

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14b: ANALOG ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Analog Electronics PHYSICS DSE – 14b	4	2	0	2	Class XII Pass with Science	NIL

LEARNING OBJECTIVES

This course introduces the concept of semiconductor devices and their analog applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

LEARNING OUTCOMES

At the end of this course, the following concepts will be learnt.

- To learn about diodes and its uses in rectification
- To gain an insight into working principle of photodiodes, solar cells, LED and zener diode as voltage regulator
- To gain an understanding of construction and working principle of bipolar junction transistors (BJTs), characteristics of different configurations, biasing and analysis of transistor amplifier
- To be able to design and understand use of different types of oscillators
- To learn the fundamentals of operation amplifiers and understand their operations to compare, add, or subtract two or more signals and to differentiate or integrate signals etc.

In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, and oscillators. Also different applications using Op-Amp will be designed.

SYLLABUS OF Physics DSE – 14b

THEORY COMPONENT

Unit – I - Two-terminal devices and their applications (5 Hours)

IV characteristics of a diode and its application as rectifier (half-wave and full wave rectifier), IV characteristics of a zener diode and its use as voltage regulator, principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell

Unit – II - Bipolar junction transistors (4 Hours)

n-p-n and p-n-p transistors, IV characteristics of CB and CE configurations, active, cut-off and saturation regions, current gains α and β , relations between α and β , physical mechanism of current flow

Unit – III – Amplifiers and sinusoidal oscillators (11 Hours)

Load line analysis of transistor, DC load line and Q-point, fixed bias and voltage divider bias, transistor as 2-port network, h-parameter equivalent circuit of a transistor, analysis of a

single-stage CE amplifier using hybrid model (input and output impedance, current and voltage gain)

Sinusoidal Oscillators: General idea of positive and negative feedback, Barkhausen's criterion for self-sustained oscillations, RC phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators

Unit – IV - Operational Amplifiers (Black Box approach) (10 Hours)

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

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Comparator and Zero crossing detector (7) Wein bridge oscillator

References:

Essential Readings:

- 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) Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- 4) Microelectronic circuits, A. S. Sedra, K. C. Smith and A. N. Chandorkar, 6th edition, 2014, Oxford University Press.
- 5) Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
- 6) Electronic Principles, A. Malvino, D. J. Bates, 7th edition, 2018, Tata Mc-Graw Hill Education.
- 7) Electronic Devices and circuit Theory, R. L. Boylestad and L. D. Nashelsky, 2009, Pearson

Additional Readings:

- 1) Learning Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd edition, 2012, Tata Mc-Graw Hill
- 2) Microelectronic Circuits, M. H. Rashid, 2nd edition, Cengage Learning
- 3) Microelectronic Devices and Circuits, D. A. Bell, 5th edition, 2015, Oxford University Press
- 4) Basic Electronics: Principles and Applications, C. Saha, A. Halder and D. Ganguli, 1st edition, 2018, Cambridge University Press
- 5) Solid State Electronic Devices, B. G. Streetman and S. K. Banerjee, 6th edition, 2009, PHI

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on the construction and use of specific analogue devices and experimental apparatuses used in the lab, including necessary precautions
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

- 1) To study the V-I characteristics of a Zener diode and its use as voltage regulator.

- 2) Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
- 3) To study the characteristics of a Bipolar Junction Transistor in CE configuration.
- 4) To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
- 5) To design a Wien bridge oscillator for given frequency using an op-amp.
- 6) To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
- 7) To design inverting amplifier using Op-amp (741, 351) and study its frequency response
- 8) To design non-inverting amplifier using Op-amp (741, 351) and study frequency response
- 9) To add two dc voltages using Op-amp in inverting and non-inverting mode
- 10) To study the zero-crossing detector and comparator
- 11) To investigate the use of an op-amp as an integrator
- 12) To investigate the use of an op-amp as a differentiator.

References for laboratory work:

- 1) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1994, Mc- Graw Hill
- 2) Student Manual for The Art of Electronics, T. C. Hayes and P. Horowitz