

# GUJARAT TECHNOLOGICAL UNIVERSITY

## ELECTRONICS (10), ELECTRONICS & COMMUNICATION (11), ELECTRONICS & TELECOMMUNICATION ENGINEERING (12)

ANALOG CIRCUIT DESIGN

SUBJECT CODE: 2141002

B.E. 4<sup>th</sup> SEMESTER

**Type of Course:** Circuit Design and Analysis

**Prerequisite:** Basic knowledge of electronic active and passive components and low frequency circuit analysis techniques etc

**Rationale:** This course aims to familiarize students with high frequency analysis of BJT circuits, various oscillators, differential amplifier, op-amp and its applications, and op-amp based filter circuits.

### Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	2	6	70	20	10	20	10	20	150

### Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	<b>The Transistor at High Frequencies:</b> Hybrid- $\pi$ CE transistor model, Hybrid- $\pi$ conductance, Hybrid- $\pi$ capacitances, Validity of hybrid- $\pi$ model, Variation of hybrid- $\pi$ parameters, CE short-circuit current gain, Current gain with resistive load, Single-stage CE transistor amplifier response, Gain-bandwidth product, Emitter follower at high frequencies	<b>07</b>	14
2	<b>Oscillators:</b> Sinusoidal oscillators, Phase-shift oscillator, Resonant circuit oscillators, A general form of oscillator circuit, Wien bridge oscillator, Crystal oscillators, Frequency stability	<b>05</b>	10
3	<b>Operational Amplifiers:</b> The basic operational amplifier, The differential amplifier, The emitter-coupled differential amplifier, Transfer characteristics of a differential amplifier	<b>03</b>	6
4	<b>Introduction to Operational Amplifiers, Interpretation of Data Sheets and Characteristics of an Op-amp:</b> Introduction, Block Diagram representation of a typical op-amp, its equivalent circuits, types of ICs, Manufacturers' designations and package types for ICs, Power supplies for ICs, Interpreting datasheet, Ideal op-amp, Equivalent circuit of an op-amp, Ideal voltage transfer curve, Open-loop op-amp configurations	<b>03</b>	6
5	<b>An Op-amp with Negative Feedback:</b> Voltage series feedback amplifier, Voltage shunt feedback amplifier, Differential Amplifier	<b>04</b>	8
6	<b>Op-amp Offset Voltage:</b> Introduction, Input offset voltage, Input bias current, Input offset	<b>04</b>	8

	current, Total output offset voltage, Thermal Drift, Effect of variation in power supply voltages on offset voltage, Change in input offset voltage and input offset current with time, Other temperature and supply voltage sensitive parameters, Noise		
7	<b>General Linear Applications:</b> DC and AC Amplifiers, AC amplifiers with single supply voltage, Peaking amplifier, Summing, Scaling and Averaging Amplifier, Instrumentation Amplifier – its block diagram along with applications, Differential input and differential output amplifier, Voltage-to-current converter with floating load (low voltage DC voltmeter, low voltage AC voltmeter, Diode match finder, Zener diode tester, Light emitting diode tester), Current-to-voltage converter, Integrator, Differentiator	<b>08</b>	15
8	<b>Comparators and Converters:</b> Comparator, Zero crossing detector, Schmitt Trigger, Voltage limiters, Clipper and clampers, Absolute value output circuit, Peak detector, Sample and hold circuit, Precision rectifier – Half/Full Wave, Square, Triangular and Saw tooth wave generator, Common mode configuration and common mode rejection ratio, Slew rate and its equations, Effect of slew rate in applications	<b>06</b>	11
9	<b>Specialized ICs and its Applications:</b> <b>a. 555 Timer and its applications:</b> Block diagram, Monostable and Astable multivibrator, Applications as Frequency divider, Square wave generator <b>b. Phase Locked Loops and its Applications:</b> Block diagram and operation, Applications as Frequency Multiplier, Frequency Shift Keying <b>c. Design of Power Supply:</b> Simple op-amp voltage regulator, Three terminal voltage regulators, Fixed and adjustable voltage regulators (78XX, LM317), Heat sink, Dual power supply (LM320, LM317), Basic switching regulator and its characteristics	<b>04</b>	7
10	<b>Op-amp based Filter Circuits:</b> Classification of filters, Magnitude and frequency scaling, Magnitude and attenuation characteristics of ideal and practical filters, Design parameter Q and $\omega_0$ , Biquad (Universal) filter design, Butterworth low-pass and high-pass filters – 1st and 2nd order circuits design, Butterworth pole location, Sallen and key circuit, Butterworth bandpass filters – frequency transformation, Deliyannis – friend Circuit, Chebyshev filter characteristics, Band reject filters	<b>08</b>	15

