LAB COURSE FILE CONTENTS

PART-1

1. Vision, Mission, Program Educational Objectives (PEOs), Program Outcomes (POs), Program Specific Outcomes (PSOs).

VISION

To be recognized as full- fledged centre for learning and research in various fields of Electronics and Communication Engineering through industrial collaboration and provide consultancy for solving the real time problems

MISSION

- To inculcate a sprit of research and teach the students about contemporary technologies in Electronics and Communication Engineering to meet the growing needs of the industry.
- To enhance the practical knowledge of students by implementing projects based on real time problems through industrial collaboration.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Upon completion of B. Tech Electronics and Communication Engineering Our Students will

PEO 1: Have strong foundation in mathematical, scientific, engineering fundamentals and communication skills necessary to formulate, understand, analyze and solve technological problems.

PEO 2: Have a technical background to design and develop systems in the main fields of electronics and communication systems.

PEO 3: Practice the ethics of their profession consistent with a sense of social responsibility and develop their engineering design, problem solving skills and aptitude for innovations as they work individually and in multi disciplinary teams.

PEO 4: Be receptive to new technologies and attain professional competence through lifelong learning such as advanced degrees, professional registration, publications and other professional activities.

PROGRAM OUTCOMES (POs)

PO1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

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.

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.

PO6: **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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.

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.

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.

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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: **Problem Solving Skills** – Graduate will be able to apply latest electronics techniques and communications principles for designing of communications systems.

PSO 2: **Professional Skills** – Graduate will be able to develop efficient and effective Communications systems using modern Electronics and Communications engineering techniques.

PSO 3: **Successful Career** – To produce graduates with a solid foundation in Electronics and Communications engineering who will pursue lifelong learning and professional development including post graduation.

PSO 4: **The Engineer and Society**– Ability to apply the acquired knowledge for the advancement of society and self.

2. SYLLUBUS (UNIVERSITY COPY)

3. COURSE OBJECTIVES, COURSE OUTCOMES

COURSE OBJECTIVES (the student should be made to):

CO1: Perform the Reflex klystron Characteristics using Microwave bench setup
CO2: Perform the Gunn diode Characteristics using Microwave bench setup
CO3: Measure the Frequency, attenuation, VSWR, Impedance using Klystron Bench Setup
CO4: Perform the modulation and demodulation of PCM, DM, DPCM, TDM, QPSK, DPSK, ASK, PSK, FSK, QAM using DC trainer kits

COURSE OUTCOMES

At the end of the course, student will able to

CO1: Explain and Perform the Reflex klystron Characteristics using Microwave bench setup
CO2: Explain and Perform the Gunn diode Characteristics using Microwave bench setup
CO3: Measure the Frequency, attenuation, VSWR, Impedance using Klystron Bench Setup
CO4: Explain the concepts of PCM, DM, DPCM, TDM, QPSK, DPSK, ASK, PSK, FSK, QAM.

4. COURSE PREREQUISITES

1. Electromagnetic waves and Transmission lines (EMTL)
2. Microwave Engineering (MWE)
3. Antennas & Wave propagation (AWP)

5. CO'S, PO'S MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1	3								
CO2	1		1	3								
CO3	2	2		3								
CO4	3	1		1								

Legends:

1: Low
2: Medium
3: High

6. COURSE INFORMATION SHEET (CIS)

a) **COURSE DESCRIPTION**

COURSE TITLE	Microwave and Digital Communication Lab			
COURSE CODE	A70499			
REGULATION	R15			
COURSE STRUCTURE	LECTURES	TUTORIALS	PRACTICALS	CREDITS
	-	-	3	2
COURSE COORDINATOR	T Gayatri, Assistant Professor, ECE Dept.			

