7. SUBJECT DETAILS

7.5 MICROWAVE ENGINEERING

7.5.1 OBJECTIVE AND RELEVANCE

The central theme of this subject concerns with the basic principles and applications of microwave devices and circuits. As microwaves behave more like rays of light than the ordinary radio waves, this unique behaviour of microwaves leads to a broad range of applications in modern technology. The diverse applications of these microwaves are radio astronomy, long distance communication, space navigation, radar system, medical equipment and missile electronic systems.

As a result of the rapid rate of growth of microwave technology in research and industry, there is need for electronic engineers to understand and study the theoritical and experimental design and analysis of microwave devices and circuits.

7.5.2 SCOPE

Microwave Engineering is the study of centimeter and millimeter waves. Division of total frequency is made by different standards. The tube version microwave amplifiers and oscillators, like klystron, magnetron, TWT etc., are studied quantitatively and are compared on the basis of power and efficiency. Low-power solid state microwave devices that can be used for amplification and generation like Gunn diode, Avalanche diodes etc., are studied in detail. In addition, different components used in microwave systems like wave guides, tee junctions, directional couplers etc., are studied and their scattering matrices are derived. Measurement techniques for gain, radiation patterns, SWR are also covered at the end.

7.5.3 PRE-REQUISITES

Knowledge of Electromagnetic theory and transmission line theory

7.5.4.1 SYLLABUS - JNTU

UNIT - I
MICROWAVE TRANSMISSIONLINES [1]
OBJECTIVE
This unit provides microwave frequency bands, applications of microwaves and microwave transmission lines(wave guides),types of wave guides ,analysis of Rectangular wave guides ,propagation of EM waves in different modes and power handling capabilities of wave guides

SYLLABUS
Introduction, Microwave Spectrum and Bands, Applications of Microwaves. Rectangular Waveguides-Solution of wave equation in rectangular wave guides, 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; Related problems.

UNIT - II
MICROWAVE TRANSMISSIONLINES [2]
OBJECTIVE
This unit deals with circular waveguide analysis, mode characteristics **.**microstrip lines, rectangular and cylindricaL cavities, modes and resonant frequencies of cavity resonators

SYLLABUS
Rectangular guides: Power transmission and Power losses, Impossibility of TEM mode.
Microstrip Lines [1]--Introduction, Z Relations, Effective Dielectric constant, Losses, Q factor. Cavity Resonators [1]-Introduction, Rectangular and Cylindrical Cavities, Dominant Modes and Resonant Frequencies Q factor and Coupling coefficients. Related problems.

UNIT - III
WAVEGUIDE COMPONENTS AND APPLICATIONS-1
OBJECTIVE
This unit gives complete idea about wave guide components, hybrid circuits including the devices used for power division or combiners, their constructional details, properties and their wide range of applications and also components details used to connect the wave guides.

SYLLABUS
Coupling mechanisms-Probe, Loop, Aperture types, waveguide Discontinuities-Waveguide irises, Tuning screws and Posts, Matched loads, waveguide attenuators-Resistive Cards, Rotary vane type, waveguide phase shifters-Dielectric, Rotary Vane types. Waveguide multiport junctions-E plane and H-plane Tees, Magic Tee, Directional couplers-2 Hole, Bethe hole types. Illustrated problems.

UNIT - IV
WAVEGUIDE COMPONENTS AND APPLICATIONS-1I
OBJECTIVE
This unit deals with ferrites used in wave guides, ferrite components, and microwave guide components analysis in terms of scattering parameters

SYLLABUS
Ferrites[3]- Composition and characteristics, Faraday Rotation; Ferrite Components Gyrator, Isolator, Circulator, Scattering Matrix [3]-Significance, Formulation and properties, S-matrix Calculations for 2-port junction, E plane and H plane Tees, Magic Tee, Directional coupler, Circulator and Isolator. Related problems.

UNIT - V
MICROWAVE TUBES-I [1, 2]
OBJECTIVE
This unit provides the advantage of microwave tubes over conventional tubes, O type tubes, their constructional details, characteristics and their applications in various fields.

SYLLABUS
Limitations and Losses of conventional tubes at microwave frequencies. Microwave tubes-O type and M type classifications. O-type tubes: 2 Cavity Klystrons-Structure, Re-entrant 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 output characteristics, effect repeller voltage on power output, illustrated problems

UNIT - VI
HELIX TWTS [1, 2]
OBJECTIVE
This unit deals with slow wave structures, TWT amplifier analysis, M-type tubes , 8-cavity cylindrical travelling wave magnetron, principle of operation, mode operation and output characteristics.

SYLLABUS
Helix TWTS [1, 2]
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.
M-type Tubes [1,2]
Introduction, crossed field effects, Magnetrons-Different Types, 8-Cavity Cylindrical Travelling Wave Magnetron-Hull Cut-off and Hatree Conditions, Modes of Resonance and Pi-Mode operation, Separation of Pi-Mode, o/p characteristics.

UNIT - VII
MICROWAVE SOLID STATE DEVICES [1]
OBJECTIVE
This unit will give an explanation in depth about various types of microwave solid state devices which operate in negative resistance region, their characteristics and applications

SYLLABUS
Introduction, Classification, Applications. TEDs-Introduction, Gunn diode-Principle, RWH Theory, Characteristics, Basic Modes of Operation, Oscillations Modes, Avalanche Transit time Devices.

UNIT - VIII

MICROWAVE MEASUREMENTS [1]
OBJECTIVE
This unit deals with measurements of various parameters of microwaves and also gives the complete features of the microwave bench.

SYLLABUS
Description of Microwave Bench-Different Blocks and their Features, Precautions, microwave Power Measurement-Bolometer Method, Measurement of Attenuation, Frequency, VSWR, Cavity Q, Impedance measurements.

7.5.4.2 GATE SYLLABUS

UNIT - I
Rectangular Wave Guides

UNIT - II
Not Applicable

UNIT - III
Not Applicable

UNIT - IV
Not Applicable

UNIT - V
Not Applicable

UNIT - V
Not Applicable

UNIT - VI
Not Applicable

UNIT - V II
Not Applicable

UNIT - V III
Not Applicable

7.5.4.3 IES SYLLABUS

Microwaves tubes and solid state devices, Microwave generation and amplifiers, wave guides and other microwave components and circuits, Microstrip circuits, Microwave measurements, Masers, Lasers, Microwave propagation. Microwave communication systems terrestrial and satellite based.

UNIT - I
Wave guides, Micro Wave propagation

UNIT - II
Resonators, Micro strip Circuits

UNIT - III
Microwave components and circuits

UNIT - IV
Microwave components and circuits

UNIT - V
Microwave tubes and generation and amplifiers

UNIT - VI
NOT APPLICABLE

UNIT - VII
Microwaves solid state devices, Masers, Lasers

UNIT - VIII
Microwave measurements, Microwave communication systems terrestrial and satellite based.

7.5.5 SUGGESTED BOOKS

TEXT BOOKS

T1. Microwave Devices and Circuits- Samuel Y. Liao, PHI, 3rd edition, 2003
T2. Microwave Principles, Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss, CBS Publishers and Distributors, New Delhi ,2004.

REFERENCE BOOKS

R1. Foundation for Microwave Engineering -R.E. Collin, IEEE Press, John Wiley,2nd Edition ,2002.

R2. Microwave Circuits and Passive Devices-M.L. Sisodiaand G.S. Raghuvanshi,Wiley Eastern Ltd, New Age International Publishers Ltd,1995
R3 Microwave Engineering Passive Circuits-Peter A.Rizzi, PHI, 1999.
R4. Electronic and Radio engineering -F.E. terman,McGraw-hill,4th Edition, 1955.
R5. Microwave Engineering, A Das and S.K. Das, TMH, 2nd Edition, 2009

7.5.6 WEBSITES

1. www.eecs.tufts.edu
2. www.peeas.ecs.umass.edu/degee/ece_degeee.html
3. www.georgefox.edu/catlog/undergrad/enge.htmlr
4. www.eciu.org/core/smg_hamburg.php
5. www.rfcafe.com
6. www.ecs.umas.edu
7. Www. mwrf.com
8. www.eagleware.com

7.5.7 EXPERTS' DETAILS

INTERNATIONAL

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   SNIST. College.

3. Prof. K.V. Srinivasa Rao,
   Dept of ECE,
   Aurora Engg. College.

7.5.8 JOURNALS

INTERNATIONAL

1. Microwave Jounral on IEEE
2. Microwave Magazine on IEEE
3. Microwave Theory Techniques on IEEE
4. Solid State circuits Magazine on IEEE
5. Microwave Engineering
6. Planar Microwave Engineering
7. RF and Microwave Engineering

NATIONAL

1. Technical Review on IETE
2. Telecommunication
3. Journal on Communication Technology
4. Journal of Research on IETE
5. Journal of Telecommunication
6. Microwave and antenna Engineering
7. RF and Microwave Engineering professional networks.

7.5.9 FINDINGS AND DEVELOPMENTS

1. Characterization of wave guide with combination of conductor and periodic boundary contours, application to the analysis of by periodic structures, F.Ferranti, M.Nakhla, G. Antonini, T.Dhanene, L.knockaert & A.E. Ruehli, IEEE Transactions on MTT, Vol.16, Page No. 419-431, March 2012.
2. Multimode coupling wave theory for helically corrigated wave guide, W.H.K. Ronald, ADR Phelps, IEEE Transaction of MTT, Vol.60, Page No.1-8, January 2012.
3. A Circular pathc resonator for the measurement of microwave permitivity of Nematic liquid crystal, D.E. Schaub and D.R. Oliver, IEEE Transactions on MIT, Vol.59, Page No.185-195, July 2011.
4. Comprehensive technique to determine the boradband physically consitent material characteristics of microstrib lines, Z.Zhou & K.L Meido, IEEE Transactions on MTT Vol.58, Page No.1855-1863, January, 2010.

