# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Diploma Engineering**
**Level: Diploma**
**Branch: Electronics & Communication Engineering**
**Subject Code : DI04011011**
**Subject Name : Microwave & Its Applications**

| | |
|---|---|
| **w. e. f. Academic Year:** | 2025-26 |
| **Semester:** | 4th |
| **Category of the Course:** | PCC |

| | |
|---|---|
| **Prerequisite:** | Basic knowledge of Electronic Devices & Circuits, Network Theory |
| **Rationale:** | This subject develops knowledge of microwave frequency bands, transmission lines, waveguides, and propagation modes essential for high-frequency communication. It enables students to understand the working of microwave components, tubes, semiconductor devices, and measurement techniques. The course provides application-oriented learning of radar and satellite communication systems. |

**Course Outcome:**

| No | Course Outcomes | RBT Level |
|---|---|---|
| 01 | Enlist microwave frequency bands, transmission line parameters, standing waves and impedance matching. | R, U, A |
| 02 | Analyze wave propagation in waveguides of rectangular and circular, cutoff wavelength, velocities, and compare modes. | R, U, A |
| 03 | Describe microwave components, tubes, oscillators and perform basic microwave measurements. | R, U, A |
| 04 | Enlist microwave diodes, parametric amplifiers and semiconductor devices with applications. | R, U, A |
| 05 | Distinguish various Microwave applications | R, U, A |

**Revised Bloom's Taxonomy (RBT)*

**Teaching and Examination Scheme:**

| Teaching Scheme (in Hours) | | | Total Credits L+T+ (PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | Tutorial / Practical | | |
| L | T | PR | C | ESE (E) | PA(M) | PA(I) | ESE (V) | |
| 2 | 0 | 2 | 3 | 70 | 30 | 20 | 30 | 150 |

**Course Content:**

| Unit No. | Content | No. of Hours | % of Weightage |
|---|---|---|---|
| 1. | **Fundamentals of Microwaves & Transmission Lines**<br>1.1 Electromagnetic Waves & Microwave Frequency Bands<br>• Electromagnetic spectrum, frequency ranges.<br>• Microwave frequency bands (L, S, C, X, Ku, K, Ka,W).<br>1.2 Advantagesand Disadvantages of Microwaves<br>1.3 Transmission Line Basics<br>• Primary constants (R, L, G, C).<br>• General transmission line equation.<br>• Lossless line.<br>1.4 Standing Waves & Impedance Matching<br>• VSWR (Voltage Standing Wave Ratio)<br>• Reflection coefficient (Γ).<br>• Stub matching techniques: single and double stub.<br>• Single stub matching.<br>• Double stub matching. | 4 | 15 |
| 2. | **Microwave propagation and Waveguides**<br>2.1 Microwave Transmission & Modes<br>• Concept of propagation modes.<br>• Characteristics of TEM, TE, and TM modes.<br>2.2 Waveguides: Propagation of electromagnetic waves through guided medium and reflection phenomena<br>2.3 Rectangular Waveguide :<br>• Structure and working principle.<br>• Propagation of microwaves through waveguide.<br>• Cut-off wavelength – concept, derivation & examples.<br>• Group velocity & phase velocity.<br>• Characteristic wave impedance.<br>• TE and TM modes, field patterns.<br>2.4 Circular Waveguide<br>• Structure and propagation.<br>• Cutoff wavelength, modes, examples.<br>2.5 Comparison<br>• Transmission line vs. Waveguide.<br>• Rectangular waveguide vs. Circular waveguide. | 5 | 20 |

