

**Government of Karnataka**  
**Department of Technical Education**  
**Board of Technical Examinations, Bengaluru**

|  |                                 |
|--|---------------------------------|
| Course Title: <b>BASICS OF SEMICONDUCTOR DEVICES</b> | Course Code : <b>15EC21T</b>    |
| Semester : <b>2</b>                                  | Course Group : <b>Core</b>      |
| Teaching Scheme in Hrs (L:T:P) : <b>4:0:0</b>        | Credits : <b>4</b>              |
| Type of course : <b>Lecture + Assignments</b>        | Total Contact Hours : <b>52</b> |
| CIE : <b>25 Marks</b>                                | SEE : <b>100 Marks</b>          |

### Prerequisites

Knowledge of physics and principles of electrical engineering.

### Course Objectives

Acquire the fundamental knowledge and expose to the field of semiconductor theory and devices and their applications.

### Course Outcomes

On successful completion of the course, the students will be able to

1. Describe the properties of materials and application of semiconductor electronics
2. Apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices.
3. Demonstrate the switching and amplification application of the semiconductor devices.
4. Demonstrate the control applications using semiconductor devices.
5. Identify the fabrication methods of integrated circuits.
6. Classify and describe the semiconductor devices for special applications.

### Course Contents

#### UNIT - 1:Introduction to Semiconductor Devices

**Duration: 11 Hr.**

**Semiconductor Physics:**Atomic structure, Neil Bohr's atomic theory, definition of conductors, insulators and semiconductors, energy level diagrams.**Semiconductors:** Classification and types, intrinsic and extrinsic, P-type and N-type semiconductors, majority and minority carriers, recombination, effect of temperature.**PN junction:**Formation, depletion region, barrier potential, reverse breakdowns, PN junction as diode, symbol, biasing modes, V-I characteristics, reverse saturation current, diode current equation, effect of temperature on diode current,ideal diode, basic diode ratings.**Zener diode:** Symbol, Principle,Zener breakdown, V-I characteristics.**Application of Diodes:**diode as a switch, voltage regulator.

## **UNIT - 2: Bipolar Transistors Duration: 10 Hr.**

**Transistor Basics:** Definition, formation of transistor-PNP and NPN, symbols, working principle, transistor current equation. **Modes of operation:** CB, CE and CC Configuration modes, input and output characteristics in CB and CE configuration, definition of  $R_i$  &  $R_o$ ,  $\alpha$ ,  $\beta$ , and  $\gamma$  relation between them, simple problems, comparison of CB, CE and CC modes. **Applications:** Switch and amplifier in CE configuration, thermal runaway, role of heat sinks.

## **UNIT -3: Field Effect Transistor Duration: 10 Hr.**

**FET basics:** Physical structure of FET, principle of operation, P-channel and N-channel, symbols, drain and transfer characteristics, definition of pinch-off voltage,  $r_d$ ,  $g_m$ ,  $\mu$  and their relationship, comparison of JFET and BJT, applications of JFET. **MOSFET:** Types-Depletion and enhancement, P-channel and N-channel, physical structure, comparison of MOSFET and JFET. **CMOS:** Working principle, low-power consumption feature, limitations, inverter, applications of CMOS, comparison with MOSFET.

## **UNIT - 4: Special Semiconductor Devices Duration: 08 Hr.**

Physical structure, Working principle, characteristic curves, symbol and applications of following semiconductor devices: UJT, SCR, DIAC and TRIAC. Features of varactor, tunnel diode, Gunn diode, PIN diode, and Schottky diode.

## **UNIT -5: Fabrication of Integrated ICs Duration: 06 Hr.**

Definition and need of IC's, advantages and disadvantages, classification of ICs based on structure, scale of integration, function. Fabrication process of monolithic ICs. Fabrication of diode and capacitor.

## **UNIT- 6: Opto-semiconductor Devices Duration: 07 Hr.**

Definitions: photo emission, photoconduction, photovoltaic effect with application examples. Features: photodiode, phototransistor, LED, Opto-coupler, LED lamps, solar cell, solar panel, LASER and MASER.

## **References**

1. *Principles of Electronics*, Rohit Mehta & V K Mehta, S. Chand Publishing ISBN: 9788121924504
2. *Electronic Devices and Circuits*, David A. Bell, Oxford University Press, ISBN: 9780195693409
3. *Fundamentals of Electrical and Electronics Engineering*, B. L. Theraja, S. Chand and Company. REPRINT 2013, ISBN 8121926602.
4. <http://www.electronics-tutorials.ws>

## Course Delivery

The course will be delivered through lectures, presentations and support of modern tools.

## Mapping Course Outcomes with Programme Outcomes

| Course outcomes | Programme Outcomes |   |   |   |   |   |   |   |   |    |    |    |
|-----------------|--------------------|---|---|---|---|---|---|---|---|----|----|----|
|                 | 1                  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1               | S                  |   |   |   |   |   |   |   |   |    |    | M  |
| 2               | S                  | S |   | M |   |   |   |   |   |    |    |    |
| 3               | S                  | S | S | S |   |   |   |   |   | M  |    |    |
| 4               | S                  | S | S | S |   |   |   |   |   | M  |    |    |
| 5               | S                  |   |   |   | M | M | M | M |   |    |    |    |
| 6               | S                  | S | M | M |   |   |   |   |   |    | M  | M  |

Legends-S: Strong Relationship M: Moderate Relationship.

