GANPAT UNIVERSITY

FACULTY OF DIPLOMA ENGINEERING

Programme	Diploma in Electronics and Communication Engineering		
Semester	III	Version	1.0.0.0
Effective from Academic Year	2026-27	Effective for the batch Admitted in	JULY 2025
Course code	1EC3101	Course Name	OPAMP Integrated Circuits

I.TEACHING-LEARNING AND ASSESSMENT SCHEME

Course Type	Course Code	Learning Scheme						Assessment Scheme										Total Marks
		Actual Contact Hrs./Week			SLH	NLH	Credits	Theory				Practical				Based on SL		
		CL	TL	LL				FA-TH	SA-TH	TOTAL		FA-PR	SA-PR	TOTAL		SLA		
								MAX	MAX	MAX	MIN	MAX	MAX	MAX	MIN	MAX	MIN	
SEC	1EC3101	3	-	2	3	8	4	40	60	100	40	30	20	50	20	20	8	170

Abbreviation:	**CL-** Classroom Learning	**TL -** Tutorial Learning	**LL -** Laboratory Learning
	SLH - Self Learning Hours	**NLH -** Notional Learning Hours	**SLA -** Self Learning Assessment
	FA - Formative Assessment (Term work +Mid Sem Exam +Attendance)		**SA -** Summative Assessment

II. PRE-REQUISITES

Basic knowledge of Electronics device and circuit.

III. INDUSTRY / EMPLOYER EXPECTED OUTCOMES

Students will be able to efficiently translate complex analog schematics into functional, high-performance hardware on breadboards and PCBs, adhering to industrial standards for signal integrity. Also able to identify and rectify critical non-ideal effects—such as DC offsets, slew rate limitations, and thermal drift—ensuring the stability and reliability of industrial electronics.

IV. COURSE LEARNING OUTCOMES

At the end of the course, students will be able to achieve the following course learning outcomes:

CO1: Understand the basics of Operational Amplifiers (OPAMP), their ideal characteristics and various Practical parameter.

CO2: Analyze linear applications OPAMP.

CO3: Evaluate non-linear applications of OPAMP.

CO4: Design active filters, data converter (A/D and D/A) and Oscillator using OPAMP.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT:

Name of Unit	Theory Learning outcomes (TLO's) aligned to CO's	Learning Content mapped with Theory Learning outcomes (TLO's) & CO's	Marks	Hours
Unit-1 Operational Amplifier and its characteristics	**TLO 1.1:** Explain the operation of a Differential Amplifier in DC and AC modes. **TLO 1.2:** Describe the internal stages of an OPAMP using its block diagram. **TLO 1.3:** Compare the characteristics of an Ideal OPAMP with a practical one. **TLO 1.4:** Analyze the impact of Negative Feedback on amplifier stability and gain. **TLO 1.5:** Interpret technical specifications from standard OPAMP Datasheets.	**1.1** Differential Amplifier (AC & DC Analysis). **1.2** Block Diagram Representation of op-amp. **1.3** Ideal op-amp characteristics. **1.4** Equivalent Circuit of an OPAMP. **1.5** Op-amp with Negative Feedback. **1.6** Reading and using Datasheets.	**10**	**08**

