GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)
Semester-II

Course Title: Analog Devices and Circuits
(Course Code: 1324102)

Diploma programme in which this course is offered	Semester in which offered
Automation and Robotics	2nd Semester

1. RATIONALE:

An effective catalyst for the digital world, analogue electronics has a highly elegant design with many components. Modern digital systems would be powerless and unable to accept or output data without analogue techniques, processes, and subsystems. This course will give students the opportunity to learn about the significance of analogue devices and circuits like field effect transistors, operational amplifier, oscillators, miscellaneous ICs, voltage regulators, etc. and their applications for efficient functioning in the field of electronic service industry after gaining a foundational understanding of electronic devices like diodes, transistors, and elementary circuits in the first semester.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop different types of skills leading to the achievement of the following competency.

- **Test circuits that transform the output quantities from different sensors into the appropriate types of outputs within a range by using operational amplifiers, power electronic devices, and special purpose ICs.**

3. COURSE OUTCOMES (COs)

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

a) Demonstrate the working of semiconductor devices like FET, SCR, IGBT, DIAC and TRIAC.
b) Apply op-amps fundamentals for given applications.
c) Test various applications of op-amp.
d) Test the functionality of crucial electrical and electronic circuits and parts such LED display units, relays, opto-isolators, isolation amplifiers, and crystal oscillators.
e) Illustrate the function of special purpose ICs.

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	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

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

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the subcomponents of the COs. *These PrOs need to be attained to achieve the COs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Test V/I Characteristics of MOSFET.	1	2
2	Test V/I Characteristics of SCR.	1	2
3	Test V/I Characteristics of DIAC.	1	2
4	Test V/I Characteristics of TRIAC.	1	2
5	Test V/I Characteristics of IGBT.	1	2
6	Test the offset voltage of Op-amp.	2	2
7	Test the working of Op-amp as a differential amplifier.	2	2
8	Test the working of Op-amp as a non-inverting amplifier.	2	2
9	Test the working of Op-amp as an inverting amplifier.	2	2
10	Add 3 different signals using Op-amp	3	2
11	Convert Sine signal to Cosine signal and vice versa using Op-amp	3	2
12	Make Schmitt trigger circuit using Op-amp	3	2
13	Make zero cross detector using Op-amp	3	2
14	Make 4 to 20 mA to 1 to 10 volt convertor using Op-amp	3	2
15	Make 1 to 10 volt to 4 to 20 mA convertor using Op-amp	3	2
16	Make square root extractor for input, using Op-amps	4	2
17	Using different crystal oscillator generate the frequency and plot it on DSO	4	2
18	Make relay based logic card, make 2 input AND, OR, NOR and NAND gates.	4	2
19	Using an Opto-isolator IC circuit, convert square wave signals of the function generator into PWM output.	4	2
20	Using AD284J make an isolation amplifier	4	2
21	Display different characters on 7 segment LED	4	2
22	Display different characters on 16 segment LED	4	2
23	Make +5V and -5V power supply using 7805 and 7905.	5	2

24	Make PWM generator for different frequencies using 555 timer.	5	2
25	Make ramp generator using 555 timer.	5	2
26	Make missing pulse detector using 555 timer.	5	2
27	Make a 4x1 channel analog multiplexer circuit using CD4052.	5	2
28	Make a 1x4 channel analog de-multiplexer circuit using CD4052.	5	2
29	Make an instrumentation amplifier for various values of gain using AD623.	5	2
30	Make an H-bridge circuit driver for DC motor using L293D.	5	2
	Total Hrs.		60

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**.** While designing exercises make sure that all COs are covered equally.*

ii. *Care must be taken in assigning and assessing study report. Teacher can assign group of students a drawing that is available from industry/catalog/manuals and ask them to answer simple questions related to interpretation of drawing. Teacher can also ask them to find material required from the problem of surface development and bill of material (part list). .*

iii. *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.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1.	Efficiency in experimental setup.	**20**
2.	Test the circuits following the sequence of procedure.	**20**
3.	Follow safety precautions	**20**
4.	Record observations correctly.	**20**
5.	Interpret and conclude the results correctly.	**20**
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr. No.	Equipment Name with Broad Specifications
1	Bread-board, different value resistors and capacitors, SCR, Diac, Triac, MOSFET and IGBT. DC power supply, Function generator, Digital Oscilloscope/Oscilloscope, Diodes, Power Diodes, Transistors, and Crystal Oscillator.
2	OP-07 operational amplifier IC, AD623 IC, CD4052 IC, AD284J IC, L239D IC, 555 timer IC, 7805, 7905, 7812 and 7912 voltage regulator ICs, PC817 IC.
3	12 or 24 Volt DC motor, 4 pole stepper Motor, Different power rating Relays. General Purpose PCB, 7 segment LED, 16 segment LED, Dot matrix LED Display