5. High-efficiency fast RF/Microwave power amplifiers, S. Gao from IEEE Microwave Magazine, Feb 2006, Vol. 7, No. 1
6. Ku band MMIC phase shifter using a parallel resonator, D. W. Kang, H. D. Lee, Ch. Kim/S.Hang from IEEE microwave magazine, Jan 2006, Vol. 54, No. 1
7. Novel batler matrix using CPW multilayer technology, Mourad Nedil, Tayeb. from IEEE MTT, Jan 2006, Vol 54, No.1.
8. Compact wide band branch live hybrids, Y. H. Chan and J. S. Hang from IEEE MTT, Feb 2006, Vol 54, No.2.
9. Travelling wave microwave fiber-optic link's, H. H. Hashim and S. Iezekiel from IEEE MTT, Feb 2006 (Part-II) Vol-54, No. 2.
10. Time constant control of microwave integrators using tranmission lines, Ching-Wen Huse, Lin Chuan Tsai from IEEE MTT, Vol. 54, No. 3, March 06.
11. Improved wide -band schiffman phase shifter, Yang-Xin Guo, Zhen-Yu Zang from IEEE MTT, Vol.54, No. 3, March 06.
12. Broad band high efficiency circularly polarized active antenna and array for RF-front end applications, Y. Qln, S. Gao. A. Sambell, IEEE MTT, Vol. 54, NO. 7, July-2006.
13. Micromachined rectangular-coarial TXL, J. R. Reid, E. D. Marsh and R. T. Webster from IEEE, MTT, Vol. 54, No. 7 July-2006.
14. Distortion mechanism in varactor-diode tuned microwave filter A, B.E. Carey, Smith and P. A. Warr from IEEE, MTT, Vol. 54, No. 9, Sept.-2006.
15. Microwave Circuits Simulation Softwares

i.IE 3D Simulation Software - www.zeland.com
ii.ADS- Ansoft
iii.HF SS Simulation Solutions - www. sonnetsoftware.com
iv.Microstrip Line Simulation - www.microstriper.com

7.5.10 I SESSION PLAN

Sl. No	Topics in JNTU syllabus	Modules and Sub modules	Lecture No.	Suggested books	Remarks
1	Introduction, Microwaves Microwave spectrum and bands, Applications of microwaves.	Objectives and relevance, prerequisites of microwaves	L1	T1-Ch0,T2-Ch1 R2-Ch1	GATE IES
		Introduction to microwaves. Microwave region and bands, applications, and advantages	L2	T1-Ch0,T2-Ch1 R2-Ch1, R5-Ch11	GATE IES
2	Rectangular wave guides-TE/TM mode analysis, expressions for fields, characteristic equation, and cutoff frequencies, filter characteristics, dominant and degenerate modes, sketches of TE and TM mode fields in the cross section	Equations for fields in rectangular wave guides, derivation of equations for TE waves, dominant modes and cutoff frequencies, sketches of fields.	L3&L4	T1-Ch4,T2-Ch2 R2-Ch10, R1-Ch5 R5-Ch4	GATE IES
		Derivation of equations for TM waves, dominant modes, and cutoff frequencies, sketches of fields.	L5	T1-C4,T2-Ch2 R1-Ch5, R2-Ch10	
		TEM wave expressions, Filter characteristics of wave guides,	L6	T1-Ch 4,T2-Ch 2 R2-Ch10	
4	Illustrated problems	Problems in dominant modes, cutoff frequencies, characteristic impedances, and power.	L7	T1-Ch 4,T2-Ch 2 R2-Ch10	GATE IES
UNIT – II (MICROWAVE TRASMISSION LINES-II)					
5	Rectangular Guides Power transmission and power losses in rectangular guides, Impossibility of TEM Mode	Derivation of expressions for fields in circular waveguides.	L8	T1-Ch4,T2-Ch2 R2-Ch10	GATE IES
		Expressions for power in waveguides, efficiency. Impossibility of TEM Mode	L9	T1-Ch 4,T2-Ch 2 R2-Ch10	
6	Microstrip lines, Z_0 relations, effective dielectric constant, losses , Q-factor.	Strip lines and microstrip lines, equations for characteristic impedances, equations for effective dielectric constant, Q-factor and losses.	L10 & L11	T1-Ch11,T2-Ch7 R2-Ch11	GATE IES

Sl. No	Topics in JNTU syllabus	Modules and Sub modules	Lecture No.	Suggested books	Remarks
7	Cavity resonators, introduction, rectangular cavities, dominant modes and resonant frequencies, Q-factor and coupling coefficients, related problems.	Types of cavity resonators, rectangular, modes of operation.	L12	T1-Ch4,T2-Ch7 R1-Ch9, R5,Ch7	
		Expressions for resonant frequencies, Q-factor, and coupling coefficients.	L13	T1-Ch4,T2-Ch7 R1-Ch9, R5-Ch7	
		Problems in resonant frequencies of cavity resonators, Q-factor.	L14	T1-Ch4, R1-Ch9 R5-Ch7	
UNIT – III (WAVEGUIDE COMPONENTS AND APPLICATIONS)					
8	Coupling mechanisms-probe, loop, aperture types. Waveguide discontinuities-waveguide irises, tuning screws and posts, matched loads Waveguide attenuators-resistive card, rotary wane types.	Description and structures of probe, loop, and aperture coupling mechanisms, different types of waveguide irises, and posts and their comparison	L15	T2-Ch3, R2-Ch12, R1-Ch7,	IES
		Types of attenuators, variable and fixed attenuators, resistive pad structure, and mechanism of rotary vane type attenuator.	L16	T2-Ch3, R2-Ch12, R1-Ch7,	
9	Wave guide phase shifters-dielectric, rotary vane types.	Principle of working of a waveguide phase shifter, types of phase shifters.	L17	T1-Ch4, R2-Ch12, R1-Ch7	IES
		Description of dielectric type and rotary type phase shifters	L18	T2-Ch3, R1-Ch7	
10	Waveguide multi port junctions-E plane and H plane tees, magic tee, hybrid ring	Introduction to junctions, E plane tee junction, principle of working by using power division.	L19	T1-Ch4,T2-Ch3 R1-Ch8	IES
		H plane tee junction, principle of working by using power division.	L20	T1-Ch4,T2-Ch3 R1-Ch8	
		Combination of junctions, hybrid tee junction, principle of working by using power division, applications, principle of operation of hybrid ring structure.	L21	T1-Ch4,T2-Ch3 R1-Ch8	
11	Directional coupler-two hole, Bethe- hole types Illustrated Problems	General description of a directional coupler, principle of working of two-hole and multi-hole directional couplers, construction and working principle of Bethe-hole D.C., applications.	L22	T1-Ch4,T2-Ch3 R1- Ch12 R2-Ch12	IES
UNIT IV					
12	Ferrites[3]-Composition and characteristics, Faraday Rotation	Ferrites-materials Composition and characteristics, Faraday Rotation	L23	T1-Ch4, R2-Ch12	IES

Sl. No	Topics in JNTU syllabus	Modules and Sub modules	Lecture No.	Suggested books	Remarks
13	Ferrite Components Gyrator,Isolator, Circulator	Ferrite Components Gyrator,Isolator, Circulator	L24	T1-Ch4,R2-Ch12	IES
14	Scattering matrix, Significance, formulation and properties	Scattering parameters, scattering matrix formulation, properties of scattering matrix.	L25	T1-Ch4,R2-Ch12	IES
15	S-matrix calculation for 2-port junction, E-plane and H plane Tees, Magic tee, Directional coupler, Circulator and isolator. Related problems	Derivation of S matrix for E plane tee and H plane tee	L26	T1-Ch4,R1-Ch8 R2-Ch12	IES
		Derivation of S matrix for Magic Tee	L27	T1-Ch4,R1-Ch8 R2-Ch12	
		Derivation of S matrix for directional coupler	L28	T1-Ch4,R1-Ch8 R2-Ch12	
		Derivation of s matrix for a circulator and Isolator..	L29	T1-Ch4,R1-Ch8 R2-Ch12	
		Problems in S- matrix determination.	L30	T1-Ch4,R1-Ch8 R2-Ch12	
		UNIT-V (MICROWAVE TUBES –I)			
16	Limitations and losses of conventional tubes at microwave frequencies	Limitations and losses of a conventional tubes at UHF	L31	T1-Ch9,T2-Ch9 R2-Ch2	IES
17	Microwave tubes- O type and M type classifications,	Classification of microwave tubes, O type & M type tubes, comparison based on the type of interaction of d.c and r.f fields.	L32	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	IES
18	O type tubes:2 cavity Klystrons- structure, reentrant cavities ,velocity modulation process and Applegate diagram, bunching process and small signal theory, expressions for output power and efficiency.	Two cavity Klystron tube structure,. reentrant cavities, and working principle .	L33	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	IES
		Velocity modulation , small signal theory and bunching process ,applegate diagram.	L34 & L35	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	
		Derivation of output power and efficiency ,and mutual conductance	L36	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	
19	Reflex Klystrons- structure, Applegate diagram and principle of working Mathematical theory of bunching, power output, efficiency, Electronic admittance; Oscillation modes and o/p characteristics , Electronic, Effect of power, Repeller voltage on power output	Structure of Reflex klystron Introduction, Working principle.	L37	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	IES
		Velocity modulation and Applegate diagram Mathematical theory of bunching, electronic admittance. Expression for output power and maximum efficiency	L38 & L39	T1-Ch9,T2-Ch10 R2-Ch2, R5-Ch9	

Sl. No	Topics in JNTU syllabus	Modules and Sub modules	Lecture No.	Suggested books	Remarks
UNIT-VI (HELIX TWTS AND M -TYPE TUBES)					
20	Significance, types and characteristics of slow wave structure Structure of TWT and amplification process(qualitative treatment) Suppression of oscillations ,nature of the four propagation constants, Gain consideration	Types of slow wave structures, condition, significance.	L40	T1-Ch9,T2-Ch12 R2-Ch4	IES
		Construction of TWT, principle of working, propagation constants, gains calculation methods.	L41 & L42	T1-Ch9,T2-Ch12 R2-Ch4	
21	M-type tubes: introduction, Cross field effects.	Introduction to M-type tubes, perpendicular dc and rf fields, interaction.	L43	T1-Ch10,T2-Ch11 R2-Ch5, R5-Ch9	IES
22	Magnetron- different types, 8-cavity cylindrical traveling wave magnetron Hull cut-off and Hatree conditions Modes of resonance and Pi-mode operation, separation of Pi-mode,o/p characteristics	Structure of magnetron, principle of working,.	L44	T1-Ch10,T2-Ch11 R2-Ch5, R5-Ch9	IES
		Derivation of Hull cutoff voltage and magnetic flux density, Hatree condition.	L45	T1-Ch10, R2-Ch5 R5-Ch9	
		Modes of resonance, output characteristics, frequency pulling and frequency pushing, rising sun structure.	L46	T1-Ch10, R2-Ch5 R5-Ch9	
		Problems in parallel plane magnetron, Hull voltages.	L47	T1-Ch10,R2-Ch5	
UNIT –VII (MICROWAVE SOLID STATE DEVICES)					
23	Introduction, classification, applications	Introduction to microwave solidstate devices, advantages over tube versions, applications of different types of devices.	L48	T1-Ch7,R2-Ch9	IES
24	TEDs -introduction, GUNN Diode – principle, RWH theory ,basic modes of operation, oscillation modes	Gunn dide structure, principle of working,.	L49	T1-Ch7,R2-Ch9 R5-Ch10	IES
		RWH theory, modes of operation, oscillation and LSA modes.	L50	T1-Ch7, R5-Ch10	
25	Avalanche transit time devices- introduction , IMPATT and TRAPATT diodes Principle of operation and characteristics	Introduction to avalanche transit time devices, types, comparison.	L51	T1-Ch8,R2-Ch8 R5-Ch10	IES
		IMPATT and TRAPATT, BARITT diodes, principles of working.	L52 & L53	T1-Ch8,R2-Ch8 R5-Ch10	
UNIT-VIII (MICROWAVE MEASUREMENTS)					
26	Description Microwave bench- different blocks and their features, precautions.	Description of various blocks in a microwave bench set-up, precautions.	L54	T1-Ch 5,R2-Ch13 R5-Ch13	IES

