ECE 3401: Digital Systems Design

Credits and contact hours: 3 Credits (Two 75-minute lectures per week)

Instructor: Omer Khan

Textbook: Digital Systems Design Using VHDL by Charles H. Roth, Jr. and Lizy Kurian John**,** 3rd Edition, Thomson.

***Specific course information*:**

a. *Catalog Description*: Design and evaluation of control and data structures for digital systems. Hardware design languages are used to describe and design alternative register transfer level architectures and control units with a micro-programming emphasis. Consideration of computer architecture, memories, digital interfacing timing and synchronization, and microprocessor systems.

b. *Prerequisite*: CSE 2300 - Digital Logic Design

c. *Required, elective, or selected elective:* Required (CMPE)

***Specific goals for the course*:**

a. *Specific outcomes of instruction*: The students will learn the theory of data-path and control logic for synchronous digital systems, and how to use a hardware descriptive language (VHDL) a) to describe the architectural aspects of digital systems, b) to design and simulate the functional and timing characteristics of digital systems including data-path arithmetic units, finite state machines, microcontrollers, etc. c) to target a VHDL design of an arithmetic logic unit, finite state machines, and a simple microcontroller that supports compute, data access and control flow instructions.

b. *ABET Criterion 3 Student Outcomes addressed by the course*:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
Students apply Boolean logic, Finite State Machine, Computer Arithmetic, and Microprogramming theoretical concepts to analyze digital systems and their applications. Computer based simulation and analysis tools enable students to model, design, implement, and test complex digital systems of practical relevance.

(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
Contemporary computer aided design and simulation tools enable students to design and simulate real life digital systems, and optimize for practical constraints, such as performance, space, and power consumption.

(3) an ability to communicate effectively with a range of audiences
Each student demonstrates his or her design's functionality to the instructor or the teaching assistant.

(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
n/a

(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
n/a

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
Significant effort is devoted to learning and modeling digital systems using a Hardware Descriptive Language (VHDL). A Xilinx tool-chain is adopted for modeling, simulating and testing numerous synchronous designs in VHDL. The students build several digital system artifacts (an arithmetic logic unit, a finite state machine, and a simple microcontroller), followed by a course project to implement and evaluate a digital system application in VHDL. The metrics for evaluation include functional correctness and performance.

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
Students are introduced to modern microprocessor specifications and architectural concepts. The students are also introduced to a concurrent programming language to model digital synchronous hardware.

Topics covered:

- Logic Design Review for Combinatorial and Sequential Circuits
- Introduction to a Hardware Description Language (VHDL)
- VHDL: Design Modeling, Simulation, Synthesis, and Verification
- Synchronous Data-path and Control for Digital Systems
- State Machine (SM) Charts
- Microprogramming
- Design Example of a Microcontroller
- Memory Design
- Programmable Logic Devices
- Verification and Testing of Digital Designs
- High Level Synthesis of Digital Systems