INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**MICROWAVE ENGINEERING**			
Course Code	**R15-A70442**			
Class	**IV BTECH I Sem**			
Course Structure	**Lectures**	**Tutorials**	**Practicals**	**Credits**
	4	**--**	**--**	**4**
Course Coordinator	**Dr. V Siva Nagaraju, Professor, Dept of ECE**			
Team of Instructors	**Dr. S Pedda Krishna, Professor, Dept of ECE** **Mr. V Naresh Kumar, Asst. Prof, Dept of ECE,**			

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.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	4	4	Electromagnetic Theory and Transmission Lines(EMTL), Antennas and Wave Propagation (AWP)

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 test and objective test. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each subject shall contain 4 questions; the student has to answer any 2 questions, each carrying 5 marks. The objective test is for 10 marks, with duration of 20 min. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. Five marks are marked for assignments. There shall be two assignments in every theory course. First assignment marks will be allotted to 1st mid for first two and half units and second assignment marks will be allotted for remaining portion. So each mid exam is conducted for 25 marks.	75	100

IV. EVALUATION SCHEME

S.No	Component	Duration	Marks
1	I mid examination	80 minutes	20
2	I assignment	--	05
3	II mid examination	80 minutes	20
4	II assignment	--	05
5	External examination	3 hours	75

V. COURSE EDUCATIONAL OBJECTIVES

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

I. Develop the knowledge on transmission lines for microwaves, cavity resonators and waveguide components and applications.
II. Enable the students understand and analyze the operation of microwave tubes like klystron, magnetron, travelling wave tube, etc.,
III. Familiarize with microwave solid state devices.
IV. Understand the scattering matrix parameters and its use.
V. Introduce the student the microwave test bench for measure different parameters like attuneation, VSWR, impedance etc.

VI. COURSE OUTCOMES

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

1. Understand the significance microwaves and microwave transmission lines.
2. Analyze wave propagation in TE, TM or TEM modes, in structures such as rectangular waveguides.
3. Compare the passive microwave components and applications such as directional couplers, power dividers / Combiner and etc., with given characteristics.
4. Analyze and design microwave resonators.
5. Analyze the characteristics of microwave tubes and compare them.
6. Understand the characteristics of slow wave structures.
7. Differentiate the performance characteristic of microwave solid state devices.
8. Compare different types of magnetrons and their characteristics.
9. Understand the microwave bench setup for measuring microwave parameters.
10. Understand the measurement of Q, attenuation and impedance.

VII. HOW COURSE OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiency
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	H	Assignments, Exercises
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and	H	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	S	--
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	H	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	Assignments, seminars.
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	S	Oral Discussions
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	N	--
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.	S	Document Preparation, Presentation
PO11	**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
PO12	**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	H	Assignments

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

MICROWAVE TRANSMISSION LINES-I: Introduction, Microwave Spectrum and Bands, Applications of Microwaves. Rectangular Waveguides –solution of Wave Equations in Rectangular Coordinates, TE/TM mode analysis, Expressions for Fields, Characteristic Equation and Cut-off Frequencies, Filter characteristics, Dominant and Degenerate Modes, Sketches of TE and TM mode fields in the cross-section. Mode

Characteristics – Phase and Group Velocities, Wavelengths and Impedance Relations. Illustrative Problems.
Rectangular Guides: Power Transmission and Power Losses Impossibility of TEM mode. Micro strip Lines– Introduction, Zo Relations, Effective Dielectric Constant, Losses, Q factor.

UNIT - II

Cavity Resonators– Introduction, Rectangular Cavities, Dominant Modes and Resonant Frequencies, Q factor and Coupling Coefficients. Illustrative Problems.
Waveguide Components And Applications: Coupling Mechanisms – Probe, Loop, Aperture types. Waveguide Discontinuities – Waveguide windows, Tuning Screws and Posts, Matched Loads. Waveguide Attenuators – Resistive Card, Rotary Vane types; Waveguide Phase Shifters – Dielectric, Rotary Vane types. Waveguide Multiport Junctions – E plane and H plane Tees, Magic Tee, Hybrid Ring; Directional Couplers – 2 Hole, Bethe Hole types. Illustrative Problems.
Ferrites– Composition and Characteristics, Faraday rotation; Ferrite Components – Gyrator, Isolator, Circulator.

UNIT – III

MICROWAVE TUBES: Limitations and Losses of conventional tubes at microwave frequencies. Microwave tubes – O type and M type classifications. O-type tubes : 2 Cavity Klystrons – Structure, Reentrant Cavities, Velocity Modulation Process and Applegate Diagram, Bunching Process and Small Signal Theory – Expressions for o/p Power and Efficiency. Reflex Klystrons – Structure, Applegate Diagram and Principle of working, Mathematical Theory of Bunching, Power Output, Efficiency, Oscillating Modes and o/p Characteristics, Effect of Repeller Voltage on power O/P. Illustrative Problems.