Sl. No	Topics in JNTU syllabus	Modules and Sub modules	Lecture No.	Suggested books	Remarks
27	Microwave power measurements – Bolometer method	Power measurement using ratio method and bolometer method, comparison.	L55	T1-Ch 5,R2-Ch 13 R5-Ch13	IES
28	Measurement of attenuation, frequency, VSWR, cavity Q	Bench set-up for the measurement of attenuation, comparison method.	L56	T1-Ch 5,R2-Ch 13 R5-Ch13	IES
		Bench set-up for the measurement of frequency and wavelength.	L57	T1-Ch 5,R2-Ch 13 R5-Ch13	
		Bench set-up for the measurement of VSWR, measurement of low VSWR and high VSWR, application of Smith chart	L58	T1-Ch 5,R2-Ch 13 R5-Ch13	
		Bench set-up for the measurement of Q-factor of a resonant cavity.	L59	T1-Ch 5,R2-Ch 13 R5-Ch13	
		Bench set-up for the measurement of attenuation, comparison method.	L60	T1-Ch 5,R2-Ch 13 R5-Ch13	
29	Impedance measurements	Bench set-up for the measurement of unknown impedance, use of Smith chart.	L61	T1-Ch 5,R2-Ch 13 R5-Ch13	IES

II TUTORIAL PLAN

Tutorial No	Title	Salient topics to be discussed
T1	Microwave transmission lines	Formulas & expressions derivations on Rectangular wave guides
T2	Microwave transmission lines	Related problems on Rectangular waveguides
T3	Circular wave guides	Formulas & expressions derivations on Circular wave guides and microstrip lines
T4	Circular wave guides	Related problems on Circular waveguides
T5	Wave guide components and applications-I	Problems related to E-Plane, H -Plane and Magic Tee
T6	Wave guide components and applications-I	Problems related to Hybrid ring and directional couplers
T7	Wave guide components and applications-II	Problems related to Isolator and Circulator
T8	Microwave Tubes-I	Problems related to Two -cavity klystron amplifier and Reflex klystron oscillator.
T9	Microwave Tubes-I	Problems related to Two -cavity klystron amplifier and Reflex klystron oscillator
T10	Helix TWTs	Problems on TWT amplifier
T11	Helix TWTs	Problems related to Magnetron
T12	Microwave solid state devices	Problems related to GUNN diode
T13	Microwave measurements	Problems related to Attenuation, Frequency measurements
T14	Microwave measurements	Problems related to impedance measurements

7.5.12. QUESTION BANK

UNIT-I

1. i. Explain the wave impedance of a rectangular waveguide and derive the expression for the wave impedance of TE and TM modes.
   ii. Calculate the cut-off frequency of the following modes in a square waveguide 4 cm $\times$ 4 cm TE_{10}, TM_{11} and TE_{22}. **(Nov13)**

2. i. Show that TM_{01} and TM_{10} modes in a rectangular waveguide do not exist.
   ii For a wave guide having cross section 3cm $\times$ 2cm, compute the cut-off frequency in the TE01 mode. Also, calculate the phase velocity and guide wavelength at a frequency equal to 50% above the cut-off frequency. **(Nov/Dec 13)**

3. i. Use Maxwell's equations to show that it is impossible for TEM wave to exit within any single conductor wave guide.
   ii. Explain the significance of mode indices 'm' and 'n' for fields in the rectangular waveguide.
   iii. Design a dielectric fields (ε_r=4) rectangular waveguide such that the cut-off frequency for the dominant mode is 14 GHz and the cut-off frequency for the TM_{11} mod is 30 GHz **(Dec 12)**

4. i. Determine the phase and group velocities, guide wavelength and characteristic impedance for a rectangular guide of 2.5 cm. x 1.0 cm. cross-section, for the TE_{20} mode at 15 GHz.
   ii. Identify the frequency ranges associated with microwave frequencies and hence distinguish between the different types of standard microwave band designations **(Nov 11)**

5. Given $H_Z = H_o \cos(m\pi x/a).\cos(n\pi y/b).\exp(-j\beta Z)$ A/m., establish the relations for the E field components of TE_{mn} modes in a rectangular waveguide. Explain the meaning of the different symbols involved. Give its typical sketch in a rectangular coordinate system, and list out the boundary conditions for the tangential E components involved. **(Nov 11)**

7. i. For a rectangular guide of 7.2 cm x 3.4 cm. determine m, n and all the propagation characteristics for the lowest possible TM mode at 6 GHz (no derivations). Can a TE mode exist for such m and n? If so, what will be the change in propagation characteristics for such a TE mode?
   ii. Determine the changes in of the above modes, if this waveguide is filled with a medium of dielectric constant 4.0? **(Nov 11)**

8. i. Starting with the equation for the propagation constant of a mode in a rectangular wave guide, derive the expression $\lambda_g = \frac{\lambda_0\lambda_c}{\sqrt{\lambda_0^2+\lambda_c^2}}$
   Where λ_g is the guide wave length and λ_c is the cutoff wave length
   ii. An air filled rectangular wave guide has the dimensions of 4 and 3cm and is supporting TE_{10} mode at a frequency of 9800MHz. Calculate
   a. The wave guide impedance
   b. The percentage change in the impedance for a 10% increase in the operating frequency. **(May 10)**

9 i. Derive the wave equation for a TE wave and obtain all the field components in a rectangular wave guide.
   ii. Consider a rectangular wave guide of 8 cm x 4 cm. Given critical wave length of TE_{10} = 16cm, TM_{11} = 7.16 cm, TM_{21} = 5.6 cm. What modes are propagated at a free space wave length of λ
   a. 5 cm and

b. 10 cm. **(May 10,09, 08, 07, Sep 06)**

10. i. Derive the wave equation for a TM wave and obtain all the field components in a rectangular wave guide.
    ii. A rectangular wave guide with dimension of 3 x 2 cm operates in the TM_{11} mode at 10 GHz. Determine the characteristic wave impedance.

11. i. Obtain the field equations of rectangular wave guides in TE_{mn} modes.
    ii. An air field rectangular wave guide of dimensions (7x3.5 cm) operates in the dominant TE10 mode.
    a. Find the cut off frequency
    b. Find the phase velocity of the wave in the guide at the frequency of 3.5 GHz.
    c. Determine the guided wave length at the same frequency. **(May 10)**

12 i. Derive the expressions for cut off frequency, phase constant, group velocity, phase velocity and wave impedance in a rectangular wave guide.
    ii. An rectangular wave guide is filled by dielectric material of $2\varepsilon_r= 9$ and has dimensions of 7 × 3.5 cm. It operates in the dominant TE mode.
    a. Determine the cut off frequency.
    b. Find the phase velocity in the guide at a frequency of 2 GHz.
    c. Find the guided wave length at 2 GHz. **(May 09)**

13. i. Find expressions for the electric surface current density on the wall of a rectangular wave guide for a TE_{10} mode.
    ii. A rectangular wave guide of cross section 5 cm × 2 cm is used to propagate TM_{11} mode at 9 GHz. Determine the cut off wave length and wave impedance. **(May 09)**

14. i. Mention different microwave regions & band designations.
    ii. Discuss the war and peace time applications of microwaves. **(May 09, Sep 08)**

15. i. Derive the wave equation for a TM wave and obtain all the field components in a rectangular wave guide.
    ii. A rectangular wave guide with dimension of 3 × 2 cm operates in the TM_{11} mode at 10 GHz. Determine the characteristic wave impedance. **(May 09, 08)**

16. Show that the TEM, TM_{01} and TM_{10} modes in a rectangular wave-guide do not exist. **(May 09, 06)**

17. i. What is a cavity resonator? Explain the principle of operation of a rectangular cavity resonator?
    ii. Explain why single conductor hollow or dielectric filled wave guide cannot support TEM waves. **(May 09, 06)**

18. i. Derive the expressions for cutoff frequency, phase constant, group velocity, phase velocity and wave impedance in rectangular wave guide, for TE modes.
    ii. An air filled circular waveguide is to be operated at a frequency of 6 GHz and is to have dimensions such that f_c=0.8f for the dominant mode. Determine
    i. The diameter of the guide ii. Guide wave length and iii. Phase velocity in the guide **(May 09, Nov 05)**

19. i. A rectangular guide of inner dimensions 2.5 cm × 1.2 cm is to propagate energy in TE_{10} mode. Calculate the cut off frequency. If the frequency of signal is 1.2 times this cut off frequency, compute the guide wave length, phase velocity and wave impedance. Derive the relations used.
    ii. Prove that for any wave guide. **(Sep 08)**

20. i. An air field rectangular wave guide has dimensions of a = 6 cm, b = 4 cm. The signal frequency is 3 GHz. Compute the following for TE_{10}, TE_{11} modes.
    a. Cut off frequency
    b. Wave length in the waveguide
    c. Phase constant and phase velocity in the wave guide
    d. Group velocity and wave impedance in the wave guide.

ii. Discuss the methods of excitations of modes in the rectangular wave guide. **(Sep 08)**

21. i. Derive the expression for guide wave length of TE_{mn} mode in rectangular wave guide.
    ii. What are the advantages of dominant mode propagation? **(May 08)**

22. i. What are TEM, TE, TM and HE modes? Sketch the field patterns for dominant modes in a rectangular wave guides.
    ii. A rectangular wave guide has a = 4 cm, b = 3 cm as its sectional dimensions. Find all the modes which will propagate at 500 MHz **(May 08)**

