MICROWAVE ENGINEERING

Subject Code: **(A70442)**
Regulations : R16 JNTUH
Class :IV Year B.Tech ECE I Semester

Department of Electronics and communication Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

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MICROWAVE ENGINEERING (A70442)

COURSE PLANNER

I. COURSE OVERVIEW:

The subject Microwave Engineering may be also referred to as Applied Electromagnetics. 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. PREREQUISITS:

1. Electromagnetic Theory and Transmission Lines(EMTL)
2. Antennas and Wave Propagation

III. COURSE OBJECTIVES:

1.	To develop the knowledge on transmission lines for microwaves, cavity resonators and waveguide components and applications.
2.	To enable the students understand and analyze the operation of microwave tubes like klystron, magnetron, travelling wave tube, etc.
3.	To familiarize with microwave solid state devices.
4.	To understand scattering matrix parameters and its use.
5.	To introduce the student the microwave test bench for measure different parameters like attenuation, VSWR, impedance etc.

IV. COURSE OUTCOMES:

S.No.	Description	Bloom's Taxonomy Level
1.	Understand the significance microwaves and microwave transmission lines.	Knowledge, Understand (Level1, Level2)
2.	Design waveguide and micro strip transmission lines with given characteristics.	Apply, Create (Level 3, Level 6)

3.	Analysis & design passive microwave components such as directional couplers, power dividers / Combiner and etc, with given characteristics.	Analyze (Level 4)
4.	Understand operating principles of basic passive and active microwave devices.	Knowledge, Understand (Level1, Level2)
5.	Analysis the behavior and evaluate the performance of the microwave components using Scattering matrix theory.	Analyze (Level 4)
6.	Conduct a microwave measurement experiment such as microwave impedance or SWR measurement.	Apply, Create (Level 3, Level 6)

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		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 related to Electronics & Communication and Engineering.	3	Assignments, Exercises
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems related to Electronics & Communication Engineering and reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignments
PO3	**Design/development of solutions**: Design solutions for complex engineering problems related to Electronics & Communication Engineering 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.	3	Assignments, Exercises
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.	3	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.	3	Assignments, Seminars

Program Outcomes (PO)		Level	Proficiency assessed by
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 Electronics & Communication Engineering professional engineering practice.	2	Seminars
PO7	**Environment and sustainability**: Understand the impact of the Electronics & Communication Engineering professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	Assignments, Seminars
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	-	-
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Oral 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.	3	Document Preparation, Presentation
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.	3	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.	3	Assignments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VI. 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	3	Lectures, Assignments

	systems.		
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.	2	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.	1	Seminars, Projects

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VII. SYLLABUS:

UNIT I

MICROWAVE TRANSMISSION LINES: Introduction, Microwave Spectrum and Bands, Applications of Microwaves. Rectangular Waveguides – 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.

RECTANGULAR WAVE GUIDES:

Power Transmission and Power Losses in Rectangular Guide. Related Problems. Impossibility of TEM mode. Micro strip Lines– Introduction, Zo Relations, Effective Dielectric Constant, Losses, Q factor.

UNIT II

CAVITY RESONATORS– Introduction, Rectangular and Cylindrical Cavities, Dominant Modes and Resonant Frequencies, Q factor and Coupling Coefficients. Related Problems.

WAVEGUIDE COMPONENTS AND APPLICATIONS - I : Coupling Mechanisms – Probe, Loop, Aperture types. Waveguide Discontinuities – Waveguide irises, 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.

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, Electronic Admittance;

Oscillating Modes and o/p Characteristics, Electronic and Mechanical Tuning. Related Problems.

HELIX TTS: Significance, Types and Characteristics of Slow Wave Structures; Structure of TWT and Amplification Process (qualitative treatment), Suppression of Oscillations, Nature of the four Propagation Constants, 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.

MICROWAVE SOLID STATE DEVICES: Introduction, Classification, Applications. TEDs – Introduction, Gunn Diode – Principle, RWH Theory, Characteristics, Basic Modes of Operation, Oscillation Modes. Avalanche Transit Time Devices, Gunn oscillation modes, LSA Mode.

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 IsolatorDescription of Microwave Bench – Different Blocks and their Features, Precautions; Microwave Power Measurement – Bolometer Method. Measurement of Attenuation, Frequency, VSWR, Cavity Q. Impedance Measurements.

TEXT BOOKS:

1. Microwave Devices and Circuits – Samuel Y. Liao, PHI, 3rd Edition, 1994.
2. Microwave Principles – Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss, CBS Publishers and Distributors, New Delhi, 2004.

REFERENCE BOOKS:

1. Foundations for Microwave Engineering – R.E. Collin, IEEE Press, John Wiley, 2nd Edition, 2002.
2. Microwave Circuits and Passive Devices – M.L. Sisodia and G.S.Raghuvanshi, Wiley Eastern Ltd., New Age International Publishers Ltd., 1995.
3. Microwave Engineering Passive Circuits – Peter A. Rizzi, PHI, 1999.
4. Electronic and Radio Engineering – F.E. Terman, McGraw-Hill, 4th ed., 1955.
5. Elements of Microwave Engineering – R. Chatterjee, Affiliated East-West Press Pvt. Ltd., New Delhi, 1988.
6. Micro Wave and Radar Engineering – M. Kulkarni, Umesh Publications, 1998.

NPTEL Web Course: Microwave Theory and Techniques

NPTEL Video Course: Microwave Theory and Techniques

GATE SYLLABUS:

S-parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies.

IES SYLLABUS:

Microwave Tubes and solid state devices, Microwave generation and amplifiers, Waveguides and other Microwave Components and Circuits, Misconstrue circuits, Microwave Antennas, Microwave Measurements, Masers, lasers; Microwave propagation. Microwave Communication Systems terrestrial and Satellite based.

