**ECE 446 - Advanced Logic Design**

**2012 Catalog Data:**
ECE 446: Advanced Logic Design. Credit 4
Design and implementation of complex digital systems under practical design constraints. Timing and electrical considerations in combinational and sequential logic design. Digital system design using Algorithmic State Machine (ASM) diagrams. Design with modern logic families and programmable logic. Design-oriented laboratory stressing the use of programmable logic devices.
Prerequisite(s): [(ECE 218 and ECE 311)]
(3-3-4) (C)(P)

**Enrollment:**
Hardware-design electives for CPE and an elective course for EE majors.

**Textbook:**

**Coordinator:**
J. Saniie, Filmer Professor of ECE

**Course goals:**
After completing this course, the student should be able to do the following:
1. Utilize computer-based tools such as VHDL in the design and analysis of logic devices.
2. Utilize FPGAs and MSI ICs to design and implement logic devices.
3. Perform testing and troubleshooting of logic devices using logic analyzers.
4. Design and analyze basic and complex combinational logic devices.
5. Design and analyze basic and complex sequential logic devices.
6. Analyze electrical properties of logic devices (e.g., delay and hazards, power, noise margin, fanout).
7. Design circuits with an array of widely used MSI combinational and sequential logic devices.
8. Design and implement error correcting codes, testing and signature analysis, A/D and D/A converters, parallel-to-serial and serial-to-parallel converters.
9. Complete an engineering design project by incorporating engineering standards and realistic constraints.
10. Prepare an informative and organized design project report.

**Prerequisites by topic:**
1. Boolean algebra
2. Combinational logic design
3. Sequential logic design
4. Basic electronics

**Lecture schedule:**
Two 75-minute sessions per week

**Laboratory schedule:**
One 150-minute session per week

**Topics:**
1. Introduction to Digital Design, Number systems and Codes; Survey Logic Design Technology (chip packaging and manufacturing); Overview of Laboratory Assignments; VHDL Programming and FPGAs (2 weeks)
2. Boolean Algebra, Combinational Circuits, Karnaugh Maps, Logic Minimization; Discussion of Error Correcting Codes; Combinational Circuit Analysis and Synthesis; Schematics and Documentation Standards (2 weeks)
3. Operation of the Logic Analyzer; Combinational Logic Delay; Hazard Detection and Correction (1 week)
4. Design of Parity Generators and Checkers, Comparators, Encoders and Decoders, and Arithmetic Circuits; Transmission Gates; Schmitt Trigger Inputs; Three-State Outputs, Open-Drain Outputs; Wired Logic; Multiplexers, Demultiplexers; Buses; Building Block Designs; Barrel Shifter; Simple Floating Point Encoder; Mode-Dependent Comparators; Design of D/A and A/D
Converters; Design Examples Using VHDL and FPGAs (5 weeks)
5. Sequential Logic Design Principles (3 weeks)
6. Synchronous Design Methodology; Synchronizer Failure and Metastability; Dynamic Electrical Behavior; Noise Margin and Fanout (1 week)
7. Tests (1 week)

Computer usage: Students use VHDL software to program and simulate Programmable Logic Devices in all lab assignments.

Laboratory topics:
1. Introduction to FPGAs and VHDL programming.
2. Code Conversion Design using FPGA and VHDL.
3. Four-Bit Ripple-Carry Adder/Subtractor Design using FPGA and VHDL
4. Familiarization with Logic Analyzer and Measurement of Delays and Hazards.
5. Design and Implementation of Error Correcting Codes
6. Design and Implementation of High-Speed Adder/Subtractor
7. Design and Implementation of Barrel Shifters
8. Sequential Logic Design and Finite State Machine of Turn Signal
9. Design and Implementation of Data Encryption Using LFSRs
10. Design and Implementation of Traffic Light Controller
11. Design and Implementation of D/A and Basic A/D Converters
12. Design and Implementation of a Successive Approximation A/D Converter
13. Design and Implementation of a Parallel-to-Serial Transmitter
14. Design and Implementation of a Serial-to-Parallel Receiver

Relationship of ECE 446 Course Goals to Student Outcomes:

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<tr>
<th>Student Outcomes:</th>
<th>Course Goals</th>
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<tbody>
<tr>
<td>a. Apply knowledge of math, engineering, science</td>
<td>1,2,4,5,6,7,8,9</td>
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<td>b. Design and conduct experiments /Analyze and Interpret Data</td>
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<td>c. Design system, component, or process to meet needs</td>
<td>1,2,3,4,5,7,8,9</td>
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<td>d. Function on multi-disciplinary teams</td>
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<td>e. Identify, formulate, and solve engineering problems</td>
<td>1,2,4,5,6,7,8,9</td>
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<td>f. Understand professional and ethical responsibility</td>
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<td>g. Communicate effectively</td>
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<td>h. Broad education</td>
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<td>i. Recognize need for life-long learning</td>
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<td>j. Knowledge of contemporary issues</td>
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<td>k. Use techniques, skills, and tools in engineering practice</td>
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Prepared by: J. Saniie Date: October 20, 2013