SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES
(AUTONOMOUS)
QUESTION BANK

Year / Semester: III B.Tech VI Semester **Regulation: R23**

Subject and Code: MICROWAVE AND OPTICAL COMMUNICATIONS 23ECE362T

SYLLABUS

COURSE EDUCATIONAL OBJECTIVES:

1.To analyze different modes of operation in rectangular wave guides, circular wave guides and resonators.
2.To study and analyze various microwave components and microwave sources.
3.To gain knowledge on different microwave semiconductor devices and microwave measurements procedures.
4.To analyze different optical fiber modes and to study different types of distortions and losses in optical communication.
5.To study various optical sources, optical detectors and to analyze various optical links.

UNIT I – WAVEGUIDES:-

Waveguides: Introduction, Rectangular waveguides, Field expressions for TE and TM modes, Wave propagation in the guide, Phase and group velocities, Power transmission and attenuation, Waveguide current and mode excitation, Circular waveguide – TE and TM modes (Qualitative treatment only), Wave propagation, Cavity resonators (Qualitative treatment only).

UNIT II - MICROWAVE DEVICES, AMPLIFIERS AND OSCILLATORS:-

Passive Microwave Devices:

Introduction to scattering parameters and their properties, Terminations, Variable short circuit, Attenuators, Phase shifters, Hybrid Tees (H-plane, E-plane, Magic Tees), Directional Couplers – Bethe hole and Two hole Couplers, Deriving Scattering matrix for Microwave passive devices. Microwave propagation in Ferrites: Gyrator, Isolator, and Circulator.

Microwave Amplifiers and Oscillators:

Microwave Tubes: Linear Beam Tubes – Two cavity Klystron amplifier -velocity modulation, bunching process, output power, Reflex Klystron oscillator, power output and efficiency, Travelling Wave Tube (TWT) – Bunching process and amplification process (Qualitative treatment only). Crossed Field Tubes – Magnetron oscillator, pi-mode operation, power output and efficiency, Har tree Condition.

UNIT III - MICROWAVE SEMICONDUCTOR DEVICES, AND MEASUREMENTS:-

Microwave Semiconductor Devices: Gunn Oscillator – Principle of operation, Characteristics, Two valley model, IMPATT, TRAPATT diodes.

Microwave Measurements: Description of Microwave bench-different blocks and their features, errors and precautions, Microwave power measurements, Measurement of attenuation, frequency, VSWR (low, medium, high), Measurement of Q‘ of a cavity, Impedance measurements.

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UNIT IV - OPTICAL FIBERS AND TRANSMISSION CHARACTERISTICS:-

Introduction to Optical Fibers and Transmission Characteristics - The propagation of light in optical waveguides – Classification of optical fibers – Numerical aperture, Step index and Graded index fiber – Modes in cylindrical fiber – Linearly polarized modes, Attenuation: Absorption, Scattering, Bending losses. Modal dispersion and chromatic dispersion – Single mode fiber - waveguide dispersion– MFD – PMD

UNIT V - OPTICAL TRANSMITTERS, RECEIVERS AND LINK DESIGN:-

Optical Transmitters and Receivers:

Optical Sources: - Light source materials – LED homo and hetero structures–surface and edge emitters–Quantum efficiency– Injection Laser Diode – Modes and threshold condition – Structures and Radiation Pattern.

Optical Detectors: – Physical principles – PIN and APD diodes – Photo detector noise

Optical Link Design: Point-to-point links–System considerations – Link Power budget – Rise time budget.

Total Hours: **45**

COURSE OUTCOMES:-

On successful completion of the course the student will be able to		POs related to COs
CO1	Analyze different modes of operation in rectangular wave guides, circular wave guides and resonators.	PO1, PO2
CO2	Understand and analyze various microwave components and microwave sources	PO1, PO2, PO3
CO3	Gain knowledge on different microwave semiconductor devices and microwave measurements procedures.	PO1, PO2
CO4	Analyze different optical fiber modes and to study different types of distortions and losses in optical communication.	PO1, PO2
CO5	Understand study various optical sources, optical detectors and to analyze various optical links.	PO1, PO2, PO3

TEXT BOOKS

1.David M. Pozar, Microwave Engineering ||John Wiley & Sons, Inc. 4thedition,2012
2.Samuel Y.Liao, Microwave Devices and Circuits, PHI publications, Third Edition, 1997.
3.Ger Keiser, Optical Fiber Communications, McGrawHill, Third Edition,2000.