VIII. COURSE PLAN (WEEK-WISE):

Session	Week	Unit	Topics	Course Learning Outcomes	Reference
1	1	1	Microwave Transmission Lines: Introduction, Microwave Spectrum and Bands	**Describe** the Microwave.	**T1, R6**
2			Applications of Microwaves	**List** out applications of Microwaves.	**T1, R6**
3			Rectangular Waveguides – TE/ TM mode analysis	**Analyze** the Rectangular Waveguides – TE/ TM mode analysis	**T1, R6**
4			Rectangular Waveguides – TE/ TM mode analysis	**Analyze** the Rectangular Waveguides – TE/ TM mode analysis	**T1, R6**
5			Rectangular Waveguides – TE/ TM mode analysis	**Analyze** the Rectangular Waveguides – TE/ TM mode analysis	**T1, R6**
6	2		Expressions for Fields, Characteristic Equation and Cut-off Frequencies	**Analyze** Mathematical Derivations for various field configurations in Rectangular Waveguides	**T1, R6**
7			Expressions for Fields, Characteristic Equation and Cut-off Frequencies	**Analyze** Mathematical Derivations for various field configurations in Rectangular Waveguides	**T1, R6**
8			Filter Characteristics, Dominant and Degenerate Modes	**Identify** various types of Modes	**T1, R6**
9			Sketches of TE and TM mode fields in the cross-section	**Analyze** Spatial representation of Modes	**T1, R6**
10			Mode characteristics –Phase and Group velocities & Wavelengths and Impedance Relations	**Explain** Wavelengths and Impedance Relations	**T1, R6**
11			Mode characteristics –Phase and Group	**Explain** Wavelengths and	**T1,**

			velocities & Wavelengths and Impedance Relations	Impedance Relations	**R6**
12	3		Power Transmission and Power Losses in Rectangular Guide, Related Problems	**Summarize** Power Transmission and Power Losses in Waveguides	**T1, R6**
13			Power Transmission and Power Losses in Rectangular Guide, Related Problems	**Summarize** Power Transmission and Power Losses in Waveguides	**T1, R6**
14			Micro strip Lines–Introduction, Zo Relations	Compare various parameters of Microstrip Lines	**T2**
15			Effective Dielectric Constant	Explain effective dielectric constant	**T2**
16	4	2	Q factor, Cavity Resonators–Introduction	Define Q factor	**T2**
17			Rectangular and Cylindrical Cavities	Classify various cavities	**T2**
18			Dominant Modes and Resonant Frequencies	Analyze Mode Characteristics	**T2**
19			Q factor and Coupling Coefficients, Related Problems.	Distinguish Mode Characteristics	**T2**
20			Waveguide Components and Applications : Coupling Mechanisms – Probe, Loop, Aperture types	List out various types of coupling	**T2**
21	5		Waveguide Discontinuities –Waveguide irises, Tuning Screws and Posts, Matched Loads	Illustrate waveguide discontinuities	**T2**
22			Waveguide Attenuators – Resistive Card, Rotary Vane attenuators	Define Attenuators	**T2**
23			Waveguide Phase Shifters – Dielectric, Rotary Vane types.	Explain about Phaseshifters	**T2**
24-25			Waveguide Multiport Junctions – E plane and H plane Tees	Compare different types of T Junctions	**T2**
26	6		Directional Couplers – 2 Hole, Bethe Hole types, Problems.	Explain Directional Coupler, Magic Tee, Hybrid Ring	**T2**
27			Ferrites– Composition and Characteristics, Faraday Rotation	Classify Ferrites and their Characteristics	**T2**
28			Ferrites– Composition and Characteristics, Faraday Rotation	Classify Ferrites and their Characteristics	**T2**
29			Ferrite Components – Gyrator, Isolator	Distinguish Ferrite Components-Gyrator, Isolator	**T2**
30			Ferrite Components – Gyrator, Isolator	Distinguish Ferrite Components-Gyrator, Isolator	**T2**
31	7		Circulator. Scattering Matrix– Significance, Formulation and Properties.	Define Circulator	**T1**
32			S-Matrix Calculations for – 2 port Junction, E plane and H plane Tees	Formulate T Junction S-Matrix derivation	**T1**
33			S-Matrix Calculations for – 2 port	Formulate T Junction S-Matrix	**T1**

			Junction, E plane and H plane Tees	derivation	
34			Magic Tee, Directional Coupler, Circulator and Isolator, Problems	Solve problems based on Ferrites	**T1**
35			Magic Tee, Directional Coupler, Circulator and Isolator, Problems	Solve problems based on Ferrites	**T1**
36	8	3	Microwave Tubes: Limitations and Losses of conventional tubes at microwave frequencies	Illustrate about Conventional Tubes	**T1**
37			Microwave tubes – O type and M type classifications	Compare Microwave tubes – O type and M type classifications	**T1**
38			O-type tubes : 2 Cavity Klystrons – Structure, Reentrant Cavities	**Categoriz**e O-type tubes : 2 Cavity Klystrons	**T1**
39			Velocity Modulation Process and Applegate Diagram	**Apply** Velocity Modulation Process	**T1**
40			Bunching Process and Small Signal Theory – Expressions for output Power and Efficiency	**Analyze** Bunching Process and its mathematical treatment	**T1**
41	9		Reflex Klystrons – Structure, Applegate Diagram and Principle of working	**Examine** Reflex Klystron Operation	**T1**
42			Mathematical Theory of Bunching, Power Output, Efficiency	**Formulat**e derivation of Klystron Parameters	**T1**
43			Oscillating modes and output characteristics, Effect of repeller voltage on power output	**Classif**y different oscillating modes	**T1**
44			Significance, Types and Characteristics of Slow Wave Structures	**List** out various types of Slow Wave Tubes	**T1**
45			Structure of TWT and Amplification Process (qualitative treatment)	**Apply** Structure of TWT and Amplification Process	**T1**
46	10		Suppression of Oscillations, Gain Considerations	**Interpret** Suppression of Oscillations, **Learn** about Gain Considerations	**T1**
47		4	M-Type Tubes : Introduction, Crossfield effects, Magnetrons – Different Types	**Compare** M-Type Tubes	**T1**
48			8-Cavity Cylindrical Travelling Wave Magnetron – Hull Cut-off and Hartree Conditions	**Analyze** 8-Cavity Cylindrical Travelling Wave Magnetron and its characteristics	**T1**
49			Modes of Resonance and PI-Mode Operation, Separation of PI-Mode, output characteristics.	**Identify** different modes in M Tubes	**T1**
50			Related Problems	**Solve** Related Problems	**T1**
51	11		Microwave Solid State Devices: Introduction, Classification, Applications	**Demonstrate** Introduction, Classification, Applications	**T1**
52			TEDs – Introduction, Gunn Diode – Principle, RWH Theory, Characteristics	**Compare** Transferred Electronic Devices	**T1**
53			Basic Modes of Operation, Oscillation Modes	**Examin**e basic modes of Operation, Oscillation Modes	**T1**
54			Avalanche Transit Time Devices –	**Classify** Avalanche Transit Time	**T1**