Unit-2 Practical op-amp and Various Parameters	**TLO 2.1:** Describe the procedures to measure Input Offset Voltage and Current. **TLO 2.2:** Evaluate the effects of Input Bias Current on circuit performance. **TLO 2.3:** Differentiate between Differential Input Resistance and Output Resistance. **TLO 2.4:** Calculate Common Mode Rejection Ratio (CMRR) and Power Supply Rejection Ratio (PSRR). **TLO 2.5:** Analyze high-speed performance using Slew Rate and Gain Bandwidth Product. **TLO 2.6:** Explain transient response and power consumption limits in OPAMPs.	**2.1** Measurement of Input Offset Voltage and Input Offset Current. **2.2** Input Bias Current & Input Capacitance. **2.3** Differential Input and Output Resistance. **2.4** CMRR, Slew rate, and PSRR. **2.5** Gain Bandwidth Products & Transient Response. **2.6** Power Consumption specifications.	**08**	**05**
Unit-3 Linear Applications	**TLO 3.1:** Design and analyze basic Inverting, Non-Inverting, and AC/DC amplifiers. **TLO 3.2:** Implement Summing, Scaling, and Averaging circuits for analog signal processing. **TLO 3.3:** Explain the operation of Instrumentation Amplifiers in sensor-based data acquisition. **TLO 3.4:** Formulate the mathematical transfer functions for Integrator and Differentiator circuits. **TLO 3.5:** Design subtractor and Voltage follower.	**3.1** AC/DC, Inverting, and Non-Inverting Amplifiers. **3.2** Summing, Scaling, and Averaging Amplifiers. **3.3** Instrumentation and Differential input/output Amps. **3.4** Integrator, Differentiator. **3.5** Subtractor and Voltage Follower.	**16**	**12**
Unit-4 Non Linear Applications	**TLO 4.1** Analyze non-linear switching circuits including Comparators, Zero Crossing Detectors, Schmitt Triggers and limiters. **TLO 4.2:** Understand precision signal processing using Peak Detectors, Sample-and-Hold, and Precision Rectifiers. **TLO 4.3:** Explain logarithmic and exponential signal transformation using Log/Antilog amplifiers **TLO 4.4:** Design clipper and clamper circuits.	**4.1** Comparator and Zero Crossing Detector, Schmitt Trigger and Voltage Limiters. **4.2** Peak Detector. Sample and Hold Circuit, Precision Rectifiers (Half/Full Wave). **4.3** Square, Log/Antilog Amplifiers. **4.4** Clipper and Clamper circuits.	**16**	**12**
Unit-5 Active filters, Data converters and Oscillators	**TLO 5.1:** Classify filters based on frequency response and identify the advantages of active over passive filters. **TLO 5.2:** Apply magnitude and frequency scaling to modify existing filter designs. **TLO 5.3:** Analyze the magnitude and attenuation characteristics of	**5.1** Classification of filters. **5.2** Magnitude and frequency Scaling. **5.3** Characteristics of ideal and practical filters. **5.4** Butterworth Low pass and High pass filters. **5.5** Band pass and Band reject filters.	**10**	**08**

	ideal versus practical filters. **TLO 5.4:** Design First-order Butterworth Low Pass and High Pass filters using design parameters Q and ꞶO0. **TLO 5.5:** Explain the working of Band Pass and Band Reject (Notch) filters. **TLO 5.6:** Describe the fundamental operations, principles, and applications of data converters. **TLO 5.7:** Compare various classifications of Analog-to-Digital (ADC) and Digital-to-Analog (DAC) converters. **TLO 5.8:** Identify common Data converter ICs. **TLO 5.9:** Explain the basic principles of oscillators and the Barkhausen criteria. **TLO 5.10:** Design RC phase shift and Wien bridge oscillators for sine wave generation.	**5.6** Data converter operations and principles. **5.7** Classification of ADC and DAC. **5.8** Data converter ICs. **5.9** Oscillator principles and types. **5.10** Phase shift and Wien bridge oscillators.		