**Suggested Specification table with Marks (Theory):**

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
10	15	15	15	15

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

## Reference Books:

1. Electronics Device and Circuits by Jacob Milman, Christos C. Halkias, Chetan D. Parikh, Tata Macgraw Hill Publication [Second Edition].
2. Op-amps and Linear Integrated Circuits, Ramakant A. Gaikwad, Fourth Edition, PHI.
3. Electronics Principles by Albert Malvino [seventh Edition]

## Course Outcomes:

After successful completion of the course students should be able to:

1. To analyze BJT circuits at high-frequency.
2. To analyze various oscillator circuits.
3. To analyze differential amplifier circuit.
4. To interpret and measure op-amp parameters.
5. To analyze various application circuits designed using op-amp.
6. To design Biquad filter circuits.
7. To design Sallen and Key filter circuits.
8. To design Delyiannis-Friend circuits

## List of Experiments:

1. To build transistor based RC phase shift oscillator circuit, and measure and verify its frequency of operation.
2. Measurement of input and output offset voltage of 741 ICs.
3. To configure op-amp in voltage follower mode and to measure its slew rate.
4. To configure op-amp in inverting and non-inverting amplifier mode and measure their gain and bandwidth.
5. To prepare precision rectifier using op-amp and verify its operation using measurements.
6. To prepare full-wave rectifier using op-amp and verify its operation using measurements.
7. To measure PSRR and CMRR of given op-amp.
8. To design Schmitt trigger circuit using op-amp and take measurements.
9. To design, build astable and monostable multivibrators using 741 IC and verify their operation using measurements by observing waveforms.
10. To design, build and obtain the frequency responses of first order low pass and band pass active filters.
11. To build op-amp based Weign bridge oscillator circuit, and measure and verify its frequency of operation.
12. Design the following amplifiers:
  - a. A unity gain amplifier
  - b. A non-inverting amplifier with a gain of 'A'
  - c. An inverting amplifier with a gain of 'A'Apply a square wave of fixed amplitude and study the effect of slew rate on the three type of amplifiers.
13. Design and test the integrator for a given time constant.
14. Design a second order butter-worth band-pass filter for the given higher and lower cut-off frequencies.
15. Design and test a notch filter to eliminate the 50Hz power line frequency.
16. Design and test a function generator that can generate square wave and triangular wave output for a given frequency.

17. Design and test voltage controlled oscillator for a given specification (voltage range and frequency range).
18. Design and test a Low Dropout regulator using op-amps for a given voltage regulation characteristic and compare the characteristics with standard IC available in market.
19. Design and test an AGC system for a given peak amplitude of sine-wave output.
20. Design and test a PLL to get locked to a given frequency 'f'. Measure the locking range of the system and also measure the change in phase of the output signal as input frequency is varied within the lock range.

**Design based Problems (DP)/Open Ended Problem:**

1. Design single stage CE amplifier for high frequency.
2. Design Wien bridge oscillator for a particular frequency.
3. Design voltage series feedback amplifier with op-amp.
4. Design averaging amplifier with op-amp.
5. Design an instrumentation amplifier for particular application.
6. Design zener diode tester with op-amp.
7. Design zero crossing detector circuit using op-amp.
8. Design antilog amplifier.
9. Design touch switch using 555 IC.
10. Design two different color driver using 555 IC.
11. Design a buzzer to indicate end of the class using 555 IC.
12. Design adjustable voltage regulator using LM317 IC.
13. Design 2<sup>nd</sup> order High Pass Butterworth filter using op-amp.

**Major Equipments and Components:**

C.R.O., Function Generator, Power Supply, Multi-meter, Digital Storage Oscilloscope, Experimental Trainer Kits (e.g. Analog System Lab Kits, Operational Amplifier Trainer Kits, Linear IC Trainer, etc. ), Bread Board, General Purpose PCB, 741/082 op-amp, 555 Timer, Resistors, Capacitors, Diodes, etc.

**List of Open Source Software/learning website:**

Ng-spice/Multisim  
[www.nptel.com](http://www.nptel.com)

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.