GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Medical Electronics
(Course Code: 4330301)

Diploma programme in which this course is offered	Semester in which offered
Biomedical Engineering	Third

1. RATIONALE

Medical electronics is a very important subject since the growth of biomedical industry depends upon electronics to a great extent. The objective this course is to make the students aware about importance of electronics in the field of biomedical engineering. The course contains basics of operational amplifier which is the most versatile linear integrated circuit (IC) used to develop various applications in electronic circuits and equipment of biomedical engineering. Hence, this course is intended to develop skills to build, test, diagnose & rectify the Op-amp based electronic circuits. This course contains various linear & non-linear applications of Op-amp. Skills acquired through this course will help the student to troubleshoot medical equipments.

2. COMPETENCY

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

- **To develop skills to build, test and troubleshoot the Op-amp based electronic circuits of medical equipment.**

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. Describe basic block diagram, parameters and configurations of Opamp.
2. Build opamp circuits for General Linear applications.
3. Demonstrate the application of opamp as comparators and converters.
4. Use opamp as filters and oscillators.
5. Illustrate the Applications of Opamp for Healthcare

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 sub-components of the 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'.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Describe the basics of Opamp 741 IC	I	2
2	Demonstrate open loop inverting and non inverting amplifier.	I	2
3	Demonstrate open loop differential amplifier.	I	2
4	Test closed loop inverting amplifier.	II	2
5	Test closed loop non-inverting amplifier.	II	2
6	Build differential amplifier using one op-amp.	II	2
7	Test voltage follower using op-amp.	II	2
8	Build Substractor using op-amp.	II	2
9	Test summing amplifier, Scaling and Averaging Amplifier using inverting configuration.	II	2
10	Build Integrator circuit.	II	2
11	Build Differentiator circuit.	II	2
12	Test comparator circuit.	III	2
13	Test D-A converter using Binary weighted register op-amp.	III	2
14	Test A-D converter using op-amp.	III	2
15	Test first order Low Pass Filter	IV	2
16	Test first order High Pass Filter	IV	2
17	Test RC Phase Shift oscillator circuit.	IV	2
18	Test Wein bridge oscillator circuit.	IV	2
19	Build Instrumentation Amplifier	V	2
	Total		**38**

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 experimental set up	20
2	Operate the equipment and electronic set up/ kits	20
3	Follow safety practice guidelines	10
4	Record/ Measure observations	20
5	Interpret the result and conclude	20
6	Question answer	10
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

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

Sr. No.	Equipment Name with Broad Specifications	Practical No.
1	Digital multimeter (3 1/2 digit) 3 1/2 digit display, 9999 counts digital multimeter measures: AC and DC Volatge and Current, Resistance (0 - 100 MΩ), Capacitance.	All
2	Digital Storage Oscilloscope or Cathode Ray Oscilloscope (2 channel, preferably digital) Sensitivity in 1, 2, 5 sequence: 10 mV/cm to 20 V/cm Bandwidth : DC to 5 MHz Sweep Speed in 1, 2, 5 sequence : 0.5 S/cm to 0.1 ms/cm Power : 230 V ± 10% 50 Hz 30W Calibrator : 1 V, 1 kHz Display Area : 8 cm x 10 cm	All
3	Function Generator 0-2 MHz with Sine, square and triangular output with variable frequency and amplitude	All
4	Bread Board Trainer ➢ Built-in Fixed DC Power Supply Source : + 5V/1A ➢ Built-in Variable DC Power Supply Source : 0 to +15V/500mA, 0 to -15V/500mA ➢ Breadboard/Module Mounting Place : 3nos (2400 Pts approx.) ➢ Input Line Voltage :230V AC ± 10% , 50Hz	All
5	DC dual power supply(-15V- 0 - 15V) Input: 230 V AC,+/- 10%, 50 Hz, Single phase. Output Voltage: 0 – 40 V DC continuously variable through coarse and fine potentiometers. Current 0-2 A (0-30 V range) Dual Supply: +/- 15 V DC	All
6	Inverting and Non-inverting Amplifier trainer kit • Inbuilt Variable/Fixed AC & DC Regulated Power Supplies • Output Voltages : 0-5VDC (2Nos.) (Variable), +12VDC (Fixed) • 741 ICs, Resistors (1K, 2.2K, 3.3K,4.7K,6.8K,10K, 22K, 33K,47K, 68K,100K etc) and Capacitors (.1 uF, 0.22 uF, 0.47 uF, 0.01 uF etc)Components Provided • Test points provided at various stages in the circuit. • Set of required number of patch cords	2,3,4,5,7
7	Differential Amplifier trainer kit • Inbuilt Variable/Fixed AC & DC Regulated Power Supplies • Output Voltages : 0-5VDC (2Nos.) (Variable), +12VDC (Fixed) • 741 ICs, Resistors (1K, 2.2K, 3.3K,4.7K,6.8K,10K, 22K, 33K,47K, 68K,100K etc) Provided • Test points provided at various stages in the circuit. • Set of required number of patch cords	6,8
8	Integrator and Differentiator Trainer Kit • Inbuilt Variable/Fixed AC & DC Regulated Power Supplies • Output Voltages : 0-5VDC (2Nos.) (Variable), +12VDC	10,11