b) **COURSE PLAN**

S.NO	List of experiments	Name of the Equipment	Course outcomes
1.	**Week-1:** **Batch 1:** 1. ASK 2. PSK 3. FSK 4. DPSK 5. QPSK 6. TDM **Batch 2:** 1. ASK 2. PSK 3. FSK 4. DPSK 5. QPSK 6. TDM	DC Trainer kits	CO 4
2.	**Week-2:** **Batch 1:** 1. TDM 2. ASK 3. PSK 4. FSK 5. DPSK 6. QPSK **Batch 2:** 1. TDM 2. ASK 3. PSK 4. FSK 5. DPSK 6. QPSK	DC Trainer kits	CO 4
3.	**Week-3:** **Batch 1:** 1. QPSK 2. TDM		CO 4

	3. ASK 4. PSK 5. FSK 6. DPSK **Batch 2:** 1. QPSK 2. TDM 3. ASK 4. PSK 5. FSK 6. DPSK	DC Trainer kits	
4.	**Week-4:** **Batch 1:** 1. DPSK 2. QPSK 3. TDM 4. ASK 5. PSK 6. FSK **Batch 2:** 1. DPSK 2. QPSK 3. TDM 4. ASK 5. PSK 6. FSK	DC Trainer kits	CO 4
5.	**Week-5** **Batch 1:** 1. FSK 2. DPSK 3. QPSK 4. TDM 5. ASK 6. PSK **Batch 2:** 1. FSK 2. DPSK 3. QPSK 4. TDM 5. ASK 6. PSK	DC Trainer kits	CO 4
6.	**Week-6:** **Batch 1:** 1. PSK 2. FSK 3. DPSK 4. QPSK 5. TDM 6. ASK **Batch 2:** 1. PSK 2. FSK 3. DPSK 4. QPSK 5. TDM	DC Trainer kits	CO 4

	6. ASK		
7.	**Week-7** INTERNAL EXAMINATION-I		
8.	**Week-8** **Batch 1:** 1. Reflex Klystron Characteristics. 2. Gunn Diode Characteristics. 3. Directional Coupler Characteristics. 4. VSWR Measurement. 5. Attenuation Measurement. 6. Microwave Frequency Measurement. **Batch 2:** 1. Reflex Klystron Characteristics. 2. Gunn Diode Characteristics. 3. Directional Coupler Characteristics. 4. VSWR Measurement. 5. Attenuation Measurement. 6. Microwave Frequency Measurement.	Microwave Bench setup	CO1, CO2, CO3.
9.	**Week-9** **Batch 1:** 1. Microwave Frequency Measurement 2. Reflex Klystron Characteristics. 3. Gunn Diode Characteristics. 4. Directional Coupler Characteristics. 5. VSWR Measurement. 6. Attenuation Measurement. **Batch 2:** 1. Microwave Frequency Measurement 2. Reflex Klystron Characteristics. 3. Gunn Diode Characteristics. 4. Directional Coupler Characteristics. 5. VSWR Measurement. 6. Attenuation Measurement.	Microwave Bench setup	CO1, CO2, CO3.
10.	**Week-10** **Batch 1:** 1. Attenuation Measurement. 2. Microwave Frequency Measurement 3. Reflex Klystron Characteristics. 4. Gunn Diode Characteristics. 5. Directional Coupler Characteristics. 6. VSWR Measurement. **Batch 2:** 1. Attenuation Measurement. 2. Microwave Frequency Measurement 3. Reflex Klystron Characteristics. 4. Gunn Diode Characteristics. 5. Directional Coupler Characteristics. 6. VSWR Measurement.	Microwave Bench setup	CO1, CO2, CO3.
11.	**Week-11** **Batch 1:** 1. VSWR Measurement. 2. Attenuation Measurement. 3. Microwave Frequency Measurement 4. Reflex Klystron Characteristics. 5. Gunn Diode Characteristics.	Microwave	CO1, CO2, CO3.

