

ELECTRONICS
Semester-III
Semiconductor Materials and Devices

Core V

Course Outcomes

- Explain the properties of semiconductors and their significance in Electronics, including concepts such as energy band diagrams, doping, and carrier transport mechanisms.
- Describe the operation and characteristics of semiconductor diodes and transistors, including their biasing, small-signal models, and applications in electronic circuits.
- Analyze and design single-stage transistor amplifiers, considering aspects such as gain, input/output impedance, frequency response, and stability.
- Identify the different types of field-effect transistors (FETs) and describe their operation modes, including MOSFETs and JFETs, and analyze their characteristics and applications.
- Explain the operation and characteristics of thyristors, optoelectronic devices (such as LEDs and photodiodes), and power semiconductor devices (such as power diodes and power transistors), considering their applications in power electronics and optoelectronics.

Unit 1

Semiconductor Materials Basics: Introduction to Semiconductor Materials, Crystal Structure, Planes and Miller Indices, Energy Band in Solids, Concept of Effective Mass, Density of States, Carrier Concentration at Normal Equilibrium in Intrinsic Semiconductors, Derivation of Fermi Level for Intrinsic & Extrinsic Semiconductors, Donors, Acceptors, Dependence of Fermi Level on Temperature and Doping Concentration, Temperature Dependence of Carrier Concentrations. Carrier Transport Phenomena: Carrier Drift, Mobility, Resistivity, Hall Effect, Diffusion Process, Einstein Relation, Current Density Equation, Carrier Injection, Generation And Recombination Processes, Continuity Equation.

Unit 2

P-N Junction Diode : Formation of Depletion Layer, Space Charge at a Junction, Derivation of Electrostatic Potential Difference at Thermal Equilibrium, Depletion Width and Depletion Capacitance of an Abrupt Junction. Concept of Linearly Graded Junction, Derivation of Diode Equation and I-V Characteristics. Zener and Avalanche Junction Breakdown Mechanism. Tunnel diode, varactor diode, solar cell: circuit symbol, characteristics, applications

Unit 3

Bipolar Junction Transistors (BJT): PNP and NPN Transistors, Basic Transistor Action, Emitter Efficiency, Base Transport Factor, Current Gain, Energy Band Diagram of Transistor in Thermal Equilibrium, Quantitative Analysis of Static Characteristics (Minority Carrier Distribution and Terminal Currents), Base Width Modulation, Modes of operation, Input and Output Characteristics of CB, CE and CC Configurations. Metal Semiconductor Junctions: Ohmic and Rectifying Contacts.

Unit 4

Field Effect Transistors: JFET, Construction, Idea of Channel Formation, Pinch-Off and Saturation Voltage, Current-Voltage Output Characteristics. MOSFET, types of MOSFETs, Circuit symbols, Working and Characteristic curves of Depletion type MOSFET (both N

channel and P Channel) and Enhancement type MOSFET (both N channel and P channel). Complimentary MOS (CMOS). Power Devices: UJT, Basic construction and working, Equivalent circuit, intrinsic Standoff Ratio, Characteristics and relaxation oscillator-expression. SCR, Construction, Working and Characteristics, Triac, Diac, IGBT, MESFET, Circuit symbols, Basic constructional features, Operation and Applications.

Suggested References:

- ✓ *S. M. Sze, Semiconductor Devices: Physics and Technology, 2nd Edition, Wiley India edition (2002).*
- ✓ *Ben G Streetman and S. Banerjee, Solid State Electronic Devices, Pearson Education (2006)*
- ✓ *Dennis Le Croisette, Transistors, Pearson Education (1989)*
- ✓ *Jasprit Singh, Semiconductor Devices: Basic Principles, John Wiley and Sons (2001)*
- ✓ *Kanaan Kano, Semiconductor Devices, Pearson Education (2004)*
- ✓ *Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education (2006)*
- ✓ *CORE-3(LAB)*

Practical:

1. Study of the I-V Characteristics of Diode – Ordinary and Zener Diode.
2. Study of the I-V Characteristics of the CE configuration of BJT and obtain r_i , r_o , β .
3. Study of the I-V Characteristics of the Common Base Configuration of BJT and obtain r_i , r_o , α .
4. Study of the I-V Characteristics of the Common Collector Configuration of BJT and obtain voltage gain, r_i , r_o .
5. Study of the I-V Characteristics of the UJT.
6. Study of the I-V Characteristics of the SCR.
7. Study of the I-V Characteristics of JFET.
8. Study of the I-V Characteristics of MOSFET.
9. Study of Characteristics of Solar Cell
10. Study of Hall Effect.

Online Resources:

1. MIT OpenCourseWare: "Introduction to Solid State Chemistry"
(<https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/>)
2. All About Circuits: "Semiconductor Basics"
(<https://www.allaboutcircuits.com/textbook/semiconductors/>)
3. Electronics Tutorials: "Semiconductor Diodes" (https://www.electronicstutorials.ws/diode/diode_1.html)
4. Semiconductor Engineering: (<https://semiengineering.com/>)