

EE 366 CMOS VLSI Design

Credits: 4

Categorization of credits: engineering topic

Instructor's or course coordinator: Updated, Yingfei Dong, Jan 8, 2021

Text Book and Other Required Materials: Neil H.E. Weste, David Harris, "CMOS VLSI Design – A circuits and Systems Perspective," Addison-wesley, **3rd ed.** 2004. Douglas L. Perry, "VHDL – Programming by Example," McGraw-Hill 2002.

Designation: Elective

Catalog Description: EE 366 CMOS VLSI Design (4) (3 Lec, 1 3-hr Lab) Introduction to the design of very large scale integrated (VLSI) systems and use of CAD tools and design languages. Lab includes hands-on use of CAD tools. Pre: 260.

Pre-and Co-requisites: Digital design basics (EE 260), basic circuit theory (EE211).

Class/Lab Schedule: 3 lecture hours and one 3-hour lab per week

Topics Covered:

(1) CMOS Basics (20 hr) Introduction to modern digital design and Technology Trends; Basics of Solid State Physics and MOS Transistors ; Manufacturing Process and Design Rules; CMOS Logic and elementary design ; Types of ASICs and Structured Design; MOS transistor theory ; CMOS inverter: DC analysis; CMOS inverter: transient analysis; MOS SPICE Models and Simulations; Delay estimation (RC and Elmore Delay model); Delay estimation and Gate sizing (Logical Effort); Power Dissipation and Low Power Design; Interconnect modeling and wire engineering; Design margin, process variation and Device Scaling

(2) CMOS VLSI Design (14½ hr): CMOS combinational logic – Static, Ratioed, Dynamic, Pass-Transistors Families; Sequencing Methods (Static, Two-Phase, Time Borrowing, Clock Skew); Sequential logic design; Adders: Single-bit circuits; Adders: Ripple, Generation and Propagation, Manchester, Carry Skip; Adders: Look-ahead, Select, Conditional-Sum, Tree; Other Arithmetic Building Blocks: One-Zero, Comparators, Counters, Shifters; Designing Arithmetic Building Blocks: Multipliers; Array subsystems: SRAM; Array subsystems: DRAM, ROM, CAM, PLA; Power Distribution (IR Drop, di/dt noise) and I/O circuits; Clock generation and Distribution

(3) Hardware Description Languages (10 hr) Hardware description languages: Introduction and Rationale; VHDL: Hands-on; VHDL: Basic Terminology and Design Units; VHDL: Behavioral Modelling; VHDL: Process Semantics and Interaction; VHDL: Basic Syntax and Data Types; VHDL: Subprogram and Packages – the std_logic types; VHDL: Configurations; VHDL and synthesis.

Course Objectives and Their Relationship to Program Objectives:

The student learns design skills and uses tools that are essential for the practice and theory of design for advanced digital systems. [Program Objectives this course addresses: 1, 2, 3, and 5.]

Course Outcomes and Their Relationship to Program Outcomes:

The following are the course outcomes and the subset of Program Outcomes (numbered 1-7 in square braces "[]") they address:

- Understand CMOS technology. [1]
- Be able to do DC and transient analysis, of digital CMOS circuits. [1]
- Be able to use a circuit simulator (HSPICE) to perform analysis and optimizations of digital circuits. [1,2,7]
- Become proficient in a hardware description language (e.g., VHDL). [1,2,7]
- Be able to do design trade-offs considering area, speed, power and reliability. [1]
- Be able to estimate area and power dissipation. [1]
- Be able to design small ASICs. [2]
- Understand logic synthesizers and be able to synthesize a simple circuit. [7]

Computer Usage: All the lab assignments are simulations or designs that require operating a computer skillfully. The CAD tools used are installed on a UNIX system.

Design Credits and Features: There are two design credits. There is a lab component that is dedicated to CMOS VLSI and ASIC design and counts for one of the design credits. About a third of the lectures cover design techniques, methodologies, and tools. Therefore, the lecture component has a design credit.