			Introduction	Devices	
55			IMPATT and TRAPATT Diodes – Principle of Operation and Characteristics	**Explai**n IMPATT and TRAPATT Diodes – Principle of Operation and Characteristics	**T1**
56			Classification, Applications	**Summarize** Classification, Applications	**T1**
57			Microwave Measurements: Description of Microwave Bench – Different Blocks and their Features Precautions; Microwave Power Measurement – Bolometer Method	**Compare** various types of microwave measurement techniques and Classify various types of Microwave Measurement Techniques	**R6**
58	12	5	Microwave Measurements: Description of Microwave Bench – Different Blocks and their Features Precautions; Microwave Power Measurement – Bolometer Method	**Compare** various types of microwave measurement techniques and Classify various types of Microwave Measurement Techniques	**R6**
59			Measurement of Attenuation	**Illustrate** various types of Microwave Measurement Techniques	**R6**
60			Frequency standing wave measurements- measurement of low VSWR, measurement of high VSWR	**Illustrate** various types of Microwave Measurement Techniques	**R6**
61	13		Frequency standing wave measurements- measurement of low VSWR, measurement of high VSWR	**Illustrate** various types of Microwave Measurement Techniques	**R6**
62			Measurement of Cavity Q & Impedance Measurements	**Explai**n measurement of Q and **Analyze** microwave impedance measurement	**R6**

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO 10	PO11	PO 12	PSO1	PSO 2	PSO3
CO1	2	3	2	2	2	2	2	-	1	2	2	2	2	2	1
CO2	2	2	2	2	2	1	2	-	2	3	3	2	3	1	1
CO3	3	3	3	3	3	2	3	-	1	3	2	3	2	2	1
CO4	2	3	2	2	2	2	2	-	1	2	2	3	2	2	1
CO5	3	2	3	3	3	1	3	-	2	2	3	2	3	1	1
CO6	3	2	3	3	3	1	3	-	2	3	3	3	3	3	1
Average	2.5	2.5	2.5	2.5	2.5	1.5	2.5	-	1.5	2.5	2.5	2.5	2.5	1.83	1
Average (Rounded)	3	3	3	3	3	2	3	-	2	3	3	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

X. JUSTIFICATIONS FOR CO-PO MAPPING:

Mapping	Low (1), Medium (2), High(3)	Justification
CO1-PO1	2	Students will be able to understand the Microwaves.
CO1-PO2	3	Analyze the Rectangular Waveguides.
CO1-PO3	2	Students will be able to know the TE and TM modes.
CO1-PO4	2	Derive various field configurations in rectangular waveguides.
CO1-PO5	2	Analyze mathematical derivations for various field configurations in rectangular waveguides.
CO1-PO6	2	Derive various field configurations in circular waveguides.
CO1-PO7	2	Analyze mathematical derivations for various field configurations in circular waveguides
CO1-PO9	1	Identify various types of Modes .
CO1-PO10	2	Study various modes of operation.
CO1-PO11	2	Derive expressions for various parameters of waveguides.
CO1-PO12	2	Solve problems on various parameters of waveguides.
CO1-PSO1	2	Perform experiments to understand various parameters of waveguides.
CO1-PSO2	2	Students will be able to perform miniprojects using waveguides.
CO1-PSO3	1	Understand wavelengths and impedance relations.
CO2-PO1	2	Solve problems on wavelengths and impedance relations.
CO2-PO2	2	Study power transmission in waveguides.
CO2-PO3	2	Illustrate power transmission in waveguides.
CO2-PO4	2	Study power losses in waveguides.
CO2-PO5	2	Illustrate power losses in waveguides.
CO2-PO6	1	Solve problems on power losses.
CO2-PO7	2	Summarize power transmission and power losses in waveguides
CO2-PO9	2	Understand the concept of microstrip lines.
CO2-PO10	3	Study the characteristics of microstrip lines.

CO2-PO11	3	Design using microstrip lines.
CO2-PO12	2	Compare various parameters of microstrip lines,
CO2-PSO1	3	Study the characteristics of dielectric materials.
CO2-PSO2	1	Explain effective dielectric constant
CO2-PSO3	1	Able to define Q factor.
CO3-PO1	3	Analyse the impact of various effeccts on Q-factor.
CO3-PO2	3	Know various classifications of various cavities.
CO3-PO3	3	Know various classifications of various cavities.
CO3-PO4	3	Analyze mode characteristics.
CO3-PO5	3	Distinguish mode characteristics.
CO3-PO6	2	Able to solve problems on mode characteristics.
CO3-PO7	3	Describe the characteristic features of resonant windows.
CO3-PO9	1	Know the applications of H-plane Tee.
CO3-PO10	3	Know the applications of E-plane Tee.
CO3-PO11	2	Know the applications of Hybrid Tee junction.
CO3-PO12	3	Know the applications of ratrace.
CO3-PSO1	2	Derive the s-parameters of H-plane tee.
CO3-PSO2	2	Derive the s-parameters of E-plane tee.
CO3-PSO3	1	Derive the s-parameters of magic tee.
CO4-PO1	2	Derive the s-parameters of rat race.
CO4-PO2	3	Know the applications of resonant Iris.
CO4-PO3	2	Understand the details of directional couplers.
CO4-PO4	2	Know various types of directional couplers.
CO4-PO5	2	Study the working of a wave guide attenuator.
CO4-PO6	2	Able to list out various types of coupling.
CO4-PO7	2	Illustrate waveguide discontinuities
CO4-PO9	1	Understand the basic principle of attenuators.
CO4-PO10	2	Analyse the operation and parameters of attenuators.
CO4-PO11	2	Explain the applications of attenuators.
CO4-PO12	3	Analyse the properties of S-matrix.
CO4-PSO1	2	Explain about Phaseshifters.

