GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Linear Electronic Circuits
(Course Code: 4332403)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	Third

1. RATIONALE

Linear electronic circuits that containing Operational amplifier is one of the most common electronic parts in sensor and signal conditioning equipment. To maintain signal conditioning circuits, it is essential to test the performance of operational amplifiers. Hence, this course deals with all those aspects of operational amplifiers with positive and negative feedback for various configurations. Therefore, undertaking this course will help to maintain the linear electronics circuits comprising of the operational amplifiers used in various applications.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain linear electronic circuits comprising of operational amplifiers.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

1. **Explain IC technology and basic terminology of Operational Amplifier.**
2. **Test Op-Amp in Closed loop Configuration.**
3. **Use Op-Amp for various Linear applications.**
4. **Use Op-Amp for various Non-Linear applications.**
5. **Use Op-Amp for Waveform generation and Audio applications.**

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	4	30	70	25	25	150

(*): For this practical only course, 25 marks under the practical CA has two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15 marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that are thesub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Interpret the parameters of given Op-Amplifier using Data Sheet.	1	2*
2	Test the performance of open loop inverting amplifier.	2	2*
3	Test the performance of open loop Non-inverting amplifier.	2	2
4	Test the performance of open loop differential amplifier.	2	2*
5	Test the performance of closed loop inverting amplifier.	2	2*
6	Test the performance of closed loop non-inverting amplifier.	2	2*
7	Test the performance of differential amplifier using one op-amp.	2	2*
8	Test the performance of differential amplifier using two op-amp.	2	2*
9	Test the performance of AC amplifier using single supply.	2	2
10	Test the performance of Summing amplifier using inverting and non-inverting configuration.	3	2*
11	Test the performance of Averaging amplifier using inverting and non-inverting configuration.	3	2
12	Test the performance of Subtractor using inverting, non-inverting and differential configuration of Op-amp.	3	2*
13	Test the performance of voltage to current converter.	3	2
14	Test the performance of Practical Integrator circuit.	3	2*
15	Test the performance of Practical differentiator circuit.	3	2*
16	Check the performance of zero crossing detector.	4	2
17	Determine the frequency of Schmitt trigger circuit.	4	2*
18	Test the performance of wave form generator using IC 555.	5	2*
19	Test the performance of Monostable Multivibrator using IC 555.	5	2
20	Test the performance of regulated power supply using LM317.	5	2*
	Total		**28**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Operational Amplifier Trainer** **Mains Power Supply:** 90 - 270V ±10%, 50Hz (SMPS) **Fixed DC Power Supply:** +12V Regulated, -12V Regulated, +5V Regulated, -5V Regulated **Variable DC Power Supply:** +1.5V to +10V Regulated, -1.5V to -10V Regulated **Function Generator:** **Sine Wave** Frequency: 1KHz to 100KHz, Frequency Control: 100KV, 10 turn Potentiometer Amplitude: 0V to 5Vpp, Amplitude Control: 100KV, Single turn Potentiometer **Triangular Wave** Frequency: 1KHz to 100KHz, Frequency Control: 100KV, 10 turn Potentiometer Amplitude: 0V to 5Vpp, Amplitude Control: 100KV, Single turn Potentiometer **Square Wave** Frequency: 1KHz to 100KHz, Frequency Control: 100KV, 10 turn Potentiometer Amplitude: 5Vpp, fixed **Bread Board** Distribution strips: 2, Distribution holes: 200, Terminal holes: 640 **Op-Amp**: IC uA741 (2 nos.) All pins terminated on 2 mm Banana Sockets Supply Voltage: ±22V max, Differential Input Voltage: ±30V max. Input Voltage: ±15V max., Slew Rate: 0.5 V/µs (VCC = ±15V) **Resistor Bank** SMD Resistance 1KV 1% 1/4W (5 nos.), SMD Resistance 10KV 1% 1/4W (5 nos.), SMD Resistance 100KV 1% 1/4W (5 nos.) **Diode**: Diode 1N 4007 **Capacitor Bank**: Electrolyte 1mf/63V, Disc 1nf/63V, Disc 10nf/63V, Disc 100nf/63V **Variable Resistance Bank** 1KV Single turn Potentiometer (2 nos.), 10KV Single turn Potentiometer (2 nos.), 100KV Single turn Potentiometer (2 nos.), 1MV Single turn Potentiometer (2 nos.) **Study of Operational Amplifier as:** • Inverting Amplifier • Non - inverting Amplifier • Buffer • Comparator • Adder • Subtractor • Square Wave Generator • Differentiator and its working as High Pass Filter • Integrator and its working as Low Pass Filter • Logarithmic Amplifier • Voltage Controlled Current Source • Current Controlled Voltage Source	2 to 17
2	**Astable and Monostable Multivibrator** **Mains Supply:** 230V ±10%, 50Hz **DC Bias Voltage**: +5V **Frequency of Trigger**: 1KHz **Pulse Generator Frequency Range**: 600Hz – 3.2KHz (approximate) **of Astable Multivibrator Frequency Range**: 350Hz – 1KHz (approximate) **of Bistable Multivibrator Output Voltage**: 5V (approximate) **Scope of Learning** • To study the IC 555 as a Monostable (One-Shot) Multivibrator • To study the IC 555 as an Astable (Free-Running) Multivibrator	18, 19
3	**4½ Digit Multimeter**	2-20