REFERENCES:

1.R.E.Collin, Foundations for Microwave Engineering, Wiley Student Edition, Second Edition, 2009.
2.Om.P.Gandhi, Microwave: Engineering and applications, KaiFa Book Company, 1981.
3.ReichH.J.,etal, Microwave Principles||, MIT Press, 1972.
4.FETerman, Electronic and Radio Engineering, McGrawHill, 4th Edition, 1984

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CO-PO Mapping

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-	-
CO*	**3**	**2**	**1**	**-**	-	-	-	-	-	-	-	-

Max Marks: 10

Prepared by Dr K Yogaprasad, Professor

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S.No.	CO	Questions	BT
		Unit I: (WAVEGUIDES)	
1	1	Discuss how the microwave spectrum is categorized into different bands.	L1
2	1	What is the need of microwave frequency? Explain different applications of microwaves.	L1
3	1	Derive the expressions for the field components due to TM waves in rectangular waveguide.	L4
4	1	Derive the expressions for the field components due to TE waves in rectangular waveguide.	L4
5	1	A waveguide having dimensions a = 5 cm, b = 2 cm. The signal applied to waveguide is 10 GHz. Determine the modes that are propagating in the waveguide.	L4
6	1	The dominant mode TE10 is propagated in a rectangular waveguide of dimensions a = 6 cm and b = 4 cm. The distance between a maximum and a minimum is 4.47 cm. Determine the signal frequency of the dominant mode.	L4
7	1	Draw the circular resonator cavity diagram and derive equation for resonator cavity.	L1,L4
8	1	Derive the necessary relation on wave propagation in the guide, Phase and group velocities.	L4
9	1	Briefly discuss the TE/TM concepts in Circular waveguide.	L1
10	1	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 i. Cut off frequency of the propagating mode ii. The frequency of operation iii. Maximum frequency of propagation in this mode.	L4

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S.No.	CO	Questions	BT
Unit II: (MICROWAVE DEVICES, AMPLIFIERS AND OSCILLATORS) **Passive Microwave Devices:-**			
1	2	With the help of diagrams, clearly explain the principle and operation of Attenuator & its types.	L1
2	2	Draw a typical Directional Coupler and define directivity and coupling coefficient.	L1
3	2	Explain the operation of circulator. What is Faraday rotation?	L1
4	2	Distinguish between E-plane and H-plane Tees and hence discuss the construction and working of a Magic Tee.	L2
5	2	What is an isolator? Explain the principle of working.	L1
6	2	Briefly discuss the following Microwave Devices Terminations, Variable short circuit, Attenuators, Phase shifters.	L2
7	2	With the help of diagrams, clearly explain the principle and operation of Phase shifters.	L1
8	2	Deriving Scattering matrix for E-plane Tee.	L4
9	2	Deriving Scattering matrix for H-plane Tee.	L4
10	2	Deriving Scattering matrix for Magic Tee.	L4
11	2	Deriving Scattering matrix for Directional Coupler.	L4
12	2	Clearly explain the principle and operation of Gyrator.	L1
Microwave Amplifiers and Oscillators:-			
13	2	Describe with the neat sketch the constructional details and principle of operation of a Reflex Klystron Tube.	L1
14	2	With the help of Applegate diagram illustrate the phenomenon of bunching.	L4
15	2	Describe with the neat sketch the constructional details and principle of operation of a 2-Cavity klystron tube.	L1
16	2	Explain the operation of a two cavity klystron amplifier. Derive expressions for bunched beam current and efficiency.	L1
17	2	List two discriminations between conventional tube and microwave tube. What can be the possible solutions to the limitations of conventional tubes at high frequencies? Which one is the best?	L2
18	2	Write short notes on bunching process in a two-cavity Klystron amplifier.	L1
19	2	With the help of velocity diagram explain principle of two-cavity Klystron amplifier.	L1
20	2	Explain the possibility of oscillations in a TWT amplifier. Suggest method to prevent oscillations.	L1
21	2	Discuss about the differences between a TWT and a Klystron.	L1
22	2	Explain the operation of TWT amplifier with a neat diagram.	L1
23	2	Describe with the neat sketch the constructional details and principle of operation of a Magnetron in Microwave.	L1