Helix TWTS: Significance, Types and Characteristics of Slow Wave Structures; Structure of TWT and Amplification Process (qualitative treatment), Suppression of Oscillations, Gain Considerations.

UNIT-IV

M-TYPE TUBES: 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, Separation of PI-Mode, o/p characteristics. Illustrative Problems.
Microwave Solid State Devices: Introduction, Classification, Applications. TEDs – Introduction, Gunn Diode – Principle, RWH Theory, Characteristics, Basic Modes of Operation, Gunn Oscillation Modes. LSA mode Avalanche Transit Time Devices.

UNIT-V

MICROWAVE MEASUREMENTS: Scattering Matrix– Significance, Formulation and Properties. S Matrix Calculations for – 2 port Junction, E plane and H plane Tees, Magic Tee, Directional Coupler, Circulator and Isolator. Illustrative Problems.
Description of Microwave Bench – Different Blocks and their Features, Precautions; Microwave Power Measurement – Bolometers. Measurement of Attenuation, Frequency standing wave measurements – measurement of low and high VSWR, Cavity Q. Impedance Measurements.

TEXT BOOKS:

1. Microwave Devices and Circuits – Samuel Y. Liao, Pearson, 3rd Edition, 2003. **[T1]**
2. Microwave Principles – Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss, CBS Publishers and Distributors, New Delhi, 2004. **[T2]**

REFERENCE BOOKS:

1. Foundations for Microwave Engineering – R.E. Collin, IEEE Press, John Wiley,, 2nd Edition, 2002**.[R1]**
2. Microwave Engineering Passive Circuits – Peter A. Rizzi, PHI, 1999. **[R2]**
3. Electronic and Radio Engineering –F.E. Terman McGraw-Hill, 4th ed., 1955. **[R3]**
4. Microwave and Radar Engineering – M. Kulkarni, Umesh Publications, 1998. **[R4]**
5. Microwave Circuits and Passive Devices – M.L. Sisodia and G.S.Raghuvanshi, Wiley Eastern Ltd., New Age International Publishers Ltd., 1995. **[R5]**

X. COURSE PLAN

At the end of the course, the students are able to achieve the following course learning outcomes:

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
1	Describe the Microwaves	**MICROWAVE TRANSMISSION LINES** Introduction, Microwave Spectrum and Bands	R4 1
2	List out applications of Microwaves	Applications of Microwaves	R4 1
3-5	Analyze the Rectangular Waveguides – TE/TM mode analysis	Rectangular Waveguides – TE/TM mode analysis	R4 4.3.5
6-7	Analyze Mathematical Derivations for various field configurations in Rectangular Waveguides	Expressions for Fields, Characteristic Equation and Cut-off Frequencies	R4.3.7
8	Identify various types of Modes	Filter Characteristics, Dominant and Degenerate Modes	R4 4.3.14
9	Analyze Spatial representation of Modes	Sketches of TE and TM mode fields in the cross-section	R4 4.3.5
10-11	Explain Wavelengths and Impedance Relations	Mode characteristics –Phase and Group velocities & Wavelengths and Impedance Relations	R4 4.3.8
12-13	Summarize Power Transmission and Power Losses in Waveguides	Power Transmission and Power Losses in Rectangular Guide, Related Problems	R4 4.3.12-13
14	Compare various parameters of Micro strip Lines	Micro strip Lines– Introduction, Zo Relations,	R4
15	Explain effective dielectric constant	Effective Dielectric Constant	R4
16	Define Q factor	Q factor, Cavity Resonators– Introduction	R4 5.9
17	Classify various cavities	Rectangular and Cylindrical Cavities	R4 5.2
18	Analyze Mode Characteristics	Dominant Modes and Resonant Frequencies	R4 5.3
19	Distinguish Mode Characteristics,	Q factor and Coupling Coefficients, Related Problems.	R4 5.11
20	List out various types of coupling	**WAVEGUIDE COMPONENTS AND APPLICATIONS** : Coupling Mechanisms– Probe, Loop, Aperture types	R4 6.9
21	Illustrate waveguide discontinuities	Waveguide Discontinuities – Waveguide irises, Tuning Screws and Posts, Matched Loads	R4 6.8
22	Define Attenuators	Waveguide Attenuators – Resistive Card, Rotary Vane attenuators	R4 6.15
23	Explain about Phase Shifters	Waveguide Phase Shifters – Dielectric, Rotary Vane types.	R4 6.14
24-25	Compare different types of T Junctions	Waveguide Multiport Junctions – E plane and H plane Tees	R4 6.3.1
26	Explain Directional Coupler	Magic Tee, Hybrid Ring; Directional Couplers – 2 Hole, Bethe Hole types. Problems.	R4 6.3.3
27-28	Classify Ferrites and their Characteristics	Ferrites– Composition and Characteristics, Faraday Rotation	R4 6.11
29-30	Distinguish Ferrite Components – Gyrator, Isolator	Ferrite Components – Gyrator, Isolator	R4 6.11.2
31	Define Circulator	Circulator. Scattering Matrix– Significance, Formulation and Properties.	R4 6.11.2
32-33	Formulate T Junction S Matrix derivation	S Matrix Calculations for – 2 port Junction, E plane and H plane Tees	R4 6.2.1
34-35	Solve problems based on Ferrites	Magic Tee, Directional Coupler, Circulator and Isolator, Problems	R4 6.16