	6. Directional Coupler Characteristics. **Batch 2:** 1. VSWR Measurement. 2. Attenuation Measurement. 3. Microwave Frequency Measurement 4. Reflex Klystron Characteristics. 5. Gunn Diode Characteristics. 6. Directional Coupler Characteristics.	Bench setup	
12.	**Week-12** **Batch 1:** 1. Directional Coupler Characteristics. 2. VSWR Measurement. 3. Attenuation Measurement. 4. Microwave Frequency Measurement 5. Reflex Klystron Characteristics. 6. Gunn Diode Characteristics **Batch 2:** 1. Directional Coupler Characteristics. 2. VSWR Measurement. 3. Attenuation Measurement. 4. Microwave Frequency Measurement 5. Reflex Klystron Characteristics. 6. Gunn Diode Characteristics	Microwave Bench setup	CO1, CO2, CO3.
13.	**Week-13** **Batch 1:** 1. Gunn Diode Characteristics 2. Directional Coupler Characteristics. 3. VSWR Measurement. 4. Attenuation Measurement. 5. Microwave Frequency Measurement 6. Reflex Klystron Characteristics **Batch 2:** 1. Gunn Diode Characteristics 2. Directional Coupler Characteristics. 3. VSWR Measurement. 4. Attenuation Measurement. 5. Microwave Frequency Measurement 6. Reflex Klystron Characteristics	Microwave Bench setup	CO1, CO2, CO3.
14.	**Week-14** INTERNAL EXAMINATION-II		

c) **ADDITIONAL EXPERIMENTS**

1. Measurement of Waveguide Parameter.
2. Measurement of Impedance of a given Load.
3. Measurement of Scattering parameter of a Magic Tee.
4. Measurement of scattering parameters of a Circulators.
5. PCM Generation and Detection.
6. Differential Pulse Code Modulation.
7. Delta Modulation.
8. Study of the spectral characteristics of PAM,QAM.

d) Marks Distribution

Sessional marks	End semester exam	Internal marks
There shall be a continuous evaluation during the semester for 25 marks. Day-to-day work in the laboratory shall be evaluated for 15 marks and internal practical examination conducted by the concerned teacher shall be evaluated for 10 marks.	**75**	**25**

e) Evaluation Scheme

SR.NO	Component	Duration	Marks
1.	Day-to-day Evaluation	-	15
2.	Internal Practical Examination	3hours	10
3.	End Semester Examination	3 hours	75

f) **Text books & Reference books**

T/R	**BOOK TITLE/AUTHORS/PUBLICATION**
Text Book	Microwave Devices and Circuits — Samuel V. Liao, Pearson, 3rd Edition, 2003.
Text Book	Microwave Principles — Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss, CBS Publishers and Distributors, New Delhi, 2004.
Reference Book	Microwave and Radar Engineering - M.Kulkarni
Reference Book	Foundations for Microwave Engineering — R.E. Collin, IEEE Press, John Wiley, 2ndEdition, 2002.
Reference Book	Microwave Circuits and Passive Devices — M.L. Sisodia and G.S.Raghuvanshi, Wiley Eastern Ltd.,New Age International Publishers Ltd., 1995.
Reference Book	Microwave Engineering Passive Circuits — Peter A. Rizzi, PHI, 1999.

Reference Book	Electronic and Radio Engineering F.E. Terman, McGraw-Hill, 4th Ed., 1955.
Reference Book	Microwave Engineering —A. Das and S.K. Das, TMH, 2nd Ed., 2009
Reference Book	Microwave Engineering – G. S. Raghuvanshi and K. Satya Prasad, Cengage Learning, 2012.

7. MICRO LESSON PLAN

S.NO	Topic	Schedule date	Actual Date
1	**Batch 1:** 1. ASK 2. PSK 3. FSK 4. DPSK 5. QPSK 6. TDM **Batch 2:** 1. ASK 2. PSK 3. FSK 4. DPSK 5. QPSK 6. TDM	10/7/18, 12/7/18	
2	**Batch 1:** 1. TDM 2. ASK 3. PSK 4. FSK 5. DPSK 6. QPSK **Batch 2:** 1. TDM 2. ASK 3. PSK 4. FSK 5. DPSK 6. QPSK	17/7/18, 19/7/18	
3	**Batch 1:** 1. QPSK 2. TDM 3. ASK 4. PSK 5. FSK 6. DPSK **Batch 2:** 1. QPSK 2. TDM 3. ASK 4. PSK 5. FSK 6. DPSK	24/7/18, 26/7/18	
4	**Batch 1:** 1. DPSK 2. QPSK 3. TDM 4. ASK 5. PSK 6. FSK	31/7/18, 2/8/18	

