Digital Circuit Design

Course Syllabus

Fall Semester

Abstract

This is the fundamental course in computer engineering. Digital electronics and computers surround us. This course will provide the fundamental background needed to understand how these systems work and how to design digital circuits. We begin by covering the mathematical concepts necessary in the study of digital systems. We will then move onto electronic gates and how digital logic works. We will design and analyze combinatorial circuits, and show how to construct the minimal (least number of gates) circuit necessary to implement a specific function. We will then move on to sequential circuits which add a concept of memory or feedback to the combinatorial design. We will analyze and design these circuits. Finally, we will look at common electronic components (such as counters and shift registers) and then look into programmable logic devices.

This course will stress fundamentals. It is imperative that the concepts covering in this class are well understood if any further study in computer engineering is to be undertaken. We will pay particular attention to design principles and techniques, timing analysis, and finite state machines.

The material covered in this course is not hard, but it does require significant amounts of effort, especially if it is your first exposure to these topics and to design in general (and it will be for most students!). Be prepared to work hard...and come out of this course with a good knowledge of the fundamentals of computer engineering and digital systems.

Contents

1. Instructor

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2. Course Goals and Objectives

Goal: The goal of this course is for the students to develop the ability to analyze an existing digital circuit or to synthesize a new digital design to meet stated specifications.

Objectives: Students will be able to

- Work with a variety of number systems and numeric representations, including signed and unsigned binary, hexadecimal, 2's complement.
- Design and analysis of digital logic circuits.
- Apply fundamental analysis skills to correctly describe the behavior of a given digital logic circuit.

3. Course Prerequisites

The student must have satisfactorily completed MATH.

4. Course Grading

4.1. Breakdown of Graded Events

Graded material is given the following weights.

	Weight
Homework	10%
Quizzes	10%
Midterm Exam	20%
Final Exam	60%
Total	100%

4.2. Turn-In Policy

There will be a number of problem sets throughout the semester. These will consist of a mix of analysis and design problems. The analysis problems will be normal "book" questions, designed to make sure you understand the fundamental concepts covered in class and in the textbook. The design problems will ask you to design original circuits. These problem sets will be pencil-and-paper based.

Everyone should try their best to submit all assignments on their due dates. However, there are various circumstances that may prevent a student from completing an assignment on time. Therefore, late assignments will be penalized 20% per class period late.

All homework assignments are due at the *beginning* of the lecture period on the associated due date (1 week from the assignment date unless otherwise stated). The accepted turn-in method for the homework is to:

- Place your homework on the table at the front of the classroom before lecture begins.

5 Course Materials and Resources

5.1. Textbook

The textbook used for this course, by M. Morris Mano, is listed as [1] in the reference section of this syllabus. You will use this text extensively throughout the semester, as we will cover nearly the entire book. Take advantage of the many examples in the book and the selected answers to end-of-chapter problems in the appendix.

5.2. Web Site

For this section of the course, I will make frequent use of the course web site at

http://ce.sharif.edu/~naser/DigitalCircuit.html

A copy of this syllabus, assignments, homework solutions, and other supplemental material will be posted on this web site. You are responsible for checking it regularly.

6. Collaboration Policy

Quizzes and exams must always be the *student's own work.* You may not (1) copy or allow another student to copy anything that contains another student's assignment and submit it, or any part of it, as your own, (2) work together on an assignment, sharing schematics, wiring, or design, or (3) anything else along these lines. Any evidence of performing any form of academic dishonesty will bring about that you miss your grade.

7. Course Overview

Welcome to Digital Circuit Design! This course will prepare you to deal competently with myriad digital system design challenges that regularly confront electrical and computer engineers and computer scientists. The emphasis in the course is on

fundamental principles and practical applications, rather than esoteric theory or arcane derivations.
Just like with anything worthwhile in life, if you aren't willing to put in the time and effort, you won't ever become good at it. Be prepared to devote considerable time and effort to this class. I promise to be sensitive to the time requirements of every assignment I give you, but *you* have to put forth the effort.

Some recommendations for success in this class which you might want to consider. . .

Don't miss class. New material is covered each lecture. If you miss class, you are responsible for covering the missed material on your own. Repeat lectures will *not* be given during office hours.

Read in advance. The reading assignments are listed in the next section. Your textbook author has written many digital design and computer engineering texts, and your text in particular is considered one of the most "readable" in print. The argument "but the book is difficult to read" receives very little respect in any forum.