23. i. Discuss the attenuation in wave guides in detail.
    ii. A wave guide operating in TE10 mode has dimensions a = 2.26 cm and b = 1 cm. The measured guide wave length is 4 cm. Find
    a. Cut off frequency of the propagating mode
    b. The frequency of operation
    c. Maximum frequency of propagation in this mode. **(May 08)**

24. The field component is given as.
    Determine
    i. The mode of operation
    ii. The cut off frequency
    iii. The phase constant
    iv. The propagation constant
    v. The wave impedance. **(May 08, 07, Sep 06)**

25. A 6.0 GHz signal is to be propagated in the dominant mode in a rectangular waveguide. If its group velocity is to be 80% of the free space velocity of light. What must be the breadth of the waveguide? What impedance will it offer to this signal if it is correctly matched? **(May 07, Sep 06)**

26. Distinguish between TEM, TE and TM modes of the propagation in rectangular wave guides. **(May 06)**

27. If the height of the wave guide is halved, its cut-off wave length will be **(IES 03)**

28. In a rectangular wave guide with broader dimension a and narrow dimension **b,** the dominant mode of Microwave propagation would be? **(IES 03)**

29. A metal probe inserted into a rectangular waveguide through the broader wall of the guide will provide a property across the guide, this property is known as? **(IES 03)**

30 An X-band rectangular waveguide filled with a dielectric of 2.6 is operating at 9.5 GHz. Calculate group and phase velocities. Also calculate the TE and TM wave impedances. **(IES 02)**

31. An air filled hollow rectangular conducting waveguide has cross-section of 8 x 10 cm. How many TE modes will this waveguide transmit at frequencies below 5 GHz? How these modes designated and what are the cut-off frequencies? **(IES 2000)**

UNIT-II

1 i. Derive the expression for the characteristic impedance of micro strip lines.
  ii. Find the first five resonances of an air-filled rectangular cavity with dimensions of a = 5 cm, b = 4 cm and c = 10 cm (d $> a > b$). **(Nov13)**

2. i. Prove by Maxwell's equations that it is impossible for a TEM wave to be propagated inside a hollow conducting tube, whether cylindrical or rectangular.

ii. An air filled circular waveguide is to be operated at a frequency of 6 GHz and is to have dimensions such that $f_c = 0.8 f$ for the dominant mode of operation. Determine
(i) Diameter of the guide (ii) the wave length (λ_g) and (iii)the phase velocity in the guide. **(Nov/Dec 13)**

3. i. Derive the expression for power transmission in rectangular waveguides supporting only dominate mode propagation. On what factor does the power handling capacity of the waveguide mainly depend?
   ii. Write a brief not on micro-strip lines.
   iii. Find the resonant frequencies of first 3 lowest order modes in a n air filled rectangular cavity resonator of dimensions (5cmx4cmx2.5cm) **(Dec 12)**

4. i. For an air-filled rectangular guide cavity resonator of 4 cm x 2 cm. cross section and 5 cm. axial length, determine the resonant frequency of the lowest 3 possible modes.
   ii. Sketch and explain the constructional features and field lines associated with the propagation in Microstrip Lines. What are the applications of such lines at microwave frequencies? **(Nov 11)**

5 i. Identify the dominant mode configurations of Rectangular and Circular Waveguides, Rectangular, Cubical and Circular Cavity Resonators. What are the common types of losses that exist in all these structures? What happens to their performances as the frequency of application increases?
   ii. An air-filled circular guide operates at 9.375 GHz with a guide wavelength of 5.0 cm. Determine its phase constant, group velocity and Z_o . **(Nov 11)**

6. i. List out the first 5 modes of propagation in a circular waveguide, defining and accounting for the dominant and degenerate modes in them.
   ii. Define and establish an expression for the Q factor of a cavity resonator. Hence distinguish between $Q_{ext,}$ Qo , Q_{Loaded} and $Q_{Unloaded}$, and list their inter-relation. **(Nov 11)**

7. i. Evaluate the phase and group velocities, Z_o for the lowest order TM mode in an air filled circular waveguide of 2.0 cm. diameter at 12 GHz. (Data : X01= 2:405andX; 11= 1:841):
   ii. Explain how a rectangular waveguide can be configured as a Cavity Resonator. Hence establish an expression for its dominant mode resonant frequency if its axial dimension is larger than the cross sectional dimensions. **(Nov 11)**

8. i. Account for the different types of power losses in a rectangular waveguide. Hence obtain an expression for its attenuation factor in terms of power lost and power transmitted.
   ii. For an air-filled rectangular guide of a=2.3 cm, and b= 1.0 cm. determine the different types of wavelengths and Z_o associated with the TE_{01} mode at 16 GHz. **(Nov 11)**

9. i. Discuss the power transmission in circular wave guides.
   ii. An air filled circular wave guide of 2 cm inside radius is operated in the TE_{01} mode.
   a. Compute the cut off frequency
   b. If the guide is to be filled with a dielectric material of $\varepsilon = 2.25$, to what value must its radius be changed in order to maintain the cut off frequency at its original values. **(May 10, Sep 08)**

10. i. Derive the Q for TM_{111} mode of rectangular cavity assuming lossy conducting walls and lossless dielectric.
    ii. The quality factor of micro strip line is reciprocal of the dielectric loss tangent ¸ and is relatively constant with frequency. Prove this statement. **(May 10, Sep 08)**

11. i. What is cavity resonator? Explain the principle of operation of rectangular cavity resonator.
    ii. A rectangular cavity resonator has dimensions of a=5cms, b=2cms and d=10cms. Compute the resonant frequency of the dominant mode if the cavity is
    a. Air filled and
    b. Dielectric filled with =2.3 **(May 10)**

12. i. Explain how a rectangular cross section of a micro strip line can be transformed in to equivalent circular conductance.

ii. In the above transformation, what is the significance of t/w ratio? **(May 10)**

13. i. State the factors up on which the attenuations constant of a parallel strip line are dependent.
    ii. Derive an expression for the attenuation factor of a micro strip line. **(May 09)**

14. i. Prove that a cavity resonator is nothing but an LC circuit.
    ii. Derive an expression for Q of a cavity supporting TE_{101} mode. What is the resonant frequency of the cavity if each side of the guide is 3 cm? **(May 09)**

15. i. Distinguish between the properties of TEM mode of propagation and that of TE and TM type of propagation.
    ii. Write short notes on "Cavity resonators and its applications". **(May 09)**

16. i. With a schematic diagram, explain the construction of a micro strip line.
    ii. Mention the advantages of strip lines over other transmission lines. **(Sep 08)**

17. i. What is the effect of conductivity on the dielectric loss of a strip line?
    ii. Derive the expression for attenuation constant for dielectric loss. **(Sep 08)**

18. i. What is the impact of skin effect on a micro strip line?
    ii. Derive an expression for attenuation factor for ohmic skin loss. **(May 08)**

19. i. Derive the Q for TM_{111} mode of rectangular cavity assuming lossy conducting walls and lossless dielectric.
    ii. The quality factor of micro strip line is reciprocal of the dielectric loss tangent and is relatively constant with frequency. Prove this statement **(Sep, May 08)**

19. i. Explain the concepts of propagation delay time for a strip line.
    ii. Is the effective dielectric constant of a micro strip line a function of relative dielectric constant justify. **(May 08)**

20 Derive the expression for the resonant frequency of a rectangular cavity resonator **(May 07)**

21. i Write a short notes on "Cavity resonators'. **(May 05)**
    ii Derive the expression for the resonant frequency of a rectangular cavity resonator.

22. i. An X band waveguide filled with a dielectric is operating at 9 GHz. Calculate the phase and group velocities in the wave-guide. Take $\in_r$ has 2.25 for the dielectric.
    ii. What are cavity resonators? What are their most desirable properties? **(May 05)**

23 i. A rectangular cavity of width 'a' height 'b' and length 'd' is to resonance with TE_{101}mode obtain the frequency of response. If resonant frequency is 10GHz, a=2 cm. and b=1cm, find 'd'
    ii. An air filled resonant cavity with dimension a=5 cm, b=4 cm and c=10 cm is made of copper. It is filled with a lossless material where permeability is 1. Find the resonant frequency and the quality factor for the dominant mode. **(May 05)**

24. Explain the methods of excitation and tuning of a cavity resonator. **(May 04)**

25. As related to excitation and coupling of microwave resonators, define the following terms:
    i. Critical coupling ii. Under coupling iii.Over coupling **(May 04)**

    How is coefficient of coupling defined in Microwave circuits? Define the Q factors involved in these cases.

26. Guided wavelength of a rectangular waveguide (1 D 2.285 cm x 1.016 cm) is 5.42 cm. When the waveguide is short-circuited, find the distance between two consecutive voltage minimum positions of standing wave pattern so formed. Obtain the operating frequency of the microwave source. **(Nov 04)**

27 The inner dimension of an x-band WR 90 waveguide are a= 2.286cm and b = 1.016cm. Assume that the wave guide is air filled and operates in dominant TE10 mode, and can be transmitted at f =9 GHz in the wave guide before air break down occurs. Derive all necessary equations. **(IES 03)**

28. What three characteristics of waveguides are affected by the addition of a ridge to a rectangular waveguide? **(IES 03)**

UNIT – III

1.i. Explain coupling probes and coupling loops.
ii What is phase shifter? Explain its principles of operation with a neat sketch. Give its applications. **(Nov13)**

2.i. What is meant by normalized voltage and normalized current with respect to the microwave circuit concept. Draw a neat sketch of a Magic Tee and obtain its S matrix. Explain two applications of Magic Tee.
ii. Using the properties of scattering matrix of a lossless, reciprocal microwave junction, prove that for a four port network if all the four ports are matched, the device shall be a directional coupler. **(Nov/Dec 13)**

3. i. Distinguish between E-plane and H-plane Tees and hence discuss the construction and working of a Magic-Tee
ii. Write a note on different types of attenuators used in microwave frequency range. **(Dec 12)**

4. i. With reference to a 4-port symmetrical 2-hole coupler, define and distinguish between the terms : Coupling, Directivity, Isolation and Insertion Loss. How can this coupler be configured as a forward directional coupler? How can the coupling be varied in this case?
ii. List out the output characteristics of a Magic Tee, when
a. in-phase inputs are fed at both the main arm ports, and
b. input is fed at the series arm port. **(Nov 11)**

5. i. With neat schematics, explain the need and functioning of a Matched Waveguide Load. What should be its reflection coefficient and VSWR?
ii. With neat sketches, account for the differences in transmission characteristics of 3-port Series and Parallel Tee Junctions. **(Nov 11)**

6. i. What is the need for phase shifters at microwave frequencies? Explain the concept of realizing phase shifting through Dielectric Materials.
ii. List out the 3 Theorems associated with the 3-port Tee Junctions, and mention their applications.**(Nov 11)**

7. i. Describe the characteristic features and mention the applications of:
a. Resonant Windows,
b. Tuning Screws and Posts.
ii. What is a Directional Coupler? List out two different types of couplers, identifying the phenomenon of coupling, and compare their requirements and demerits. **(Nov 11)**

8. i. Derive the expression for the coupling and directivity of a two hole directional coupler.
ii. There are two identical directional couplers connected back to back to sample incident and re ected powers. The outputs of the couplers are 12 mW and 0.12 mW respectively. What is the VSWR in the guide. **(May 10)**

9. i. Describe wave guide matching terminations with neat sketches.

ii. Explain for what purpose the posts and screws are used in wave guide. **(May 10)**

10. i. Sketch a 4 port hybrid junction and justify that it is a basically a 3 dB directional coupler.
    ii. A matched generator with a power of one watt is connected to the H arm of magic tee C (port 4). The E arm (port 3) is match terminated and the length of the coplanar arms is the same. Compute the power delivered to the termination at port 1, 2 and 3 and the power reacted at port 4 when ports 1 and 2 are match terminated.

