COURSE TITLE	**ANALOG CIRCUITS**
COURSE CODE	**01EC0112**
COURSE CREDITS	**4**

Objective:

1. The objective of this course is to develop understanding of analog circuits, including small-signal amplifiers, frequency response, feedback, oscillators, power amplifiers, and operational amplifiers, with emphasis on analysis, design, and practical applications.

Course Outcomes: After completion of this course, student will be able to:

1. Apply analog circuit concepts to analyze and implement multistage amplifiers, differential amplifiers, and oscillator applications. (Bloom's Level: Apply)
2. Analyze the impact of feedback in amplifier circuits using circuit simulation tools (e.g., LTSpice, Multisim). (Bloom's Level: Analyze)
3. Evaluate and classify different types of power amplifiers based on efficiency, distortion, and application. (Bloom's Level: Evaluate)
4. Design oscillators and amplifiers to meet given specifications using both simulation and hardware prototyping. (Bloom's Level: Create)

Pre-requisite of course: Knowledge of Electronic Devices and Circuits

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**BJT AC Analysis** Introduction to AC Analysis of BJT, BJT Small-Signal Models, Single-Stage BJT Amplifiers: Common Emitter, Common Collector, Common Base, Gain, Bandwidth, and Gain-Bandwidth Product, Effect of Source and Load Impedance on Amplifier Performance, Multistage BJT Amplifiers and Their Frequency Response, BJT Amplifiers with Reactive Components: Capacitive Coupling & Bypass, Biasing Stability, AC Signal Distortion, and Thermal Considerations	8

Contents : Unit	Topics	Contact Hours
2	**Feedback Amplifiers and Oscillators** Types of Feedback: Positive vs. Negative; Basic Feedback Principles, Feedback Topologies: Voltage Series, Voltage Shunt, Feedback Topologies: Current Series, Current Shunt, Effects of Negative Feedback: Gain Stability, Bandwidth, Input/Output Impedance, Distortion, Barkhausen Criterion: Theory and Conditions for Sustained Oscillations, RC Phase Shift Oscillator: Operation, Design, and Analysis, Wien Bridge Oscillator: Operation, Design, and Stability Considerations, LC and Crystal Oscillators: Hartley, Colpitts, and Crystal Oscillator Design and Applications	8
3	**Power Amplifiers** Classification of Amplifiers: Class A, B, AB – Operating Principle and Transfer Characteristics, Efficiency and Distortion Analysis for Class A, B, and AB Amplifiers, Push-Pull Configurations: Class A and Class B Operation, Power Handling, Crossover Distortion in Class B Amplifiers and Its Reduction in Class AB Design	4
4	**Operational Amplifiers (Op-Amp)** Block Diagram of a Typical Op-Amp, Internal Circuit Overview, and Ideal vs. Practical Op-Amp Assumptions, Op-Amp Characteristics: Input Offset Voltage, Offset Current, Bias Current, Differential Input Resistance, etc., Additional Characteristics: CMRR, SVRR, Voltage Gain, Slew Rate, Gain-Bandwidth Product, Op-Amp Equivalent Circuit, Voltage Transfer Curve, and Open-Loop Configurations (Inverting, Non-Inverting), Op-Amp as an Amplifier: Closed-Loop Configurations – Voltage Follower, Inverting and Non-Inverting Amplifiers, Practical Op-Amp Behavior and Frequency Response: Bode Plot, Unity Gain Bandwidth, Phase Margin	6
5	**Applications of Op-Amp** Op-Amp as a Comparator: Zero-crossing and Window Comparators, Summing, Scaling, and Averaging Amplifiers, Instrumentation Amplifier: Architecture and Applications, Op-Amp as an Integrator and Differentiator, Waveform Generation Using Op-Amps: Square, Triangular, and Sine Wave Generators, Active Filters (Low-pass, High-pass, Band-pass) and Oscillators (Wien Bridge, Phase Shift)	12
6	**Specialized IC Applications** 555 Timer Basics: Internal Block Diagram and Pin Configuration, 555 Timer as a Monostable and Bistable Multivibrator, 555 Timer as an Astable Multivibrator: Frequency and Duty Cycle Calculations, Block Diagram and Basic Operation of Phase-Locked Loop (PLL): Phase Detector, VCO, and Loop Filter	4
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment-1** To design and analyse a common-emitter amplifier using a small-signal model. Measure and verify its voltage gain, input and output impedance using simulation.	2
2	**Experiment-2** To determine the frequency response of a single-stage common-emitter amplifier and calculate its -3dB bandwidth and gain-bandwidth product.	2
3	**Experiment-3** To study the variation in amplifier, gain due to changes in source and load resistance. Observe loading effects and explain their significance in amplifier design.	2
4	**Experiment-4** To design and simulate a two-stage BJT amplifier and evaluate the overall voltage gain and bandwidth. Analyze how cascading stages affects the performance and frequency response.	2
5	**Experiment-5** To observe distortion in output waveform under varying input amplitudes and temperatures. Evaluate the impact of thermal instability and suggest ways to improve bias stability and reduce distortion.	2
6	**Experiment-6** To implement and analyse the four basic feedback topologies: voltage-series, voltage-shunt, current-series, and current-shunt. Measure changes in gain, input impedance, and output impedance due to feedback using simulation tools.	2
7	**Experiment-7** To investigate how negative feedback affects the gain, bandwidth, input/output impedance, and distortion in a common-emitter amplifier. Compare the amplifier's performance with and without feedback.	2
8	**Experiment-8** To design an RC phase shift oscillator using a BJT or op-amp and verify the Barkhausen criterion for sustained oscillation. Measure the frequency of oscillation and analyze waveform characteristics.	2
9	**Experiment-9** To design and construct a Wien bridge oscillator using an op-amp. Verify the generation of a low-distortion sine wave and calculate the frequency of oscillation.	2
10	**Experiment-10** To experimentally determine parameters such as input offset voltage, input bias current, CMRR, slew rate, and voltage gain of a practical op-amp (e.g., 741) using a test setup.	2
11	**Experiment-11** To simulate ideal and practical op-amp responses and compare voltage transfer curves, gain saturation, and bandwidth limitations.	2

