads
		CLO 7	Analyze the waveguide multiport junctions
		CLO 8	Understand the Faraday rotation principle and analyze the different ferrite devices.
CO 3	Explore the microwave linear tubes and analyze with microwave cross field tubes	CLO 9	Understand the limitations of conventional vacuum tubes at microwave frequencies and Understand the velocity modulation process and bunching process in microwave linear beam tubes
		CLO 10	Determine the beam current density in Multi cavity Klystron amplifiers
		CLO 11	Understand the velocity modulation process and power output in Reflex Klystron
		CLO 12	Determine the amplification process in helix Traveling wave tube (TWT)
		CLO 13	Describe the 8-cavity cylindrical travelling wave Magnetron
		CLO 14	Analyze the Hull cut-off and Hartree conditions in Magnetron
CO 4	Understand the microwave solid state devices and avalanche transit time devices	CLO 15	Illustrate the microwave solid-state devices: microwave tunnel diode and transferred electron devices
		CLO 16	Determine the RWH theory and modes of operations in Gunn diodes
		CLO 17	Understand the Avalanche transit time devices: IMPATT diode, TRAPATT diode and BARITT diode
CO 5	Demonstrate the microwave bench set up and conducting measurements of different parameters	CLO 18	Describe the microwave bench set-up with different blocks and their features
		CLO 19	Determine the measurements of microwave power, attenuation, frequency, VSWR and impedance

3 = High; 2 = Medium; 1 = Low

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEC015.01	CLO 1	Understand the microwave spectrum and applications of microwaves	PO 1, PO12	1
AEC015.02	CLO 2	Analyze the types of waveguides, rectangular waveguides and field equations in rectangular waveguide.	PO 1, PO 2 PO 4, PO 12	1
AEC015.03	CLO 3	Determine the wave impedance for a TM and TE wave in rectangular waveguide	PO 2	1
AEC015.04	CLO 4	Understand the types of cavity resonators and determine the dominant mode.	PO 1, PO 2	2
AEC015.05	CLO 5	Explore the coupling mechanisms for a cavity resonator	PO 1	1
AEC015.06	CLO 6	Understand the waveguide discontinuities: waveguide irises, tuning screws, posts and matched loads	PO 1	1
AEC015.07	CLO 7	Understand the operation of multiport junctions and its applications	PO 1, PO 4	2
AEC015.08	CLO 8	Understand the Faraday rotation principle and analyze the different ferrite devices.	PO 1	2
AEC015.09	CLO 9	Understand the limitations of conventional vacuum tubes at microwave frequencies and Understand the velocity modulation process and bunching process in microwave linear beam tubes	PO 1, PO 2 PO 4, PO 12	1
AEC015.10	CLO 10	Determine the beam current density in Multi cavity Klystron amplifiers	PO 4	2
AEC015.11	CLO 11	Understand the velocity modulation process and power output in Reflex Klystron	PO 4	2
AEC015.12	CLO 12	Determine the amplification process in helix Traveling wave tube (TWT)	PO 1, PO 4 PO 12	2
AEC015.13	CLO 13	Describe the 8-cavity cylindrical travelling wave Magnetron	PO 1, PO 4 PO 12	2
AEC015.14	CLO 14	Analyze the Hull cut-off and Hartree conditions in Magnetron	PO 1, PO 4	2
AEC015.15	CLO 15	Illustrate the microwave solid-state devices: microwave tunnel diode and transferred electron devices	PO 1, PO 12	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AEC015.16	CLO 16	Determine the RWH theory and modes of operations in Gunn diodes	PO 1	2
AEC015.17	CLO 17	Understand the Avalanche transit time devices: IMPATT diode, TRAPATT diode and BARITT diode	PO 1, PO 12	1
AEC015.18	CLO 18	Describe the microwave bench set-up with different blocks and their features	PO 1, PO 12	2
AEC015.19	CLO 19	Determine the measurements of microwave power, attenuation, frequency, VSWR and impedance	PO 2, PO4 PO12	2
AEC015.20	CLO 20	Apply the concept of microwave engineering to understand and analyze real time applications.	PO 12	2