(May 10)

11. i. Draw E - plane Tee diagram and state its properties.
    ii. Explain the principle of Ferrite phase shifter. **(May 09)**

12. i. What is the magic associated with a Magic tee? Illustrate its applications. **(May 09)**
    ii. Discuss how wave equatio ns are useful in understanding the propagation of EM waves in wave guides.

13. i. Explain the operation of a directional coupler with the help of a sketch, showing the field lines at the junction.
    ii. A 20 dB coupler has a directivity of 30 dB. Calculate the value of isolation. **(May 09)**

14. i. How is magic Tee different from hybrid ring Compare their characteristics? **(May 09)**
    ii. Write short notes on "Rotary vane Attenuator"

15. i. Show the attenuation produced by rotary vane attenuator is given by-40 log (sin)
    ii. Describe in detail about linear phase changer. **(May 09, Sep, May 08)**

16. i. Sketch a 4 port hybrid junction and justify that it is a basically a 3 dB directional coupler.
    ii. A matched generator with a power of one watt is connected to the H arm of magic tee C (port 4). The E arm (port 3) is match terminated and the length of the coplanar arms is the same. Compute the power delivered to the termination at port 1, 2 and 3 and the power reflected at port 4 when ports 1 and 2 are match terminated. **(Sep, May 08)**

17. i. Derive the expression for the coupling and directivity of a two hole directional coupler**.(Sept 08)**

18. i. With a schematic diagram, explain the construction of a micro strip line.
    ii. Mention the advantages of strip lines over other transmission lines. **(Sep 08)**

19 Write short notes on:
    i. Wave guide Irises
    ii. Rat Race hybrid.
    iii. Dielectric phase shifters. **(May 08)**

20. i. What is magic Tee? Describe the properties of magic Tee, giving its S-Matrix.
    ii. Show a wave-guide with cylindrical post and describe its behavior. How can it be used, when it is inserted half way into the wave-guide? **(May 08)**

21. i. Why 'Ferrites' are used in microwave passive devices? Explain.
    ii. Scattering matrix is a unitary matrix. Prove this statement. **(May 08)**

22. i Explain the difference between
    i. E plane Tee ii. H- Plane Tee
    Explain clearly why do you call them series and parallel Tee respectively.
    ii Describe with a neat sketch a precision Attenuator, and Explain its operation **(May 07)**

23 i. Sketch a 4 port Hybrid junction. Justify that it is basically a 3 dB directional coupler.

ii. A 2o mW signal is fed into the series arm of a loss less magic tee junction. Calculate the power delivered through each port when other ports are terminated in matched load. **(Sep 07)**

24. i. State the properties of E plane Tee and H plane Tee.
    ii. Show that a symmetrical magic Tee is a 3dB directional coupler **(May 05, Sep 07)**

25. Write short notes on the following.
    i. Directional coupler.
    ii. Wave guide windows.
    iii. Flap attenuator. **(Sep 07, May 07, 06,05)**

26. Explain the construction, operation and applications of the following microwave components.
    i. Directional couplers.
    ii. Wave guide Tees. **(May 07)**

27. i. Derive the expressions for coupling factor and directivity of a two hole directional coupler.
    ii. What are the different types of matching elements normally used in wave guide system? Distinguish between magic Tee and rat race hybrid. **(May 07)**

28. i. Discuss and compare the characteristics of E-plane Tee and H-Plane Tee.
    ii. Write short notes on "Inductive and capacitive posts". **(Sep 06,May 05)**

29. Write short notes on the following.
    i. Multi hole directional coupler.
    ii. Rotary phase shifter. **(Sep 06)**

30. i. What is a directional coupler? A 20dB coupler has a directivity of 30dB. Calculate the value of isolation, defining all the terms involved.
    ii. Explain the functioning of "rotary Vane attenuators". **(Sep 06,May 05)**

UNIT-IV

1. i. Derive the scattering matrix of H- plane Tee?
   ii. What are the properties of S matrix? Derive the scattering matrix for a 3 port circulator? **(Nov13)**

2. i What are the properties of ferrites at microwave frequencies? What is Faraday rotation? Show that it is a non-reciprocal phenomenon.
   ii. List the basic characteristics of a circulator. Discuss any one type. Obtain its S matrix**.** **(Nov/Dec13)**

3. i. What is a scattering matrix? Discuss the importance of S-parameters. List the properties of S-matrix.
   ii. What is Faraday Rotation Principle? List the properties of ferrites in the working of an isolator.
   iii. Build the S-matrix of E-[lane Tee Junction. **(Dec 12)**

4. i. Establish the Scattering Matrix for a 3-port circulator.
   ii. A matched Isolator has an Insertion Loss of 0.6 dB and an Isolation of 20 dB. Obtain its S-matrix and input VSWR. **(May 11)**

5. i. With reference to a 4-port symmetrical 2-hole coupler, define and distinguish between the terms: Coupling, Directivity, Isolation and Insertion Loss. How can this coupler be congrued as a forward directional coupler? How can the coupling be varied in this case?
   ii. List out the output characteristics of a Magic Tee, when
   i. in-phase inputs are fed at both the main arm ports, and
   ii. input is fed at the series arm port. **(May 11)**

6. i. A 2-port Reciprocal Junction has an Impedance Matrix with Z11 = Z22 = 4.0, and Z12 = 2.0. Find its S-Matrix.
   ii. Explain the Unitary Condition for S-Matrix, and establish the same for a n-port microwave junction, citing the requirements. **(May 11)**

7. i. What is the need for phase shifters at microwave frequencies? Explain the concept of realizing phase shifting through Dielectric Materials.
   ii. List out the 3 Theorems associated with the 3-port Tee Junctions, and mention their applications. **(May 11)**

8. i. Explain the significance of the S-Matrix and its elements. What happens if it is reciprocal and unitary ?
   ii. Explain the functioning of an Isolator with neat schematics. **(May 11)**

9. i. Discuss propagation of microwave energy in ferrites.
   ii. A matched isolator has insertion loss of 0.5 dB and isolation of 25 dB. Find the scattering coefficients. **(May 10)**

10. i. Explain the properties of scattering matrix.
    ii. Determine scattering matrix for the following junction as shown in figure **(May 10)**

11. i. Derive the S parameters for a two port microwave junction.
    ii. Prove that any lossless, matched, non reciprocal three port microwave junction is a perfect three port circulator. **(May 10)**

12. i. Scattering matrix is a unitary matrix. Prove this statement.
    ii. Obtain the S - matrix for a magic Tee with respect to its properties. **(May 10)**

13. i. What are the properties of ferrite material for applications at microwave frequencies? Explain the principle of ferrite phase shifter.
    ii. State and prove the S - matrix properties of a lossless junction. **(May 09)**

14. i. What are ferrites? What property do they have different from ordinary conductors and insulators?
    ii. What is scattering matrix? Explain the significance of S - matrix. **(May 09)**

15. i. Explain Faraday rotation with a neat diagram? Explain the working of ferrite isolator.
    ii. Give the scattering matrix of 3 port circulator. The scattering variables measured at a port are $a = 5 + j2$ and $b = 2 + j2$
    The normalizing impedance $Z_0 = 50$ ohms. Calculate the voltage and current. **(May 09)**

16. i. What is scattering matrix? Derive the S matrix of the two port junction shown in figure7b
    ii. Explain the principle of operation and characteristics of ferrite phase shifters. **(May 09)**

17. i. Obtain the S-Matrix of an ideal 3dB directional coupler.
    ii. Write short notes on “Ferrite Devices”. **(May 09,Sep 07)**

18. i. Sketch a 4 port Hybrid junction. Justify that it is basically a 3 dB directional coupler.
    ii. A 20-mw signal is fed into the series arm of a loss less Magic Tee junction. Calculate the power delivered through each port when other ports are terminated in matched load. **(May 09,Nov 05)**

19. i. Describe microwave component which makes use of Faraday rotation principle.
    ii. What are the advantages of scattering matrix representation over impedance or admittance matrix representation? **(May 08)**

20. What is Faraday rotation? Explain the working of a ferrite circulator with neat sketches. How can it be used as an isolator? **(May 08)**

21. i. What is Faraday rotation? Explain how a three port circulator operates.
    ii. Write short notes on "Properties of S - matrix". **(May09,08, 06,05)**

22. i. Derive the S matrix for series Tee using the properties of S parameters. **(Sep 08, May 05)**
    ii. A three port circulator has an insertion loss of 1 dB, isolation 30 dB and VSWR = 1.5. Find the S matrix.

