ECE 446 – Advanced Logic Design

Credits: 4, **Contact Hours:** Two 75 minute lecture session per week, one 160 minute laboratory session per week.

Coordinator: J. Saniie, Professor of ECE

Textbook: J. Wakerly, *Digital Design, Principles and Practices*, Prentice Hall
J. Saniie, A. Piorunski, E. Oruklu, *ECE 446 Laboratory Manual*

Reference: R. Katz, G. Borriello, *Contemporary Logic Design*, Benjamin-Cummings
M. Mano, *Digital Design*, Prentice Hall

2019 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. Lecture: 3 Lab: 3 Credits: 4 Satisfies: ECE Professional Elective (P)

Prerequisites or co-requisites by topic: ECE 218, ECE 311
Boolean algebra, combinational logic design, sequential logic design, basic electronics

Enrollment: Hardware-design electives for CPE majors; elective course for EE majors.

Specific outcomes of instruction:
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 and presentation

Relationship of ECE 446 specific outcomes of instruction to student outcomes:

	Student Outcomes	**Course Goals**
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	1-9
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	4,5,7,8,9
3	An ability to communicate effectively with a range of audiences	9,10
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1-10
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1-9
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

Topics:

- 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)
- Boolean Algebra, Combinational Circuits, Karnaugh Maps, Logic Minimization; Discussion of Error Correcting Codes; Combinational Circuit Analysis and Synthesis; Schematics and Documentation Standards (2 weeks)
- Operation of the Logic Analyzer; Combinational Logic Delay; Hazard Detection and Correction (1 week)
- 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)
- Sequential Logic Design Principles (3 weeks)
- Synchronous Design Methodology; Synchronizer Failure and Metastability; Dynamic Electrical Behavior; Noise Margin and Fanout (1 week)
- Tests (1 week)

Laboratory topics:

- Introduction to FPGAs and VHDL programming.
- Code Conversion Design using FPGA and VHDL.
- Four-Bit Ripple-Carry Adder/Subtractor Design using FPGA and VHDL
- Familiarization with Logic Analyzer and Measurement of Delays and Hazards.
- Design and Implementation of Error Correcting Codes
- Design and Implementation of High-Speed Adder/Subtractor
- Design and Implementation of Barrel Shifters
- Sequential Logic Design and Finite State Machine of Turn Signal
- Design and Implementation of Data Encryption Using LFSRs
- Design and Implementation of Traffic Light Controller
- Design and Implementation of D/A and Basic A/D Converters
- Design and Implementation of a Successive Approximation A/D Converter
- Design and Implementation of a Parallel-to-Serial Transmitter
- Design and Implementation of a Serial-to-Parallel Receiver

Prepared by: J. Saniie **Date:** February 28, 2020