## Course Assessment and Evaluation Scheme

| Assessment Method        | What                       |          | To Whom  | When/Where (Frequency in the course)                | Max. Marks | Evidence Collected    | Course Outcomes  |
|--------------------------|----------------------------|----------|----------|---|------------|-----------------------|--|
| Direct Assessment method | CIE*                       | IA       | Students | Three Tests (Average of three tests to be computed) | 20         | Blue Books            | 1 to 6   |
|                          |                            |          |          | Assignment  | 05         | Assignment Books      | 1 to 6   |
|                          | SEE*                       | End Exam |          | End of the Course                                   | 100        | Answer Scripts at BTE | 1 to 6   |
|                          |                            |          |          | Total   | 125        |                       |  |
| Indirect Assessment      | Student Feedback on course |          | Students | Middle of the Course                                | Nil        | Feedback Forms        | 1 to 6 & Delivery of course  |
|                          | End of Course Survey       |          |          | End of the Course                                   | Nil        | Questionnaires        | 1 to 6, Effectiveness of Delivery of Instructions & Assessment Methods |

\*CIE – Continuous Internal Evaluation      \*SEE – Semester End Examination

**Note:** I.A. test shall be conducted for 20 marks. Any decimals shall be rounded off to the next higher digit.

## Composition of Educational Components

Questions for CIE and SEE will be designed to evaluate the various educational components such as shown in the following table.

| Sl. No. | Component                                       | Weightage (%) |
|---------|---|---------------|
| 1       | Remembering and Understanding                   | 45            |
| 2       | Applying the knowledge acquired from the course | 20            |
| 3       | Analysis  | 20            |
| 4       | Evaluation                                      | 10            |
| 5       | Creating new knowledge                          | 05            |

## Study and Question Paper Pattern

| Unit No.     | Unit Name                             | Study Duration (Hrs.) | No. Questions for End-exam    |                                 |
|--------------|---------------------------------------|-----------------------|-------------------------------|---------------------------------|
|              |                                       |                       | 5 Marks PART - A              | 10 Marks PART - B               |
| I            | Introduction to Semiconductor Devices | 11                    | 01                            | 02                              |
| II           | Bipolar Transistor                    | 10                    | 02                            | 02                              |
| III          | Field Effect Transistor               | 10                    | 02                            | 02                              |
| IV           | Special Semiconductor Devices         | 08                    | 01                            | 02                              |
| V            | Fabrication of IC's                   | 06                    | 01                            | 01                              |
| VI           | Opto Semiconductor Devices            | 07                    | 02                            | 01                              |
| <b>Total</b> |                                       | <b>52</b>             | <b>09</b><br><b>(45marks)</b> | <b>10</b><br><b>(100 marks)</b> |

## Model Question Paper

Course Title : **Basics of Semiconductor Devices**

Course Code : **15EC21T**

Semester : **FIRST**

Time : **3Hrs**

Max.Marks : **100**

Instructions : 1. Answer any **SIX** question from **Part A** (5x6=30 Marks)

2. Answer any **SEVEN** full questions from **Part B** (7x10=70 Marks)

### Part A

1. Compare the features of insulators, conductors and semiconductors.
2. Define alpha & beta; evaluate beta in terms of alpha
3. Explain how transistor can work as a switch
4. Distinguish between BJT and JFETs.
5. Deduce the relation between  $g_m$ ,  $r_d$  and  $\mu$

6. List the features of TRIAC.
7. Tabulate advantages and disadvantages of ICs.
8. Define Photo emissive, Photoconductive and photovoltaic effect
9. List the applications of phototransistors.

### Part B

1. (a) Explain how Zener diode can act as a voltage regulator. (5)  
(b) Explain how diode can be used as electronic switch. (5)
2. (a) Describe how doping helps to increase current conduction in n-type semiconductor.(6)  
(b) Define barrier potential and reverse saturation current. (4)
3. (a) Justify the transistor current equation  $I_E = I_B + I_C$ . (4)  
(b) Compare CE and CB modes of transistors. (6)
4. (a) Explain the need for heat sink in electronic devices.(6)  
(b) Calculate the current gain in CB mode given that  $I_B = 10\mu A$  and  $I_C = 5mA$ .(4)
5. (a) Explain the working of N-channel JFET(5)  
(b) Compare enhancement and depletion MOSFETS (5)
6. (a) List the features of CMOS (5)  
(b) Explain the working of CMOS inverter (5)
7. Explain the working principle of SCR and list its applications.
8. (a) List the features of varactor diode. (6)  
(b) Define valley and peak voltages as applicable to UJT. (4)
9. Describe the steps involved in fabrication of diode in monolithic ICs.
10. (a) Explain the operation of LASER  
(b) List the features of LED bulbs.

