GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRONICS & COMMUNICATION (SIGNAL PROCESSING AND VLSI TECHNOLOGY) (26)

CMOS CIRCUIT DESIGN – I

SUBJECT CODE: 2712602

SEMESTER: I

Type of course: Basic MOSFET based analog and digital circuit design

Prerequisite: Basic knowledge of MOSFET and device modeling.

Rationale: This course provides a platform for students to analyze working of active device such as MOSFET, analog and digital circuit design like amplifier, oscillator, adders and multipliers. Students are also taught to simulate, analyze and design circuits. This is one of the foundation courses which are required for students to understand working of MOSFET based complex analog and digital electronic circuits and systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	PA (V)		PA (I)		
						ESE	OEP	PA	RP	
4	2#	2	6	70	30	20	10	10	10	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Introduction to CMOS Digital Circuit Design:** Issues in Digital Integrated Circuit Design, MOSFET Transistor Overview, Process Variations, Future Device Developments, Concept of Static and Dynamic CMOS Circuits, Power Consumption and Power-Delay Product in Static CMOS Inverter, Effects of Technology Scaling on the Performance of CMOS Inverter, Power Consumption in CMOS Gates.	8	15
2	**CMOS Arithmetic Circuits:** Introduction, Datapaths in Digital Processor Architectures, Various Adder Circuits, Multiplier, Shifter, Other Arithmetic Operators, Power Considerations in Datapath Structures, Perspective – Design as a Trade-off.	8	15
3	**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	7
4	**Single-Stage Amplifiers:** Basic Concepts, Common-Source Stage, Source Follower, Common-Gate Stage, Cascode Stage – Folded Cascode	6	12
5	**Differential Amplifiers:** Single-Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, Differential Pair with MOS Loads, Gilbert Cell.	6	12
6	**Passive and Active Current Mirrors:**	5	9

	Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors		
7	**Frequency Response of Amplifiers:** General Considerations, Common-Source Stage, Source Followers, Common-Gate Stage, Cascode Stage, Differential Pair	4	7
8	**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.	9	16
9	**Stability and Frequency Compensation:** Introduction, Multipole Systems, Phase Margin, Frequency Compensation, Compensation of Two-Stage Op amp, Other Compensation Techniques.	4	7

Reference Books:

1. Design of Analog CMOS Integrated Circuits, Behzad Razavi, TMH
2. J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India
3. CMOS Circuit Design, Layout, and Simulation, R. Jacob Baker, Wiley, 2nd Edition

Course Outcome:

1. To study and understand the basic concept of static and dynamic power consumption in CMOS circuits.
2. To apply the effect of Technology Scaling on the Performance of CMOS Inverter.
3. To analyze the Power-Delay Product in Static CMOS Inverter.
4. To understand, study and compare various adders, multipliers and shifter circuits.
5. To derive Power Considerations in Datapath Structures.
6. To analyze the basic principle, operation and applications of single stage amplifiers like Common-Source Stage, Source Follower, Common-Gate Stage, Cascode Stage – Folded Cascode.
7. To analyze the basic principle, operation and applications of Basic Differential Pair, Common-Mode Response, Differential Pair with MOS Loads, Gilbert Cell.
8. To analyze the basic principle, operation and applications of Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.
9. To analyze the Frequency Response of Common-Source Stage, Source Followers, Common-Gate Stage, Cascode Stage, Differential Pair.
10. To analyze the basic principle, operation and applications of one-stage Op Amps, Two-Stage Op Amps.
11. To study and understand the Input Range Limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps.
12. To study and understand Multipole Systems, Phase Margin, Frequency Compensation, and other Compensation Techniques.

List of Experiments:

1. (A) To implement and analyze the CMOS inverter (DC Analysis) using NG spice tool.
   (B) To analyze effect of Kr parameter in CMOS inverter
   (C) To implement and analyze the CMOS inverter (Transient Analysis)
2. To implement and analyze the CMOS AND gate.
3. To Implement and analyze the CMOS XOR gate
4. To implement 1-bit magnitude comparator and try to extend it up-to 2 bits.
5. To implement common source with diode connected load.

6. To implement cascode circuit
7. To implement 3-stage ring oscillator circuit
8. To implement and analyze Cascade OP-AMP with input and output shorted.
9. To implement and analyze the Half adder circuit
10. 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 Gm.
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 an inverter with n-type enhancement MOSFET and draw its VTC characteristics using NgSpice. Find all components of power dissipation.
12. Compare all types of adders with standard performance parameters.
13. Compare all types of multipliers with standard performance parameters.
14. 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/Multisim
www.nptel.com
www.nptel.ac.in