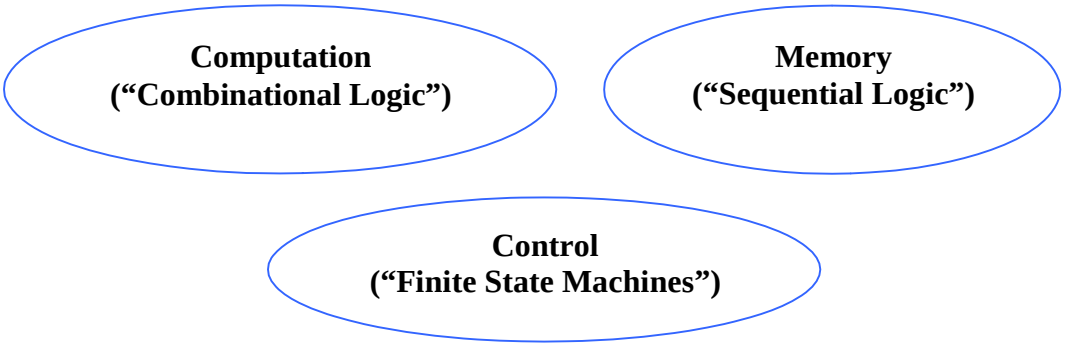
ECE241F - Digital Systems - Course Outline

Fall 2010 S. Brown, P. Aarabi, J. Anderson



Goals

1. To understand basic digital logic circuit design, optimization and concepts.
2. To become comfortable using Computer-Aided Design (CAD) tools in design.
3. To gain hands-on experience with the design and debug of digital systems, using programmable logic.

1. Introduction to Combinational Logic

- switches and logic gates
- logic functions, truth tables and variables
- Boolean axioms and laws, sum of products, product of sums
- simple algebraic minimization - making things cheaper with a new kind of algebra

2. Technology

- logic voltage levels
- transistors as a switch
- NMOS and CMOS logic gates
- real propagation delay, and timing diagrams, timing analysis of digital circuits
- TTL Logic, Field-Programmable Gate Arrays (FPGAs)
- introduction to Verilog (a language for describing hardware) and CAD tools that implement hardware given the Verilog description language

3. Combinational Logic Optimization

- minimization goals - speed and cost
- Karnaugh Map optimization technique
- Optimization of logic that have "Don't Care" conditions
- critical path through combinational logic

4. Sequential Logic

- cross-coupled NOR/NAND gates basic latch
- gated latch
- Master-Slave D flip-flop
- shift registers
- counters
- Set-up & hold time, clock-to-Q

5. Finite State Machines

- how logic is controlled
- state diagrams
- Moore-type state machines
- State machine synthesis
- State machines in Verilog
- state encoding and optimization

6. Numbers and Arithmetic

- number representation, binary, ones & twos complement representation of negative numbers
- basic adder/subtracter
- carry look-ahead methods for fast addition
- bit serial addition

7. Miscellaneous

- multiplexors & tristate gates
- multiplexors as logic; decoders
- fanout-dependent delay
- power dissipation, I/O devices and FPGAs
- Static Random Access Memory (SRAM);
- Controller for digital display
- De-bouncing mechanical switches
- VGA display interface

ECE241F - Digital Systems - Lab Schedule and Information

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The real learning in this course goes on in the laboratory where you design, build and test and fix real circuits. There are **seven mandatory** labs of three hours each, and so you will have one 3- hour lab every week. You will work in groups of **two**.

There is also a project based on the material of this course that you will also work with your partner on. As an alternative to the project, you may choose to do two *extra* labs. *You are encouraged to do the project instead of the labs, and there will be a prize for the top project.*

There are two parts to the lab experience: preparation, which you must do outside of the lab hours, and the actual implementation of circuits in the lab.

Preparation

Each lab usually requires you to do significant amount of preparation, and is where you must do much of the work to understand the concepts. Preparation must be complete before the lab begins. Preparation will usually require design using the CAD software supplied. **Each partner in the group of 2 must perform and submit a separate preparation.** While it is acceptable to discuss your preparation with your partner, your work may not be copied from your partner; you will be required to explain your preparation. Please be aware that severe penalties will be imposed for copying of labs, as evidenced by an inability to explain the work given as preparation. It will be graded by the TAs at the beginning of the lab, on the following basis:

Judgement of TA	Grade
Unable to explain any part of preparation	0
Some merit to work	1
Made a legitimate attempt	2
Reasonable job, may be some missing things	3-4
Correct and Done well, demonstrated clear knowledge of subject.	5

In-Lab Work

In each lab you will typically have to build a working circuit. Once this is done, for each such circuit, show it to your TA for grading, out of 3:

Judgement of TA	Grade
Did not attend or try	0
Tried, but failed to get much working	1
Most, but not all working	2
Everything worked	3

Note: Although the lab portion of the course is worth only 12%, both the midterm and the final exam will contain questions directly related to skills learned in the lab.