Start homework early. Give yourself some time to consider the problems and determine whether or not you need instructor assistance. Last-minute questions are a bad idea.

Don't ignore the homework, and quizzes. They comprise 20% of your grade!

Ask questions. This includes during class, during discussions, and during office hours. I don't like a silent class—feel free to ask questions or make reasonable comments at will (but no distracting side conversations).

Don't arrive late for class. If you know you'll be delayed (or absent) for some reason, just let me know ahead of time in person or via e-mail. It's the courteous and adult thing to do.

8. Course Schedule

Date	Lecture
29 Shahrivar	**First Day of Class** Course Introduction
5 Mehr	1. Number Systems 2. Introduction to Computer Codes
12 Mehr	Boolean & Switching Algebra
19 Mehr	1. Electronic Logic Gates 2. Implementing and Evaluating Logic Networks
26 Mehr	Minimization Methods: Karnaugh Maps
3 Abaan	**No Class** **Happy Fitr Celebration!**
10 Abaan	Minimization Methods mackalski
17 Abaan	Designing and Minimizing Circuits
24 Abaan	1. Decoders & Encoders 2. Multiplexers & Demultiplexers 3. Binary Arithmetic Elements Comparators
1 Azar	Design of Complex Combinatorial Circuits
8 Azar	**Midterm**
15 Azar	1. Intro to Sequential Logic 2. Latches
22 Azar	1. FlipFlops 2. Analysis of Synchronous Sequential Logic
29 Azar	Design of Synchronous Sequential Circuits
6 Dey	Shift Registers and Counters
13 Dey	**Review**

References

1. M. M. Mano, *Digital Design*. Prentice Hall, 3rd ed., 2002. Annotation: A very complete yet readable introductory text. Many excellent examples and the best treatment of Verilog HDL in a digital design text that I have ever seen.

2. V. P. Nelson, H. T. Nagle, B. D. Carroll, D. Irwin, *Digital Logic Circuit Analysis and Design*, Prentice Hall, 2nd ed.

3. C. Maxfield, *Bebop to the Boolean Boogie*. Newnes/Elsevier Science, 2nd ed., 2003. Annotation: A truly great book! This book is fun to read; you can learn all about digital logic while being entertained by this talented author. Too bad it isn't quite suitable as a textbook, but you do get a good seafood gumbo recipe in the appendix!

4. J. F. Wakerly, *Digital Design: Principles and Practices*. Prentice Hall, 3rd ed., 2000. Annotation: A densely written but extremely valuable book on digital design. Considered by many to be one of the best modern texts on the subject, it is sometimes used for introductory courses but mainly is used in more advanced courses. An excellent book for your professional library.

5. J. Bhasker, *A Verilog HDL Primer*. Star Galaxy Publishing, 2nd ed., 1999. Annotation: A very easy to read introduction to Verilog, but a bit on the elementary side.

6. S. Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*. Prentice Hall PTR, 2nd ed., 2003. Annotation: My favorite Verilog book. A bit harder to read than Bhasker, but very complete and well organized.

7. K. Coffman, *Real World FPGA Design with Verilog*. Prentice Hall PTR, 2000. Annotation: A bit advanced, but as the title says it is full of real-world practical tips.

8. M. D. Ciletti, *Advanced Digital Design with the Verilog HDL*. Pearson/Prentice Hall,2003. Annotation: An advanced but very well written text with lots of examples.

9. M. D. Ercegovac and T. Lang, *Digital Arithmetic*. Morgan Kaufmann Publishers, 2004. Annotation: A detailed treatment of all types of computer-based mathematics, number systems, and numerical representations.

Only one more page to go. . .

Finally …

Congratulations on reading this far! Lesser mortals gave up a page or two ago. As a reward, perhaps these quotes will inspire you in a positive manner. . .

> *There comes a time in every man's life when he is called upon to do something very special for which he and he alone has the capabilities, has the skills, and has the necessary training. What a pity if the moment finds the man unprepared*[1].
> —Winston Churchill

> *To study, and when the occasion arises to put what one has learned into practice—is that not deeply satisfying?*
> —Confucius

> *They never said it would be easy, but they never said it'd be this hard.*
> *They never said it would be easy, but I never thought we'd come this far.*
> —Sheryl Crow

> *That which does not kill us makes us stronger.*
> —Friedrich Nietzsche

[1] Here we interpret *man* to mean "a member of the hu*man* race." This quote fully applies to both men and women, and no gender bias is intended.