| | | | |
|---|---|---|---|
| 3. | **Microwave Components and Tubes**<br>3.1 Microwave components<br>• Tees (E-plane, H-plane, Magic Tee).<br>• Hybrid Ring & Directional Coupler<br>• Duplexer, Isolator, Circulator<br>• Cavity Resonators<br>• Corners, Bends, Twist and Taper<br>3.2 Limitations of Vacuum Tubes & Microwave Tubes Amplifiers<br>• Limitations of conventional vacuum tubes at microwave frequencies.<br>• **Klystron amplifiers:** Two-cavity and Multi-cavity<br>• **Travelling Wave Tube (TWT)**<br>3.3 Microwave Tube Oscillators<br>• **Reflex Klystron**<br>• **Magnetron**<br>• **Backward Wave Oscillator (BWO)** | 8 | 30 |
| 4. | **Microwave Semiconductor Devices**<br>4.1 Tunnel diode – principle, V–I characteristics, microwave applications.<br>4.2 Varactor diode – principle, V–I characteristics, microwave applications.<br>4.3 PIN diode – operation, microwave applications.<br>4.4 Gunn diode – negative resistance, microwave oscillators. | 5 | 15 |
| 5. | **Applications of Microwaves**<br>5.1 Telecommunication:<br>RADAR Communication<br>• Basic principle of **Radar**<br>• **Radar range equation** with examples.<br>• Factors affecting maximum range.<br>• Applications<br>• Pulse Radar Systems<br>• Continuous Wave (CW)Radar<br>Satellite Communication<br>• Introduction to Satellite<br>• Types of Satellite (Based on Orbit: LEO, MEO, GEO)<br>• Block Diagram of Satellite Communication with Earth Stations and Ground Equipment (Uplink/Downlink Transmission)<br>• Applications of Satellite Communication<br>5.2 Commercial and Industrial applications<br>• Microwave Ovens, Heating and Drying Machines, food processing industry, Rubber industry, Mining | 8 | 20 |

| | | | |
|---|---|---|---|
| | 5.3 Medical Applications: Microwave Ablation, Diathermy | | |
| **Total** | | **30** | **100** |

**Suggested Specification Table with Marks (Theory):**

| Distribution of Theory Marks (in %) | | | | | |
|---|---|---|---|---|---|
| **R Level** | **U Level** | **A Level** | **N Level** | **E Level** | **C Level** |
| **40** | **35** | **25** | **-** | **-** | **-** |

*Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)*

**References/Suggested Learning Resources:**

| S. No. | Title of Book | Author | Publication (Place, Year) |
|---|---|---|---|
| **1** | Microwave Engineering | M. Kulkarni | Tech-Max Publication, Pune, 2018 |
| 2 | Microwave Engineering | David M. Pozar | Wiley, New York, 2012 |
| 3 | Foundations for Microwave Engineering | Robert E. Collin | McGraw-Hill, New York, 2001 |
| 4 | Microwave Devices and Circuits | Samuel Y. Liao | Prentice Hall, New Jersey, 2003 |
| 5 | Microwave Solid-State Circuit Design | Inder J. Bahl, P. Bhartia | Wiley, New Jersey, 2003 |
| 6 | Microwave & Radar Engineering | Er. Rajesh Dhiman | S.K. Kataria & Sons, 2014 |
| 7 | Radar and Radio Navigation | Merrill I. Skolnik | McGraw-Hill, New York, 2001 |
| 8 | Satellite Communication | Dennis Roddy | McGraw-Hill, New York, 2006 |

**(b) Open source software and website:**

1. https://nptel.ac.in/courses/108101112
   **Microwave Theory and Techniques, IIT Bombay,** Prof. Girish Kumar.
2. https://me-iitr.vlabs.ac.in/Virtual Labs of Microwave Engineering
3. http://www.rf-mw.org/transmission_lines_and_distributed_systems_transmission_lines_transmission

**Suggested Course Practical List:**

Following practical outcomes (PROs) are the sub-components of the Course Outcomes (Cos). Some of the PROs marked '*' are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

