

ANALOG Electronics AND APPLICATIONS

(B.Sc. Sem. IV (PAS 6202))

(Credit: 04)

Theory: 60 Lectures

The emphasis of the course is on basic understanding of semiconducting diodes and transistors used in analog systems. Students will be introduced to conceptual understanding of basic semiconductor devices and its applications.

Semiconductor Diodes: 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. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(10 Lectures)**

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency (2). Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(6 Lectures)**

Bipolar Junction transistors: 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. **(6 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 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. **(10 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(4 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(4 Lectures)**

Operational Amplifiers (Black Box approach): 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. **(4 Lectures)**

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. **(9 Lectures)**

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) **(3 Lectures)**

Text Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall

Reference Books:

- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Evaluation Criteria:

The overall evaluation of the students shall be for 100 marks distributed as per following scheme. Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in the examination.

1. Mid Term Examination 25% (50 marks)

At the end of 7th week the midterm examination shall be held for duration of *two hours* and shall consist of 50 marks question paper. The question paper shall consist of three sections. Section A (10 marks) shall contain 5 to 10 very short answer type questions of 2/1 marks each, all being compulsory. Section B (20 marks) shall contain 6 short answer type questions of 5 marks each, out of which students have to attempt any 4. Section C (10 marks) shall consist of 2 compulsory long answer type questions of 10 marks each. The questions in section C shall have internal choice.

2. End Term Examination 50% (100 marks)

At the end of 14th week the end term examination shall be held for duration of *three hours* and shall consist of 100 marks question paper. The question paper shall consist of three sections. Section A (20 marks) shall contain 10 to 20 very short answer type question of 2/1 marks each, all being compulsory. Section B (30 marks) shall contain 9 short answer type questions of 5 marks each, out of which students have to attempt any 6. Section C (50 marks) shall consist of 5 compulsory long answer type questions of 10 marks each. Every question in section C shall have internal choice.

3. Continuous Internal Assessment 25% (50 Marks):

Consisting of assignments/quizzes/presentation, shall contribute 20% of the total 200 marks i.e. (40M) and 5% of the marks (i.e. 10M) towards internal assessment shall be on the basis of attendance.

Waves and Optics

Course Code: PAS6201

Course Type: Major

Credit: 4

Course Objectives: The emphasis of this course is to introduce students to concepts and phenomena related to oscillatory systems. The fundamentals of such oscillatory systems are applied to understanding of waves and optics.

Learning Outcomes: After completing this course, the students will be able to understand:

- Simple harmonic oscillations and their origin
- Superposition of oscillatory quantities and their applications
- Wave equation and its significance
- How the superposition principle play crucial role in explaining many optical phenomenon such as interference, diffraction.
- Fundamentals of holography

Course contents

Unit 1: Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.
(6 Lectures)

Unit 2: Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.
(2 Lectures)

Unit 3: Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.
(4 Lectures)

Unit 4: Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.
(6 Lectures)

Unit 5: Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.
(7 Lectures)

Unit 6:Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(3 Lectures)**

Unit 7:Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

Unit 8:Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(4 Lectures)**

Unit 9:Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only) **(2 lectures)**

Unit 10:Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(7 Lectures)**

Unit 11:Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(7 Lectures)**

Unit 12:Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(3 Lectures)**

Text books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, (2007), Tata McGraw-Hill
2. The Physics of Waves and Oscillations by N.K. Bajaj (1988), Tata McGraw-Hill

Reference texts:

1. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, (2011) R. Chand Publications
2. Principles of Optics, Max Born and Emil Wolf, 7thEdn., (1999) Pergamon Press
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, (1981) McGraw-Hill
4. Optics, Ajoy Ghatak (2008) Tata McGraw Hill
5. Vibrations and Waves, A. P. French (1987) CBS Pub. & Dist.
6. Vibrations and Waves, Benjamin Crowell, Light & Matter Series (www.lightandmatter.com)
7. Fundamentals of Waves & Oscillations K. Uno Ingard (1988) Cambridge University Press