

ES-105: SEMICONDUCTOR DEVICES AND CIRCUITS

Course Title:	SEMICONDUCTOR DEVICES AND CIRCUITS	Course Code	ES-105
Year	1	Course Group	Core
Teaching Scheme in Periods (L:T:P)	4:1:0	Credits	3
Methodology	Lecture + Tutorials	Total Contact Periods	150
CIE	60 Marks	SEE	40 Marks

Basic knowledge of Physics and Mathematics, also concepts of AC and DC voltages and

Pre requisites

currents.

Course Outcomes

Upon completion of the course, the student shall be able to

CO1	Identify various passive and electro-mechanical components and demonstrate soldering/desoldering techniques on PCBs.
CO2	Analyze the V-I characteristics of diodes and construct a regulated DC power supply using rectifiers and filters.
CO3	Explain the operation of Bipolar Junction Transistors (BJT) in different configurations and apply biasing techniques for stability.
CO4	Compare BJT with FET/MOSFET and illustrate the handling precautions for CMOS devices against ESD.
CO5	Differentiate between Small Signal and Power Amplifiers and analyze the frequency response and efficiency of different amplifier classes.
CO6	Design basic sinusoidal oscillator circuits and apply thyristors/optoelectronics in control and isolation circuits.

Course Content and Blue Print of Marks for SEE

Unit No	Unit Name	Periods	Questions to be set for SEE			
				R	U	A
I	Electronic Components and PCB Basics	20	Q4	Q1	Q9(a)	Q13(a)
II	Semiconductor Diodes and Power Supplies	25				
III	Bipolar Junction Transistors (BJT)	30		Q2	Q10(a)	Q14(a)
IV	Field Effect Transistors (FET and MOSFET)	25				

V	Amplifiers (Small Signal and Power Amplifiers)	25			Q5,Q6	Q9(b),Q11(a), Q11(b)	Q13(b),Q15(a), Q15(b)
VI	Oscillators and Special Semiconductor Devices	25		Q3	Q7,Q8	Q10(b),Q12(a), Q12(b)	Q14(b),Q16(a), Q16(b)
	Total	150	8			8	8

Course Contents

UNIT-1: Electronic Components and PCB Basics

Duration: 20 Periods (L: 16 – T:4)

Fundamentals of electricity – voltage, current, power – Ohm’s law –KCL-KVL- passive components – resistors: fixed and variable resistors, colour coding, power rating, series and parallel combination – capacitors: function, types of capacitors (ceramic and electrolytic), voltage rating – inductors and transformers: concept of inductance, transformer principle, step-up and step-down transformers – electro-mechanical components – switches (SPST, SPDT, toggle switches) – relays: electromagnetic principle and applications – printed circuit boards – types of PCBs – breadboard and copper clad boards – soldering tools – soldering techniques – use of desoldering pump.

UNIT-2: Semiconductor Diodes and Power Supplies

Duration: 25 Periods (L: 20 – T:5)

Basic semiconductor physics – conductors, semiconductors, and insulators – intrinsic and extrinsic semiconductors – P-type and N-type doping – PN junction formation and depletion region – semiconductor diodes – forward and reverse biasing – V-I characteristics of diode – knee voltage and breakdown voltage – Zener diode and its working principle – DC power supplies – block diagram of regulated power supply – rectifiers – half-wave rectifier – full-wave centre-tapped rectifier – bridge rectifier – efficiency and ripple factor – filters – need for filters – capacitor filter and pi filter – voltage regulators – Zener diode as voltage regulator – three-terminal IC regulators (78xx and 79xx series).

UNIT-3: Bipolar Junction Transistors (BJT)

Duration: 30 Periods (L: 24 – T:6)

Bipolar junction transistor – construction and operation of NPN and PNP transistors – transistor action – current relations in BJT) – transistor configurations – common base (CB), common emitter (CE), and common collector (CC) configurations – input and output characteristics – biasing of transistors – need for biasing – stability of operating point – potential divider bias – applications of BJT – transistor as a switch – cut-off and saturation regions – driving LEDs and relays – thermal management – power dissipation – thermal runaway – heat sinks and their applications.