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S.No.	CO	Questions	BT
Unit III: (MICROWAVE SEMICONDUCTOR DEVICES, AND MEASUREMENTS) **Microwave Semiconductor Devices:-**			
1	3	Explain the V-I characteristics of a Gunn diode.	L1
2	3	List the differences between microwave transistor and TED devices.	L1
3	3	Describe with the neat sketch the constructional details and principle of operation of a Gunn Diode in Microwave.	L2
4	3	With the help of diagrams, clearly explain the principle and operation of Two Valley Theorem in Gunn.	L1
5	3	Discuss about the differences between IMPATT & TRAPATT diodes.	L2
6	3	What is Transferred Electron Effect? Explain clearly how a GUNN diode is different from a tunnel diode both being a negative resistance device.	L2
7	3	Write down basic requirements for two-valley theory of Gunn diode. Explain.	L2
8	3	What is the main idea behind obtaining negative resistance in a Gunn diode?	L2
Microwave Measurements:-			
9	3	What are the precautions to be taken while setting up microwave bench for measurement of various parameters? Explain.	L1
10	3	Describe a microwave bench	L2
11	3	Describe how an ordinary voltmeter can be calibrated to VSWR directly. What are the drawbacks of such a VSWR meter?	L1
12	3	Explain the method to measure VSWR and Reflection Co-efficient.	L1
13	3	Describe the measurement of impedance using slotted line and Smith chart.	L2
14	3	Describe the measurement of Microwave power measurements.	L2
15	3	Describe the measurement of Measurement of attenuation.	L2

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S.No.	CO	Questions	BT
Unit IV: (OPTICAL FIBERS AND TRANSMISSION CHARACTERISTICS)			
1	4	With the help of electromagnetic spectrum, explain about the historical development of optical fiber communications.	L1
2	4	Explain the function of each block with a help of neat block diagram of Analog optical fibre communication system.	L1
3	4	Draw a block diagram of a digital optical receiver showing its various components. Explain the function of each component.	L2
4	4	Explain the Elements of an optical fiber Transmission link.	L2
5	4	What is the concept of total internal reflection? Explain with a suitable optical cable setup.	L2
6	4	A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.5 and cladding refractive index of 1.47. Determine: (i) The critical angle at the core-cladding interface. (ii) The NA for the fiber. (iii) The acceptance angle in air for the fiber.	L4
7	4	Discuss the mode theory of circular waveguide.	L1
8	4	Explain about the following: (i) Refractive index. (ii) Snell's law. (iii) Critical angle.	L1
9	4	Using Ray Theory Transmission approach, explain the following: (i) Total internal reflection ad critical angle. (ii) Acceptance angle. (iii) Numeral aperture.	L1
10	4	A typical relative refractive index difference for an optical fiber designed for long distance communication is 1%. Estimate the NA and solid acceptance angle in air for the fiber when the core index is 1.46. Further, calculate the critical angle at the core-cladding interface within the fiber. It may be assumed that the concepts of geometric optics hold for the fiber.	L4
11	4	Derive an expression for number of modes exists in step indexed fiber. Also explain about mode field diameter.	L4
12	4	Write in brief about optical fiber modes and configurations.	L1
13	4	Explain about single mode fibers in detail.	L1
14	4	Clearly explain the propagation modes in single-mode fibers.	L1
15	4	Compare step index and gradded index fibres in all aspects.	L1
16	4	A single-mode fiber optical fiber has a beat length of 8 cm at 1300 nm. Determine modal birefringence (BF) and birefringence .	L1
17	4	If a single mode fibre has a step index of 0.03, the core refractive index is 1.45 at the cut off wavelength 1300 nm, then calculate the core radius.	L4
18	4	A graded index fiber has a core with a parabolic refractive index profile which has a diameter of 50μm. The fiber has a NA of 0.2. Estimate the total number of guided modes propagating in the fiber when it is operating at a wavelength of 1 μm.	L4
19	4	An optical fiber in air has an NA 0.4. Compare the acceptance angle for meridional rays with that for skew rays which change direction by 100 degrees at each reflection.	L4
20	4	Explain about bending losses in optical fiber.	L1
21	4	Explain about intermodal dispersion and chromatic dispersion.	L2
22	4	Explain about intrinsic and extrinsic absorption exists in optical fiber.	L1

