

Analog Electronics

(Semester IV)

Credits 4: (Theory: 3 + Practical: 1) **PHY040304**

(Total Marks 100: Internal-25+External-75)

Total Lectures: 45

Course Objectives:

- To introduce students to analog electronics with hands-on practice on implementing some of these in hardware.
- To make the students understand the physics of semiconductor p-n junction and application in devices like diodes, rectifiers, etc.
- To understand the working of bipolar junction transistors, biasing, stabilization circuits, and various applications like amplifiers, oscillators, etc. together with feedback.
- To know the basics of Operational Amplifiers and applications.
- To understand the basics of the use of CRO in measurements with hands-on experience with some applications.

Course Outcome: On successful completion of the course, students will be able to understand the physics of semiconductor p-n junction and devices such as rectifier diodes, zener diode, photodiode, etc.; they will understand the basics of bipolar junction transistors, transistor biasing, and stabilization circuits; the concept of feedback in amplifiers and the oscillator circuits. Students will also have an understanding of operational amplifiers and their applications.

Unit I: Semiconductor Diodes (Lectures 07)

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width, and Current for Step Junction.

Unit II: Two-terminal Devices and their Applications (Lectures 05)

Rectifier Diode: Half- wave Rectifiers. Centre-tapped and Bridge type Full-wave Rectifiers. Calculation of Ripple Factor and Rectification Efficiency. C-filter. Zener Diode and Voltage

Regulation. Power supply without filter circuit and with C-filter circuit. Principle LEDs, Photodiode, and Solar Cell (Basic concept).

Unit III: Bipolar Junction Transistors (Lectures 05)

n-p-n and p-n-p Transistors. Characteristics of CB, CE, and CC Configurations. Current gains α and β . Relations between α and β . Load line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff, and Saturation Regions.

Unit IV: Amplifiers (Lectures 07)

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as a 2-port Network. h-parameter. Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage, and Power Gains. Classification of Class A, B & C Amplifiers. Differential amplifiers.

Unit V: Coupled Amplifier (Lectures 02)

Two-stage RC-coupled amplifier and its frequency response.

Unit VI: Feedback in Amplifiers (Lectures 04)

Effects of Positive and Negative Feedback on Input Impedance. Output Impedance. Gain. Stability. Distortion and Noise.

Unit VII: Sinusoidal Oscillators (Lectures 05)

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator. Determination of Frequency. Colpitt's oscillator.

Unit VIII: Operational Amplifiers (Black Box approach) (Lectures 03)

Characteristics of an Ideal and Practical Op-Amp (IC 741). Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and Concept of Virtual Ground.

Unit IX: Applications of Op-Amps (Lectures 04)

Inverting and non-inverting amplifiers. Adder. Subtractor. Differentiator. Integrator. Log and Anti Log amplifier. Zero crossing detector. Wein bridge oscillator. Comparator.

Unit X: Introduction to CRO (Lectures 03)

Block Diagram of CRO. Electron Gun, Deflection System, and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Laboratory

A minimum of four experiments are to be done.

1. To study V-I characteristics of PN junction diode, and light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as a voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal Class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of an RC-coupled transistor amplifier.
8. Using an Op-amp, design a Wien bridge oscillator for a given frequency.
9. To design a phase shift oscillator of given specifications using BJT.
10. To design and study Colpitt's oscillator.
11. To design an inverting amplifier using Op-amp for the DC voltage of a given gain.
12. To design inverting amplifier using Op-amp and study its frequency response.
13. To design a non-inverting amplifier using Op-amp and study its frequency response.
14. To study the zero-crossing detector and comparator.
15. To add two DC voltages using Op-amp in inverting and non-inverting modes.
16. To design a precision Differential amplifier of given I/O specification using Op-amp.
17. To investigate the use of an Op-amp as an Integrator.
18. To investigate the use of an Op-amp as a Differentiator.
19. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO. Construct a series LR circuit. Display the two waveforms on the CRO and measure the phase differences between the voltages across R and L.
20. To test a Diode and Transistor using a Multimeter. Draw the forward bias characteristic of the diode. Using only the base-emitter junction of the transistor draw a characteristic curve and show that it behaves as a forward-biased diode.

Note: All students will have to do an electronic project on the circuits, for example, the power supply, the AM detector, etc. to get acquainted.

Suggested Books

1. Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning
4. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
8. Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M. H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
11. Electronics Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, 17th Ed, 2023, New Age International Publishers