	Batch 2: 1. DPSK 2. QPSK 3. TDM 4. ASK 5. PSK 6. FSK		
5	**Batch 1:** 1. FSK 2. DPSK 3. QPSK 4. TDM 5. ASK 6. PSK **Batch 2:** 1. FSK 2. DPSK 3. QPSK 4. TDM 5. ASK 6. PSK	7/8/18, 9/8/18	
6	**Batch 1:** 1. PSK 2. FSK 3. DPSK 4. QPSK 5. TDM 6. ASK **Batch 2:** 1. PSK 2. FSK 3. DPSK 4. QPSK 5. TDM 6. ASK	14/8/18, 16/8/18	
7	INTERNAL EXAMINATION-I	21/8/18, 23/8/18	
8	**Batch 1:** 1. Reflex Klystron Characteristics. 2. Gunn Diode Characteristics. 3. Directional Coupler Characteristics. 4. VSWR Measurement. 5. Attenuation Measurement. 6. Microwave Frequency Measurement. **Batch 2:** 1. Reflex Klystron Characteristics. 2. Gunn Diode Characteristics. 3. Directional Coupler Characteristics. 4. VSWR Measurement. 5. Attenuation Measurement. 6. Microwave Frequency Measurement.	28/8/18, 30/8/18	
9	**Batch 1:** 1. Microwave Frequency	11/9/18, 18/9/18	

	Measurement 2. Reflex Klystron Characteristics. 3. Gunn Diode Characteristics. 4. Directional Coupler Characteristics. 5. VSWR Measurement. 6. Attenuation Measurement. **Batch 2:** 1. Microwave Frequency Measurement 2. Reflex Klystron Characteristics. 3. Gunn Diode Characteristics. 4. Directional Coupler Characteristics. 5. VSWR Measurement. 6. Attenuation Measurement.		
10	**Batch 1:** 1. Attenuation Measurement. 2. Microwave Frequency Measurement 3. Reflex Klystron Characteristics. 4. Gunn Diode Characteristics. 5. Directional Coupler Characteristics. 6. VSWR Measurement. **Batch 2:** 1. Attenuation Measurement. 2. Microwave Frequency Measurement 3. Reflex Klystron Characteristics. 4. Gunn Diode Characteristics. 5. Directional Coupler Characteristics. 6. VSWR Measurement.	20/9/18, 25/9/18	
11	**Batch 1:** 1. VSWR Measurement. 2. Attenuation Measurement. 3. Microwave Frequency Measurement 4. Reflex Klystron Characteristics. 5. Gunn Diode Characteristics. 6. Directional Coupler Characteristics. **Batch 2:** 1. VSWR Measurement. 2. Attenuation Measurement. 3. Microwave Frequency Measurement 4. Reflex Klystron Characteristics. 5. Gunn Diode Characteristics. 6. Directional Coupler Characteristics.	27/9/18, 4/10/18	
12	**Batch 1:** 1. Directional Coupler Characteristics. 2. VSWR Measurement.	9/10/18, 11/10/18	

	3. Attenuation Measurement. 4. Microwave Frequency Measurement 5. Reflex Klystron Characteristics. 6. Gunn Diode Characteristics **Batch 2:** 1. Directional Coupler Characteristics. 2. VSWR Measurement. 3. Attenuation Measurement. 4. Microwave Frequency Measurement 5. Reflex Klystron Characteristics. 6. Gunn Diode Characteristics		
13	**Batch 1:** 1. Gunn Diode Characteristics 2. Directional Coupler Characteristics. 3. VSWR Measurement. 4. Attenuation Measurement. 5. Microwave Frequency Measurement 6. Reflex Klystron Characteristics **Batch 2:** 1. Gunn Diode Characteristics 2. Directional Coupler Characteristics. 3. VSWR Measurement. 4. Attenuation Measurement. 5. Microwave Frequency Measurement 6. Reflex Klystron Characteristics	23/10/18, 25/10/18	
14	INTERNAL EXAMINATION-I	30/10/18, 1/11/18	