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23	4	Explain about the following: (i) Material dispersion. (ii) Wave guide dispersion.	L1
24	4	Find the radius of curvature R at which the number of modes decreases by 50 percent in a gladded index fiber take α = 2, η_2 = 1.5, Δ = 0.01, a = 25 μm, λ = 1.3 μm.	L4
25	4	A single mode fibre operating at the wavelength of 1.3 $\mu\mu$m is found to have a total material dispersion of 2.81 ns and a total waveguide dispersion of 0.495 ns. Determine the received pulse width of 0.5ns.	L4
26	4	What is linear scattering? Explain about Rayleigh and Mie scattering.	L1
27	4	Describe any two types of Losses in Optical Fiber Communication System.	L2
28	4	Explain in detail absorption, scattering and bending losses.	L4

S.No.	CO	Questions	BT
Unit V: (OPTICAL TRANSMITTERS, RECEIVERS AND LINK DESIGN)			
Optical Transmitters and Receivers:-			
1	5	What is LASER diode? Compare its performance with that of LED.	L1
2	5	Establish the threshold gain condition for lasing to occur in a fabry-perot resonator based laser diode.	L1
3	5	With the help of neat diagram, Explain the LED structures.	L1
4	5	Explain the surface emitters and edge emitter LEDS.	L1
5	5	Explain the following: (i) Laser diode rate equation. (ii) External quantum efficiency. (iii) Resonant frequencies.	L1
6	5	Explain about analog links in optical communication.	L1
7	5	Explain about Avalanche Photo Diode.	L1
8	5	Explain with the neat diagram the digital signal transmission link through on optical data line.	L2
9	5	Derive an expression for power coupling from a large surface emitting LED into smaller step index fiber.	L4
10	5	Draw the schematic block diagram of optical receiver and explain each block in detail.	L2
11	5	Discuss about the point to point fibre optic link.	L1
12	5	Explain the principle behind the operation of an avalanche photo diode.	L1
13	5	Briefly discuss about the working of Photo Diode?	L1
14	5	Write short notes on external quantum efficiency.	L1
15	5	Analyze the Power Budget of Optical Fibre Communication in terms of analog system design.	L4
16	5	Describe in detail about Rise time Budget of Optical Fibre Communication in-terms of digital system design.	L2
17	5	Explain in detail about system design considerations and components choice. With necessary equations, explain the following: (a) Rise time budget. (b) Bandwidth budget.	L3

Note: L1-Remembering, L2-Understanding, L3-Applying, L4-Analyzing, L5-Evaluating, and L6-Creating

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Instruction to Faculty Members:

The Six Levels of Bloom's Taxonomy:

1. **Remembering:** Retrieving, recognizing, and recalling relevant knowledge from long-term memory (e.g., list, define, name, locate).
2. **Understanding:** Constructing meaning, explaining ideas, or concepts (e.g., summarize, interpret, classify, compare).
3. **Applying:** Using information in new situations or implementing procedures to solve problems (e.g., solve, use, demonstrate, implement).
4. **Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure (e.g., contrast, categorize, distinguish, diagram).
5. **Evaluating:** Making judgments based on criteria and standards through checking and critiquing (e.g., judge, critique, justify, defend, argue).
6. **Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure (e.g., design, construct, develop, formulate).