23. i. Explain the principle of operation of an isolator? What is the significance of using isolator in microwave circuits?
    ii. Why are S - parameters used at microwave frequencies explain. Give the properties of S -parameters. **(Sep 08)**

24. What is a Gyrator? Describe how isolators can be realized by using Gyrators and Hybrids. Give the S matrix for ideal Gyrators. **(Sep 08)**

25. i. Explain the characteristics of ferrite materials.
    ii. Derive the S - matrix for 4 port directional coupler when the coupling factor is 3dB. **(May 08)**

26. i. Explain the working of two hole directional coupler with a neat diagram.
    ii. Explain about E plane Tee junction with a neat sketch. Why it is called a series Tee? **(May 08)**

27. i. Enumerate the properties of S parameters.
    ii. Formulate the S parameter matrix of a 4 port circulator. **(May 08)**

28. i. Derive the expressions for coupling factor and directivity of a two hole directional coupler.
    ii. What are the different types of matching elements normally used in wave guide system? Distinguish between magic Tee and rat race hybrid. **(May 08)**

29. Explain the construction, operation and applications of the following microwave components.
    i. Circulator
    ii. Gyrator. **(May 08, 06, 05)**

30. i. Derive the S matrix for E-plane Tee.
    ii. What is Faraday's Rotation? What are its applications in microwaves? Explain in detail. **(Sep 07)**

31 Find the scattering coefficients for an ideal directional coupler having a coupling coefficient C=3 dB. **(IES 91)**

32. A two port non-reciprocal device which produces minimum attenuation EM wave propagation in one direction and a very high attenuation in opposite direction is generally known as. **(IES 03)**

UNIT-V

1. i. Explain the principle of operation of a two cavity klystron with a neat diagram?
   ii. The operating frequency of a reflex klystron is 5 GHz, it has a DC beam of 250V, a repeller spacing of 0.1 cm for 1 43mode. Determine the maximum value of power and the corresponding repeller voltage for a beam current of 60mA. **(Nov 13)**

2. i. Draw the schematic diagram of a reflex klystron. Explain its operation. Draw the power output and frequency characteristics of a reflex klystron and explain.
   ii. Derive an expression for the maximum efficiency of a reflex klystron oscillator. **(Nov/Dec13)**

3. i. What are limitations of conventional tubes at microwave frequencies?
   ii. Discuss in detail bunching process for a two cavity Klystron amplifier and obtain expression for bunching parameter.

iii. What are the performance characteristics of a klystron amplifier? **(Dec 12)**

4. i. With reference to 2-Cavity and Single Cavity Klystrons, compare the following
   i. Bunching Parameters, and their optimum values for maximum efficiency,
   ii. Types of Cavities used,
   iii. Grid Interceptions, and
   iv. Type of energy delivered in the output cavities.
   ii. List out the microwave applications of 2-Cavity Klystrons and Reflex Klystrons. **(May 11)**

5. i. Derive the expression for the beam current of a 2-Cavity Klystron Amplifier, and hence evaluate its power output and maximum electronic efficiency.
   ii. A Reflex Klystron has a dc beam voltage of 2500 V, repeller-cavity spacing of 6 mm. Find the repeller voltages for the tube to oscillate at 3 GHz, in 1 3/4 and 2 3/4 modes, and the corresponding maximum permissible efficiencies. **(May 11)**

6. 1. List out the expressions for the Zin , Yin and Gain-Bandwidth Product of conventional tubes at UHF. What happens to the resulting circuits at still higher frequencies ?
   ii. Write short notes on Electronic Admittance of a Reflex Klystron tube, and its significance. **(May 11)**

7. i. With a neat velocity diagram, explain the process of energy transfer in 2-cavity Klystron cavities, and account for the signal amplification.
   ii. A Reflex Klystron operates at Vo = 300 V; Vr = -500 V and f = 10 GHz. If it is to operate in the same mode at a frequency of 9.5 GHz, find the re ector voltage required (no derivations needed). **(May 11)**

8. i. Derive the expression for bunching parameter of reflex klystron
   ii. A reflex klystron operates at the peak of n = 2 mode. The dc power input is 40mV. If 20% of the power delivered by the beam is dissipated in the cavity walls, find the power delivered to the load. **(May 10)**

9. i. Give the analysis of reflex klystron & derive the expression for repeller voltage V_r in terms of l,n & V_a.
   ii. Explain clearly the classification of microwave sources. **(May 10)**

10. i. A reflex klystron has following parameters: V_0 = 3000V; L = 5mm; f = 2GHZ:
    Calculate the repeller voltage for which the tube can oscillate in mode.
    ii. Give the quantitative analysis of electron bunching in two cavity klystron. **(May 10)**

11. i. The parameters of a two cavity klystron are
    V_b = 900v: Rd = 30k ohm; I_b = 20mA; f = 32GHZ d = 10^{-3}m:
    Determine
    a. Electron velocity
    b. Transit angle
    c. Beam coupling coefficient
    ii. Draw the voltage characteristics of Reflex klystron & explain. **(May 10)**

12. i. A reflex klystron operates with V_b = 400V, R_{sh} = 20kΩ, f = 9GHZ, L = 10^{-3}m. n = 2. Find the repeller voltage & electronic efficiency.
    ii. Derive the expressions used in the above problem. **(May 09)**

13. i. Derive the expression for output power & Efficiency of a 2 cavity klystron. (b) In a two-cavity klystron the parameters are input power = 10mv, voltage gain = 20dB, R_{sh} of input cavity = 25k **Ω**, R_{sh} of output cavity = 35k - , load resistance =40k - . Find the input voltage, output voltage & power to the load. **(May 09)**

14. i. Discuss the applications of microwaves. What are the limitations of conventional tubes at UHF.
    ii. Derive an expression for the efficiency of a two-cavity Klystron amplifier. Show that the theoretical efficiency is 58%. **(May 09)**

15. i. Discuss in detail about lead inductance and inter electrode capacitance effects of conventional tubes at microwave frequencies.
    ii. What is electronic Admittance? Discuss its significance and the mode patterns of Reflex Klystron Oscillator.

(May 09)

16. i. A reflex klystron operates at the peak mode of n = 2 with
    Beam voltage V_0 = 300v
    Beam current I_0 = 20mA
    Signal Voltage V_1 = 40v.
    Determine:
    a. Input power in watts.
    b. Output power in watts.
    c. The efficiency.
    ii. Derive the relation between accelerating voltage V_0 , repeller voltage V_R & repeller space L

(May 09Sep 08)

17. i. In a circular Magnetron, a=0.10m, b=0.40m, = 1.0 mT, V_b=5KV. Find the Hulls Cut-off Voltage & cut-off magnetic flux density.
    ii. Compare & contrast TWT & Klystron amplifier. **(May09, 08)**

18. i. Explain in detail bunching process & obtain expression for bunching parameter in a two cavity klystron amplifier.
    ii. A reflex klystron is to be operated at a frequency of 10GHZ. With dc beam voltage 400v.
    Repeller spacing 0.1cm for mode. Determine the maximum value of power & corresponding repeller voltage for beam current of 30mA. **(May 09, 08)**

19. i. Compare "Drift space bunching" and "Reflector bunching" with the help of Applegate diagrams.
    ii. A reflex Klystron operates at the peak of n=1 or 3/4 mode. The dc power input is 40mW and ratio of V1 to V_0 is 0.278.
    i. Determine the efficiency of the Reflex Klystron Oscillator
    ii. Find the total power output in mW.
    iii. If 20% of the power delivered by the electron beam is dissipated in thecavity walls, find the power delivered to the load.. **(May 09,Sep 07)**

20. i What is velocity modulation? Explain how amplification takes place in a twocavity Klystron amplifier.
    ii. What is transit time? How it is made use of in realization of microwave tubes. **(May 09,Sep 07)**

21. i. A reflex klystron has following operators:
    V_0 = 800v, L = 1.5mm., R_{sh} = 15k - 2, f = 9GHZ. Calculate
    a. The repeller voltage for which the tube can oscillate in
    b. The direct current necessary to give a microwave gap voltage of 200V
    c. Electron efficiency

    ii. Name different methods of generating microwave power. Describe the necessary theory & working of reflex klystron.. **(Sep 08)**

22. i. Give the analysis of reflex klystron & derive the expression for repeller voltage V_r interms of l, n &V_a
    ii. Explain clearly the classification of microwave sources **(Sep 08)**

23. i. A reflex klystron operates under the following conditions:
    V_0 = 600v, I_0 = 11.45mA, L = 1mm.
    R_{sh} = 15k - 2, f_r = 9GHZ.
    The tube is oscillating at fr at the peak of n = mode.
    Assume Find

a. The microwave gap voltage.
b. Repeller Voltage for the mode

ii. Draw the equivalent circuit of reflex klystron & explain about the electronic admittance of it. **(May 08)**

24. i. Explain the gain Bandwidth product limitation & Transit angle effects in conventional tubes at microwave frequencies.

ii. A reflex klystron operates under the following conditions
V = 900v, L = 1mm
R_{sh} = 25k - 2, , f_r = 9GHZ
The tube is oscillating at fr at the peak of n =2 mode or n = mode.
Assume that the transit time through the gap & beam loading can be neglected.
i. Find the value of repeller voltage Vr.
ii. Find the D.C. current necessary to give a microwave gap voltage of 100v.
iii. What is the electronic efficiency under this condition? **(May 08)**

25. i. In a circular Klystron , a=0.10m, b=0.40m, = 1.0 mT, Vb=5KV. Find the Hulls Cut-off Voltage & cut-off magnetic flux density.

ii. Compare & contrast TWT & Klystron amplifier. **(May 08)**

26. i. Discuss various losses that occur at UH frequencies and suggest theremedies.

ii What is velocity modulation? How is it different from normal modulation?Explain how velocity modulation is utilized in Klystron amplifier. **(Sep 07)**

27. Explain the construction, operation and applications of the following microwave components.

i. Circulator

ii. Gyrator. **(May 07,Sep 06,May,May 05)**

28. i. Write short notes on "Two cavity Klystron oscillator".

ii. Derive the expression for trans-admittance of Reflex Klystron Oscillator and explain the condition of oscillation from admittance spiral. **(May 07)**

29. i. Discuss the advantages of microwaves over low frequencies.

ii. A two cavity Klystron amplifier has the following parameters.
V0 = 1200V, I0 = 25mA, Ro = 30 K, f= 10GHz, d= 1 mn, L = 4 cm, Rsh= 30 Calculate
i. the input voltage for maximum output voltage
ii. The Voltage gain in decibels
iii. Efficiency. **(May 07)**

30. i Explain clearly the different high frequency effects in electron tubes and show how these are eliminated in the design of a high frequency microwave tube.

ii. The bunching grids of a Klystron amplifier are 2 mm apart. The beam voltage is 2KV and the drift space is 2.8 cm. Long. What must be the value of the RF voltage at the bunching grid to produce maximum fundamental components of the current at the catcher? Assume the operating frequency 2.8 GHz. On what factors does the bunching parameter depend upon?. **(May 07)**

UNIT-VI

1 .i. Explain why there are four propagation constants in TWT and derive equations to these propagation constants.

ii. Explain the π mode operation of magnetron. How to separate it from other modes? **(Nov13)**

2. i. Describe the structure of an O-type TWT and its characteristics, then explain how it works. Obtain an expression for the gain of a TWT amplifier.

ii. Write a note on slow wave structure used in TWT. **(Nov/Dec13)**

3. i. Give the Hull cutoff and Hartree conditions of Cylindrical Magnetron.
   ii. What is a slow wave structure? List the different slow wave structures. Mention their relative merits and demerits.
   iii. Explain how amplification takes place in a TWT. **(Dec 12)**