CO4-PSO2	2	Compare different types of T Junctions .
CO4-PSO3	1	Explain Directional Coupler, Magic Tee, Hybrid Ring
CO5-PO1	3	Classify Ferrites and their Characteristics
CO5-PO2	2	Distinguish Ferrite Components-Gyrator, Isolator
CO5-PO3	3	Define Circulator .
CO5-PO4	3	Compare various parameters of Microstrip Lines
CO5-PO5	3	Formulate T Junction S Matrix derivation
CO5-PO6	1	Solve problems based on Ferrites
CO5-PO7	2	Illustrate about Conventional Tubes
CO5-PO9	2	Compare Microwave tubes – O type and M type classifications
CO5-PO10	2	Categorize O-type tubes : 2 Cavity Klystrons
CO5-PO11	3	Apply Velocity Modulation Process
CO5-PO12	2	Analyze Bunching Process and its mathematical treatment
CO5-PSO1	3	Examine Reflex Klystron Operation
CO5-PSO2	1	Formulate derivation of Klystron Parameters
CO5-PSO3	1	Classify different oscillating modes
CO6-PO1	3	List out various types of Slow Wave Tubes
CO6-PO2	2	Apply Structure of TWT and Amplification Process
CO6-PO3	3	Interpret Suppression of Oscillations, Learn about Gain Considerations
CO6-PO4	3	Compare M-Type Tubes
CO6-PO5	3	Analyze 8-Cavity Cylindrical Travelling Wave Magnetron and its characteristics
CO6-PO6	1	Identify different modes in M Tubes and Solve Related Problems
CO6-PO7	3	Compare Transferred Electronic Devices
CO6-PO9	2	Examine basic modes of Operation, Oscillation Modes
CO6-PO10	3	Classify Avalanche Transit Time Devices
CO6-PO11	3	Summarize the applications of transit time devices.
CO6-PO12	3	Compare various types of microwave measurement techniques.
CO6-PSO1	3	Illustrate various types of Microwave Measurement Techniques
CO6-PSO2	3	Perform experiments to measure Q value.
CO6-PSO3	1	Analyze microwave impedance measurement

XI. QUESTION BANK (JNTUH) :

UNIT - I
Long Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Derive** the TMmn mode field equation in rectangular waveguide.	Remember	1
2.	**What** are the dominated and degenerate modes? **What** is the significance of dominant modes? **Indicate** the dominant mode in rectangular wave guide and calculate fc for the same.	Remember	1
3.	A rectangular waveguide has dimensions 2.5 X 5 cms. **Determine** the guide wavelength, phase constant and phase velocity at a wavelength of 4.5 cms for dominant mode.	Apply	1
4.	**What** is a Microwave spectrum bands? **Explain** briefly the applications of microwaves at various frequency bands.	Remember	1
5.	**Explain** the TE and TM modes of propagation in waveguides. **Why** TEM wave does not exist in a rectangular wave guide.	Understand	1
6.	**Explain** the wave impedance of a rectangular waveguide and derive the expression for the wave impedance of TE and TM modes.	Understand	1
7.	A rectangular wave guide with dimension of 3 x 2 cm operates in the TM11 mode at 10 GHz. **Determine** the characteristic wave impedance.	Analyze	1
8.	A Rectangular wave guide is filled by dielectric material of εr= 9 and has dimensions of 7× 3.5 cm. It operates in the dominant TE mode. (i) **Determine** the cut off frequency. (ii) Find the phase velocity in the guide at a frequency of 2 GHz. (iii) Find the guided wave length at 2GHz.	Understand	1
9.	**Derive** the expression for cutoff frequency of TEmn mode in rectangular wave guide.	Remember	1
10.	**Derive** an expression for microwave impedance for TE waves in rectangular wave guide.	Understand	1
11.	**Derive** an expression for microwave impedance for TM waves in rectangular wave guide.	Understand	1
12.	**Derive** the expression for power transmission in waveguide.	Remember	1

Short Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**List** the typical applications of microwaves.	Remember	1
2.	**Define** the dominant mode of a waveguide?	Understand	1
3.	**What** are microwaves? **Why** they are so called?	Understand	1
4.	**Define** waveguide? **Mention** some of its features?	Remember	1
5.	**What** are TE, TM & TEM modes?	Understand	1
6.	**Define** dominant mode and degenerate mode.	Remember	1
7.	**Define** cutoff frequency of a waveguide.	Evaluate	1
8.	**Wha**t is dominant mode of a rectangular waveguide for TE and TM modes and why?	Remember	1
9.	**Find** the cut–off frequency of the dominant mode for an air filled rectangular waveguide when a = 6cm and b = 2 cm for TE wave?	Understand	1
10.	**Nam**e the microwave frequency bands and spectra.	Understand	1
11.	**Define** phase velocity.	Understand	1
12.	**What** is meant by group velocity?	Understand	1
13.	**What** is the relation between phase and group velocities in terms of light velocity?	Understand	1
14.	**Define** guide wavelength.	Evaluate	1
15.	**Summarize** the advantages of microwaves.	Understand	1
16.	**Wha**t are the advantages of dominant mode propagation?	Evaluate	1
17.	**What** are the advantages and disadvantages of micro strip lines?	Analyze	2
18.	**Explain** briefly about impossibility of TEM Modes.	Understand	1