8. LAB MANUAL

9. VIVA QUESTION AND ANSWERS

1. What is Microwave Engineering?
   Ans. Microwave engineering is the study and design of microwave circuits , components , and systems. Fundamental principles are applied to analysis , design and measurement techniques in this field. The short wavelengths involved distinguish this discipline from electronic engineering . This is because there are different interactions with circuits, transmissions and propagation characteristics at microwave frequencies.
2. Write the applications of microwave engineering?
   Ans. Following are the applications of microwave engineering-
   1. Antenna gain is proportional to the electrical size of the antenna. At higher frequencies, more antenna gain is therefore possible for a given physical antenna size, which has important consequences for implementing miniaturized microwave systems.
   2. More bandwidth can be realized at higher frequencies. Bandwidth is critically important because available frequency bands in the electromagnetic spectrum are being rapidly depleted.
   3. Microwave signals travel by line of sight are not bent by the ionosphere as are lower frequency signals and thus satellite and terrestrial communication links with very high capacities are possible.
3. What are the major bands available in microwave frequencies?
   Ans. The microwave frequencies span the following three major bands at the highest end of RF spectrum.
   I. Ultra High Frequency (UHF) 0.3 to 3 GHz.
   II. Super High Frequency (SHF) 3 to 30 GHz.
   III. Extra High Frequency (EHF) 30 to 300 GHz
4. State definition of guide wavelength?
   Ans. Guide wavelength is defined as the distance between two equal phase planes along the waveguide. The guide wavelength is a function of operating wavelength (or frequency) and the lower cutoff wavelength, and is always longer than the wavelength would be in freespace.

5. State definition of guide wavelength?
   Ans. Guide wavelength is defined as the distance between two equal phase planes along the waveguide. The guide wavelength is a function of operating wavelength (or frequency) and the lower cutoff wavelength, and is always longer than the wavelength would be in freespace.
6. Define s-matrix and its properties?
   Ans. In a microwave junction there is an interaction of three or more components.There will be an output port, in addition there may be reflection from the junction of other ports. Totally there may be many combination, these are represented easily using a matrix called S matrix.

7. What are the properties of S- matrix

Ans. Properties of s- matrix

1. it possess symmetric properties $S_{ij}=S_{ji}$
2. it possess unitary property
3. [s][s]*=[i]

8. Why is s-matrix used in MW analysis?

Ans. Matrix is used in MW analysis to overcome the problem which occurs when H,Y & Z parameter are used in high frequencies.

1.Equipment is not readily available to measure total voltage &total current at the ports of the network.

2.Short and open circuits are difficult to achieve over a broad band of frequencies.

3.Active devices, such as power transistor &tunnel diodes, frequently won't have stability for a short or open circuit.

9. What are the properties of scattering matrix for a lossless junctoion?

Ans. 1.The product of any column of the S-matrix with conjugate of this column equals unity.

2.The product of any column of the scattering matrix with the complex conjugate of any other column is zero.

10. Define VSWR

Ans. Voltage standing wave ratio is defined as the ratio of maximum voltage to the minimum voltage VSWR=Vmax/Vmin

11. State the characteristics of magnetron and of 2-cavity klystron amplifier.

Ans. Magnetron:

a. Operating frequencies _ 70 GHz
b. Output power _ 40 MW
c. Efficiency _ 40 to 70%

2-cavity klystron:

a) Efficiency _ 40%
b) Power output _ average power _> 500 KW
c) Pulsed power _> 30 MW
d) Power gain _ about 30 db.

