



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE04000111

Subject Name : Analog Signal Processing

WEF Academic Year:	2025-2026
Semester:	4
Category of the Course:	Professional Core

Prerequisite:	1. Fundamental of Basic electronics 2. Electronics devices like transistor, diode etc.
Rationale:	Analog Signal Processing is fundamental to understanding real-time signal behavior in sensors, transducers, and instrumentation systems. It equips the students with essential skills to design and analyze filters, amplifiers, and signal conditioning circuits used in control and measurement applications.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level*
01	Define and explain DC and AC performance characteristics/parameters of op-amp as well as apply basic voltage regulator ICs for the design of dual power supply.	RM/UN/AP
02	Analyze and design various linear electronic circuits such as DC and AC amplifiers, integrator, differentiator, V to I and I to V converters etc. based on operational amplifiers.	AP/AN
03	Analyze and design various non-linear electronic circuits such as Schmitt trigger, clippers, clampers, precision rectifiers as well as DAC and ADC based on op-amp.	AP/CR
04	Explain, analyze and design various active filters and oscillator circuits using operational amplifier.	UN/AP/CR
05	Explain, analyze and design various special purpose electronic circuits such as monostable and astable multivibrator circuits, instrumentation amplifier, logarithmic amplifier etc. using op-amp as well as specialized ICs such as 555 timer.	AP/AN/CR

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create



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Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	TW/SL	TH		Theory		Tutorial/Practical			
						ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
60	0	30	30	120	04	70	30	20	30	50	200

- **Problem Based Learning (PBL)** aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	<p>Introduction to OP-AMP:</p> <p>1.1 Basic ideas about: Dual input-balanced output differential amplifier, Inverting and non-inverting inputs, Dual input-unbalanced output differential amplifier, Single input-balanced output differential amplifier, Single input-Unbalanced output differential amplifier.</p> <p>1.2 Basic introduction to block diagram of a typical op-amp, Basic introduction to equivalent circuit of the 741 op-amp, Schematic symbol and 8 pin functions and power supply of op-amp.</p> <p>1.3 Open loop op-amp configuration, the differential amplifier, the inverting amplifier, the non-inverting amplifier, positive saturation output, negative saturation output.</p> <p>1.4 Definition and explanation to the terms of op-amp as:- Input offset voltage, Input offset current, Input bias current, Total output offset voltage, Thermal drift, Differential input resistor, Input capacitance, Offset voltage adjustment range, Input voltage range, Common mode rejection ratio, Supply voltage rejection ratio, Output voltage swing, Output resistance, Output short circuit current, Supply current, Slew Rate.</p>	10	18



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2	<p>An Op-amp with Negative Feedback (Closed Loop):</p> <p>2.1 Introduction, Block diagram representation of feedback configuration</p> <p>2.2 Voltage series feedback amplifier (Non-inverting amplifier with feedback), Derivation of closed loop voltage gain, Input resistance with feedback, Output resistance with feedback, Bandwidth with feedback, Total output offset voltage with feedback, Voltage follower.</p> <p>Voltage shunt feedback amplifier (Inverting amplifier with feedback), Derivation of closed loop voltage gain, Input resistance with feedback, Output resistance with feedback, Bandwidth with feedback, Total output offset voltage with feedback, Current to voltage converter.</p> <p>Differential amplifier with one op-amp</p> <p>Differential amplifier with two op-amp</p>	8	13
3	<p>General Linear Application:</p> <p>3.1 DC Amplifier</p> <ul style="list-style-type: none"> - Inverting amplifier, Non-inverting amplifier, Differential amplifier - Inverting amplifier with external offset voltage-compensating network, Non-inverting amplifier with external offset voltage-compensating network, Differential amplifier with external offset voltage compensating network. <p>3.2 AC Amplifier</p> <ul style="list-style-type: none"> - AC inverting Amplifier - AC non-inverting Amplifier <p>3.3 The Peaking Amplifier</p> <p>3.4 Summing Scaling and Averaging Amplifier</p> <ul style="list-style-type: none"> - Inverting configuration:- Summing amplifier, Scaling amplifier, Averaging amplifier - Non-inverting configuration:- Summing amplifier, Averaging amplifier - Differential configuration:- A subtractor, Summing amplifier <p>3.5 Voltage to Current Converter with Floating Load</p> <p>3.6 Voltage to Current Converter with Grounded Load</p> <p>3.7 Current to Voltage Converter</p> <p>3.8 Very High Input Impedance Circuit</p> <ul style="list-style-type: none"> - DC-coupled voltage follower - AC-coupled voltage follower with input resistance bootstrapped <p>3.9 The Integrator, with its 0db gain frequency (fb) and gain limiting frequency derivation(fa)</p> <p>3.10 The Differentiator, with its 0db gain frequency(fa) and gain limiting frequency derivation(fb)</p>	10	17
4	<p>Comparators and Converters:</p>	8	13