Sr. No.	Equipment Name with Broad Specifications	Practical No.
	(Fixed) • 741 ICs, Resistors (1K, 2.2K, 3.3K,4.7K,6.8K,10K, 22K, 33K,47K, 68K,100K etc) and Capacitors (.1 uF, 0.22 uF, 0.47 uF, 0.01 uF etc)Components Provided • Test points provided at various stages in the circuit. • Set of required number of patch cords	
9	Active filter trainer kit • Inbuilt Variable/Fixed AC & DC Regulated Power Supplies • Output Voltages : 0-5VDC (2Nos.) (Variable), +12VDC (Fixed) • 741 ICs, Resistors (1K, 2.2K, 3.3K,4.7K,6.8K,10K, 22K, 33K,47K, 68K,100K etc) and Capacitors (.1 uF, 0.22 uF, 0.47 uF, 0.01 uF etc)Components Provided • Test points provided at various stages in the circuit. • Set of required number of patch cords	15,16
10	8 bit Successive Approximation Register type Analog to Digital converter it • 3 ½ digit DPM meter. • Test Points. • Circuit Printed on board • 0-15 Decoder display using seven segment.. • 220V mains operated. • 8-bit discrete ADC • On-board signal generator with adjustable amplitude levels • On-board LED bank to observe digital outputs\ • Power supply : +5V, ± 12V GND • Interconnection is provided by 2mm connectors	14
11	Digital to Analog converter trainer kit • 8-bit resistors DAC • 8-bit ladder type D to A converter • 8-bit D to A converter using monolithic IC • Simple construction using Op-Amp and resistors • On-board switches are provided for digital pattern generation • 8-bit digital inputs ranges from 00 to FF • Variable frequency counter to study the settling time	13
12	Comparator Trainer kit Power Supplies: • Dual DC Power Supply IC Regulated +15V DC, 150mA. • Operated on Mains power 230V, 50Hz +10% Components are mounted on the panels are: • 741 IC (Op-amp) • Resistors • Test points provided at various stages in the circuit. • Set of required number of patch cords	12
13	RC Phase shift Oscillator Trainer kit • DC Power Supply IC Regulated +15V DC, 150mA. Operated on Mains power 230V, 50Hz +10% • Components are mounted on the panels are: 741 Op-Amp Resistors	17

Sr. No.	Equipment Name with Broad Specifications	Practical No.
	Capacitors Variable Resistor	
14	Wein Bridge Oscillator Trainer kit • DC Power Supply IC Regulated +15V DC, 150mA. Operated on Mains power 230V, 50Hz +10% • Components are mounted on the panels are: 741 Op-Amp Resistors Capacitors Variable Resistor	18
15	Instrumentation Amplifier Trainer kit Power Supplies: • Dual DC Power Supply IC Regulated +15V DC, 150mA. • DC Power Supply IC Regulated 0-5V DC, 150mA. • DC Power Supply IC Regulated 0-5V DC, 150mA. • Operated on Mains power 230V, 50Hz +10% Digital Meter: • Voltmeter 20V • Components are mounted on the panels are: 741 IC (Op-amp) Resistors Capacitors	19

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 fulfil the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical appliances.
c) Practice environmental friendly methods and processes. (Environment related)

