GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3141002
Semester – IV
ANALOG CIRCUIT DESIGN

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	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Transistor at High Frequencies:** 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	**8**	**15**
2	**Oscillators:** Sinusoidal oscillators, Phase-shift oscillator, Resonant circuit oscillators, A general form of oscillator circuit, Wien bridge oscillator, Crystal oscillators, Frequency stability	**6**	**12**
3	**Feedback Amplifiers:** Classification of Amplifiers, Feedback Concept, Transfer Gain with Feedback, General Characteristics of Negative Feedback Amplifiers, Input Resistance, Output Resistance, Method of Analysis of a Feedback Amplifier, Voltage Series Feedback, A Voltage Series Feedback Pair, Current Series Feedback, Current Shunt Feedback, Voltage Shunt Feedback	**8**	**15**
4	**Operational Amplifiers:** The Basic Operational Amplifier, Transistor based Differential Amplifier, The Emitter –Coupled Differential Amplifier. **Linear Analog Systems:** Basic Operational Amplifier Applications, Differential DC Amplifier, Stable AC-Coupled Amplifier, Analog Integration and Differentiation. **Non-Linear Analog Systems:** Comparators, Sample-and-Hold Circuits, Precision AC/DC Converters, Logarithmic Amplifiers, Waveform Generators,	**8**	**15**

	Regenerative Comparator (Schmitt Trigger), Emitter-Coupled Logic (ECL)		
5	**Specialized ICs and its Applications:** i) 555 Timer and its applications: Block diagram, Monostable and Astable multivibrator, Applications as Frequency divider, Square wave generator ii) Phase Locked Loops and its Applications: Block diagram and operation, Applications as Frequency Multiplier, Frequency Shift Keying iii) Design of Power Supply: 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	**6**	**13**
6	**Power Circuits and Systems:** Class A large Signal Amplifiers, Second Harmonic Distortion, Higher –Order Harmonic Generation, Transformer Coupled Audio Power Amplifier, Efficiency, Push-Pull Amplifiers, Class B Amplifiers, Class AB Operation	**8**	**15**
7	**Active Filters:** Ideal Responses, Approximate Responses, Passive Filters, First-Order Stages, VCVS Unity –Gain Second-Order Low-Pass Filters, Higher-Order Filters, VCVS Equal-Component Low-Pass Filters, VCVS High-Pass Filters, MFB Bandpass Filters, Bandstop Filters, The All-Pass Filter, Biquadratic and State-Variable Filters.	**8**	**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. Electronics Principles by Albert Malvino [seventh Edition]
3. Op-amps and Linear Integrated Circuits, Ramakant A. Gaikwad, Fourth Edition, PHI.

Course Outcomes:

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

1. To analyse transistor circuits at high-frequency as well as various application circuits such as Oscillator, Differential Amplifier, etc.
2. To analyse various feedback topologies.
3. To analyse and design various application circuits using op-amp and 555 timers including active filters.
4. To analyse various power amplifier circuits and power supply regulator.
5. To analyse operation of PLL and other specialized application 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:
    1) A unity gain amplifier
    2) A non-inverting amplifier with a gain of 'A'
    3) An inverting amplifier with a gain of 'A'
        a) Apply a square wave of fixed amplitude and study the effect of slew rate on the three types 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 2nd 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