## Question Bank

**Note:** The questions in the question bank are indicative but not exhaustive.

### UNIT-1

#### 5-mark questions

1. Distinguish between conductor and semiconductor materials
2. State the properties of semiconductors.
3. Explain intrinsic and extrinsic semiconductors with examples
4. Define doping, explain the atomic structure of N-type semiconductor
5. Define doping, explain the energy band diagram of a P-type semiconductor
6. Outline the differences between N and P type semiconductors
7. Describe the use of PN junction diode as switch
8. Describe forward characteristics of a PN junction diode
9. List the specifications of a PN junction diode
10. Analyze the equivalent circuit of ideal diode

#### 10-mark Questions

1. (a) Explain PN junction diode as a switch  
(b) Describe the effect of temperature on reverse saturation current in PN junction.
2. (a) Show how Zener diode can be used as voltage regulator  
(b) Distinguish between Zener breakdown and Avalanche breakdown.
3. Describe the working of Zener diode in forward and reverse bias
4. Explain the effect of temperature on barrier voltage in PN junction diode.

- Describe the formation of PN junction, depletion region and potential barrier
- Sketch V-I characteristics of PN junction diode with circuit in both FB and RB modes.
- Describe how dopants can increase the current conduction in semiconductors.
- (a) Sketch V-I characteristics of Zener diode in FB and RB bias modes.  
(b) Outline the relevance of RB mode in Zener diode.

## UNIT-2

### 5-mark questions

- List the constructional features of an NPN transistor
- List the constructional features of an PNP transistor
- Explain the working principle of NPN/PNP transistor
- Write a note on transistor current equation.
- Base width of transistor is thin and collector is thick, justify.
- Emitter is heavily doped and base is lightly doped, justify.
- Define alpha and beta, deduce the relation between them.
- Sketch and explain the input characteristics of CE mode
- Sketch and explain the output characteristics of CE mode
- Justify the need for heat sink.

### 10-mark Questions

- (a) List the physical features of a transistor.  
(b) Explain the working principle of a transistor
- Sketch and explain the input and output characteristics of CE mode
- Compare CE, CB and CC modes of a transistor
- Justify how transistor can act as a switch with support of circuit and waveforms
- Justify how transistor can act as an amplifier with support of circuit and waveforms in CE mode
- (a) Explain the terms cut-off, saturation and active region of a transistor and their relevance.  
(b) Write a note on transistor as emitter follower.

## UNIT-3

### 5-mark Questions

- Compare BJT and JFET.
- Define JFET parameters.
- List the applications of JFET and SCR
- List the constructional features of JFET
- List the advantages of JFET over BJT.
- Write the applications of CMOS.
- List the features of CMOS
- Compare the enhancement and depletion modes of MOSFET
- Correlate the JFET parameters  $r_d$ ,  $g_m$  and  $\mu$ .
- Explain CMOSFET as an inverter

### 10-mark Questions

- Explain the concept of field effect and analyse how it controls current in JFET.
- (a) Sketch the symbols of JFET (n and p channels), MOSFET (enhancement and depletion) and CMO  
(b) JFET is a voltage controlled device, justify.

3. Sketch and discuss the drain characteristics of N- channel JFET
4. Sketch and discuss the transfer characteristics of a JFET
5. Construct and explain enhancement type MOSFET

#### **UNIT-4**

##### **5-mark Questions**

1. Describe the construction of UJT
2. Explain the operation of UJT
3. Write the equivalent circuit of UJT. Define intrinsic stand-off ratio.
4. List the applications of UJT and varactor diode
5. Describe the construction of SCR
6. Explain holding and latching currents of SCR
7. List the applications of SCR and TRIAC
8. List the applications of PIN diode and Gunn diode
9. Sketch and discuss the VI characteristics of DIAC
10. List the features of GUNN diode
11. Write the features of Varactor diode
12. List the features of Schottky diode

##### **10-mark Questions**

1. Sketch and discuss the V-I characteristics of UJT
2. Discuss the V-I characteristics of SCR
3. Describe the construction and Explain the operation of TRIAC
4. Explain the constructional features and the operation of DIAC
5. Discuss the characteristics of TRIAC

#### **UNIT-5**

##### **5-mark Questions**

1. List the advantages of ICs
2. Classify Integrated circuits based on scale of integration
3. List the classification of ICs by structure
4. Define SSI, MSI,LSI and VLSI
5. Compare ICs with discrete components

##### **10-mark Questions**

1. Describe the steps in fabricating monolithic ICs with diagrams
2. Describe the fabrication of capacitor and diode with diagrams
3. List the advantages and disadvantages of ICs

#### **UNIT-6**

##### **5-mark Questions**

1. Explain the terms Photo emissive, Photoconductive and photovoltaic effect
2. Write the advantages of Opto-couplers
3. Write a short note on solar cell
4. List the applications and advantages of LED
5. List the applications of phototransistor and photo diodes.

##### **10-mark Questions**

1. Describe the construction and operation of LED
2. List the features of LASER and MASER.

**End**