UNIT-4: Field Effect Transistors (FET and MOSFET)

Duration: 25 Periods (L: 20 – T:5)

Introduction to field effect transistors – comparison between BJT and FET – JFET – construction of N-channel JFET – operation of JFET – pinch-off voltage – drain characteristics – MOSFET – construction and operation of enhancement mode and depletion mode MOSFETs – introduction to CMOS technology – concept and advantages of CMOS in digital logic circuits – handling precautions – sensitivity of MOS devices to static electricity – electrostatic discharge (ESD) protection measures.

UNIT-5: Amplifiers (Small Signal and Power Amplifiers)

Duration: 25 Periods (L: 20 – T:5)

Amplifiers – concept of amplification – voltage gain, current gain, and power gain – small signal amplifiers – common emitter amplifier – frequency response of CE amplifier – bandwidth – multistage amplifiers – need for cascading – block diagram of two-stage RC-coupled amplifier – loading effect – power amplifiers – difference between voltage amplifiers and power amplifiers – classes of power amplifier operation – class A, class B, and class AB amplifiers – push-pull amplifier configuration – efficiency and cross-over distortion.

UNIT-6: Oscillators and Special Semiconductor Devices

Duration: 25 Periods (L: 20 – T:5)

Oscillators – feedback in amplifiers – positive and negative feedback – Barkhausen criterion for oscillations – RC phase shift oscillator – Hartley oscillator – Colpitts oscillator – crystal oscillator and frequency stability – thyristors – silicon controlled rectifier (SCR) – construction of SCR – two-transistor analogy – V-I characteristics – applications of SCR in motor speed control – optoelectronic devices – light emitting diode (LED) – working principle and current limiting – photodiode – opto-couplers – working principle and applications of opto-coupler (MCT2E) for electrical isolation.

Text Books

1. Boylestad and Nashelsky, *Electronic Devices and Circuit Theory*, Pearson Education.
2. S. Salivahanan and N. Suresh Kumar, *Electronic Devices and Circuits*, Tata McGraw-Hill.

Reference Books

1. Millman and Halkias, *Integrated Electronics*, McGraw-Hill.
2. Jacob Millman, *Microelectronics*, McGraw-Hill.
3. Manufacturer datasheets of diodes, transistors, MOSFETs, and IC regulators.

Suggested E-learning references

1. <http://electrical4u.com/>
2. www.nptel.ac.in

Suggested Learning Outcomes

Upon completion of the course, the student shall be able to

CO1: Identify various passive and electro-mechanical components and demonstrate soldering/desoldering techniques on PCBs.

- 1.1 define voltage, current, and power.
- 1.2 apply Ohm's law, KCL, KVL to simple electrical circuits.
- 1.3 calculate current, voltage, and power in DC circuits.
- 1.4 identify different types of resistors.
- 1.5 interpret resistor colour codes correctly.
- 1.6 determine power rating requirements of resistors.
- 1.7 analyse series and parallel resistor combinations.
- 1.8 explain the function of capacitors in circuits.
- 1.9 identify different types of capacitors and their applications.
- 1.10 explain voltage rating and safety margins of capacitors.
- 1.11 explain the concept of inductance.
- 1.12 describe the working principle of transformers.
- 1.13 differentiate between step-up and step-down transformers.
- 1.14 identify different types of switches and their applications.
- 1.15 explain the electromagnetic principle of relays.
- 1.16 describe practical applications of relays.
- 1.17 differentiate between breadboards and copper-clad PCBs.
- 1.18 identify soldering tools and accessories.
- 1.19 demonstrate correct soldering techniques.
- 1.20 explain desoldering methods using a desoldering pump.

CO2: Analyze the V-I characteristics of diodes and construct a regulated DC power supply using rectifiers and filters.

- 2.1 differentiate between conductors, semiconductors, and insulators.
- 2.2 explain intrinsic and extrinsic semiconductors.
- 2.3 describe P-type and N-type doping mechanisms.
- 2.4 explain PN junction formation and depletion region.
- 2.5 explain forward and reverse biasing of diodes.
- 2.6 analyze V-I characteristics of a PN junction diode.
- 2.7 identify knee voltage and breakdown voltage.
- 2.8 explain the working principle of a Zener diode.
- 2.9 describe the block diagram of a regulated power supply.