12. What are the advantages of TWT?

Ans. 1. Bandwidth is large.
2. High reliability
3. High gain
4. Constant Performance in space
5. Higher duty cycle.

13. What are the elements that exhibit Gunn effect?

Ans. The elements are

a. Gallium arsenide
b. Indium phosphide

c. Cadmium telluride
d. Indium arsenide.

14. State the applications of magnetrons. why magnetron is called as cross filed device?

Ans. 1) Pulse work in radar
2) Linear particle accelerators.

In cavity magnetron, there exists a radial electric field and an axial magnetic field perpendicular to each other and hence magnetron is called as a cross filed device.

15. Define GUNN EFFECT.

Ans. Gunn effect was first observed by GUNN in n_type GaAs bulk diode. According to GUNN, above some critical voltage corresponding to an electric field of 2000-4000v/cm,the current in every specimen became a fluctuating function of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit.

16. What are the applications of reflex klystron?

Ans. The main applications of a reflex klystron are as follows-

1. Signal source in MW generator
2. Local oscillators in receivers
3. It is used in FM oscillator in low power MW links.
4. In parametric amplifier as pump source.

17. What is the purpose of slow wave structures used in TWT amplifiers?

Ans. Slow wave structures are special circuits that are used in microwave tubes to reduce wave velocity in a certain direction so that the electron beam and the signal wave can interact. In TWT, since the beam can be accelerated only to velocities that are about a fraction of the velocity of light, slow wave structures are used.

18. How to increase the band width in klystron amplifier

Ans. Klystron amplifiers use one or more intermediate cavities in addition to buncher and catcher cavity., When one or more intermediate cavities are used the bandwidth can be increased.

19. Write about the features of multi cavity klystron

Ans. The features of a multicavity klystron are :

1. Frequency range - 0.25 GHz to 100 GHz
2. Power output - 10 kW to several hundred kW
3. Power gain - 60 dB (nominal value)
4. Efficiency - about 40%.

A multicavity klystron is used in UHF TV transmitters, Radar transmitter and satellite communication.

20. What is bunching effect

Ans. Bunching effect converts velocity modulation into current modulation of beam in the klystron.

21. What are junctions ? Give some example

Ans. A microwave circuit consists of several microwave devices connected in some

way to achieve the desired transmission of MW signal. The interconnection of two or more microwave may be regarded as MW junction.
E.g.: TEE, HYBRID RING

22. What are non-reciprocal devices ?Give two examples?
Ans. The devices which are having the properties that the forward characteristics are not equal to the reverse characteristics are called non-reciprocal devices.

23. Give two examples for two port junctions.
Ans. Following are the two examples of two port junctions-
1. The junction of two rectangular guides of unequal height
2. A symmetrical junction consisting of two similar rectangular guides joined by an Intermediate guide of greater width.

24. What is Faraday's rotation law?
Ans. If a circularly polarized wave is made to pass through a ferrite rod which has been influenced by an axial magnetic field B ,then the axis of polarization gets tilted in clockwise direction and amount of tilt depends upon the strength of magnetic field and geometry of the ferrite.

25. What is Gyrator?
Ans. Gyrator is a two port device which provides a relative phase shift of 180 degree for transmission from port 1 to port 2 as compared to the phase for transmission from Port2 to port 1.

26. What are the dominant and degenerate modes
Ans: Dominant mode:
- The mode with the lowest cut-off frequency is called the *dominant mode.*
- Since TM modes for rectangular waveguides start from TM_{11} mode, the dominant frequency is

$$(f_c)_{11} = \frac{1}{2\sqrt{\varepsilon\mu}}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2}\ (Hz)$$

- TE_{10} mode is the minimum possible mode that gives nonzero field expressions for rectangular waveguides, it is the dominant mode of a rectangular waveguide with a>b and so the dominant frequency is

$$(f_c)_{10} = \frac{1}{2a\sqrt{\mu\varepsilon}}\ (Hz)$$

Degenerate modes:
- In a waveguide when two or more modes have the same cut off frequency then they are said to be degenerate modes.
- In a rectangular waveguide the TE_{mn} and TM_{mn} with $m \neq 0$ and $n \neq 0$ are degenerate modes.