Lab Workstation Number and Maintenance

Each digital workstation that you'll be sitting at has a number. Please use the same station each week. If a piece of equipment is not working, please tell a TA to tag the board with the problem and notify someone to have it repaired. Otherwise it will be broken the next time you need to use it!

Lab Sections, Day Time and Location

Section	Day	Time	Location(s)
1	Monday	3-6pm	BA 3135 & 3145
2	Tuesday	2-5pm	BA 3145 & 3155
3	Friday	10am-1pm	BA 3135 & 3145
4	Monday	9am-12	BA 3135 & 3145

Lab and Project Schedule for 2010

Date of Monday	Lab
September 13	#1: Building simple logic functions using 7400-series chips.
September 20	Self-guided tutorial in the lab with Quartus II and the DE2 board. No marks for this lab. TAs will be available to assist you.
September 27	#2 Lights, switches, multiplexers
October 5	#3 Numbers and displays
October 11	**Thanksgiving week -- no lab; midterm exam this week!**
October 18	#4 Latches, flip-flops and registers
October 25	#5 Counters and clocks
November 1	#6 Adders, subtractors, multipliers
November 8	#7 Finite state machines
November 15	**Project or Extra Lab Period 1**
November 22	**Project or Extra Lab Period 2**
November 29	**Project or Extra Lab Period 3**

ECE241F - Digital Systems - Access to CAD Software

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The lab in this course depends heavily on the use of Computer-Aided Design (CAD) software to implement the circuits, usually on a programmable logic device. We will be using Field-Programmable Gate Arrays (FPGAs) from Altera, and Altera's **Quartus II** Version 9.1 CAD software. You will be able to access this software in one of three ways:

1. On your own home computer.

If you have a Windows 7, Vista or XP-based home computer with at least 1 GBytes of physical RAM. You can download the Quartus II 9.1 SP2 Web edition directly from the Altera web site:

https://www.altera.com/download/archives

In the lab we will be using the full version of the software, but web edition has all you need as well.

2. On the Windows Machines in the lab – Bahen 3125, 3135, 3145 and 3155

There are a total of one hundred Windows XP-based machines in these Bahen Centre labs. These will have the latest release of the full license (not web edition) of Quartus version 9.1 SP2 software installed on them. These machines will have access to your home directory on the ECE ugsparc system.

3. On the ECE and ECF PC Systems

Quartus is available on the ECE and ECF Windows PC systems.

ECE 241 Project

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The Task

The purpose of the project is to:

1. Gain experience dealing with the design of a larger digital system, and to deal with the issues in going from a soft simple specification ("make a digital toaster controller") to an actual complete design. There is no substitute for experience!

2. Express your creativity by applying what you have learned in this course to a project of your own choosing.

You will design and implement a project of your own choosing that uses digital logic in some creative way. You may use any of the parts available in the lab, but are restricted to using just one of the Altera DE2 boards. An important part of this lab is the creativity required to think up an interesting project, and then negotiate with a TA or instructor as to the final form of the project.

Originality/Uniqueness Approval

The first step in your project is to come up with an original idea. You must submit your idea, in a 1-3 line description, via email to your ECE 241 instructor for "originality" or "uniqueness" approval. The instructor will quickly respond to tell you if the idea has already been proposed more than once. If it has, you'll have to come up with something different. Please note that this approval is only the first step and only deals with the basic idea, and not the scope/effort required for the project; that comes next:

Before the First Project lab

You will submit a short project proposal of what your project is about. This should be a short description that gives:

- The basic idea of the project, and the basic function of your circuit.
- Describe the inputs and outputs, and give a simple block diagrams describing how the various parts of your circuit interact.
- Your plan of action for each of the three lab periods - "milestones"
- Present this to your TA to get their opinion on whether the project is viable. Once approved, you should get their signature. This is just a check to make sure that you do not try something overly ambitious.

Demonstration and Report

You will demonstrate your project to your supervising TA in the final lab period, and will be required to provide a short report describing your project.