- 2.10 explain the operation of half-wave rectifier.
- 2.11 explain the operation of full-wave centre-tapped rectifier.
- 2.12 explain the working of bridge rectifier.
- 2.13 compare rectifier efficiency and ripple factor.
- 2.14 explain the need for filters in power supplies.
- 2.15 describe capacitor and pi filters.
- 2.16 explain Zener diode as a voltage regulator.
- 2.17 explain the working of 78xx IC voltage regulators.
- 2.18 explain the working of 79xx IC voltage regulators.
- 2.19 identify applications of regulated power supplies.
- 2.20 select suitable rectifier and regulator circuits for applications.

CO3: Explain the operation of Bipolar Junction Transistors (BJT) in different configurations and apply biasing techniques for stability.

- 3.1 describe the construction of NPN and PNP transistors.
- 3.2 explain the principle of transistor action.
- 3.3 explain current relationships in BJT.
- 3.4 identify different operating regions of a transistor.
- 3.5 describe CB, CE, and CC configurations.
- 3.6 compare input and output characteristics of BJT configurations.
- 3.7 explain the need for transistor biasing.
- 3.8 explain Q-point stability.
- 3.9 describe potential divider bias method.
- 3.10 analyze transistor characteristic curves.
- 3.11 explain BJT operation as a switch.
- 3.12 differentiate between cut-off and saturation regions.
- 3.13 design a transistor switching circuit for LED control.
- 3.14 design a relay driver circuit using BJT.
- 3.15 explain power dissipation in transistors.
- 3.16 describe thermal runaway phenomenon.
- 3.17 explain the role of heat sinks.
- 3.18 select suitable heat sinks for power transistors.
- 3.19 identify applications of BJTs in electronic circuits.
- 3.20 analyze safe operating conditions of BJTs.

CO4: Compare BJT with FET/MOSFET and illustrate the handling precautions for CMOS devices against ESD.

- 4.1 differentiate between BJT and FET operation.
- 4.2 explain voltage-controlled characteristics of FETs.
- 4.3 describe the construction of N-channel JFET.
- 4.4 explain the operation of JFET.
- 4.5 define pinch-off voltage.
- 4.6 analyze JFET drain characteristics.
- 4.7 describe the construction of MOSFET.
- 4.8 differentiate enhancement and depletion mode MOSFETs.
- 4.9 explain MOSFET operating principles.
- 4.10 identify advantages of MOSFETs over BJTs.

- 4.11 explain the concept of CMOS.
- 4.12 describe advantages of CMOS technology.
- 4.13 identify applications of MOSFETs.
- 4.14 explain ESD sensitivity of MOS devices.
- 4.15 describe ESD protection techniques.
- 4.16 apply safe handling procedures for MOS devices.
- 4.17 compare JFET and MOSFET characteristics.
- 4.18 select appropriate FET devices for applications.
- 4.19 explain power handling limitations of FETs.
- 4.20 analyze MOSFET usage in digital circuits.

CO5: Differentiate between Small Signal and Power Amplifiers and analyze the frequency response and efficiency of different amplifier classes.

- 5.1 define amplification and amplifier.
- 5.2 explain voltage, current, and power gain.
- 5.3 describe CE amplifier operation.
- 5.4 analyze frequency response of CE amplifier.
- 5.5 define bandwidth of an amplifier.
- 5.6 explain low-frequency and high-frequency response.
- 5.7 describe the need for multistage amplifiers.
- 5.8 explain RC-coupled amplifier operation.
- 5.9 analyze loading effect in multistage amplifiers.
- 5.10 differentiate voltage and power amplifiers.
- 5.11 explain Class A amplifier operation.
- 5.12 explain Class B amplifier operation.
- 5.13 explain Class AB amplifier operation.
- 5.14 describe push-pull amplifier configuration.
- 5.15 explain efficiency of power amplifiers.
- 5.16 analyze cross-over distortion.
- 5.17 compare efficiency of amplifier classes.
- 5.18 select amplifier class for applications.
- 5.19 explain thermal issues in power amplifiers.
- 5.20 identify applications of amplifiers in electronics.

CO6: Design basic sinusoidal oscillator circuits and apply thyristors/optoelectronics in control and isolation circuits.

- 6.1 define oscillation and oscillator.
- 6.2 explain positive and negative feedback.
- 6.3 state Barkhausen criterion for oscillations.
- 6.4 explain RC phase shift oscillator operation.
- 6.5 explain Hartley oscillator operation.
- 6.6 explain Colpitts oscillator operation.
- 6.7 compare RC and LC oscillators.
- 6.8 explain crystal oscillator operation.
- 6.9 explain frequency stability of crystal oscillators.
- 6.10 describe construction of SCR.
- 6.11 explain two-transistor analogy of SCR.
- 6.12 analyze V-I characteristics of SCR.