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 Basics of Operational Amplifier	1a. Describe the block diagram of Operational amplifier 1b. Illustrate Op-Amp IC 741 Pin Diagram 1c. Select the parameter to be considered for given application of Op-amp 1d. Differentiate between open loop inverting, non-inverting and differential configuration of Op-amp. 1e. Compare Positive & Negative Feedback	1.1 Operational Amplifier, Block Diagram, Equivalent Circuit, Circuit Symbol 1.2 Op-Amp IC 741 Pin Diagram & Its Description 1.3 Open Loop Configuration: Inverting, Non-inverting, Differential 1.4 Op-Amp Parameters: Input Offset Voltage, Input Offset Current, Input Bias Current, Differential Input Resistance, Differential Input Capacitance, Input Voltage range, Offset Voltage Adjustment range, Common Mode Rejection Ratio (CMRR), Supply Voltage Rejection Ratio (SVRR), Slew Rate, Large Signal Voltage Gain, Output Voltage Swing, Gain Bandwidth Product, Output Short Circuit Current, Transient Response Parameters 1.5 Ideal Op-Amp Characteristics 1.6 Concept of Feedback: Positive & Negative Feedback
Unit – II Negative Feedback Configurations of Opamp and General Linear Applications of Op-amp	2a. Elaborate voltage gain derivation for closed loop inverting and noninverting and differential amplifier 2b. Explain Virtual Ground & Virtual Short Concept 2c. Explain the voltage follower and Subtractor Circuit 2d. Illustrate the operation of opamp as Summing, Scaling, Averaging Amplifier using Inverting Configuration 2e . Interpret the operation of opamp as Integrator and Diffrentiator 2f. Derive the output voltage equation for Instrumentation Amplifier	2.1 Closed Loop Inverting & Non-Inverting amplifier 2.2 Virtual ground and Virtual short concept 2.3 Differential amplifier, Subtractor, Voltage Follower 2.4 Summing, Scaling, Averaging Amplifier using Inverting Configuration 2.5 Differentiator, Integrator 2.6 Instrumentation Amplifier
Unit– III Comparators and converters	3a. Describe operation of opamp as comparator 3b. Explain Sample & Hold Circuit 3c. Classify different types of ADC and DAC	3.1 Basic Comparators: Inverting & Non-Inverting Configuration 3.2 Sample & Hold Circuit 3.3 List types of ADC and Application of ADC, Successive Approximation Register type A to D Converter

	3d. Enlist application of ADC and DAC 3e. Demonstrate the Analog to digital conversion using Successive Approximation Register ADC 3f. Demonstrate the digital to Analog conversion using Binary Weighted DAC	3.4 List types of DAC and Application of DAC, Binary Weighted type D to A Converter
Unit– IV Active Filters & Oscillators	4a. Classify different types of filter 4b. Compare Active and Passive Filters 4c. Design Low Pass & High Pass Butterworth Filter 4d. Design Band Pass, Band Reject and Notch filter 4e. Illustrate the operation of All Pass filter 4f. Describe the working Principle of oscillator 4g. Demonstrate the working of RC Phase Shift & Wein Bridge Oscillator	4.1 Introduction to Filter & Its Classification 4.2 Advantages of Active Filters over Passive Filters 4.3 Types of Active Filters: First Order Low Pass & High Pass Butterworth Filter 4.4 Band Pass, Band Reject & Notch Filter 4.5 All Pass Filter 4.6 Oscillator working Principle, Types, RC Phase Shift & Wein Bridge Oscillator
Unit– V Designing & Applications of Opamp for Healthcare	5a. Design Instrumentation Amplifier for Biomedical Applications 5b. Explain the block diagram of ECG,EEG and EMG Signal Conditioning	5.1 Design Instrumentation Amplifier 5.2 ECG, EEG and EMG Signal Conditioning Circuit

***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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Operational Amplifier	8	12	4	0	16
II	General Linear applications of Op-amp	12	3	8	7	18
III	Comparators and converters	8	2	6	6	14
IV	Active Filters & Oscillators	9	3	4	7	14
V	Applications of Opamp for Healthcare	5	0	2	6	8
Total		**42**	**20**	**24**	**26**	**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 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:

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.11***, 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 for using data manuals.