UNIT - II

Long Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Derive** the cut-off frequency expression for Rectangular cavity resonator.	Evaluate	2
2.	**Prove** that a cavity resonator is nothing but an LC circuit.	Analyze	2
3.	**Explain** E-H plane Tee junction. Why a hybrid E-H plane Tee referred to as Magic Tee.	Understand	2
4.	**Explain** the applications of Directional Couplers.	Understand	2
5.	**What** is the application of Circulator?	Remember	2
6.	**Explain** about quality factor of a cavity resonator.	Understand	2
7.	**Explain** the principle of working an H-plane Tee junction with neat schematics.	Understand	2
8.	**Explain** the principle of working an E-plane Tee junction with neat schematics?	Analyze	2
9.	**Explain** the principle of working a Magic Tee junction with neat schematics?	Evaluate	2
10.	**Explain** the principle of working of two-hole Directional coupler with neat schematics?	Understand	3
11.	**Explain** Bethe hole Directional coupler and write applications of directional couplers?	Evaluate	3
12.	**Explain** the following characteristics related to Directional coupler i)Coupling factor ii)Directivity iii) Isolation.	Remember	3

Short Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Define** the attenuation constant.	Remember	2
2.	**What** is meant by cavity resonator?	Understand	2
3.	**Define** resonant frequency and give its expression.	Understand	2
4.	**Derive** the resonant frequency for TE101 mode.	Understand	2
5.	**What** are the applications of cavity resonator?	Evaluate	2
6.	**Define** quality factor of a cavity resonator	Evaluate	2
7.	**Explain** the waveguide discontinuities?	Remember	2
8.	**Describe** the characteristic features of resonant windows?	Understand	2

9.	**Mention** the applications of Hybrid Tee junction?	Remember	2
10.	**Mention** the applications of resonant Iris?	Understand	2
11.	**Mention** the applications of capacitive and inductive Iris.	Evaluate	2
12.	**Wha**t is directional coupler?	Understand	3
13.	**Describe** the principle of working of a wave guide attenuator, with neat schematics?	Understand	2
14.	**List** out the different types of waveguide Irises.	Understand	2
15.	**Give** the properties of S-matrix.	Evaluate	2
16.	**What** is an isolator?	Analyze	2
17.	**What** is a Gyrator?	Analyze	2

UNIT - III
Long Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**What** is Gunn effect? **Explain** the operation of Gunn diode.	Remember	4
2.	**Explain** is the principle of working for Two – Cavity Klystron with velocity diagram.	Understand	4
3.	**Derive** the expression for output power and efficiency of a 2 cavity klystron.	Understand	4
4.	**Explain** in detail bunching process & obtain expression for bunching parameter in a two cavity klystron amplifier.	Understand	4
5.	**What** are the limitations of conventional tubes at microwave frequencies? Explain how these limitations can be overcome.	Understand	4
6.	A reflex klystron having an accelerated field of 300v oscillates at a frequency of 10GHZ with a retarding field of 500v. If its cavity is returned to 9GHZ. **Wha**t must be the new value of retarding field for oscillations in the same mode to take place?	Analysis	4
7.	**Name** different methods of generating microwave power. **Describe** the necessary theory and working of reflex klystron.	Understand	4
8.	**Explain** in detail bunching process and **obtain** expression for bunching parameter in a two cavity klystron amplifier.	Understand	4
9.	**Explain** the principle of operation of a reflex Klystron oscillator and **derive** an expression for the bunching parameter.	Understand	4
10.	**Explain** the construction and working of two cavity klystron amplifier.	Remember	4

Short Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**State** the limitations of conventional tubes at microwave frequencies.	Remember	4
2.	**What** is the principle of two cavity Klystron amplifier?	Remember	4
3.	**What** are the applications of reflex klystron?	Understand	4
4.	**State** the characteristics of the two-cavity klystron amplifier.	Remember	4
5.	**Compare** TWT and Klystron amplifier.	Analyze	4
6.	**Draw** the schematic diagram of helix travelling wave tube?	Understand	4
7.	**What** is meant by reflex klystron?	Remember	4
8.	**What** are the performance characteristics of klystron amplifier?	Remember	4
9.	**Differentiate** between klystrons and TWT.	Analyze	4
10.	**State** the applications of the two-cavity klystron amplifier.	Remember	4
11.	**Why** multi-cavity klystrons are preferred?	Remember	4
12.	**How** are oscillations avoided in travelling wave tube?	Remember	4
13.	**Discuss** in detail about lead inductance and inter electrode capacitance effects of conventional tubes at microwave frequencies.	Understand	4
14.	**Differentiate** between O – type tubes and M – type tubes.	Analysis	4
15.	**What** is the condition for obtaining the power output in reflex klystron?	Apply	4
16.	**What** is transit time?	Analyze	4
17.	**What** is the operating principle of reflex klystron?	Remember	4
18.	**Wha**t is velocity and current modulation in a reflex klystron?	Remember	4
19.	**How** does bunching occur in a reflex klystron?	Remember	4
20.	**Explain** clearly the classification of microwave sources.	Understand	4
21.	**What** is the operating frequency, power output and efficiency of a reflex klystron?	Remember	4
22.	**Wha**t are the devicesused as a microwave signal sources?	Remember	4
23.	**Write** the classification of microwave tubes.	Apply	4
24.	**Wha**t is TWTA?	Remember	4
25.	**What** is the need of slow – wave structures?	Remember	4