- 6.13 explain SCR triggering methods.
 6.14 describe SCR application in motor speed control.
 6.15 explain working of LED.
 6.16 explain current limiting requirement for LED.
 6.17 explain working of photodiode.
 6.18 explain opto-coupler operation.
 6.19 explain electrical isolation using opto-couplers.
 6.20 select appropriate optoelectronic devices for applications.

Suggested Student Activities

1. Visit the Institute's Library / internet center and list the books/journals/ e-books and any other resources available on the topics suggested by the teacher.
2. Prepare a chart showing the symbols and names of various devices.
3. Prepare a PPT identifying the need for these SEMICONDUCTOR DEVICES CIRCUITS and their use in electronic industry.

CO-PO Mapping Matrix

	Basic and Discipline Specific Knowledge	Problem Analysis	Design/Development of Solutions	Engineering Tools, Experimentation and Testing	Engineering Practices for Society, Sustainability and Environment	Project Management	Lifelong Learning	Linked PO
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	
CO1	3	2	3	3	1		1	1,2,3,4,5,7
CO2	3	3	3	2			1	1,2,3,4,7
CO3	3	3	2	1			1	1,2,3,4,7
CO4	2	3	2	1	2		2	1,2,3,4,5,7
CO5	2	3	3	2			1	1,2,3,4,7
CO6	2	3	3	1	1		2	1,2,3,4,5,7,

QUESTION PAPER PATTERN FOR MID SEMESTER EXAMS

Sl.No	Description	Level	No of Questions	Marks for each question	Choice	Total Marks
01	Part-A	Remembering(R)	4	1	Nil	4 Marks
02	Part-B	Understanding(U)	4	3	2	6 Marks
03	Part-C	Application(A)	4	5	2	10 Marks
Total Marks						20 Marks

MID SEM-I EXAM

MID SEM EXAM					
S.No	Unit No	R	U	A	Remarks
1	Unit-I	1,2	5(a)	7(a)	
			5(b)	7(b)	
2	Unit-II	3,4	6(a)	8(a)	
			6(b)	8(b)	
Total Questions		4	4	4	

MID SEM-II EXAM

MID SEM I EXAM					
S.No	Unit No	R	U	A	Remarks
1	Unit-III	1,2	5(a)	7(a)	
			5(b)	7(b)	
2	Unit-IV	3,4	6(a)	8(a)	
			6(b)	8(b)	
Total Questions		4	4	4	

The length of answer for each question framed in respect of Part-A, B&C shall not exceed $\frac{1}{4}$ of a page, 1 page and 2 pages respectively

QUESTION PAPER PATTERN FOR SEMESTER END EXAM

Sl.No	Description	Level	No of Questions	Marks for each question	Choice	Total Marks
01	Part-A	Remembering(R)	8	1	Nil	8 Marks
02	Part-B	Understanding(U)	8	3	4	12 Marks
03	Part-C	Application(A)	8	5	4	20 Marks
Total Marks						40 Marks

Unit No	Questions to be set for SEE				
	R		U	A	
I	Q4	Q1		Q9(a)	Q13(a)
II					
III		Q2		Q10(a)	Q14(a)
IV					
V		Q3	Q5,Q6	Q9(b), Q11(a), Q11(b)	Q13(b), Q15(a), Q15(b)
VI			Q7,Q8	Q10(b), Q12(a), Q12(b)	Q14(b), Q16(a), Q16(b)
Total Questions	8		8	8	

State Board of Technical Education and Training, Telangana
Model Question paper
Mid Semester-I Examination

Course Code: ES-105

Course Name: Semiconductor Devices And Circuits

Duration: 1 hour

Max.Marks: 20 Marks

PART-A

Answer **all** questions, Each Question carries **ONE** mark

4x1 = 4 Marks

1. Define Ohm's Law.
2. What is the colour code for a 1K OHM resistor with 5% tolerance?
3. Define "Knee Voltage" of a diode.
4. What is the Peak Inverse Voltage (PIV) of a Bridge Rectifier?

PART-B

Answer **TWO** questions. Each question carries **THREE** marks **2x3 = 6 Marks**

- 5(a). Calculate the equivalent resistance of three resistors R₁, R₂, and R₃ connected in parallel.