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
12	**Experiment-12** To design and test inverting and non-inverting amplifiers for different gains using a 741 or equivalent op-amp. Measure voltage gain and compare with theoretical values.	2
13	**Experiment-13** To configure an op-amp as a comparator and zero-crossing detector. Observe switching behavior and output transitions for different input waveforms.	2
14	**Experiment-14** To design and implement op-amp circuits that perform analog summation, scaling, and averaging of multiple input voltages. Verify outputs experimentally.	2
15	**Experiment-15** To construct and analyze op-amp based integrator and differentiator circuits. Observe the phase shift and waveform transformation for sine and square inputs.	2
16	**Experiment-16** To design waveform generator circuits such as square wave, triangular wave, and sawtooth using op-amps and passive components. Analyze output waveform parameters.	2
17	**Experiment-17** To design and test low-pass, high-pass, and band-pass filters using op-amps. Measure frequency response and validate the cutoff frequency.	2
18	**Experiment-18** To configure the 555 timer as an astable multivibrator for square wave generation. Measure the output frequency and duty cycle. Adjust R1, R2, and C to observe changes in waveform parameters.	2
19	**Experiment-19** To study the block diagram, working principle, and behavior of a PLL system. Observe how the PLL locks to an input frequency and track frequency variations using a VCO and phase comparator.	2
20	**Experiment-20** To design and analyze a Class A power amplifier using a BJT. Measure power output, input and output waveforms, power dissipation, and overall efficiency. Observe signal amplification and thermal performance.	2
21	**Experiment-21** To construct and compare Class B and Class AB push-pull amplifiers using complementary BJTs. Observe crossover distortion in Class B and demonstrate its reduction in Class AB configuration.	2
22	**Note:** Any 12 to 14 experiments have to be conducted.	0
Total Hours		**42**

Textbook :

1 Electronic Devices and Circuit Theory, Boylestad & Nashelsky, Pearson Education, 10th Edition, 2009

2 Microelectronic Circuits, Adel S. Sedra and Kenneth C. Smith, Oxford University Press, 2020

References:

1 Electronic Devices and Circuits, Electronic Devices and Circuits, Millman & Halkias, McGraw Hill, 3rd Edition, 2008

2 Electronic Devices and Circuits, Electronic Devices and Circuits, David A. Bell, Oxford University Press, 5th Edition, 2008

3 Electronic Devices, Electronic Devices, Thomas L. Floyd, Pearson Education, 7th Edition, 2008

4 Op-Amps and Linear Integrated Circuits, Op-Amps and Linear Integrated Circuits, Ramakant A Gayakwad, Pearson Education, 4th Edition, 2010

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
5.00	10.00	30.00	20.00	20.00	15.00

Instructional Method:

1 The internal evaluation will be done based on the continuous evaluation of students in the laboratory and class-room.

2 Practical examination will be conducted at the end of the semester for evaluation of practical performance.

3 Students may use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory, etc.

4 The course delivery method will depend upon the requirement of content and need of the students. The teacher in addition to conventional teaching method (Chalk and Talk) may use any of the tools/techniques such as demonstration, role play, Quiz, brainstorming, Flipped class, Project based learning, Collaborative learning, MOOCs, etc. for effective teaching.

Supplementary Resources:

1 NPTEL video lectures: https://www.youtube.com/watch?v=2bprLH4cUSo&list=PLbMVogVj5nJRdd1G38L_8GzxvcW11zMwN

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Digitally signed by (Name of HOD) — **Digitally signed by (Name of Dean/ Principal)**