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL

Sr. No.	Practical/Laboratory Learning Outcome (LLO)	Practical Titles	Relevant COs
1	**LLO 1.1**: Introduce OPAMP 741 IC.	To study about 741 Operational Amplifier.	CO1
2	**LLO 2.1**: Design and check Inverting Amplifier by OPAMP.	To perform practical related to OPAMP as Inverting Amplifier.	CO2
3	**LLO 3.1:** Design and check Non-Inverting Amplifier by OPAMP.	To perform practical related to OPAMP as Non-inverting Amplifier.	CO2
4	**LLO 4.1:** Design voltage follower by OPAMP.	To perform practical related to OPAMP as Voltage follower.	CO2
5	**LLO 5.1:** Design and check wave form of summing Amplifier by OPAMP.	To perform practical related to OPAMP as Summing Amplifier.	CO2
6	**LLO 6.1:** Design and check Difference Amplifier by OPAMP.	To perform practical related to OPAMP as Difference Amplifier.	CO2
7	**LLO 7.1**: Design differentiator by OPAMP.	To perform practical related to OPAMP as differentiator.	CO2
8	**LLO 8.1:** Design Integrator by OPAMP.	To perform practical related to OPAMP as integrator.	CO2
9	**LLO 9.1:** Design Square wave Generator.	To perform practical related to OPAMP as Square wave Generator.	CO3
10	**LLO 10.1:** Design and check Schmitt trigger.	To perform practical related to OPAMP as Schmitt trigger.	CO3
11	**LLO 11.1:** Design Low Pass filter.	To design a Low pass Filter using OPAMP.	CO4
12	**LLO 12.1:** Design Oscillator circuit.	To perform practical related to OPAMP as Oscillator.	CO4
13	**LLO 13.1**: Design A to D and D to A converter.	To design A to D or D to A converter using OPAMP.	CO4

VII. SUGGESTED MICRO PROJECT / ASSIGNMENTS / ACTIVITIES FOR SELF LEARNING / SKILL DEVELOPMENT (SELF LEARNING)

A.Self-Learning Assignments / Activities

1. **Datasheet Analysis**: Download the datasheet for IC 741 and IC TL081. Compare their Slew Rate, Input Bias Current, and Supply Voltage ranges. Summarize why TL081 is preferred for high-speed applications.
2. **Filter Design Challenge:** Design a second-order Low Pass Butterworth filter with a cut-off frequency of 2.5 kHz. Calculate the values of all resistors and capacitors.
3. **Circuit Debugging:** Given a schematic of an Inverting Amplifier that is producing a "clipped" output, identify three possible causes (e.g., Vcc saturation, excessive gain, input offset).
4. **Converter Resolution:** Calculate the output voltage for a 4-bit R-2R Ladder DAC for the binary inputs 1010 and 1111, assuming Vref = 5V.
5. **Circuit Simulation:** Use free tools like Tinkercad, Proteus, or LTSpice to simulate an Instrumentation Amplifier. Observe how the Gain changes by varying only the "Gain Resistor" (Rg).
6. **Virtual Lab (IIT Bombay/Kharagpur)**: Perform the "Integrator and Differentiator" experiment on the Virtual Labs (V-Lab) platform. Compare the theoretical waveforms with the simulated outputs.
7. **MOOC Video Analysis:** Watch the NPTEL lecture on "Non-ideal characteristics of Op-amps" and prepare a 2-page summary of how "Input Offset Voltage" affects high-gain DC amplifiers.
8. **Hardware Identification:** Visit a local electronics repair shop or lab and identify various IC packages (DIP-8, SOIC-8) and explain the significance of the "Notch" or "Dot" for Pin 1 identification.

B. Mini Projects (Skill Development Focused)

1. **Electronic Thermometer:** Design a circuit using an LM35 temperature sensor and an OPAMP in a non-inverting configuration to calibrate voltage output (e.g., 10mV/°C) for display on a DMM.
2. **Audio Pre-Amplifier:** Build a low-noise pre-amplifier for a dynamic microphone using an OPAMP to interface with a power amplifier.
3. **Light Intensity Controller:** Design a circuit using an LDR (Light Dependent Resistor) and an OPAMP as a comparator to automatically turn on an LED when the room goes dark.
4. **Function Generator:** Construct a circuit that generates square and triangular waves using a single OPAMP integrator and a comparator (Schmitt Trigger).
5. **Water Level Indicator:** Use multiple OPAMPs as comparators to detect various water levels in a tank and trigger a buzzer at the "Overflow" level

