Program Name : **Diploma in Medical Electronics**

Program Code : **MU**

Semester : **Fourth**

Course Title : **Analog Circuits**

Course Code : **22433**

1. RATIONALE

Today the growth of any industry depends upon electronics to great extent.This course is intended to develop the skills to diagnose and rectify the analog circuit related problems in the industry. The contents of this course are the basic building blocks of different analog circuits. This course acquaints student with general analog principles and design methodologies using integrated circuit for effective functioning in the field of electronic service related work of biomedical equipment and systems.

2. COMPETENCY

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

- **Maintain electronic circuits comprising of linear ICs.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented COs associated with the above mentioned competency:***

a. Use differential amplifier circuits.
b. Use IC 741 as the basic analog integrated circuit.
c. Troubleshoot linear and non-linear circuits.
d. Troubleshoot different active filters.
e. Maintain multivibrator and oscillator circuits.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

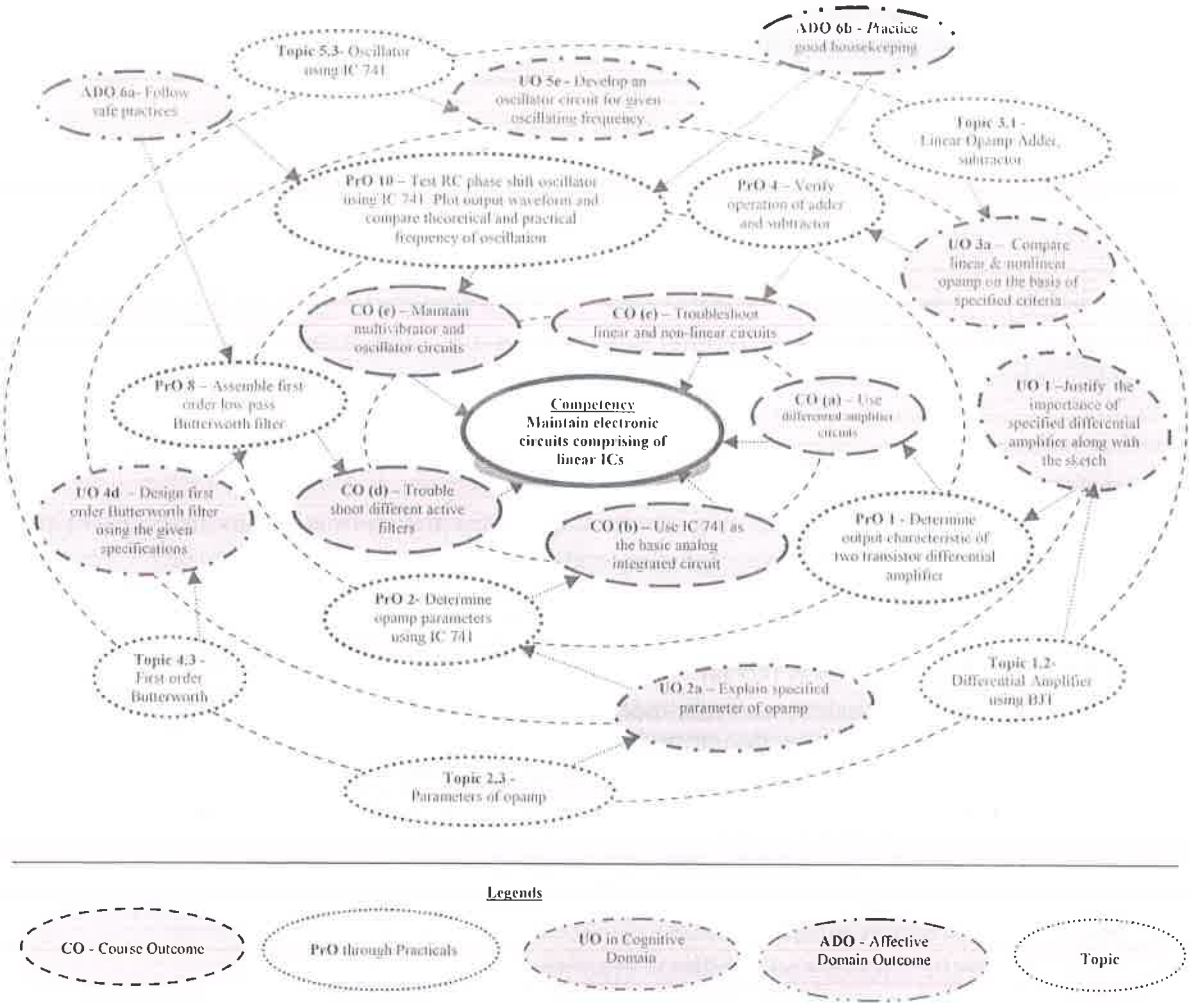

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Determine output characteristic of two transistor differential amplifier.	I	02*
2	Determine Opamp parameters using IC 741: input offset voltage, output offset voltage and CMRR.	II	02*
3	Determine gain of inverting and non-inverting amplifier using Opamp IC 741 and compare it with theoretical gain. Part - I	II	02
4	Determine gain of inverting and non-inverting amplifier using Opamp IC 741 and compare it with theoretical gain. Part - II	II	02
5	Troubleshoot the operation of adder and subtractor using IC 741. Part - I	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
6	Troubleshoot the operation of adder and subtractor using IC 741. Part - II	III	02*
7	Troubleshoot the operation of integrator and differentiator using IC 741 by applying input as sine wave. square wave and rectangular wave. Part - I	III	02
8	Troubleshoot the operation of integrator and differentiator using IC 741 by applying input as sine wave. square wave and rectangular wave. Part - II	III	02
9	Assemble converter using IC 741. Part - I	III	02
10	Assemble converter using IC 741. Part - II	III	02
11	Troubleshoot the operation of comparator as zero crossing detector and Schmitt trigger using IC 741. Part - I	III	02
12	Troubleshoot the operation of comparator as zero crossing detector and Schmitt trigger using IC 741. Part - II	III	02
13	Assemble first order low pass butterworth filter using IC 741. Plot frequency response.	IV	02*
14	Assemble first order high pass butterworth filter using IC 741. Plot frequency response.	IV	02
15	Test RC phase shift oscillator using IC 741. Plot output waveform and compare theoretical and practical frequency of oscillation.	V	02*
16	Assemble astable multivibrator using IC 555. Plot output waveform and calculate ON time. OFF time.	V	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices.

b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical practices.

The ADOs are not specific to any one PrO. but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Experimental trainer kits / Universal trainer kit	1 to 11
2	ICs: 741	2 to 10
3	Digital multimeter: auto ranging, 3 and ½ digit display	1 to 11
4	Analog multimeter	1 to 11
5	Single power supply: 0-30V, 10Amp	1 to 11
6	Dual power supply: 0-30V, 10Amp	2 to 10
7	Function generator upto 100 MHz	11
8	Oscilloscope: 50 MHz, dual trace	1 to 11
9	Digital storage oscilloscope: 50 MHz, auto capturing	1 to 11
10	IC: 555	11

