

# EE411: Introduction to VLSI Design

## Course Syllabus

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Spring 2008

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### Course Overview

This is an introductory course which covers basic theories and techniques of digital VLSI design in CMOS technology. In this course, we will study the fundamental concepts and structures of designing digital VLSI systems include CMOS devices and circuits, standard CMOS fabrication processes, CMOS design rules, static and dynamic logic structures, interconnect analysis, CMOS chip layout, simulation and testing, low power techniques, design tools and methodologies, VLSI architecture.

### Course Aim

The course is designed to give the student an understanding of the different design steps required to carry out a complete digital VLSI (Very-Large-Scale Integration) design in silicon.

### List of course topics

- Introduction to VLSI Systems
- CMOS logic, fabrication and layout
- MOS Transistor theory
- Layout Design Rules
- Circuit characterization and performance estimation
- Circuit Simulation
- Combinational and sequential circuit design
- Memory system design
- Design methodology and tools

**Course Learning Objectives :**

1. Be able to use mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their interconnect.
2. Be able to create models of moderately sized CMOS circuits that realize specified digital functions.
3. Be able to apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect, and to verify the functionality, timing, power, and parasitic effects.
4. Have an understanding of the characteristics of CMOS circuit construction.
5. Be able to complete a significant VLSI design project having a set of objective criteria and design constraints.
6. To introduce the concepts and techniques of modern integrated circuit design and testing (CMOS VLSI).
7. To provide experience designing integrated circuits using Computer Aided Design (CAD) Tools.
8. Be able to design static CMOS combinational and sequential logic at the transistor level, including mask layout.
9. Describe the general steps required for processing of CMOS integrated circuits.
10. Estimate and optimize combinational circuit delay using RC delay models and logical effort
11. Estimate and optimize interconnect delay and noise
12. Design for higher performance or lower area using alternative circuit families
13. Describe and avoid common CMOS circuit pitfalls and reliability problems
14. Compare the tradeoffs of sequencing elements including flip-flops, transparent latches, and pulsed latches
15. Design functional units including adders, multipliers, ROMs, SRAMs, and PLAs
16. Describe the sources and effects of clock skew

## Course Learning Outcomes

The learning outcomes for this course (i.e., what you should be able to do at the end of the course) are as follows:

1. Be able to use mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their interconnect.
2. Be able to create models of moderately sized CMOS circuits that realize specified digital functions.
3. Be able to apply CMOS technology-specific layout rules in the placement and routing of transistors and interconnect, and to verify the functionality, timing, power, and parasitic effects.
4. Have an understanding of the characteristics of CMOS circuit construction and the comparison between different state-of-the-art CMOS technologies and processes.
5. Be able to complete a significant VLSI design project having a set of objective criteria and design constraints.

## Course Logistics

Instructor	Dr. Mohammad H. Awedh Department of Electrical and Computer Engineering King Abdulaziz University
Office Location	Building 42B, Room 412
Office Phone	68093
Office Hours	Saturday, Monday and Wednesday 9:30 to 11:00 or by appointment
E-mail	mhawedh@kau.edu.sa
Meeting	Lectures: Sun, Tue 8:00 – 9:20 Building A, Room 212
Course Web Page	<a href="http://inonezero.com/moodle/">http://inonezero.com/moodle/</a>

## Prerequisite

- Basic understanding of circuits and electronics (**EE 311**)
- Basic understanding of logic design (**EE 360**)
- Familiarity with Unix or Linux.

## Textbook

The textbook for the course is *Weste & Harris, CMOS VLSI Design: A Circuits and Systems Perspective, 3rd ed, Addison Wesley, 2005*

## References

- Digital Design, 3rd edition by M. Morris Mano.
- Principles of CMOS VLSI design by N H E Weste & K Eshraghian
- Modern VLSI Design: System on Silicon by Wayne Wolf

## Tentative Schedule

This is a tentative Schedule that may change during the semester. The schedule lists reading assignment associated with each lecture. You are expected to do the reading before class and be prepared to discuss it.

Title	Sections	Note
Introduction and overview	1.1-1.4	
Circuits, fabrication, and layout	1.5	
CMOS transistor theory	2.1-2.3	
Non-ideal transistor characteristics	2.4	
DC and transient response	2.5,2.6, 4.1,4.2	
Logical effort	4.3	
Interconnect engineering	4.5, 4.6	
Simulation	5.1-5.3	
Combinational circuit design	6.1-6.2.1	
Circuit families	6.2.2-6.2.5	
Sequential circuit design	7.1-7.3.6	
Adders	10.1-10.2	
Datapath functional units	10.3-10.9	
Memories	11.1-11.2	
Memories	11.5-11.7	
Low power	4.4, 6.5	

## Assignments

Prior to each lecture, a **reading assignment** is assigned for that lecture. Students are expected to have read the sections assigned for the class before the class. In class I will talk about elements from the reading assignment and solve some related problems. We will be exploring the material together, your participation and engagement are critical.

## Project

The class project is to design a reasonably complex digital circuit. The project will be performed as a team of two or three students.

## Grading

- Assignments 10%
- Participation 5%
- Quizzes 10%
- Midterm Exam 15%
- Labs 15%
- Project 15%
- Final Exam 30%

## Class Web Page

We shall use **Moodle** for this class. Moodle is a Course Management System (CMS) which helps to communicate outside of the classroom. Students in this class should visit the site <http://inonezero.com/moodle/> and create an account. This site contains information about the class - syllabus, homework list, due dates for assignments, links to other web sites, etc. In addition, We shall also use it for discussion and questions about the material covered in the course.

For each course, students should register for that course on the moodle site. Registration is enabled by a key that will be given to students in class during the first lecture. You have to notice that registration for the course does not automatically entail registration on the moodle site and vice versa.

## Policies

- Attendance Policy: I expect you to attend classes regularly and participate in class discussion. If you must miss a class for some unavoidable reason, I would appreciate knowing ahead of time.
- All assignments (homework, labs) will be due at the beginning of the class on the due date. No late submissions will be accepted unless a valid excuse is given to the instructor by the day prior to the due date.
- You are expected to attend all classes. If you miss a class, you are responsible for finding out the material covered in that class. If you miss an exam, a grade of zero will be assigned, unless a valid excuse is given.
- All assignments are expected to be done by each student individually. Verbal and informal exchange of ideas is permitted, indeed encouraged. However, written solution should NOT be shown to another student or copied from another student. Any act of academic dishonesty will result in an **F** grade.

**Hope you work hard, learn a lot, and enjoy the course.**