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Function Range and Resolution Basic Accuracy DC volts, AC volts: 50.000 mV,500.00 mV, 5.0000 V, 50.000 V, 500.00 V, 1000.0 V. Accuracy: 0.025 %, 0.4 % (true-rms) DC current, AC current: 500.00 µA, 5000.0 µA, 50.000 mA, 400.00 mA, 5.0000 A, 10.000 A, Accuracy: 0.15 %, 0.7 % (true-rms) Temperature: -200.0 °C to 1350.0 °C (-328.0°F to 2462.0°F) Accuracy:1.0 % Resistance 50.000 Ω, 500.00 Ω, 5.0000 kΩ, 50.000 kΩ, 500.00 kΩ, 5.0000 MΩ, 50.00 MΩ, 500.0 MΩ, Accuracy: 0.05 % Capacitance 1.000 nF,10.00 nF 100.0 nF, 1.000 µF, 10.00 µF, 100.0 µF, 1000 µF, 10.00 mF, 100.0 mF, Accuracy: 1.0 % Frequency 99.999 Hz, 999.99 Hz, 9.9999 kHz, 99.999 kHz, 999.99 kHz. Accuracy: .005 %	

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical instruments and tools.
c) Realize importance of sensors and transducers in electronic circuits.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – I Introduction to Operational Amplifiers	1a. Classify IC based on their type, Temperature, User, No of Component. 1b. Identify various types of ICs and packages. 1c. Give Advantages of ICs over Discrete components. 1d. Define various operational amplifier parameters.	1.1 Classification of IC: based on type, Temperature, Type of user, No of integrated components 1.2 IC packages, pin identification 1.3 Operational amplifier: definition, block diagram, Pin Outs (TO-5, 8-DIP,14-DIP), Circuit symbol 1.4 Operational Amplifier Parameters: Input offset voltage and current, Input

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	1e. Analyze Operational Amplifier Datasheet. 1f. List ideal characteristics of Op-Amp.	bias current, Input capacitance, Input voltage range, Common mode rejection ratio, Output voltage swing, output resistance, Power consumption, slew rate, Thermal Drift, Power Supply rejection ratio, Noise. 1.5 Characteristics of Ideal Op-Amp
Unit– II Op-Amp with Negative Feedback	2.a Explain working of open loop Op-Amp Configurations. 2.b Compare various parameters of Ideal Op-Amp and Practical Op-Amp. 2.c List parameters to be considered for AC and DC application. 2.d Analyze closed loop Op-Amp configurations. 2.e Use closed loop Op-Amp as Voltage follower and Buffer.	2.1 Open loop Op-Amp Configurations: Non-Inverting, Inverting and Differential. 2.2 Performance comparison of ideal and practical Op-Amp 2.3 Closed loop Op-Amp Configurations: Inverting, Non-Inverting, Differential Amplifier (1 Op-Amp, 2 Op-Amp). 2.4 Voltage follower, Buffer.
Unit– III Linear Applications of Op-Amp	3a. Analyze summing amplifier configurations. 3b. Analyze Integrators, Differentiator, V-I converter, I-V Converter and Instrumentation Amplifier.	3.1 Summing Amplifier configurations: Inverting, Non-Inverting, Differential. 3.2 Ideal Active Integrator, Practical Integrator, Summing Integrator. 3.3 Ideal Active Differentiator, Practical Differentiator, 3.4 Voltage to Current Converter: Grounded Load, Inverting Amplifier. 3.5 Current to Voltage converter 3.6 Instrumentation Amplifier: Requirements, Three Op-Amp Amplifier, Using Transducer Bridge, Using Programmable Gain
Unit– IV Non-Linear Applications of Op-Amp	4a. Use Op-Amp configurations with Input offset voltage and Input Bias current compensation technique.	4.1 Input Offset Voltage Compensation. 4.2 Input Bias Current Compensation.
	4b. Explain the working of comparator circuits and their applications.	4.3 Comparator: Ideal (Inverting, Non-Inverting), Practical circuit, Limitations, 4.4 Comparator Applications: Zero Crossing Detector, Schmitt Trigger (Inverting, Non-Inverting)
Unit– V Special Applications of Op-Amp	5a. Use IC 555 as Astable and Monostable Multivibrator.	5.1 Waveform Generator: pin diagram and basics of 555, Square wave generator using 555 with calculations of frequency and duty cycle, 555 in