4. Describe the mechanism of interaction between electrons and fields, and account for the energy delivery and build up of oscillations in a Cylindrical Magnetron, with neat sketches. **(May 11)**

5. i. With neat sketches, describe the constructional requirements of an N cavity Cylindrical Magnetron tube and associated electrode arrangement for π/2 mode of resonance.
   ii. A TWT works at an efficiency of 30% with an Output power of 270W, at V_0 =4.5kV. Determine I_0, Gain parameter and phase constant at 8.0 GHz, if its circuit length is 40cm and helix impedance is 16 ohms. Explain the relations used. **(May 11)**

6 i. Explain the need for mode separation in Magnetrons, and list out the different methods of mode separation.
   ii. For TWT amplifier having V_0=2000V, I_0=4mA, Z_0=25 ohms, circuit length=45, find the Gain parameter, Power Gain and Phase constant e at 9.0GHz. How many propagation constants exist in this case, and why? **(May 11)**

7. i. Explain how mode separation takes place in magnetron.
   ii. A pulsed cylindrical magnetron is operated with following parameters: Anode Voltage =25KV
   Beam current = 25A, Magnetic density = 0.34 wb/m2, Radius of Cathode cylinder = 5cm
   Radius of Anode cylinder =10cm
   Find Angular frequency **(May 10)**

8. i. Explain the working Magnetron with mode oscillation.
   ii. A magnetron operates with following parameters: V_o =25KV, I_o=25A, diameter of Cathode = 8cm, Radius of vane edge to Center =8 cm, B=0.34 T. Find the Cyclotron frequency & cutoff Voltage. **(May 10)**

9. i. Explain the construction &working of 8-cavity cylindrical magnetron.
   ii. Explain PI mode operation &mode separation. **(May 10)**

10. i. Give different types & explain the characteristics of slow wave structures.
    ii. A TWT operates with following parameters: Vb=2.5KV, Ib=25mA, Zo=10, circuit length,L=50,f=9GHz Find the gain parameter & power gain. **(May 10)**

11. i. Derive the Hartree anode Voltage equation for linear magnetron.
    ii. A linear magnetron has following operating pars:
    Vo=15KV, Io=1.2A,f=8GHZ, Bo= 0.015 wb/m2, d= 5CM,h=2.77CM. Calculate
    a. Electron velocity at hub surface
    b. phase velocity for synchronism
    c. Hartree anode Voltage. **(May 09,Sep 08)**

12. i. A Magnetron operates with following parameters
    Vo=25KV
    Io=25A
    Bo=0.34T
    Diameter of cathode =8cm,
    Radius of vane edge to centre= 8cm.
    Find the cyclotron frequency and cut off voltage.
    ii. Compare magnetron and reflex klystron. **(May 09)**

13. i. Explain the terms:
    a. Strapping
    b. Frequency pushing

c. Frequency Pulling.

ii. Derive a simple relation for frequency of oscillation for magnetron in terms of mode number of oscillation and angular velocity or electrons. **(May 09)**

14. i. A helix traveling wave tube is operated with a beam current of 300 mA, beam voltages of 5 KV and characteristic impedance of 20 Ohm. What length of the helix will be selected to give a output power gain of 50 dB at 10 GHz.

ii. Explain how the amplification takes place in TWT. Compare its bandwidth with Klystron amplifier.. **(May 09,08)**

15. i. With the aid of neat sketches, describe the construction and operation of TWT.

ii. Starting with the assumption that there are three forward traveling waves in TWT, derive an expression for power gain of the tube. **(May 09, 08**

16. i. What is a slow wave structure? Explain and differentiate between different structures.

ii. Explain the working principle of TWT amplifier.. **(May 09,Sep 07)**

17. i. A magnetron is operating in the mode and has the following specifications, N=10, f= 3MHz, a = 0.4cm, b= 0.9 cm, l = 2.5 cm, V0 = 18 KV, B = 0.2wb/m2.

Determine

i. the angular velocity of the electron.

ii. The radius at which radial forces due to electric and magnetic fields are equal and opposite.

ii. What are Hatree harmonics? Explain in detail. **(May 09,Sep 07)**

18. i. What is a cylindrical Multi-cavity Travelling wave magnetron oscillator? Explain.

ii. Write short notes on "Hatree resonance condition" **(May 09, 07)**

19. i. Explain how magnetron is different from Reflex Klystron both being oscillators.

ii. Explain about Hull cut off voltage and Hull cut off magnetic flux density in a circular magnetron. **(May 09,Nov 05)**

20 i. Draw a labeled schematic diagram of Helix TWT & show that output power gain of TWT is G = -9.54 + 47.3 NC db

ii. A TWT has the following parameters V_o=3KV, I_o = 4mA, f = 10 GHz, Z_o = 30 & N=50. Calculate the

a. Gain parameter

b. Power gain in db **(Sep 08)**

21. i. A TWT operates under following parameters:

Beam Voltage V_o=3KV, Beam current I_o = 30mA, characteristic Impedance of helix Z_o=10 ohm ,circuit length , N=50 & frequency f =10 GHz. Determine

a. Gain parameter

b. output power gain in dB &

c. all four propagation constants .

ii. Explain why there are four propagation constants in TWT & derive equations to these propagation constants. **(Sep 08)**

22. i. Give the different types & explain the characteristics of slow wave structure.

ii. A TWT operates with following parameters: V_b=2.5KV, I_b=25mA, Z_o=10 ohm, circuit length, L=50, f=9GHz

Find the gain parameter & power gain. **(Sep 08)**

23. i. What is a cavity resonator? Discuss the applications of cavity resonators.

ii. Describe the method of designating the modes of transmission in rectangular waveguides. Why is transmission in the dominant mode most often used in waveguides? **(May 08)**

24. i. Give the different types & explain the characteristics of slow wave structure.

ii. A TWT operates with following parameters:

V_b=2.5KV, I_b=25mA, Z_o=10 , circuit length, L=50,f=9GHz

Find the gain parameter & power gain. **(May 08)**

25. i The linear magnetron has the following parameters: **(May 08)**
V_0=32LV. I_0=60A, f=10GHz, B_0=0.01Wb/m^2, d=6cm.
Find.
a. Electron velocity at the hub space.
b. Phase velocity for synchronization.
c. Hatee anode voltage.
ii. Describe the effect of dc axial field on the electrons traveling from cathode to anode of a magnetron & describe the combined effect of the axial magnetic field & radial dc field. Define the cutoff field.

26. i. Draw neatly the cross section of a 8 cavity magnetron and explain the mechanism of oscillations.
ii. For a magnetron a= 0.6 m, b = 0.8m, N=16, B= 0.06T, f= 3 GHz and V_0 =1.6 KV. Calculate the average drift velocity for electrons in the region between cathode and anode. **(May 08)**

27. i. A magnetron is operating in the mode and has the following specifications, N=10, f= 3MHz, a = 0.4cm, b= 0.9 cm, l = 2.5 cm, V0 = 18 KV, B = 0.2 wb/m^2.
Determine:
a. the angular velocity of the electron.
b. The radius at which radial forces due to electric and magnetic fields are equal and opposite.
ii What are Hatree harmonics? Explain in detail. **(May 08)**

28. i. What is magnetron? How it is different in principle of operation from that of Backward wave oscillator.
ii. What is meant by wheel spoke bunching. Explain in detail. **(May 08)**

29. i What is a slow wave structure? Explain and differentiate between different structures.
ii. Explain the working principle of TWT amplifier. **(Sep 07)**

30. i. Distinguish between different types of slow wave structures. Why is a slow wave structure used in TWT?
ii. Compare the performance characteristics applications and limitations of Klystron amplifiers, TWT amplifiers and parametric amplifiers. **(Sep, May 07)**

UNIT-VII

1. i. Explain the construction of GUNN diode using RWH theory.
ii. What is TRAPATT diode and explain the principle of operation. **(Nov13)**

2. i. Explain about Transferred electron devices. Describe different modes of operation of Gunn diode.
ii. Compare Avalanche transit time devices. **(Nov/Dec13)**

3. i) Explain the principle of operation of the Gunn diode as an oscillator.
ii) Describe the principle of operation of avalanche Transit Tim Devices. Explain the operation of IMPATT **(Dec 12)**

4. i. Give typical examples of materials that produce Bulk Negative Differential Resistance Effect. Hence characterize their four basic modes of operation.
ii. Sketch the doping profile of a double drift region IMPATT diode and identify the doping concentrations. **(May 11)**

5. i. Mention the High Field Domain properties of GaAs dioe. How are they useful?
ii. List out the applications of Gunn and TRAPATT diodes. **(May 11)**

6. i. A cylindrical magnetron is operating at a power output of 80 kW, anode voltage of 10 kV, and anode current of 20 A. Find its efficiency, cut-off magnetic field and voltage, if B = 200 mWb/sq.m. and the radii of the cathode and anode are 4 cm., 8 cm. respectively.

ii. Explain the need for an attenuator in a TWT amplifier. How is it positioned? **(May 11)**

7. i. Explain the nature and basic features of Transferred Electron Devices, citing examples for microwave considerations.
   ii. Describe the physical structure of an IMPATT diode, identifying its doping profile characteristics. **(May 11)**
8. i. Describe the Gunn Effect Phenomenon, illustrating the schematics for a Gunn Diode and explain its `drift velocity-field' characteristics.
   ii. Compare the power output, efficiency and frequency of operation of IM- PATTs and TRAPATTs. **(May 11)**
9. i. A Ku-band IMPATT diode has a pulse operating voltage of 100V and a pulse operating current of 0.9 A. The efficiency is about 10%. Calculate
   a. The output power
   b. The duty cycle if the pulse width is 0.01ns and frequency is 16 GHz.
   ii. Describe the principle of operation of IMPATT diode. **(May 10)**

10. i. Draw the characteristics of TRAPATT diode and explain their shape.
    ii. Explain different types of modes for uniformly doped bulk diodes with low resistance contacts. **(May 10)**

11. i. Explain the J-E characteristica of a gunn diode.
    ii. Explain the construction, fabrication and encapsulation of gunn diodes. **(May 10)**

12. i. Derive the criterion for classifying the modes of operation for Gunn effect diodes
    ii. An n-type GaAs Gunn diode has following parameters
    Electron drift velocity: Vd = 2.5 x 105m/s
    Negative Electron mobility: n = 0.015 m2/ v s
    Relative dielectric constant: = 13.1
    Determine the criterion for classifying the modes of operation. **(May 10)**