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

Course Outcomes (COs)	Program Outcomes (POs)				
	PO 1	PO 2	PO 4	PO 12	PSO 1
CO 1	3	2	2	1	1
CO 2		2			
CO 3	3	2	2	2	1
CO 4	3	2	1		1
CO 5	3	2		2	

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	2											1	1		
CLO 2	1	2		1								1			
CLO 3		1													
CLO 4	2	1													
CLO 5	1														

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CLO 6	1														
CLO 7	1			2											
CLO 8	2			3									1		
CLO 9	2	1		2								1	1		
CLO 10		1		2											
CLO 11		2		1											
CLO 12	3	1		1								3			
CLO 13	3			2								3	1		
CLO 14	1			2											
CLO 15	2											2			
CLO 16	1														
CLO 17	1											3			
CLO 18	1											3	1		
CLO 19		2										2	2		
CLO 20												2			

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XIII. ASSESSMENT METHODOLOGIES–DIRECT:

CIE Exams	PO1, PO2, PO4, PO12, PSO1	SEE Exams	PO1, PO2, PO4, PO12, PSO1	Assignments	PO 1 PO 2	Seminars	PO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4, PO12, PSO1						

XIV. ASSESSMENT METHODOLOGIES–INDIRECT:

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS:

UNIT - I	WAVEGUIDES
Introduction, microwave spectrum and bands, applications of microwaves, types of waveguides, rectangular waveguides, field equations in rectangular waveguide, field components of TM and TE waves for rectangular waveguide, modes of TM and TE waves in rectangular waveguide, impossibility of TEM waves, cut off frequency of rectangular waveguide; Wave impedance in rectangular waveguide: Wave impedance for a TM and TE wave in rectangular waveguide, Dominant mode and degenerate modes, mode characteristics of phase velocity, group velocity, wavelength and impedance relations; Illustrative problems; Cavity resonators: Types of cavity resonators; Rectangular cavity resonator: Dominant modes and resonant frequencies, illustrative problems.	
UNIT - II	**WAVEGUIDECOMPONENTS AND APPLICATIONS**
Coupling mechanisms: Probe, loop, coupling to a cavity resonator, waveguide discontinuities, waveguide irises, tuning screws and posts, matched loads; Waveguide attenuators; Waveguide phase shifters; waveguide multiport junctions: E plane Tee, H plane Tee, Magic Tee, applications of Magic Tee, hybrid ring; Ferrites: Faraday rotation principle, gyrator, isolator, circulator	
UNIT - III	**MICROWAVE LINEAR BEAM AND CROSS FIELD TUBES (OTYPE AND M TYPE)**
Microwave linear beam tubes (O type): Limitations of conventional tubes at microwave frequencies; Klystron: Velocity modulation process, bunching process, output power and beam loading; Multicavity Klystron amplifiers: Beam current density, output current and output power of two cavity Klystron; Reflex Klystron: Velocity modulation, power output and efficiency. Helix Traveling Wave tube: Slow wave structures, amplification process, conventional current; Microwave cross field tubes (M type): Introduction, cross-field effects; Magnetrons: Different types, 8-cavity cylindrical travelling wave Magnetron, Hull cut-off and Hartree conditions, modes of resonance and PI-mode operation.	
UNIT - IV	**MICROWAVE SOLID-STATE DEVICES**
Microwave solid-state devices: Microwave tunnel diode; Transferred electron devices: Gunn-effect diodes, RWH theory, modes of operations; Avalanche transit time devices: IMPATT diode, TRAPATT diode, BARITT diode, Pin diodes, varactor diodes, crystal detectors.	
UNIT - V	**MICROWAVE MEASUREMENTS**
Description of microwave bench: Different blocks and their features, precautions; Microwave power measurement: Bolometer; Measurement of attenuation; Frequency standing wave measurements: measurement of low and high VSWR; Cavity Q; Impedance measurements.	
Text Books:	
1. Samuel Y. Liao, ―Microwave Devices and Circuits‖, Pearson, 3rd Edition, 2003. 2. Herbert J. Reich, J.G. Skolnik, P.F. Ordung and H.L. Krauss, -Microwave Principles‖, CBS Publishers and Distributors, New Delhi, 1st Edition, 2004. 3. F.E. Terman, ―Electronic and Radio Engineering‖, Tata McGraw-Hill Publications, 4th Edition, 1955.	