26.	**What** are the assumptions for calculation of RF Power in Reflex Klystron?	Remember	4
27.	**What** is the effect of transit time?	Remember	4
28.	**List** the applications of TWT.	Remember	4
29.	**What** do you mean by O-type tubes? Name some O-type tubes.	Understand	4
30.	**List** the parameters on which bunching depend on.	Remember	4
31.	**Compare** between two cavity klystron and reflex klystron?	Analyze	4
32.	**State** the advantages of TWT.	Remember	4
33.	**State** the effects of frequency rise in conventional tubes.	Remember	4
34.	**Explain** briefly about linear beam tubes and crossed field tubes	Understand	4
35.	**Sketch** the functional diagram of two-cavity amplifier.	Apply	4
36.	**Compare** drift space bunching and reflector bunching.	Analyze	4
37.	**Compare** magnetron and reflex klystron.	Analyze	4
38.	**List** the drawbacks of klystron amplifiers.	Remember	4
39.	**What** is the condition for oscillation in Reflex klystron?	Understand	4
40.	**List** different types of magnetrons.	Remember	4
41.	**What** are the performance characteristics of TWT?	Understand	4
42.	**What** are the desirable properties of slow wave structures to be used in TWT amplifiers?	Understand	4
43.	**What** do you mean by M-type tubes? Name some M-type tubes.	Understand	4
44.	**Draw** the schematic diagram of two cavity klystron amplifier?	Understand	4
45.	**What** is the need of slow wave structures in TWT?	Understand	4
46.	**Write** the basic modes of operation in magnetron?	Understand	4
47.	**What** is klystron tube?	Remember	4
48.	**What** is reflex klystron oscillator?	Remember	4

UNIT - IV

Long Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Explain** the working Magnetron with π-mode oscillation.	Understand	4

2.	**What** is meant by Avalanche Transit Time Devices? **Explain** the operation, construction and Applications of IMPATT.	Remember	4
3.	**Explain** avalanche transit time devices.	Understand	4
4.	**Write** short notes on "8 cavity magnetron"	Understand	4
5.	**Explain** Gunn effect using the two valley theory.	Analyze	4
6.	**Derive** the criterion for classifying the modes of operation for Gunn effect diodes.	Remember	4
7.	**Describe** the operation of IMPATT diode.	Remember	4
8.	**Explain** the physical structure and construction of IMPATT diodes.	Analysis	4
9.	**Write** short notes on LSA mode in GUNN diode.	Understand	4
10.	**Derive** the criterion for classifying the modes of operation for Gunn effect diodes.	Remember	4
11.	**Describe** the operation of TRAPATT diode.	Remember	4
12.	**Describe** the operation of BARITT diode.	Understand	4

Short Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**What** is transferred electron effect?	Remember	4
2.	**What** is negative resistance in Gunn diode?	Remember	4
3.	**What** are the applications of Microwave Solid-State Devices?	Understand	4
4.	**What** are the elements that exhibit Gunn Effect?	Remember	4
5.	**Mention** the applications of Gunn diode amplifier.	Remember	4
6.	**Why** magnetron is called as cross field devices?	Understand	4
7.	**What** are the types of magnetrons?	Remember	4
8.	**Write** short notes on negative resistance magnetron.	Understand	4
9.	**State** the power output and efficiency of magnetron.	Understand	4
10.	**Write** the applications of magnetron.	Understand	4
11.	**What** is GUNN effect?	Understand	4
12.	**Explain** transferred electron effect.	Understand	4
13.	**What** is the principle of TRAPATT diode?	Remember	4
14.	**What** is the principle of IMPATT diode?	Remember	4

15.	**What** is the principle of BARITT diode?	Remember	4

UNIT - V

Long Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Explain** the measurement of attenuation using power ratio method with neat block diagram?	Understand	6
2.	**Explain** Slotted line method for impedance measurement.	Understand	5
3.	**Draw** a neat diagram of microwave test bench and explain about each block along with its features.	Understand	5
4.	**Explain** the measurement of microwave power using bolometer method.	Remember	6
5.	**Explain** the measurement of phase shift.	Remember	6
6.	**Explain** the method of measurement of high VSWR.	Understand	6
7.	**Explain** the RF substitution method of measurement of attenuation.	Understand	6
8.	**Explain** the measurement of Q of a cavity resonator.	Understand	6
9.	**Explain** the frequency measurement techniques.	Understand	6
10.	**What** are the different techniques employed in measuring impedance? **Explain** any one method.	Remember	6
11.	**Explain** the measurement of frequency using wave meter method.	Understand	6
12.	**Explain** the high power measurements using calorimetric method.	Understand	6

Short Answer Questions:

S.No.	Question	Blooms Taxonomy Level	Course Outcome
1.	**Define** the method for measuring VSWR < 10?	Remember	6
2.	**What** is the principle of microwave frequency measurement?	Remember	6
3.	**State** various methods for measuring attenuation?	Understand	6
4.	**Write** the S-matrix for Isolator and Gyrator?	Analyze	5
5.	**Write** the S-matrix for E-Plane and H-Plane tee.	Analyze	5
6.	**Write** the s-matrix for directional coupler.	Understand	5

7.	**Define**: i) Voltage standing wave ratio ii) Reflection coefficient.	Remember	5
8.	**List** the methods used for measuring the low and high VSWR?	Remember	6
9.	**Write** a short notes on power ratio method.	Understand	6
10.	**Write** short notes on RF substitution method.	Understand	6
11.	**Write** short notes on measurement of phase shift.	Understand	6
12.	**List** the devices used in microwave bench setup.	Remember	6

OBJECTIVE QUESTIONS:

UNIT-I

1. Klystron operation is based on the principle of _____ .
(a)velocity modulation (b)amplitude modulation
(c)frequency modulation (d) Phase modulation
Answer: (a) Velocity modulation

2. The following is not an application of varactor diode _____.
(a) Parametric amplifier (b) Frequency tuner
(c) Voltage controlled oscillator (d) Phase shifter
Answer: (a) Parametric amplifier

3. Slotted line with tunable probe is not used to measure _____.
(a) VSWR (b) wavelength (c) power (d) impedance
Answer: (b) wavelength