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Practice & follow valid Design Standards to assure quality work in design of automobile components.

b) Follow ethical practices as Team leader and enable team members to do so at work.

c) Design automobile components considering human ergonomics.

d) Student should be able to identify ecofriendly or recycled material prior to selection for automobile applications. (Environment related)

The ADOs are best developed through the field based exercises/project work. 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

The major supporting theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. 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)	Topics and Sub-topics
Unit I: Semiconductor Devices	1a Define SCR, DIAC, TRIAC and FET 1b Draw the symbols of SCR, DIAC, TRIAC and IGBT. 1c Explain V/I characteristics of SCR, DIAC, TRIAC and IGBT 1d Explain the working of N type enhancement mode MOSFET. 1e Draw the circuit diagram of MOSFET application as a switch. 1f List the applications of MOSFET.	1.1 SCR, DIAC, TRIAC, FET- definition, types. 1.2 Plot and understand the V/I characteristics of SCR, DIAC, TRIAC and IGBT. 1.3 MOSFET- definition, types, symbols. N type enhancement mode- construction, working, characteristics, 1.4 Selection criteria of MOSFET as a switch. 1.5 List various applications of MOSFET and ratings of used MOSFET in application.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit II **Fundamentals of Operational Amplifier**	2a Describe block diagram of Op-amp 2b Classify the IC package types and identify the Pins of op-amp IC with proper understanding of the datasheet (Op amp - OP07). 2c Explain various op-amp terminology. 2d Explain basic open loop and closed loop configuration of operational amplifiers 2e Explain various configurations of operational - amplifier with schematic diagrams and mathematical expression	2.1 Introduction to op-amp Block diagram of op-amp 2.2 Op-amp IC package types, Pin identification and temperature Range, Power supply and Ordering Information 2.3 Op-amp terminology Input offset voltage, Input offset current, Input bias current, differential input resistance, Input capacitance, offset voltage adjustment range, Input voltage, range, CMRR (Common-Mode Rejection Ratio), SVRR, slew rate 2.4 Basic circuit of Open loop and close loop amplifier for Op-amp. 2.5 Inverting ,Non-Inverting, and Differential amplifier
Unit III **Application Of Operational amplifier**	3a Describe the application of op-amp as Adder, Integrator, Differentiator and Comparator 3b Describe the application of op-amp as Schmitt Trigger 3c Describe the application of op-amp as Instrumentation Amplifier 3d Describe the application of op-amp as Log & Antilog amplifier 3e Describe the application of op-amp as Voltage to current & Current to voltage converter.	3.1 Adder, Integrator, Differentiator, and Comparator 3.2 Schmitt Trigger 3.3 Instrumentation Amplifier 3.4 Log & Antilog amplifier 3.5 Voltage to current & Current to voltage converter.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit IV **Important Components and their circuit design.**	4a Build oscillator for different frequency. 4b Build electrical and electronics isolation circuits for different voltage and current values. 4c Understand various display components.	4.1 Definition of oscillators. Requirement of oscillators. Types of oscillators. A general form of Crystal oscillator circuit. Use of Crystal oscillators and Frequency stability of Crystal oscillators. 4.2 Definition of Relays. Requirement of Relays. Types of Relays. Selection criteria of relay. Relay circuit for AC and DC configuration. 4.3 Definition of Opto-Isolators. Requirement of Opto-Isolators. Types of Opto-Isolators. Selection criteria of Opto-Isolators. Opto-Isolators circuit for AC and DC configuration. 4.4 Introduction to Isolation Amplifiers. Block diagram and schematic diagram of Isolation Amplifiers. Introduction to Monolithic isolation amplifier AD284J. Application of AD284J. 4.5 Understand working of 7 segment LED, 16 segment LED. Identify segments on pin using multimeter.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit V **Special purpose ICs**	5a Describe Voltage regulator IC and use of it. 5b Describe 555 timer IC and use of it. 5c Describe H-bridge IC and use of it. 5d Describe analog multiplexer IC and use of it. 5e Describe Instrumentation Amplifier IC and use of it.	5.1 Introduction to 7805, 7905, 7812 and 7912 IC. Pin diagram and working of them. 5.2 Introduction to 555 timer IC. Block diagram, Pin diagram and schematic diagram of 555 timer. Astable and monostable operation of 555 timer. Applications of 555 timers: Missing Pulse detector, PWM generation, Ramp Generation. 5.3 Introduction to H-bridge IC. Block diagram, Pin diagram and schematic diagram of H-Bridge IC. Working of L293D, a dual H-Bridge IC. Operation of Stepper Motor using L293D. 5.4 Introduction to Analog multiplexer IC. Block diagram, Pin diagram and schematic diagram of Analog multiplexer IC. Working of CD4052, a 4-channel Analog multiplexer IC. 5.5 Working of AD623, an instrumentation amplifier IC.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Semiconductor Devices**	08	4	6	2	12
II	**Fundamentals of Operational Amplifier**	06	4	6	2	12
III	**Application Of Operational amplifier**	08	4	6	4	14
IV	**Important Components and their circuit design.**	10	4	6	6	16
V	**Special purpose ICs**	10	4	6	6	16
	Total	42	20	30	20	70