VIII. LIST OF INSTRUMENTS / EQUIPMENT / TRAINER BOARD	
1	**Analog Circuit Trainer Board** Built-in Dual Power Supply (±15V), Breadboard area, Function Generator (1Hz-100kHz), and Toggle Switches. Main platform for building and testing all OPAMP circuits.
2	**Passive Component Bin** Resistors (1/4 Watt, various ranges), Capacitors (Ceramic & Electrolytic), Potentiometers (10k, 100k). Building feedback networks and RC filter stages.
3	**Breadboard with Power Supply** For building and testing logic circuits using discrete components and ICs without soldering.
4	**Digital Storage Oscilloscope (DSO)** Dual Channel, Bandwidth 20MHz to 50MHz, with PC Interface. Observing input/output waveforms, measuring phase shift, and frequency response.
5	**Function / Signal Generator** 0.1 Hz to 1 MHz; Sine, Square, and Triangular wave outputs. Providing input signals for amplifiers, filters, and converters.
6	**Digital Multimeter (DMM)** 3.5 Digit Display; Measures AC/DC Voltage, Current, and Resistance. Measuring DC offset, bias currents, and nodal voltages.
7	**Dual DC Regulated Power Supply** Variable 0-30V, 2A with short - circuit protection. External biasing of OPAMP ICs if trainer board supply is insufficient.
8	**OPAMP ICs (Assorted)** IC 741 (General Purpose), IC TL081 (JFET Input), IC LM324 (Quad OPAMP). Core components for all linear and non-linear experiments.
9	**Data Converter ICs** ADC 0804/0808 (Analog to Digital), DAC 0800/0808 (Digital to Analog) For Unit-4 practical on data conversion.
10	**Breadboards & Jumper Wires** High-quality tie-point breadboards with single-strand tinned copper wires. Prototype assembly of custom projects and assignments.
11	**Circuit Simulation Software** Proteus, NI Multisim, or LTSpice (Open Source).Pre-lab simulation and verification of circuit behavior.

IX. LIST OF REFERENCE BOOKS			
Sr.No.	**Title**	**Author**	**Publication**
1	Op-amp and Linear Integrated Circuits	Ramakant A. Gayakwad	Prentice Hall India
2	Analog filter design	Van Valkenburg	Oxford Publication
3	Design with operational amplifier and analog ICs	Sergio Franco	Tata Magraw hill
4	Introduction to Operational Amplifier theory and applications	J.V. Wait, L.P. Huelsman and GA Korn	Tata Magraw hill
5	Application and design with analog Ics	J. Michael Jacob	Prentice Hall India

X. LINK OF LEARNING WEB RESOURCE	
1	**NPTEL:** Analog Circuits by Prof. Jayanta Mukherjee (IIT Bombay)
2	**Virtual Labs:** Electronics & Communications - OPAMP Lab (IIT Kharagpur)
3	**Texas Instruments:** TI Precision Labs - Op Amps Video Series
4	**All About Circuits:** Operational Amplifiers - Video Lectures and Tutorials

XI. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE							
Unit	**Unit Title**	**Aligned COs**	**Learning Hours**	**R-Level**	**U-Level**	**A-Level**	**Total Marks**
1	Operational Amplifier and its characteristics	CO1	8	3	3	4	**10**
2	Practical op-amp and Various Parameters	CO1	5	2	4	2	**8**
3	Linear Applications	CO2	12	4	4	8	**16**
4	Non Linear Applications	CO3	12	2	6	8	**16**
5	Active filters, Data converters and Oscillators	CO4	8	2	5	3	**10**
		Grant Total	**45**	**13**	**22**	**25**	**60**

XII. COs AND POs AND PSOs MAPPING									
Course outcome (Cos)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	3	0	2	1	1
CO2	3	3	3	3	2	2	2	3	2	3
CO3	3	3	3	2	2	2	2	2	2	3
CO4	3	3	2	2	2	2	0	2	3	2
Legends: - *3- High* *2-Moderate/Medium* *1-Slight/Low* *0-None*										