

### 3/4 B.Tech - SIXTH SEMESTER

EC6T3

Microwave Engineering

Credits: 4

Lecture : 4 periods/week

Tutorial: 1 period /week

Internal assessment: 30 marks

Semester end examination: 70 marks

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#### Course Objectives:

- To know the various bands and their designations in microwave spectrum and applications of microwaves.
- To understand the limitations of conventional tubes to operate in microwave region and to study the principles of operation and constructional details of various microwave tubes and solid state devices.
- To study the working of single port and multi-port passive wave guide components, resonators and ferrite components and their analysis using scattering parameters.
- To study the principles of measurement of attenuation, frequency, VSWR, impedance, cavity Q and power using microwave test bench.

#### Learning Outcomes:

- Students will be aware of various frequency bands of microwave range and their designations in electromagnetic spectrum and applications of microwaves.
- Students are aware of the propagation characteristics of electromagnetic waves in various wave guides structures and the working of different passive wave guide and wave guide components.
- Students are aware of the limitations of conventional tubes to operate in microwave region and the principles of operation of various microwave tubes and microwave solid state devices.
- Students are aware of measurement techniques at microwave range on passive and active devices and components to determine their properties.

#### UNIT-I

**Introduction:** Microwave Spectrum and Bands, Applications of Microwaves, Microwave systems, Microwave units of measure. Microwave radiation hazards.

#### UNIT-II

**Microwave Tubes–I:** Limitations and Losses of conventional tubes at microwave frequencies. Microwave tubes – O type and M type classifications. O-type tubes : two Cavity Klystrons – Structure, Reentrant Cavities, Velocity Modulation Process and Applegate Diagram, Bunching Process and Small Signal Theory – Expressions for o/p Power and Efficiency. Reflex Klystrons – Structure, Applegate Diagram and Principle of working, Mathematical Theory of Bunching, Power Output, Efficiency, Electronic Admittance; Oscillating Modes and o/p Characteristics, Electronic and Mechanical Tuning. Related Problems.

#### UNIT-III

**Microwave Tubes–II: Helix TWTs:** 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** Introduction, Cross-field effects, Magnetrons – Different Types, 8-Cavity Cylindrical Travelling Wave Magnetron – Hull Cut-off and Hartree Conditions, Modes of Resonance and PI-Mode Operation, Separation of PI-Mode, o/p characteristics.

#### **UNIT-IV**

**Microwave Passive Components- I :** Coupling Mechanisms – Probe, Loop, Aperture types. Waveguide Discontinuities – Waveguide irises, Tuning Screws and Posts, Matched Loads. Waveguide Attenuators – Resistive Card, Rotary Vane types; Waveguide Phase Shifters – Dielectric, Rotary Vane types. Waveguide Multiport Junctions – E plane and H plane Tees, Magic Tee, Hybrid Ring; Directional Couplers – 2 Hole, Bethe Hole types.

#### **UNIT-V**

**Microwave Passive Components-II :** Ferrites– Composition and Characteristics, Faraday Rotation; Ferrite Components – Gyrator, Isolator, Circulator. Scattering Matrix– Significance, Formulation and Properties. S Matrix Calculations for – 2 port Junction, E plane and H plane Tees, Magic Tee, Directional Coupler, Circulator and Isolator. Related Problems.

#### **UNIT-VI**

**Microwave Solid State Devices-I:** Transferred Electron Devices: Gunn Effect Diodes (TED), RWH Theory, Modes of Operation, LSA Diodes, PIn Diodes. Microwave Tunnel diode, Principle of Operation and Characteristics. Varactor diode

#### **UNIT-VII**

**Microwave Solid State Devices-II:** Avalanche Transit Time Devices(ATTDD) – Introduction, READ IMPATT, TRAPATT and BARITT Diodes – Principle of Operation and Characteristics. Parametric amplifier- Nonlinear Reactance and Manley-Rowe Relations, Parametric Amplifiers.

#### **UNIT-VIII:**

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

### **Learning Resources**

#### **Text Books:**

1. Microwave Engineering - Annapurna Das, Sisir K Das, Tata McGraw-Hill, Pvt.Ltd., New Delhi, 2<sup>nd</sup> Edition, 2009.
2. Microwave Devices and Circuits – Samuel Y. Liao, PHI, 3<sup>rd</sup> Edition, 2003.

#### **References:**

1. Foundations for Microwave Engineering – R.E. Collin, John Wiley, 2<sup>nd</sup> Edition, 2005
  2. Microwave Engineering- David M.Pozar, John Wiley & Sons, Inc., 2<sup>nd</sup> Edition, 2004
  3. Microwave Circuits and Passive Devices – M.L. Sisodia and G.S.Raghuvanshi, Wiley Eastern Ltd., New Age International Publishers Ltd., 1995.
- Microwave Engineering Passive Circuits – Peter A. Rizzi, PHI, 1999