| Sr No | Practical Outcomes (PROs) | Unit No | Approx. Hrs Required |
|---|---|---|---|
| 1 | Measure open circuit & short circuit parameters for the given length of Transmission line. | 1 | 2 |
| 2 | Measure VSWR & reflection coefficient for given length of transmission line. | 1 | 2 |
| 3 | Set the microwave bench for optimum frequency operation. | 2 | 2* |
| 4 | Measure the voltage maxima and minima on slotted waveguide and calculate free space, cut off and guided wavelength. | 2 | 2* |
| 5 | Identify various microwave components in the microwave circuit. (PART-1) | 3 | 2* |
| 6 | Identify various microwave components in the microwave circuit. (PART-2) | 3 | 2* |
| 7 | Determine the directivity, insertion loss, and coupling factor for a given directional coupler. | 3 | 2* |
| 8 | Determine the isolation factor for a given isolator. | 3 | 2* |
| 9 | Determine the coupling factor and insertion loss for a given circulator. | 3 | 2* |
| 10 | Calibrate the given variable attenuator. | 3 | 2* |
| 11 | Measure microwave frequency using the given (direct and/or indirect) frequency meter. | 3 | 2* |
| 12 | Measure VSWR for given microwave loads. | 2 | 2* |
| 13 | Measure attenuation of given attenuator. | 3 | 2* |
| 14 | Test different controls and functions of GUNN / KLYSTRON power supply. | 4 | 2* |
| 15 | Arranging the satellite trainer set up, performing functional checks and establishing Active satellite link between Uplink Transmitter and Downlink Receiver using tone signal and demonstrate Link Fail operations. | 5 | 2 |
| 16 | Establishing an Audio-Video satellite link between transmitter and Receiver | 5 | 2 |
| 17 | Establishing Data transmission link by transmitting and receiving PC data through satellite link between Transmitter and Receiver | 5 | 2 |
| 18 | Establish tele-command and receive Temperature and intensity of light from satellite | 5 | 2 |
| 19 | Visit companies that integrate microwave systems for various industrial applications. | 5 | 2 |
| **Minimum 15 Practical Exercises** | | | 30 |

Note

i. More Practical Exercises can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.

**List of Laboratory/Learning Resources Required:**

These major laboratory recourses with broad specifications for the PROs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

| Sr No | Equipment Name with Broad Specifications | PRO.No |
|---|---|---|
| 1 | VSWR meter Resonated at 01 KHZ | All except 15 to 18 |
| | | |
| 2 | Microwave bench. | All except 15 to 18 |
| 3 | GUNN / KLYSTRON power supply 'X' band. | All except 15 to 18 |
| 4 | Various Microwave 'X' band components. | All except 15 to 18 |
| 5 | Microwave accessories BNC to BNC cables, Main Chords | All except 15 to 18 |
| 6 | Satellite Trainer kit | 15 to 18 |
| 7 | Satellite trainer Accessories- Uplink Transmitter, Parabolic Reflector Antennas, Downlink Receiver, Connecting cable, Satellite Transponder, Microphone, Audio/Video input (VCD), Monitor(TV Monitor) | 15 to 18 |

**Competency:** Maintain and test microwave devices and components used in telecommunication applications.

**Program Outcomes (POs):**

1. **Basic &Discipline specific knowledge**: An apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
2. **Problem Analysis:** Identify and analyze well defined engineering problems using codified standard methods.
3. **Design/ Development of Solution:** Design solutions for well-defined technical problems and assist with the design of systems, components or processes to meet specified needs.
4. **Engineering Tools, Experimentation and Testing:** Apply modern engineering tools and relevant technique to conduct standard tests and measurements.
5. **Engineering practices for Society, Environment and sustainability**: Apply relevant technology in context of Society, sustainability, environment and ethical practices.
6. **Project Management**: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

7. **Life-long learning**: Ability to analyze individual needs and engage in updating in the context of context of technological changes.

**Suggested Activities for Students:**

- Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:
  - Prepare chart showing various microwave components.
  - Prepare poster showing Microwave Bench setup.
- Prepare/Download a dynamic animation to illustrate the following:
  - Microwave tubes.
  - EM waves propagation.
  - Satellite and Radar
- Visit a place where waveguides are used for microwave communication. (Such as airport, earth station, AIR/ FM Radio Station, Telephone exchange, Microwave link repeater, TV broadcast).
- Visit manufacturers of microwave equipment and integrate microwave systems for various industrial applications.

********