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Differential Amplifier	1a. Justify with sketches the importance of the specified mode of differential amplifier. 1b. Explain wih sketches the specified input and specified output of the given differential amplifier. 1c. Correlate the specified input and the specified output of the given amplifier. 1d. Describe the procedure to troubleshoot the given type of differential amplifier.	1.1 Ideal differential amplifier 1.2 Differential amplifier using BJT 1.3 Configuration: Single input balanced output, single input unbalanced output, dual input unbalanced output and dual input unbalanced output.
Unit-II	2a. Explain wih sketches the specified	2.1 Importance, block diagram,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Operational Amplifiers	parameter of the given type of opamp. 2b. Explain wih sketches the given characteristics of the given opamp with respect to given parameter. 2c. Explain wih sketches the given virtual concept with reference to the given opamp. 2d. Calculate gain of close loop configuration of the given opamp for the specified mode. 2e. Identify unity gain of the amplifier circuit for the given opamp circuits. 2f. Describe with sketches the procedure to troubleshoot the given differential amplifier	symbol, pin diagram, equivalent circuit of opamp IC 741 2.2 Transfer characteristics (practical and ideal) 2.3 Parameters of opamp 2.4 Virtual ground and virtual short concepts 2.5 Configuratuion of opamp: open loop and close loop 2.6 Close loop onfigurations of opamp: inverting mode, non-inverting mode and voltage follower
Unit– III Applications of Operational Amplifier	3a. Compare the features of the linear and non-linear opamp on the basis of specified criteria. 3b. Explain wih sketches for the specified operation the opamp. 3c. Calculate output of the given opamp(s). 3d. Compare the features of the integrator and differentiator for the specified application. 3e. Explain wih sketches the instrumentation amplifier using two opamp and three opamp for the specified application. 3f. Describe with sketches the procedure to troubleshoot the given opamp circuit.	3.1 Linear opamp: Adder, subtractor, integrator, differentiator, V to I and I to V converter and instrumentation amplifier using two and three opamp 3.2 Practical opamp: Integrator, differentiator 3.3 Non-linear opamp: Comparator, log and antilog amplifiers, analog multiplier,Schmitt trigger 3.4 Precision rectifier using opamp
Unit– IV Filter Circuits	4a. Identify the filter(s) on the basis of specified characteristic. 4b. Compare the features of the given specified filter(s) on the basis of specified parameters. 4c. Explain wih sketches the given parameter of filter. 4d. Design the given Butterworth filter using the given given data/specifications. 4e. Describe with sketches the procedure to troubleshoot the given filter circuit.	4.1 Active filters 4.2 Parameters of filter: roll off, cut off frequency, Q-factor, bandwidth 4.3 First order Butterworth filter: Low pass filter, high pass filter, band pass filter, band stop filter, all pass filter 4.4 Second order Butterworth filter: Low pass filter, high pass filter, band pass filter, band reject filter
Unit –V	5a. Identify the type of multivibrator	5.1 Block diagram of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Multivibrator and Oscillator	based on the given mode of operation. 5b. Describe the function of the specified pins of IC 555. 5c. Compare the given multivibrators for specified characteristic. 5d. Calculate ON time, OFF time and duty cycle for the given multivibrator. 5e. Develop an oscillator circuit for the given oscillating frequency. 5f. Explain wih sketches the working of the specified oscillator. 5g. Describe with sketches the procedure to troubleshoot the given multivibrator/ oscillator	multivibrator, pin configuration of IC 555 5.2 Monostable, astable and bistable multivibrator using IC 555 5.3 Oscillator using IC 741: RC phase shift oscillator, Wien bridge oscillator

