GUJARAT TECHNOLOGICAL UNIVERSITY

Programme Name: Master of Engineering

Level: PG

Subject Code : ME02000161

Subject Name : Mixed Signal CMOS Circuit Design

WEF Academic Year :	2024_25
Semester :	2
Category of the Course :	PCC

Prerequisite :	Basic knowledge of Analog and Digital VLSI Circuit Design.
Rationale :	The contemporary System-on-Chip (SoC) designs and efficient high-level embedded systems invariably comprises digital, analog, and mixed signal CMOS circuit modules. Therefore, it is utmost important for the students to develop their skills to design these modules. This course provides a platform for students to understand and design various advanced analog building blocks such as reference generators, oscillators, comparators, and phase-locked loop circuits along with the important interfaces between digital and analog modules such as digital-to-analog (DAC) and analog-to-digital (ADC) converters.

Course Outcome :

After Completion of the Course, Student will able to :

No.	Course Outcomes	RBT Level*
01	Understand and design various types of Reference generation circuits.	UN& AP
02	Understand the fundamentals of switched capacitor based designs and apply them for designing various building blocks of analog and mixed signal applications.	UN & AP
03	Design various types of oscillators and apply the designing concept of VCOs in building the PLL circuits.	UN & AP
04	Design various comparator circuits.	UN & AP
05	Explore the fundamentals of data converters architectures and implement various types of DACs and ADCs.	UN & AP

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

Teaching and Examination Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Nanometer Design Studies :** Transistor Design Considerations, Deep-Submicron Effects, Transconductance Scaling, Transistor Design, Op Amp Design Examples, High-Speed Amplifier	4	5
2	**Bandgap References :** General Considerations, Supply-Independent Biasing, Temperature- Independent References, Negative-TC Voltage, Positive-TC Voltage, Bandgap Reference, PTAT Current Generation, Constant-Gm Biasing, Speed and Noise, Low-Voltage Bandgap References, Case Study	6	10
3	**Introduction to Switched-Capacitor Circuits :** General Considerations, Sampling Switches, MOSFETS as Switches, Speed Considerations, Precision Considerations, Charge Injection Cancellation, Switched-Capacitor Amplifiers, Unity-Gain Sampler/Buffer, Noninverting Amplifier, Precision Multiply-by-Two Circuit, Switched-Capacitor Integrator, Switched-Capacitor Common-Mode Feedback	7	15
4	**Oscillators and Phase-Locked Loops (PLLs)** : Ring Oscillators, LC Oscillators, Cross-Coupled Oscillator, Colpitt Oscillator, Voltage-Controlled Oscillators **Phase-Locked Loops:** Simple PLL, Charge-Pump PLLs, Problem of Lock Acquisition, Non-ideal Effects in PLLs, Applications	6	10
5	**Nonlinear Analog Circuits :** Basic CMOS Comparator Design, Characterizing the Comparator, Clocked Comparators, Adaptive Biasing, Analog Multipliers	5	10
6	**Data Converter Fundamentals and Architectures :** Sample-and-Hold (S/H) Characteristics, Specifications of Digital-to-Analog Converter (DAC) and Analog-to-Digital Converter (ADC), Mixed- Signal Layout Issues, DAC Architectures: R-2R Ladder Networks, Current Steering, Charge-Scaling DACs, Cyclic DAC, Pipeline DAC, ADC Architectures: Single and Two-step Flash, Pipeline ADC, Integrating ADCs, Successive Approximation ADC, Oversampling ADC	12	30
7	**Implementing Data Converters :** R-2R Topologies for DACs, Implementing ADCs: Implementing the S/H, Cyclic ADC, Pipeline ADC	6	20
	Total	**46**	**100**

Suggested Course Practical List :
The listed experiments can be performed using any SPICE tool.

1. Design a Two-Stage CMOS operational amplifier (Op-Amp) and characterize its performance.
2. Compare the performance analysis of Two-Stage Op-Amps for 180 nm and 90 nm technologies.
3. Simulate self-biased supply independent band-gap reference circuit with and without start-up circuit, and obtain its current response as a function of variation in supply voltage.
4. Simulate switched capacitor amplifier circuit. Simulate basic clock signal based sense amplifier circuit and measure its performance parameters.
5. Design a CMOS ring oscillator and characterize the frequency of oscillation and power consumption.
6. Simulate a CMOS comparator circuit and measure its performance parameters.
7. Design a CMOS Voltage-controlled Oscillator (VCO) and obtain transient and frequency responses.
8. Simulate and analyze charge pump phase-locked loop (PLL) design.
9. Implement a CMOS DAC using various architectures (e.g., R-2R ladder).Study the linearity and monotonicity of the DAC.
10. Design a simple CMOS ADC using successive approximation or flash architecture. Measure its performance in terms of resolution and speed.
11. Seminar report for a given research topic.

Reference Books :

1. Design of Analog CMOS Integrated Circuits by BehzadRazavi, McGrawHill.
2. CMOS – Circuit Design, Layout and Simulation by R. Jacob Baker, Wiley.
3. CMOS Mixed-Signal Circuit Design by R. Jacob Baker, Wiley.
4. Analog Design Essentials by Willy M. C. Sansen, Springer.
5. Phillip E.Allen,Douglas R.Holberg,"CMOS Analog Circuit Design",2nd Edition,Oxford University Press,2002.

List of Open Source Software/learning website :

Ng-Spice -- https://ngspice.sourceforge.io/
LTSpice -- https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html
www.nptel.com
www.nptel.ac.in

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