Reference Books:
1. R.E. Collin, "Foundations for Microwave Engineering" IEEE Press, John Wiley, 2nd Edition, 2002.
2. Peter A. Rizzi, "Microwave Engineering Passive Circuits" PHI, 3rd Edition, 1999.
3. M.L. Sisodia, G.S.Raghuvanshi, "Microwave Circuits and Passive Devices" Wiley Eastern Ltd., New Age International Publishers Ltd, 1st Edition, 1995.
4. Microwave and Radar Engineering – M. Kulkarni, Umesh Publications, 1998.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Introduction to microwave spectrum and bands and applications of microwaves	CLO 1	T1-0.1-0.4
3-7	Analyze the rectangular waveguides-TE/TM modes, expressions for fields, characteristic equation and cut-off frequencies	CLO 2	T1-4.1.1-4.1.3
8-10	Analyze the filter characteristics, dominant and degenerate modes, sketches of TE and TM mode fields in the cross-section	CLO 3	T1-4.1.6-4.1.7
11	Understand the mode characteristics, phase and group velocities & wavelengths and impedance relations	CLO 3	T1-4.1.6-4.1.7
12-13	Understand the power transmission and power losses in rectangular guide, related problems	CLO 3	T1-4.1.4
14-16	Understand and analyze the resonant cavities, mode characteristics, and coupling coefficients	CLO 4	T1-4.3.1-4.3.1
17-20	Understand the coupling mechanisms, waveguide discontinuities, various attenuators, and phase shifters	CLO 5	R4- 6.8-6.9 R4- 6.14- 6.15
21-23	Understand the waveguide multiport junctions such as E-Plane H-plane tees, magic tee, hybrid ring;	CLO 6 CLO 7	T1-4.4- 4.5
24-25	Understand the composition and Faraday rotation of ferrite components such as gyrator, isolator, and circulators	CLO 8	T1 -4.6
26-27	Understand the Limitations and Losses of conventional tubes at microwave frequencies over microwave tubes and categorize the different types of microwave tubes.	CLO 9	T1 - 9.1
28-31	Study and understand the two cavity klystrons structure, reentrant cavities, velocity modulation process and applegate.	CLO 10	T1 - 9.2- 9.3
32-35	Understand the reflex klystron operation-structure, Applegate diagram and principle of working, mathematical theory of bunching, power output, efficiency	CLO 11	T1 - 9.4.1

36-37	Understand the oscillating modes and o/p characteristics, effect of repeller voltage on power o/p	CLO 11	T1 - 9.4.2-9.4.3
38-40	Understand the significance, types and characteristics of slow wave structures, structure of TWT and Amplification process (qualitative treatment),gain considerations	CLO 12	T1-9.5
41-43	Understand the classification of magnetrons and cross field effects	CLO 13	T1-10.1
44-47	Analyze eight-cavity cylindrical travelling wave magnetron Hull cut-off and Hartree conditions	CLO 14	T1-10.1.1-10.1.2
48-49	Understand RWH Theory, characteristics, and operation of GUNN diode	CLO 15	T1-7.1-7.3
50-53	Understand operation of avalanche transit time devices, basic modes of operation	CLO 16 CLO 17	T1-8.1-8.3
54	Understand the microwave bench setup different blocks and their features precautions	CLO 18	R4-7.2
55-58	Understand the various types of microwave parameter measurement techniques	CLO 19	R4 -7.5-7.9
59-60	Understand and analyze for the measurements in real time applications	CLO 20	R4- 7.13

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Matching networks	Seminars	PO 1, PO 2	PSO 1
2	Microwave Amplifier design	Seminars / Guest Lectures	PO 2, PO 4	PSO 1
3	Microchip transmission lines	Guest Lectures	PO 1	PSO 1

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