***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 to 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 slightly vary 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 groups and prepare reports of each activity. They should also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Identify a real time problem and provide a list of possible solutions.
b. Present a seminar on the latest trends in analog electronic industries.
c. Carry out a market survey for a list of special purpose ICs
d. Prepare a detailed list of vendors for analog devices.
e. Prepare a video on methods to read the datasheet effectively.

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) Guide students on how to address issues on environment and sustainability
g) Guide students in using datasheets.
h) Visit a nearby industry to observe the real time applications of analog devices.

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 are group-based. However, in the fifth and sixth semesters, it should be preferably being ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that she/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 be about **14 -** ***16 (fourteen to 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:

Build an op-amp based temperature control model.
Build SCR based speed control circuit for DC motor.
Test speed control of Fan motor using DIAC and TRIAC through simulation.
Prepare a case study on the failure of analog electronic devices/ circuits.
Prepare a list of advanced special purpose ICs.
Build 4 pole stepper motor controller, using special purpose ICs.
Build PID based DC motor speed controller using Op-amp, 555 timer and special purpose IC

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Power Electronics	Bimbhra P. S.	Khanna Publishers ISBN: 9788174092793, 9788174092793
2.	A Course in Electrical and Electronic Measurements and Instrumentation	A K Sawhney	Dhanpat Rai & Co. (P) Limited ISBN-10 8177001000 : ISBN-13 8177001006-978 :
3.	Process Control: Principles And Applications	Surekha Bhanot	Oxford University Press, latest edition, ISBN-13: 9780195693348
4.	Op-Amps and linear Integrated Circuits	Ramakant A.Gayakwad	Asoke k. Ghosh, PHI Learning Private Limited, Rimjhim House,111, Patparganj industrial Estate, Delhi-110092 ISBN-978-81-203-2058-1

5.	Operational Amplifiers and Their Applications	Subir Kumar Sarkar	S. Chand & Company Limited ISBN:9788121917797, 8121917794
6.	Quartz Crystal Oscillator Circuits Design Handbook	D. Firth	Magnavox Company. Government and Industrial Division ISBN 13: 4444000050546
7.	Datasheet of relevant IC		

14. SOFTWARE/LEARNING WEBSITES

a. https://vlsi-iitg.vlabs.ac.in/MOSFET_theory.html
b. https://ae-iitr.vlabs.ac.in/List%20of%20experiments.html
c. https://swayam.gov.in
d. https://www.multisim.com
e. https://nptel.ac.in
f. Multisim Software
g. Ktechlab Software
h. Logisim Software
i. Jcircuits Software
j. Circuitmaker Software
k. Coolspice Software
l. Psimsoftware
m. Simone Software
n. Partsim Software
o. Docircuits Software

15. PO-COMPETENCY-CO MAPPING

Semester II	Analog Devices and Circuits ()						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation And Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

Competency ● **Test circuits that transform the output quantities from different sensors into the appropriate types of outputs within a range by using operational amplifiers, power electronic devices, and special purpose ICs.**	3	1	2	2	1	1	1
a) Demonstrate the working of semiconductor devices like FET, SCR, DIAC and TRIAC.	3	-	-	2	1	-	1
b) Apply op-amps fundamentals for given applications.	3	1	-	2	1	-	1
c) Test various applications of op-amp.	3	2	2	2	1	1	1
d) Test the functionality of crucial electrical and electronic circuits and parts such LED display units, relays, opto-isolators, isolation amplifiers, and crystal oscillators.	3	2	2	2	1	1	1
e) Illustrate the function of special purpose ICs.	3	-	-	2	1	1	1

Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

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