GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3720511
ANALOG CMOS CIRCUIT DESIGN – I
SEMESTER: II

Type of course: MOSFET based analog circuit design

Prerequisite: Basic knowledge of MOSFET and device modeling.

Rationale: This course provides a platform for students to understand the working of active device such as MOSFET; designing aspects of analog circuit building blocks like Op-amps, sources, sinks, mirrors, Op-amps, and references. Students are also taught to design, simulate, and analyze these analog circuits. This is one of the foundation courses which are required for students to develop their skills of complex analog circuits and systems.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction to CMOS Analog Circuit Design:** Introduction to Analog Design, Basic MOS Device Physics-General Consideration, MOS I/V Characteristics, Second-Order Effects, MOS Device Models	4	5
2	**Single-Stage Amplifiers:** Basic Concepts, Common-Source Stage, Source Follower, Common-Gate Stage, Cascode Stage – Folded Cascode	5	15
3	**Differential Amplifiers:** Single-Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, Differential Pair with MOS Loads, Gilbert Cell.	5	15
4	**Passive and Active Current Mirrors:** Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors	5	15
5	**Frequency Response of Amplifiers:** General Considerations, Common-Source Stage, Source Followers, Common-Gate Stage, Cascode Stage, Differential Pair	6	10
6	**Operational Amplifiers:** General Considerations, One-stage Op Amps, Two-Stage Op Amps, Gain Boosting, Comparison, Common-Mode Feedback, Input Range Limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps.	8	20
7	**Stability and Frequency Compensation:** Introduction, Multipole Systems, Phase Margin, Frequency Compensation, Compensation of Two-Stage Op amp, Other Compensation Techniques.	5	10

8	**Band Gap Reference**: Supply independent biasing, temperature-independent references, negative and positive TC voltage, Bandgap reference, PTAT generation, constant gm biasing, speed and noise issues.	5	5
9	**Applications of Analog Building Blocks:** Comparators, Oscillators, Multipliers, PLL, Frequency Synthesizers, Sample-And-Hold Circuits, DC-DC converters	5	5
Total		52	100

Suggested Specification table* with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**10**	**10**	**5**	**5**

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

**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 from above table.*

Reference Books:

1. Design of Analog CMOS Integrated Circuits, Behzad Razavi, TMH.
2. Analysis and Design of Analog Integrated Circuits, P R Gray and R G Meyer, 5th Edition, Wiley, 2009.
3. RF Microelectronics, Behzad Razavi, Prentice Hall.
4. CMOS Analog Circuit Design, P. Allen and D. Holberg, Oxford Uni. Press.
5. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze the basic principle, operation and applications of single stage amplifiers like common-source , source Follower, common-gate stage, cascode Stage – folded cascode.	20 %
CO-2	Analyze the basic principle, operation and applications of Basic Differential Pair, common-mode response, differential pair with MOS loads, Gilbert cell.	20 %
CO-3	Analyze the basic principle, operation and applications of basic current mirrors, cascode current mirrors, active current mirrors.	20 %
CO-4	Analyze the basic principle, operation and applications of one-stage Op Amps, Two-Stage Op Amps	20 %
CO-5	Understand the input range limitations, slew rate, power supply rejection, noise in Op amps; and understand multipole systems, phase margin, frequency	10 %

	compensation techniques	
CO-6	Understand the designing aspects of supply/temperature independent, and Bandgap references.	10 %

List of Experiments:

1. To implement common source with diode connected load.
2. To implement cascode circuit
3. To implement and analyze Cascade OP-AMP with input and output shorted.
4. To implement and analyze the basic differential pair circuit

* Each student has to complete other 10 practicals based on syllabus in a group of two or three over and above the listed 10 practicals

Open Ended Problems:

1. Find static power dissipation and dynamic power dissipation for any CMOS logic gate.
2. Design a common source amplifier with typical value of gain.
3. Design a CS stage with source degeneration with typical value of g_m.
4. Design a common gate amplifier with typical value of gain.
5. Implement a folded Cascode circuits using Ngspice.
6. Find voltage gain of differential circuits.
7. Implement Gilbert cell with Ngspice.
8. Design Cascode current mirror for a typical values of current.
9. Derive large signal and small signal analysis for Active current Mirrors.
10. Find input impedance for Source follower at high frequency.
11. Design high CMRR 2- or 3-stage op-amp.
12. Design high slew-rate op-amp for given gain.
13. Seminar/Mini Project

Major Equipments : C.R.O., Function Generator, Power Supply, Multimeter, Digital Storage Oscilloscope

List of Open Source Software/ Learning website:

Ng-spice
www.nptel.com
www.nptel.ac.in