27. What is hybrid ring?
Ans. Hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions.

28. Explain Structure of magic tee

Ans. The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4 forms an E-plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the side or collinear arms. Port 3 is called the H-plane port, and is also called the Σ port, sum port or the P-port (for Parallel). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for Series). There is no one single established convention regarding the numbering of the ports.

29. What is E-plane Tee

Ans. An E-plane tee is a waveguide tee in which the axis of its side arm is parallel to the E-field of the main guide.

30. What is H-plane Tee

Ans. An H-plane tee is a waveguide tee in which the axis of its side arm is shunting the E yield or parallel to the H-field of the main guide.

31. What are the high frequency effects in conventional tubes?

Ans. The high frequency effects in conventional tubes are

i) Circuit reactance

a)Inter electrode capacitance

b) Lead inductance

ii) Transit time effect

iii) Cathode emission

iv) Plate heat dissipation area

v) Power loss due to skin effect, radiation and dielectric loss.

32. What do you mean by O-type tubes? Name some O-type tubes.

Ans. In O – type tube a magnetic field whose axis coincides with that electron beam is used to hold the beam together as it travels the length of the tube. It is also called as linear beam tube.

a. Helix Traveling wave tube
b. Coupled cavity TWT
c. Forward wave amplifier
d. Backward wave amplifier
e. Backward wave oscillator

33. What are the assumptions for calculation of RF power in Reflex Klystron?

Ans. i) Cavity grids and repeller are plane parallel and very large in extent.

ii) No RF field is excited in repeller space

iii) Electrons are not intercepted by the cavity anode grid.

i) No debunching takes place in repeller space.

ii) The cavity RF gap voltage amplitude V, is small compared to the dc beamvoltage V_o

34. Draw various reentrant cavities

Ans:

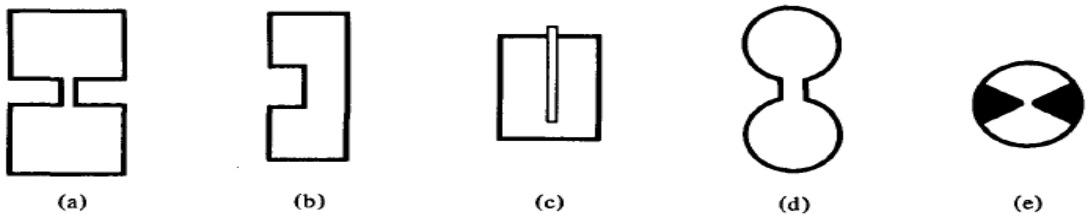


Figure Reentrant cavities. (a) Coaxial cavity. (b) Radial cavity. (c) Tunable cavity. (d) Toroidal cavity. (c) Butterfly cavity.

35. Give the eqn of velocity modulation

Ans:

$$v(t_1) = v_0\left[1 + \frac{\beta_i V_1}{2V_0}\sin\left(\omega t_1 - \frac{\theta_g}{2}\right)\right]$$

36. Give the expression for output power and efficiency of klystron

Ans:

$$P_{out} = \frac{(\beta_0 I_2)^2}{2} R_{sh} = \frac{\beta_0 I_2 V_2}{2}$$

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} = \frac{\beta_0 I_2 V_2}{2 I_0 V_0}$$