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.*

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	Differential Amplifier	06	04	02	00	06
II	Operational Amplifier	14	04	06	04	14
III	Application of Opamp	20	08	08	08	24
IV	Filter Circuits	14	04	06	04	14
VI	Multivibrator and Oscillator	10	04	04	04	12
Total		**64**	**24**	**26**	**20**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may 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 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. Use various meters to test electronic equipment and components.
b. Collect information about analog circuits used in medical equipment from different scientific periodicals.
c. Collect and understand datasheets of different types of linear integrated circuits.
d. Perform Library / Internet survey of analog circuits and present a report.
e. Prepare power point presentation or animation for understanding different circuits behavior.

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. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various theorems in circuit analysis.
f. Encourage the students to verify the results obtained in the practical exercises using any simulation software.
g. Guide student(s) in undertaking interesting micro-projects. For the identified problem in the micro-projects, let the students also use any eCAD software for designing and testing the circuit and observing the simulated output.

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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Assemble instrumentation amplifier.
b. Construct ECG preamplifier.
c. Assemble EEG preamplifier.
d. Develop EMG preamplifier.
e. Build Schmitt trigger circuit to generate square wave.
f. Construct high power car voltage regulator.
g. Creat shadow sensor alaram.
h. Develop LED DC voltage indicator.
i. Construct dark activated relay circuit.
j. Develop digital thermometer circuit.
k. Design crystal oscillator.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Op-Amps and Linear Integrated Circuits (	Gayakwad, R. A.	Pearson Education, New Delhi, 2000 ISBN: 9780132808682
2	Linear Integrated Circuits(5th Edition)	Choudhury, D. R.	New Academic Science, New Delhi, 2017, ISBN: 9781781831007
3	Linear Integrated Circuits Analysis, Design, and Applications	Nair, B. S.	Wiley India Pvt. Ltd., New Delhi, 2009 ISBN: 9788126518968
4	Linear Integrated Circuits	Salivahanan, S.; Bhaskaran, V. S. K.	McGraw-Hill Publishing Company Limited, New Delhi, 2008 ISBN: 9780070648180
5	Op Amps and Linear Integrated Circuits	Fiore, J. M.	Cengage Delmar Thomson Learning, New Delhi, 2001, ISBN: 9780766817937
6	Opeational Amplifiers and Their Applications	Sarkar, S.	S.Chand Publishing, New Delhi, 2010, ISBN: 9788121917797

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://www.electroschematics.com/tag/741-circuits/
b. http://bestengineeringprojects.com/operation-amplifier-741-based-projects/
c. https://circuitdigest.com/555-timer-circuits
d. http://www.circuitsgallery.com/2013/12/top-ten-555-timer-projects.html
e. www.youtube.com /analog circuits