36	Illustrate about Conventional Tubes	**MICROWAVE TUBES:** Limitations and Losses of conventional tubes at microwave frequencies	R4 8.2
37	Compare Microwave tubes – O type and M type classifications	Microwave tubes – O type and M type classifications	R4 8.4
38	Categorize O-type tubes : 2 Cavity Klystrons	O-type tubes : 2 Cavity Klystrons – Structure, Reentrant Cavities,	R4 8.5.1
39	Apply Velocity Modulation Process	Velocity Modulation Process and Applegate Diagram	R4 8.5.1
40	Analyze Bunching Process and its mathematical treatment	Bunching Process and Small Signal Theory – Expressions for o/p Power and Efficiency	R4 8.5.1
41	Examine Reflex Klystron Operation	Reflex Klystrons – Structure, Applegate Diagram and Principle of working	R4 8.5.4
42	Formulate derivation of Klystron Parameters	Mathematical Theory of Bunching, Power Output, Efficiency	R4 8.5.4
43	Classify different oscillating modes	Oscillating modes and o/p characteristics, Effect of repeller voltage on power o/p	R4 8.5.4
44	List out various types of Slow Wave Tubes	Significance, Types and Characteristics of Slow Wave Structures	R4
45	Apply Structure of TWT and Amplification Process	Structure of TWT and Amplification Process (qualitative treatment)	R4 8.6
46	Interpret Suppression of Oscillations, Learn about Gain Considerations	Suppression of Oscillations, Gain Considerations	R4 8.6
47	Compare M-Type Tubes	**M-TYPE TUBES :** Introduction, Cross- field effects, Magnetrons – Different Types	R4 8.8
48	Analyze 8-Cavity Cylindrical Travelling Wave Magnetron and its characteristics	8-Cavity Cylindrical Travelling Wave Magnetron – Hull Cut-off and Hartree Conditions	R4
49	Identify different modes in M Tubes	Modes of Resonance and PI-Mode Operation, Separation of PI-Mode, o/p characteristics.	R4
50	Solve Related Problems	Related Problems	R4 8.9
51	Demonstrate Introduction, Classification,	**MICROWAVE SOLID STATE DEVICES**	R4 9.4
52	Compare Transferred Electronic Devices	TEDs – Introduction, Gunn Diode – Principle, RWH Theory, Characteristics	R4 9.10
53	Examine basic modes of Operation, Oscillation Modes	Basic Modes of Operation, Oscillation Modes	R4 9.10
54	Classify Avalanche Transit Time Devices	Avalanche Transit Time Devices – Introduction	R4 9.11
55	Explain IMPATT and TRAPATT Diodes – Principle of Operation and Characteristics	IMPATT and TRAPATT Diodes – Principle of Operation and Characteristics	R4 9.11.1-3
56	Summarize Classification, Applications	Classification, Applications	R4 9.11
57-58	Compare various types of microwave measurement techniques and Classify various types of Microwave Measurement Techniques	**MICROWAVE MEASUREMENTS:** Description of Microwave Bench – Different Blocks and their Features Precautions	R4 7.2
		Microwave Power Measurement – Bolometer Method	R4 7.5
59	Illustrate various types of Microwave Measurement Techniques	Measurement of Attenuation	R4 7.6
60-61		Frequency standing wave measurements-measurement of low VSWR	R4 7.8.1
		measurement of high VSWR	R4 7.8.2
62	Explain measurement of Q and Analyze microwave impedance measurement	Measurement of Cavity Q & Impedance Measurements	R4 7.13 R4 7.9

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

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

S – Supportive **H - Highly Related**

XII. MAPPING COURSE OUTCOME LEADING TO THE ACHIEVEMENT OF THE PROGRAMME OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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

S – Supportive **H - Highly Related**

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