4. In a microwave magic-T, E plane and H plane are _____.
(a) in phase (b) out of phase (c) isolated (d) None
Answer: (b) out of phase

5. Baretters and bolometers are used for measurement of _____.
(a) VSWR (b) transmission losses (c) microwave power (d) frequency
Answer: (c) microwave power

6. Which of the following antennas exhibits circular polarization ____.
(a) small circular loop (b) folded dipole (c) helical (d) parabolic dish
Answer: (c) helical

7. Which of the following antenna is used as standard reference for calculating directive gain _____.

(a) half wave dipole (b) infinitesimal dipole
(c) elementary doublet (d) isotropic antenna
Answer: (d) isotropic antenna

8. Which of the following microwave diodes is suitable for very low power oscillations applications only _____.
(a) tunnel (b) impatt (c) varactor (d) gunn
Answer: (a) tunnel

9. Which of the following antenna is obtained by modifying a waveguide ___.
(a) miscosrtip antenna (b) helical antenna (c) horn antenna (d) dipole antenna
Answer: (c) horn antenna

10. Which of the following is a microwave power amplifier _____.
(a) gunn diode (b) reflex klystron (c) magnetron (d) travelling wave tube
Answer: (c) magnetron

UNIT-II

1) Which device can detect the presence of both forward and backward waves in a wave guide _____.
(a) filter (b) detector (c) directional coupler (d) magic T
Answer: (c) directional coupler

2) Which principle of operation of cavity wave meters is used in microwave networks
(a)phase shift (b) resonance (c) polarization shift (d) gyration
Answer: (b) resonance

3) In a magnetron oscillator the improvement of stability and efficiency is achieved by _____ technique.(a) strapping (b)cross coupling (c) bunching (d) bouncing
Answer: (b) cross coupling

4) Which one of the following is used for amplification of microwave signals
(a) gunn diode (b) strapped magnetron (c) reflex klystron (d) double cavity klystron
Answer: (c) reflex klystron

5) In microwave communication links, what causes intense fading in the 18GHz band?
(a) snow (b) rain (c) fog (d) dust
Answer: (b) rain

6) Which of the following is a microwave source with a 'cross field' structure
(a) double cavity klystron (b) reflex klystron (c) magnetron (d) travelling wave tube
Answer: (d) travelling wave tube

7) Which the following has the 'negative resistance' characteristics
9a) reflex klystron (b) gunn diode (c) PNP transistor (d) magnetron

Answer: (b) gunn diode

8) Which of the following devices is 'hot electron' diode
(a) thermionic tube diode (b) schottky barrier diode
(c) Thomson deflection diode (d) thermal electron diode
Answer: (b) schottky barrier diode

9) In wave guide networks, there is a component which consists of an E-plane Tee combined with an H-plane Tee? What this component generally known as?
(a) directional Tee (b) phased array Tee (c) coupler Tee (d) magic Tee
Answer: (d) magic Tee

UNIT-III

1. A rectangular waveguide of internal dimensions (a = 4 cm and b = 3 cm) is to be operated in TE11 mode. The minimum operating frequency is
(a) 6.25 GHz (b) 6 GHz (c) 5 GHz (d) 3.75 GHz.
Answer: 6.25 GHz

2. At 20 GHz, the gain of a parabolic dish antenna of 1 meter and 70% efficiency is
(a)15 dB (b) 25 dB (c)35 dB (d) 45 dB
Answer: (d) 45 dB

3. An air-filled rectangular waveguide has inner dimensions of 3 cm # 2 cm. The wave Impedance of the *TE*20 mode of propagation in the waveguide at a frequency of 30 GHz is (free space impedance $\eta = 377\ \Omega$).
(a) 308 Ω (b) 355 Ω © 400 Ω (d) 461 Ω
Answer: (c) 400 Ω

4. In a microwave test bench, why is the microwave signal amplitude modulated at 1kHz
(a) To increase the sensitivity of measurement
(b) To transmit the signal to a far-off place
(c) To study amplitude modulations
(d) Because crystal detector fails at microwave frequencies
Answer: (d)

5. To couple a coaxial line to a parallel wire line, it is best to use a __.
(a)slotted line (b) balun (c)directional coupler (d) λ/4 transformer.
Answer: (b) balun

UNIT-IV

1. The kinetic energy of the beam remains unchanged in the interaction between an electron beam and an RF wave in a _____.

(a)multi-cavity klystron (b) cross-field amplifier
(c) travelling wave tube (d) gyratron
Answer: (c) travelling wave tube

2. Which one of the following is a transferred electron device?
(a)BARITT diode (b) IMPATT diode (c) GUNN diode (d)Step recovery diode
Answer: (c) GUNN diode

3. A waveguide section in a microwave circuit will act as _____filter.
(a)Low pass (b)Band pass (c) High pass (d)All pass
Answer: (c) High pass

4. In a klystron amplifier, the input cavity is called _____.
(a)buncher (b) catcher (c) pierce gun (d)collector
Answer: (a)buncher

UNIT-V

1. HEMT is used in the microwave circuit is a _____.
(a) Source (b)high power amplifier (c) low noise amplifier (d) detector
Answer: (c) low noise amplifier

2. A cavity resonator can be represented by _____ circuit.
(a) LC (b) LCR (c) lossy inductor (d) lossy capacitor
Answer: (a) LC

3. The noise produced in a microwaver tube due to random nature of emission and electron flow is called _____ noise.
(a) Partition (b) Shot (c) Johnson (d) Shannon
Answer: (b) Shot

4. Why is an attenuator is used in a TWT?
(a) To help bouncing (b) To prevent oscillations
(c) To prevent saturation (d) To increase gain
Answer: (b) To prevent oscillations

5. Which is the dominant mode in rectangular waveguides?
(a) TE10 (b) TE11 (c) TM01 (d) TM11.
Answer: (b) (a) TE10

XII. GATE QUESTIONS:

1. A reflex Klystron functions as _____.
a) Microwave oscillator b) Microwave amplifier
c) Both as Microwave amplifier and oscillator d) A high gain cavity