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		monostable with calculations of pulse width.
	5b. Use LM380 to make Audio Power Amplifier and Siren/Alarm.	5.2 Audio Amplifier: Audio Power Amplifier and Siren/Alarm (using LM 380)
	5c. Use IC 317 for variable regulated power supply.	5.3 Three terminal adjustable Regulator LM317: Various regulators comparison, connection diagram, output voltage equation, Functional diagram, Limitations

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I.	Introduction to Operational Amplifiers	05	6	2	0	8
II.	Op-Amp with Negative Feedback	08	2	8	4	14
III.	Linear Applications of Op-Amp	12	0	12	8	20
IV.	Non-Linear Applications of Op-Amp	07	4	8	0	12
V.	Special Applications of Op-Amp	10	2	8	6	16

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Compare and analyze any two Op-Amp Datasheets.
b) Observe the output parameter as well waveform using simulation and compare it with practical results.
c) Prepare Hazard Analysis report for various materials used in ICs.
d) Use Op-Amp for Sensor signal conditioning and amplification circuit.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Use video/animation films to demonstrate various circuits using Op-Amps.
g) Guide students for reading data sheets.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make universal test board for op-amp to verify different applications using op-amp and discrete components.
b) Demonstrate use of Op-Amp Instrumentation Amplifier in Interfacing of various sensors and transducers for display purpose.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Op-Amps and Linear Integrated Circuits	Dr. Sharma Sanjay	S. K. Kataria & Sons,4th edition or latest ISBN 978-81-906919-0-1
2	Op-Amps and Linear Integrated Circuits	Gayakwad R. A.	Pearson Education, 4th edition or latest ISBN-10: 9353949033
3	Linear Integrated Circuit	M.Senthil Sivakumar	S. Chand Publishing, ISBN: 9788121941136
4	Linear Integrated Circuits	B. Visvesvara Rao	Pearson Education, ISBN 978-93-325-3412-4

S. No.	Title of Book	Author	Publication with place, year and ISBN
5	Electronic devices and circuits	Gupta J. B.	S. K. Kataria & Sons, 6th edition or latest ISBN 978-93-5014-314-8

14. SOFTWARE/LEARNING WEBSITES

a) https://www.electronics-tutorials.ws/opamp/opamp_1.html
b) https://www.ablic.com/en/semicon/products/analog/opamp/intro/
c) https://www.youtube.com/watch?v=kiiA6WTCQn0&list=PLwjK_iyK4LLDBB1E9MFbxGCEnmMMOAXOH
d) https://www.youtube.com/watch?v=glvuXgTZnuU&list=PLwjK_iyK4LLDyIwyax2TW1z3fSoMmoRyj
e) https://www.youtube.com/watch?v=XmOevXm8kUA&list=PLm_MSClsnwm91RcONokvGw2dRxG-s_nM-
f) https://www.tutorialspoint.com/linear_integrated_circuits_applications/index.htm
g) https://how2electronics.com/electronics-circuits/op-amp-circuits/

15. PO-COMPETENCY-CO MAPPING

Semester III	Linear Electronic Circuits (Course Code: 4332403)						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	**Select specific sensors and transducers in electronic circuits.**						
Course Outcomes							
CO 1) Explain IC technology and basic terminology of Operational Amplifier.	2	1	1	0	1	1	1
CO 2) Test Op-Amp in Closed loop Configuration.	2	1	2	2	1	1	3
CO 3) Use Op-Amp for various Linear applications.	2	1	2	2	1	1	3
CO 4) Use Op-Amp for various Non-Linear applications.	2	1	2	2	1	1	3
CO 5) Use Op-Amp for Waveform generation and Audio applications.	2	1	2	2	2	1	3

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Mr. Sunil A. Patel, Lecturer in Power Electronics	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	+91- 9898073753	Patel_sunil5@gtu.edu.in