37. What is Transferred electron effect?

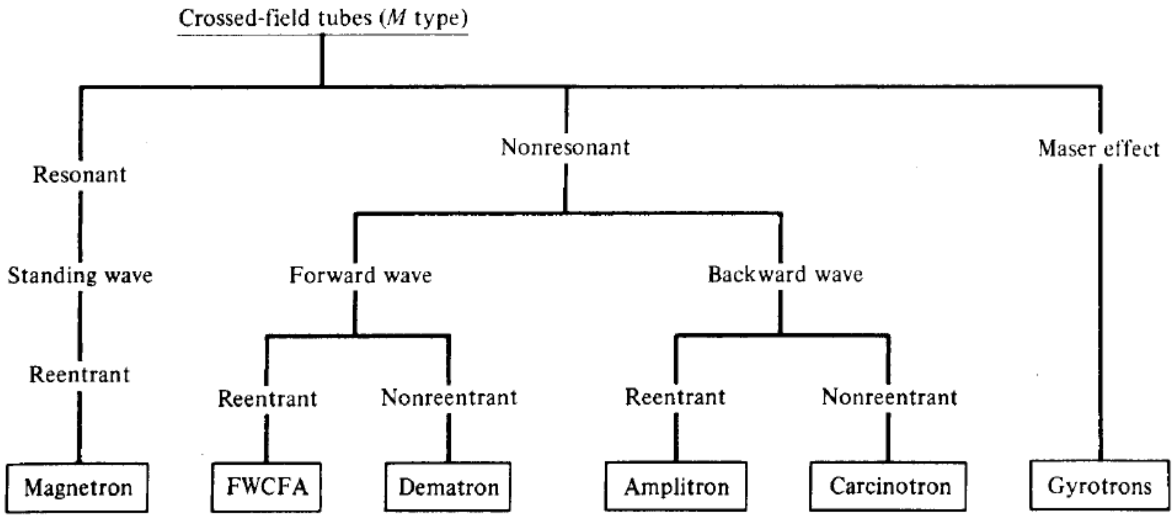
Ans. Some materials like GaAs exhibit negative differential mobility,when biased above a threshold value of the electric field. This behavior is called transferred electron effect.

38. What are the crossed fields

Ans: Crossed-field tubes derive their name from the fact that the dc electric field and the dc magnetic field are perpendicular to each other. They are also called M –type tubes after the French TPOM In a crossed-field tube, Because of the crossed-field interactions, only those electrons that have given up sufficient energy to the RF field can travel all the way to the anode.

39. Classify crossed field tubes

Ans:



40. Give the expression for Hull Cutoff Voltage

Ans: $$V_{0c} = \frac{e}{8m} B_0^2 b^2 \left(1 - \frac{a^2}{b^2}\right)^2$$

41. Give the hartree condition

Ans: $$V_{0h} = \frac{\omega B_0 d}{\beta} - \frac{m}{2e}\frac{\omega^2}{\beta^2}$$

42. What are tunable detector?

Ans. The tunable detectors are used to demodulate the signal and couple the required output to high frequency scope analyzer.The low frequency demodulated output is detected using non reciprocal detector diode monunted in the microwave transmission line.

43. What is slotted section with line carriage?

Ans. It is a microwave sectioned coaxial line connecting a coaxial E-field probe which penetrates inside a rectangular waveguide slotted section.The longitudinal slot is cut along the center of the waveguide broad walls.The probe is made to move along the slotted wall which samples the electric field propotional to probe voltage.

44. What is the main purpose of slotted section with line carriage?

Ans. 1. For determination of location of voltage standing wave maxima and minima along the line.

2.Measure the VSWR and standing wave pattern.
3.Wavelength.
4.Impedence.
5.Reflection coeffient.
6.Return loss measurement.

45. What is Bolometer?

Ans. It is a power sensor whose resistance change with changed temperature as it absorb the microwave power. It is a short thin metallic wire sensor with positive temperature coefficient of resistance.

46. What is a VSWR meter?

Ans. VSWR meter is a highly sensitive, high gain, high theta, low noise voltage amplifier tuned normally at fixed frequency of 1KHZ of which microwave signals modulated. This meter indicates calibrated VSWR reading for any loads.

10. **Internal -I Question Paper with Key**

11. **Internal -II Question Paper with Key**

12. **Result Analysis**

PART-2		
1	**Attendance Register/Teacher Log Book**	
2	**Time Table**	
3	**Academic Calendar**	
4	**Continuous Evaluation – Internal marks**	