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 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:

1. Built Instrumentation amplifier for measurement if Body temperature using RTD/Thermistor/Thermocouple/ IC Sensor (LM 35)
2. Develop temperature control DC fan using 741
3. Design bandpass filter for ECG/EEG/EMG etc. biological Signal.
4. Design right leg driver circuit for ECG Signal.
5. Design Instrumentation amplifier for ECG Signal

6. Design smoke detector using opamp
7. Design 4 bit R-2R ladder type DAC.
8. Design light intensity control using LDR
9. Design adder circuit to add two signals.
10. Design charge amplifier for piezoelectric transducer
11. Design audio amplifier using LM386 Opamp IC.
12. Design closed loop inverting amplifier on general purpose pcb.
13. Design closed loop noninverting amplifier on general purpose pcb
14. Design closed loop differential amplifier on general purpose pcb
15. Design first order Low Pass Filter on general purpose pcb
16. Design first order High Pass Filter on general purpose pcb
17. Design first order notch Filter on general purpose pcb

13. SUGGESTED LEARNING RESOURCES:

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Opamp and Linear Integrated Circuit Technology	Ramakant A. Gayakwad	4th Edition, Prentice Hall / Pearson Education, 2015, ISBN: 9332549915
2	Design with Operational Amplifiers and Analog Integrated Circuits	Sergio Franco	3rd Edition, Tata Mc Graw-Hill, 2007. ISBN: 9352601947
3	Operational Amplifiers and Linear Integrated Circuits	Robert F.Coughlin, Frederick F.Driscoll	Sixth Edition, PHI, 2001
4	Electronic Principles	Albert Paul Malvino	McGraw-Hill Inc.,US; 6th ed. edition (1 June 1999) ISBN: 0028028384
5	Medical Instrumentation Application and Design	Webster John G., Editor	WILEY India, New Delhi 2011
6	Handbook Of Bio Medical Instrumentation	Raghbir S Khandpur	3rd Edition, Tata Mc Graw-Hill, 2014.

14. SOFTWARE/LEARNING WEBSITES:

a. https://nptel.ac.in/courses/117107094
b. https://ndl.iitkgp.ac.in
c. www.electrical4u.com
d. https://ae-iitr.vlabs.ac.in/List%20of%20experiments.html
e. http://vlabs.iitkgp.ac.in/be/exp18/index.html
f. https://he-coep.vlabs.ac.in/exp/digital-analog-converter/
g. https://www.udemy.com/course/operational-amplifier-and-its-applications/
h. https://www.youtube.com/c/ALLABOUTELECTRONICS
i. https://www.youtube.com/playlist?list=PLwjK_iyK4LLDBB1E9MFbxGCEnmMMOAXOH
j. https://www.youtube.com/watch?v=ML7xFG8GBSk&list=PLAPKGqvQGg6qorYiEtedqKOy-IM6WJ3Y2

15. PO-COMPETENCY-CO MAPPING

Semester III	Medical Electronics (Course Code: 4330301)						
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 ***"Solve basic circuit problems using circuit laws and network theorems."***							
CO a) Describe basic block diagram, parameters and configurations of Opamp.	3	-	-	3	-	-	2
CO b) Build opamp circuits for General Linear applications.	3	2	3	3	-	2	1
CO c) Demonstrate the application of opamp as comparators and converters.	2	3	3	3	-	2	1
CO d) Use opamp as filters and oscillators.	2	3	3	3	-	2	2
CO e) Illustrate the Applications of Opamp for Healthcare	1	3	3	3	3	2	1

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

Sr. No	Name and Designation	Institute	Email Id
1	Mrs. Jimisha H Suthar, Lecturer	Government Polytechnic for Girls, Ahmedabad	suthar.jimisha@gmail.com
2	Mr. Jainamkumar S Shah, Lecturer	Government Polytechnic, Ahmedabad	jsshah@gpahmedabad.ac.in
3	Mr. Krunal H. Parmar Lecturer	AVPTI, Rajkot	krunal.parmar03@gmail.com
4	Mrs. Poonam G. Lakhani Lecturer	Government Polytechnic, Gandhinagar	poonamlakhani17@gmail.com