(OR)

- 5(b). Explain the difference between a Step-up and Step-down transformer.

- 6(a). Differentiate between Intrinsic and Extrinsic semiconductors.

(OR)

- 6(b). Draw the circuit diagram of a Bridge

PART-C

Answer **TWO** questions. Each question carries **FIVE** marks

2x5= 10 Marks

- 7(a). Explain the step-by-step procedure of Soldering and Desoldering components on a PCB.

(OR)

- 7(b). Compare Single-sided, Double-sided, and Multi-layer PCBs.

- 8(a). Draw and explain the block diagram of a Regulated DC Power Supply.

(OR)

- 8(b). Explain the working of a Full Wave Centre-Tapped Rectifier with input and output waveforms.

State Board of Technical Education and Training, Telangana
Model Question paper
Mid Semester-II Examination

Course Code:ES-105

Course Name: Semiconductor Devices And Circuits

Duration:1 hour

Max.Marks:20 Marks

PART-A

Answer ALL questions, Each Question carries ONE mark

4x1 = 4 Marks

1. Write the relationship between Emitter current (I_E), Base current (I_B), and Collector current (I_C).
2. What is "Thermal Runaway"?
3. Why is FET called a "Voltage Controlled Device"?
4. Define "Pinch-off Voltage".

PART-B

Answer TWO questions. Each question carries THREE marks.

2x3 = 6 Marks

5(a). Explain the need for Transistor Biasing.

(OR)

5(b). Draw the circuit diagram of a Transistor acting as a Switch to drive a Relay.

6(a). List three differences between BJT and FET.

(OR)

6(b). Explain the advantages of CMOS technology in digital circuits.

PART-C

Answer TWO questions. Each question carries FIVE marks

2x5 = 10 Marks

7(a). Explain the working of the Potential Divider Bias method and how it provides stability.

(OR)

7(b). Draw and explain the Input and Output characteristics of a Common Emitter (CE) configuration.

8(a). Explain the construction and working principle of an N-Channel JFET.

(OR)

8(b). Explain the construction and working of an Enhancement Mode

Model Question paper
I YEAR End Examination

Course Code:ES-105

Course Name: Semiconductor Devices And Circuits

Duration:2 hours

Max.Marks: 40 Marks

PART-A

Answer all questions. Each Question carries one mark

8x1 = 8 Marks

1. State the function of a Capacitor in a DC circuit.
2. Which configuration is used for impedance matching?
3. What is "Crossover Distortion"?
4. Draw the symbol of an N-Channel JFET.
5. Why is cascading used in amplifiers?
6. State the phase shift introduced by a single-stage CE amplifier.
7. Draw the symbol of a Photodiode.
8. What is the main application of an Opto-coupler?

PART-B

Answer FOUR questions.Each question carries three marks.

4 x 3 = 12 Marks

- 9(a). List the essential tools required for soldering components on a PCB.

(OR)

- 9(b). Draw the frequency response curve of an RC coupled amplifier.

- 10(a).Compare CB, CE, and CC configurations based on Input Impedance and Current Gain.

(OR)

- 10(b).Calculate the series resistor required for a 2V, 10mA LED connected to a 9V battery.

- 11(a).Explain the operation of a Class A power amplifier.

(OR)

- 11(b). List the advantages of a Class AB amplifier over Class B.

- 12(a). Explain the working principle of a Photodiode.

(OR)

- 12(b). List the conditions required for sustained oscillations.

PART-C

Answer FOUR questions. Each Question carries FIVE marks

4 x 5 = 20 Marks

- 13(a) Explain the working of a Zener Diode as a Voltage Regulator with a circuit diagram.

(OR)

- 13(b) Analyze the Frequency Response of a CE Amplifier and explain the drop in gain at low and high frequencies.

- 14(a) Discuss the structure of CMOS and its operation as an inverter.

(OR)

14(b) Explain the working of a Hartley Oscillator with a circuit diagram.

15(a) Compare Class A, Class B, and Class C amplifiers in terms of conduction angle, efficiency, and distortion.

(OR)

15(b) Explain how a Class AB configuration eliminates Crossover Distortion.

16(a) Describe the working of an Opto-coupler (MCT2E) and its application in electrical isolation.

(OR)

16(b) Explain the working of a Crystal Oscillator and why it is preferred for microcontrollers.