Answer: a) Microwave oscillator

2. The modes in a reflex Klystron _____.
a) give the same frequency but different transit times
b) result from excessive transit time across the resonator gap
c) are caused by spurious frequency modulation
d) are just for theoretical considerations
Answer: a) give the same frequency but different transit times

3. Klystron operates on the principle of _____ modulation.
a) Amplitude b) Frequency c) Pulse d) Velocity
Answer: d) Velocity

4. In Microwave we take the elements as _____.
a) Lumped circuit elements b) Distributed circuit elements c) Both a) and b) d) None
Answer: b) Distributed circuit elements

5. Short term fading in microwave communication links can be overcome by _____.
a) Increasing the transmitted power b) Changing the antenna
c) Changing the modulation scheme d) Diversity reception and transmission
Answer: d) Diversity reception and transmission

6. For handling large microwave power, the best medium is _____.
a) Coaxial line b) Rectangular waveguide c) Stripline d) Circular waveguide
Answer: b) Rectangular waveguide

7. A Microwave tube amplifier uses an axial magnetic field and radial electric field. This is the _____.
a) Reflex Klystron b) Coaxial Magnetron
c) Travelling wave magnetron d) CFA-Crossed Field Amplifier
Answer: d) CFA-Crossed Field Amplifier

8. A disadvantage of microstrips with respect to stripline circuit is that the former: _____.
a) Do not let themselves to be printed-circuits
b) Are more likely to radiate
c) Are bulkier
d) Are more expensive and complex to manufacture
Answer: d) Are more expensive and complex to manufacture

9. Most of the power measuring microwave devices measure _____.
a) Average power b) Peak power c) Instantaneous power d) None of these
Answer: a) Average power

10. HEMT used in microwave circuit is a _____.
a) Source b) High power amplifier c) Detector d) Low noise Amplifier

Answer: d) Low noise Amplifier

11. Ionospheric preparation is not possible for microwaves because _____.
a) Microwaves will be fully absorbed by the ionospheric layers
b) There will be an abrupt scattering in all directions
c) Microwave will penetrate through the ionospheric layers
d) There will be dispersion of microwave energy
Answer: c) Microwave will penetrate through the ionospheric layers

12. A waveguide section in a microwave circuit will act as a _____.
a) Low-pass filter b) Band-pass filter c) High-pass filter d) Band-reject filter
Answer: c) High-pass filter

13. The biggest advantage of the TRAPATT diode over the IMPATT diode is its _____.
a) Low noise b) Higher efficiency
c) Ability to operate at higher frequencies d) Lesser sensitivity to harmonics
Answer: b) Higher efficiency

14. A varactor diode may not be useful at microwave frequencies _____.
a) For electronic tuning b) for frequency multiplication
c) as an oscillator d) As a parametric amplifier
Answer: c) as an oscillator

15. The negative resistance in a tunnel diode _____.
a) is maximum at the peak point of the characteristic
b) is available between the peak and valley points
c) is maximum at valley point
d) may be improved by the use of reverse bias
Answer: b) is available between the peak and valley points

16. Which one of the following is a transferred electron device?
a) BARITT diode b) IMPATT diode c) Gunn diode d) Step recovery diode
Answer: c) Gunn diode

17. A PIN diode is suitable for use as a _____.
a) Microwave switch b) Microwave mixed diode c) Microwave detector d) None
Answer: a) Microwave switch

18. The semiconductor diode which can be used in switching circuits at microwave range is:
a) PIN diode b) Tunnel diode c) Varactor diode d) Gunn diode
Answer: a) PIN diode

19. Microwave antenna aperture efficiency depends on _____.
a) Feed Pattern b) Antenna Aperture c) Surface losses d) Low side lobe level

Answer: b) Antenna Aperture

20. The noise produced in a microwave tube due to random nature of emission and electron flow is called _____.
a) Partition noise b) Shot noise c) Johnson noise d) Shannon noise
Answer: b) Shot noise

XIII. WEBSITES:

1. http://www.microwaves101.com/
2. http://www.microwave-eetimes.com/
3. http://www.surrey.ac.uk/postgraduate/rf-and-microwave-engineering
4. http://www.rfcafe.com/references/magazine-links.htm

XIV. EXPERT DETAILS:

1. Dr. P. V. D. Somasekhar Rao (JNTUH)
2. Dr. T.Satya Savithri (JNTUH)
3. Mrs N Mangala Gouri (JNTUH)
4. Dr.D.Rama Krishna (O.U)
5. Dr.K.Chandra Bhushana Rao (JNTUK)
6. Dr. V. Sumalatha (JNTUA)
7. Dr. M.N Giriprasad (JNTUA)

XV. JOURNALS:

INTERNATIONAL

1. International Journal of Microwave Engineering
2. International Journal of RF and Microwave Computer-Aided Engineering
3. International Journal of Microwave Engineering and Technology
4. International Journal of Advances in Microwave Technology
5. LFMTP'12 - Proceedings of the ACM SIGPLAN Workshop on Logical Frameworks and Meta Languages, Theory and Practice
6. Proceedings of the 2012 IEEE International Conference on Multimedia and Expo Workshops, ICMEW 2012

NATIONAL

1. Journal of Microwave Engineering & Technologies
2. ICTACT Journal On Communication Technology
3. Advance Wireless & Mobile Communication
4. IETE Journal Of Research
5. Journal of Electrical Engineering and Electronic Technology

XVI. LIST OF TOPICS FOR STUDENT SEMINARS:

1. Simulation surrogate-based optimization

2. Space mapping tuning surrogate model
3. High-fidelity model coarse model

XVII. CASE STUDIES / SMALL PROJECTS:

1. Computer-aided design (CAD)
2. Microwave design simulation-driven optimization electromagnetic (EM)
3. Designing of Power Divider using Micro Strip.
4. Designing of Magic Tee.
5. Designing of Hybrid 3dB Coupler.