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	<p>4.1 Basic comparator, Zero crossing detector, Schmitt trigger</p> <p>4.2 Comparator characteristics, Limitation of OP-AMP as comparator</p> <p>4.3 OP-AMP as voltage limiter:- Positive voltage limiter and Negative voltage limiter</p> <p>4.4 CLIPPER</p> <ul style="list-style-type: none"> - Positive clippers, Negative clippers - Small signal half wave rectifiers <p>4.5 CLAMPERS Positive and negative clampers</p> <p>4.6 Absolute value output circuit, Peak detector, Sample and hold circuit</p> <p>4.7 Digital to Analog Converter (DAC)</p> <ul style="list-style-type: none"> - D/A converter with binary-weighted resistor - D/A converter with R and 2R resistor <p>4.8 Analog to Digital Converters (ADC)</p> <ul style="list-style-type: none"> - Successive approximation A/D converter 		
5	<p>Active and Passive Filters:</p> <p>5.1 Introduction to active and passive filters, Introduction to low pass and high pass filters</p> <p>5.2 Low Pass Filters</p> <ul style="list-style-type: none"> - Passive first order low pass filter with its transfer function - Active first order low pass Butterworth filter with its transfer function, filter design - Active second order low pass Butterworth filter with transfer function, filter design <p>5.3 High pass Filters</p> <ul style="list-style-type: none"> - Passive first order high pass filter with its transfer function - Active first order high pass Butterworth filter with its transfer function, filter design - Active second order high pass Butterworth filter with transfer function, filter design <p>5.4 Higher Order Active Filters:- Third order and fourth order low pass Butterworth filter</p> <p>5.5 Band Pass Filters :-1) Wide band Pass filter and 2)Narrow band pass filters</p> <p>5.6 Band–Reject Filters:-1)Wideband-reject filter and 2) Narrow band-reject filter (Notch Filter)</p> <p>5.7 All Pass Filter</p>	8	13
6	<p>OSCILLATORS:</p> <p>6.1 Introduction to oscillator, Oscillator principles, Oscillator block diagram</p> <p>6.2 Phase shift oscillator, Wien bridge oscillator, Quadrature</p>	8	13



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	oscillator, 6.3 Voltage-controlled oscillator NE/SE566		
7	Specialized IC Applications: 7.1 The 555 Timer Introduction to 555 timer IC, 555 timer pin connection diagram and block diagram 555 timer as a monostable multivibrator:- Operation and circuit diagram - Mono stable multivibrator applications:- 1) Frequency divider 2) Pulse stretcher - 555 timer as an astable multivibrator :- Operation and circuit diagram Astable multivibrator applications :- 1) Square wave oscillator 2) Ramp generator 7.2 Instrumentation amplifier 7.3 Logarithmic amplifier	8	13
	Total	60	100

Reference Book:

1. Op-amps and Linear Integrated Circuits by Ramakant A. Gayakward, Prentice Hall India.
2. Operational Amplifiers and Linear Integrated Circuits, Robert F. Coughlin, Prentice Hall Publication.
3. Design with operational amplifiers and Analog integrated circuits by Sergio Franco, McGraw Hill

Suggested Course Practical List:

1. To study and perform inverting and non-inverting and differential amplifier using op-amp without feedback.
2. To study and perform offset voltages and its compensation network.
3. To study and perform CMRR configuration and its compensation network.
4. To study the effect of temperature co-efficient and its compensation network
5. To study and perform inverting and non-inverting and differential amplifier using op-amp with feedback.
6. To study and perform summing amplifier and subtractor.
7. To study and perform voltage to current converter with grounded load and with floating load.
8. To study and perform current to voltage converter.
9. To study and perform comparator circuit using op-amp and make PWM wave forms.
10. To study and perform Schmitt trigger circuit using op-amp.
11. To study and perform positive and negative clippers.



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12. To study and perform positive and negative clampers.
13. To study and perform the integrator and the differentiator.
14. To study and design first order low pass filter and high pass filter using op-amp.
15. To measure frequency using Wien bridge oscillator.
16. Design and study of monostable, and astable multivibrators using IC555.
17. To study and perform instrumentation amplifier using RTD. Design a Circuit for converting the change in resistance of RTD into 0 to 5 V output with compensation of offset voltages, CMRR and temperature compensation for the range of 30 °C to 200 °C.

List of Laboratory/Learning Resources Required:

- 1) DTE Common Lab manual
- 2) Virtual Laboratory (vlab.co.in)
- 3) NPTEL/ MOOC Swayam Portal

Activities suggested under Problem Based learning:

Sr. No.	Name of the activity	No. of hours per activity	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit=5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations Based on industry/lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation=5h Total= 10h	Report/presentation based on the video learning outcomes.
3.	Assignment writing. Numerical Based assignment is preferable.	5 assignments of 2h each. Total= 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB,MS-EXCEL or any Other relevant software	5 small coding-based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment At the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2problem. Study of the problem and solution finding, Total= 10h	Based on the depth of the Solution submitted.



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7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation =5h Total= 10h	Based on quiz/report submitted
8	Discussion on research paper Based on relevant subject	5 research paper =20 h	Summarize research paper and Evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration=6h	Based on poster/chart Preparation and presentation skills
10	Working/non-working model on technical topics	Working=12h Non-working=8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration=15hfor industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration=1h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation=5h Total= 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration=10h	Depending on the complexity of the Application/Software
15	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
16	Patent Search and Innovation Gap Identification	10h(Search + Report)	Based on number of relevant patents analyzed and Identification of innovation scope.

Note:

- All the suggested activity should be related to the subject.
- Subject coordinator shall identify activities from above list as per the subject needs, they also declare list of activities wise hours, evaluation scheme and rubrics to students at the start of semester.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.



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- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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