13 i. Explain Gunn effect using the two valley theory.
   ii. Differentiate between transferred electron devices and transistors. **(May 09)**

14. i. Compare IMPATT and TRAPATT diodes.
    ii. Derive the criterian for classifying the modes of operation for gunn effect diodes. **(May 09)**

15. Write short notes on:
    i. Non degenerate parametric amplifier
    ii. Domains in a GUNN diode.
    iii. Applications of Masers. **(May 09)**

16. i. What is a TRAPATT diode? How is it better than IMPATT diode?
    ii. What is parametric amplifier? Explain its operation in detail. **(May 09)**

17. i. Discuss the principle of “MASER” and its applications.
    ii. Write short notes on “Parametric Amplifier”. **(May 09)**

18. i. Derive the criterion for classifying the modes of operation for Gunn effect diodes
    ii. An n-type GaAs Gunn diode has following parameters
    Electron drift velocity $V_d = 2.5 \times 10^5$m/s
    Negative Electron mobility = 0.015 m2/ v s
    Relative dielectric constant $\varepsilon_r = 13.1$
    Determine the criterion for classifying the modes of operation. **(May 09,Sep, May 08)**

19. i. Discuss in detail how negative resistance region appears in the characteristics of a GUNN diode.
    ii. What is transferred electron effect? Explain LSA diode along with its applications. **(May 09, 07)**

20. i. A Ku-band IMPATT diode has a pulse operating voltage of 100V and a pulse operating current of 0.9 A. The efficiency is about 10%. Calculate
a. The output power
b. The duty cycle if the pulse width is 0.01ns and frequency is 16 GHz.
ii. Describe the principle of operation of IMPATT diode. **(Sep, May 08)**

21. i. A Ku-band IMPATT diode has a pulse operating voltage of 100v and a pulse operating current of 0.9 A. The efficiency is about 10%. Calculate
a. The output power
b. The duty cycle if the pulse width is 0.01ns and frequency is 16 GHz.
ii. Describe the principle of operation of IMPATT diode. **(Sep 08)**

22. i. An IMPATT diode has drift length of 2 ¼m. Determine
a. Drift time of the carriers
b. Operating frequency of IMPATT diode.
ii. Compare IMPATT and TRAPATT diodes. **(Sep 08)**

23. i. Derive the equation for power output & efficiency of IMPATT diode.
ii. Determine the conductivity of n-type GaAs Gunn diode if
Electron density $n = 10^{18}$ cm^{-3}
Electron density at lower valley $n_l = 10^{10}$ cm^{-3}
Electron density at upper valley $n_u = 10^{8}$ cm^{-3}
Temperature $T = 300^0K$ **(Sep 08)**

24. i. Write short notes on "LSA mode in GUNN diode".
ii. How is it possible to exhibit negative resistance characteristics in an IMPATT diode? **(May 08)**

25. i. Describe a non-degenerate negative resistance parametric amplifier.
ii. An N type Ga As GUNN diode has the following specification **(May 08)**
Threshold field: 3KV/m
Applied field 3.5KV/m
Device length 10 micrometers
Doping Constant 10^{14} electron/ Cm^3
Operating freq. 10 GHz
Calculate the current density and (-Ve) electron mobility in the device, explaining the relations used.

26. i. Explain the Gunn Effect based on two valley model theory.
ii. Write short notes on "TRAPATT diode". **(May 08)**

27. i. Explain the physical structure and construction of IMPATT diodes.
ii. Draw the graph between negative resistances versus transit angle and explain its Shape. **(May 08)**

28. i. What are bulk properties of a GUNN diode that give rise to negative resistance like characteristics?
ii. A Ga As Gunn diode has an active region of 10 micro meters. If the electron drift velocity is 105 m/sec., calculate the natural frequency and the Threshold voltage. The critical electric field is 3 KV/cm. **(Sep 07)**

29 An N type Ga As GUNN diode has the following specification
Threshold field: 3KV/m
Applied field 3.5KV/m
Device length 10 micrometers
Doping Constant 10^{14} electron/ Cm^3
Operating frequency. 10 GHz
Calculate the current density and (-Ve) electron mobility in the device, explaining the relations used.

(Sep 07,May 06)

30. Briefly explain the basic operating mechanism of TRAPATT diode with sketch. Why is the drift though this diode much slower than through a comparable IMPATT diode? What implications does this have for the operating frequency range of the TRAPATT diode? **(Sep 06)**

UNIT-VIII

1. i. How to measure an attenuation of a given microwave signal?
   ii. What is VSWR? Explain the method measurement for low and high VSWR? (**Nov13)**

2 i. With the help of a neat sketch, briefly explain the functions of different blocks of a microwave bench.
   ii. Explain about measurement of attenuation using a microwave bench setup**.** **(Nov/Dec13)**

3. i. Give the procedure for the measurement of Attenuation of a given component.
   ii. Explain the VSWR measurement procedure in microwave laboratory with a suitable set up. **(Dec 12)**

4. i.. Explain the significance of a Waveguide Slotted Line, and describe its functional features.
   ii. Account for the different types of errors associated with the measurement of VSWR using a slotted line set up. **(May 11)**

5. i. Distinguish between the terms: Insertion Loss and Attenuation. With a neat set up, describe the method of measurement of attenuation using a waveguide bench.
   ii. Write short notes on usage of Isolator and its significance in a microwave bench. **(May 11)**

6. i. Define the term Q factor for a cavity, and explain the measurement of Q of a Cavity by VSWR measurement, with neat schematics.
   ii. Derive all the necessary relations used in the above method, and explain the VSWR versus frequency characteristics. **(May 11)**

7. With reference to waveguide slotted line measurements, explain the significance and utility of the following
   i. Tunable Probe,
   ii. Crystal Detector,
   iii. Use of dc ammeter at microwave frequencies,
   iv. Waveguide Matched Termination. **(May 11)**

8. i. Two identical 30dB directional couplers are used to sample incident and reflected power in a wave guide. VSWR=2 and the output of the coupler sampling incident power=4.5mW.What is the value of reflected power.
   ii. Describe a microwave bench. **(May 10)**

9 i. Write a short notes on power ratio method.
   ii. Write short notes on RF substitution method. **(May 10)**

10. i. An un-modulated microwave source is connected to a bolometer mount and an appropriate power meter. The microwave power level reads as 25 mW. When an attenuating device is inserted between the source and the bolometer, the power reading falls to 5mW. What is the amount of attenuation (in decibels) provided by the device?
    ii. Explain with neat block diagram the operation of spectrum analyzer. **(May 10)**

11. i. Two identical directional couplers are placed in a waveguide to sample the incident and the reflected power. The meter readings show that the power level of the reverse coupler is 10dB down from the level of the forward coupler. What is the value of the SWR on the waveguide?
    ii. How are microwave measurements different from low frequency measurements? **(May 10)**

12. i. How are microwave measurements different from low frequency measurements?
    ii. What is the average power of a periodic wave if the peak power is 1300 W and the pulse width is .56 and periodic frequency of the wave is 1500 Hz. **(May 09,Sep, May 08)**

13. i. What type of precautions are needed while doing microwave measurements?
    ii. Explain the method of microwave power measurement using Bolometer. **(May 09)**

14. i. Write a short notes on the measurement of medium microwave power.
    ii. Write short notes on the measurement of high VSWR. **(May 09)**

15. i. Two identical directional couplers are placed in a waveguide to sample the incident and the reflected power. The meter readings show that the power level of the reverse coupler is 10dB down from the level of the forward coupler. What is the value of the SWR on the waveguide?
    ii. How are microwave measurements different from low frequency measurements? **(May 09)**

16. i. Two identical 30dB directional couplers are used to simple incident and reflected power in a wave guide. VSWR=2 and the output of the coupler sampling incident power=4.5mW.What is the value of reflected power.
    ii. Describe a microwave bench. **(May 09)**

17. i. Draw the experimental setup necessary for the measurement of impedance using slotted line and explain.
    ii. What are the characteristics of detectors used in microwave measurements? **(May 09)**

18. i. Explain VSWR measurement procedure in microwave laboratory with a suitable microwave bench setup.
    ii. Calculate VSWR of a rectangular guide of 2.3cm x 1.0 cm operating at 8 GHz.
    The distance between twice minimum power points is 0.09 cm. **(May 09, 08)**

19. i. Explain how you measure VSWR of given load for all kinds of loads possible.
    ii. Give the measurement procedure of Q factor of a resonant cavity. **(May 09,06,Sep 07)**

20. i. What are the precautions to be taken while setting up microwave bench for measurement of various parameters?
    ii. How do you measure microwave power using a Bolometer. **(May 09,08)**

21. i. The calibrated power from a generator as read at the power meter is 25mw. When a 3dB attenuator with a VSWR of 1.3/1 is inserted between the generator and detector what value should the power meter read.
    ii. Compare the power ratio and RF substitution methods of measuring attenuation provided by the microwave component. **(Sep08, May 08)**

22. Write short notes on

    i. Measurement of low and high VSWR
    ii. Measurement of phase shift **(Sep 08)**

ii. There are two identical directional couplers connected back to back to sample incident and reflected powers. The outputs of the couplers are 12 mw and 0.12 mw respectively. What is the VSWR in the guide? **(Sep 08)**

23. i. Describe various techniques of measuring unknown frequency of a microwave generator.
    ii. A slotted line is used in association with an X-band microwave source, When the line is terminated by a short circuit, adjacent nulls are found at position which are shown as 9.27cm and 11.05 cm. What is the value of the guide wave length? **(May 08)**

24. i. The signal power at the input of a device is 10 mw. The signal power at the output of same device is 0.2mw. Calculate the insertion loss in db of this component.
    ii. Explain the bolometric method of measuring microwave power. **(May 08)**

25. i. Define VSWR. Describe the methods of measuring high and low VSWRs.
    ii. Write short notes on "Reflection co-efficient and Insertion loss measurement at microwave frequencies". **(Sep 07)**

26. i. Explain the method to measure VSWR and reflection co-efficient.
    ii. Describe the measurement of impedance using slotted line and Smith chart. **(Sep 07, May 06)**

27. i. With a neat diagram, explain the construction of a slotted line. **(May 07)**
    ii. Using slotted line, draw a typical microwave bench setup for measurement of unknown load and explain.

28. Write short notes on:
    i. Tunable probes
    ii. Matched loads
    iii. Crystal detectors
    iv. Use of isolators in measurements. **(May 07)**

29. i. What are the precautions to be taken while setting up microwave bench for measurement of various parameters?
    ii How do you measure microwave power using a Bolometer. **(May 07)**

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