Syllabus

UNIVERSITY OF PITTSBURGH

Department of Electrical and Computer Engineering

Advanced Digital Design

Course Description: The objective of this course is to teach the tools and techniques used in the design of large-scale digital systems. The course consists of a series of design projects and labs centered on modern microprocessor design. This design experience is intended to teach you both the context and content of the design process. You will learn to use a set of design tools in a modern commercial design flow. As content, you will explore the design of a modern microprocessor, see the design trade-offs within its implementation, and learn how to evaluate good (and bad) design choices.

Class Meetings: T/Th, 11:00 A.M. – 12:15 P.M, Benedum 1211A/B

Instructors: Dr. Amr Mahmoud (**amm418@pitt.edu, (mailto:amm418@pitt.edu)** 1228 Benedum Hall)

Teaching Assistants: Prem Bharatia, Kevin Curran, Preston Brazzle, Ehab A. Hamed

Prerequisite: ECE 0201 and ECE 0202

Textbook: No textbook is needed for this course. The lectures' content should be enough.

COVID-19:

- During this pandemic, it is extremely important that you abide by public health regulations and University of Pittsburgh health standards and guidelines. While in class, at a minimum, you must wear a face covering that covers your nose and mouth; other requirements may be added by the University during the semester. These rules have been developed to protect the health and safety

of all community members. Failure to comply with these requirements will result in you not being permitted to attend class in person and could result in a Student Conduct violation. For the most up-to-date information and guidance, please visit **pitt.edu** **(http://coronavirus.pitt.edu/)** and check your Pitt email for updates before each class.

- All students must abide by public health regulations and University of Pittsburgh health standards and guidelines, and must be familiar with the **new regulations that went into effect on August 9** **(https://universitycommunications-marketing.cmail20.com/t/ViewEmail/j/7A9EE0EFA67058772540EF23F30FEDED/7DE75FF412D8A0514415EB25BE999822)** .
- **Wearing of masks is absolutely required of all students throughout every class meeting.** Students failing to comply with health regulations, including masking, are subject to dismissal from the classroom, and reporting of the individuals to student affairs.

  No exemptions from this policy will be made by the instructors. Any accommodations must be made through DRS. It is the responsibility of students to reach out to DRS. It is not sufficient to be registered, students must request that their letters be sent to faculty each term, and no accommodations will be granted until that process is complete.

- As in any situation regarding class absence (remote or in person), a student who becomes ill (albeit COVID-19 related or not) is responsible for communicating with me regarding course absences. Please contact me and provide documentation when absences affect quizzes/exams. This should be done via email as soon as possible.

Board Kits: FPGA kits will be available for you to use during the Fall semester. The kits will be available in the lab only (1211 A/B), so please make sure not to take it away from the lab. You can use them as much as you want, but only during the lab normal hours.

Disabilities: If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Learning Outcomes: After completing this course, students will:

- Acquire practical skills of coding hardware description language VHDL for modern digital design.
- Know how to use modern EDA design tools, such as Xilinx Vivado, to perform simple and complex logic circuit design.

- Perform finite state machine with datapath design.
- Understand sequential circuit design and timing constraints and be able to design a digital system under certain constraints.
- Understand FPGA structure and being able to use it to synthesize small, as well as large scale digital systems.
- Optimize the design of a digital system to fit within the targeted FPGA board and being able to utilize different board peripherals.

Course Topics: This course will span a variety of different topics, closely related to mastering hardware description language (VHDL), and generally related to digital system design. Some of the topics to be covered (subject to adjustments):

- Introduction to VHDL and Modern Digital Design Tools.
  - Combinational Logic
  - VHDL Basics
  - Behavioral and Structural VHDL
  - Hardware Design Practices
  - Simulation
  - Testbenches
  - Synthesis
- Finite State Machine Design and Design Optimization
  - Sequential Logic
  - Finite State Machines
  - Control vs. Datapath
  - Hardware / Software Interface
  - Instruction Set Architecture
  - Hardware Concurrency
- FPGA Boards anatomy and peripherals utilization
- Sequential Circuit Design and Timing Analysis
  - Synthesizable versus un-synthesizable HDL code
  - Routing and placement
  - Timing constraints and design optimization
- Advanced Digital Design Topic

ABET: This course is designed to meet ABET accreditation requirements and contribute to student attainment of the following ABET outcomes:

> *2. 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

Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources into solutions. Engineering design involves identifying opportunities, developing requirements, performing analysis and synthesis, generating multiple solutions, evaluating solutions against requirements, considering risks, and making trade- offs, for the purpose of obtaining a high-quality solution under the given circumstances. For illustrative purposes only, examples of possible constraints include accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability.

6. develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Grading*:

- **Labs (70%)**.
  - Lab 1 (5%)
  - Lab 2 (10%)
  - Lab 3 (10%)
  - Lab 4 (20%)
  - Lab 5 (10%)
  - Lab 6 (15%)
- **Practicum (30%)**

*number of labs and grade percentage are subject to change

Plagiarism: Plagiarism of another person's work or other references is a serious offense, and can result in dismissal from the University of Pittsburgh.

- All students are expected to adhere to the standards of academic integrity. Any student engaged in cheating, plagiarism, or other acts of academic dishonesty would be subject to disciplinary action. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the Pitt Guidelines on Academic Integrity.

- All students must write their own code to complete all Labs. Students may use all code made available to them by the instructor, but use of any code written by another person is strictly forbidden.
- All code submitted by students for Labs will be evaluated using electronic resources for originality verification.
- Students are responsible for explaining how their code work whenever this is requested by the instructor. All grades are contingent on the ability of the student to explain his or her work to the instructor.
- The complete University of Pittsburgh Plagiarism policy can be viewed at the following web address: **cfo.pitt.edu/policies/policy/02/02-03-02.html (http://www.cfo.pitt.edu/policies/policy/02/02-03-02.html)** .

Diversity and Inclusion: The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices, see: **http://diversity.pitt.edu/affirmative-action/policies-procedures-and-practices (http://diversity.pitt.edu/affirmative-action/policies-procedures-and-practices)** .

I ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or e-mailing titleixcoordinator@pitt.edu. Reports can also be filed online: https://www.diversity.pitt.edu/make-report/report-form. You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

Resources:

- There is a support network of specialists in place available for us, including:
  - University Counseling Center: 412-648-7930
  - Care And Resource Support (CARS) Team: 412-624-5756
  - Resolve Crisis Services: 1-888-796-8226