### 437mcd2018

# **Master Course Description for EE-437 (ABET sheet)**

Title: ÝIntegrated Systems Project Design Capstone

Credits:Ý5 (4 lecture; 1 lab)

#### **UW Course Catalog Description:**

**Coordinator:** Chris Rudell, Associate Professor, Electrical and Computer Engineering

**Goals:**ÝTo teach electronic integrated circuit and system design techniques using contemporary CAD tools with modern semiconductor processes.Ý Students will gain first-hand experience through the completion of a capstone project involving the design of an integrated system of their choice, which could include devices for communication systems, biomedical applications, controls or power electronics.

**Learning Objectives:** ÝAt the end of this course, students will be able to:

- 1. *Understand* and apply the specifications and limitations of commercially available integrated circuits and systems intended for mass manufacturing of commercially available mm-Wave, RF, analog, digital, and mixed-signal circuits and systems.
- 2. *Understand* and apply the principles of modern IC design and the selection of semiconductor technologies, components, failure modes, reliability modes, mismatch analysis, and requirements in terms of size and cost of the end, high-volume solution.
- 3. *Design* Integrated Circuit (IC) building blocks such as bandgap circuits, low noise amplifiers, mixers, frequency synthesizers, and power amplifiers. These blocks will be designed to meet industry defined standards including performance over process voltage and temperature.
- 4. *Design* physical layouts to represent transistor level circuits. These layout designs will consider performance, manufacturability, cost and testability.
- 5. *Design* all circuits and layouts using industry accepted Computer Aided Design (CAD) tools such as Cadence, Altium and Pspice.
- 6. *Create* industry standard documentation for IC electronic system designs.

**Textbook:**ÝT. Lee, *The Design of CMOS Radio-Frequency Integrated Circuits*, Cambridge University Press, 1998.

### **Reference Textbooks:**

- 1. B. Razavi, *RF Microelectronics*, 1st Ed., Prentice Hall, 1998.
- 2. P. R. Gray, P. J. Hurst, S. L. Lewis, and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 5th Ed., John Wiley & Sons, 2009.
- 3. G. Gonzalez, *Microwave Transistor Amplifiers*, 2nd Ed., Prentice Hall, 1996.

- 4. A. Niknejad, *Electromagnetics for High-Speed Analog and Digital Communication Circuits*, Cambridge University Press, 2007.
- 5. D. O. Pederson and K. Mayaram, *Analog Integrated Circuits for Communication: Principles, Simulation and Design*, 7th Ed., Kluwer Academic Publishers, 2007.
- 6. A. Hastings, *The Art of Analog Layout*, 2nd Ed., Prentice Hall, 2006.

## **Prerequisites by Topic:**

- 1. Analog Circuit Design (EE-433)
- 2. Analog Integrated Circuit Design (EE-473)
- 3. Analog simulator proficiency (SPICE, Spectre, covered in EE-331 and EE-332)
- 4. Schematic capture proficiency (Cadence design tools and one of the following which includes Capture, Multisim, Altium, or equivalent; covered in EE-331, EE-332, EE-433)
- 5. Electronic device modeling (MOSFET and bipolar; covered in EE-331 and EE-332)

### **Topics**:

- 1. Integrated circuit design CAD [2 sessions]
- 2. Basic RF integrated Systems [2 sessions]
- 3. RF circuit implementation [2 sessions]

**Course Structure:**Ý The class meets for four 50-minute contact sessions each week.Ý The contact sessions will involve lecture-style presentation and discussion of the selected topics.Ý This course will be jointly offered with EE-536 which has its own project and homework assignments throughout the quarter. Students enrolled in EE-437 will not be responsible for the homework and projects given, only the lecture.Ý The laboratory supports the completion of a quarter-long capstone design project.Ý Laboratory time is open for the student groups to use as needed.Ý The capstone design projects will involve groups of 3-4 students.Ý Some of the design projects may originate from prior work carried out by the same student groups in a previous course such as EE-473 and EE-433.

**Computer Resources:** SpectreRF or HSPICE or PSPICE or Multisim may be used for circuit simulation; Mathcad or MATLAB or Mathematica may be used for general purpose mathematical analysis; Cadence schematic capture and layout; LabVIEW may be used for computer controlled data acquisition and instrument control.Ý HSPICE, PSPICE, MATLAB, Multisim, and Ultiboard are available in all of the general purpose computing laboratories in the EE Department.Ý LabVIEW is available in the room 137 EE1 laboratory, integrated with hardware for data acquisition and instrument control.

**Laboratory Resources:**Ý The main computer laboratory in Sieg Hall will support this class with linux-based computers that are networked to central servers at the University of Washington. All CAD software necessary to complete this design project will be found in the Cadence design environment. This will include the circuit, layout, and layout verification tools as well as the process design kit (PDK) which defines a semiconductor process to be selected by the student, based on cost, power and speed parameters.

**Laboratory Structure:** The lab will consist of one large system-on-a-chip (SoC) project, that will include:

- 1. Initial system design and definition, to include specifications for circuit blocks.
- 2. Circuit design, simulation and verification.
- 3. Physical layout of circuit schematic.

**Grading:**ÝCapstone design project documentation consisting of schematic, layout and simulation results (60%), design reviews (30%), homework (10%).

**ABET Student Outcome Coverage:** This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

- (1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics Y(H) The vast majority of the lectures deal with the application of circuit theory to electronic system analysis and design. Mathematical formulations are commonplace throughout the course. In addition, problem formulation and solving skills are required to define and resolve circuit, system and simulation problems.
- (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 (M) The capstone design project will require students to devise and execute any simulation-based experiments necessary for the development of their specific design. The system aspect of this project addresses cost and economic factors.
- (3) An ability to communicate effectively with a range of audiencesÝ(H) Design project reports are required to be styled and formatted like a product specification sheet. Emphasis is placed upon clear descriptions of circuit operation, illustrative system-level block diagrams, industry acceptable schematic diagrams, an estimate of die (chip) cost and formulation of cost estimates in a full high-volume production environment. The course ends with a poster presentation during the Electrical and Computer Engineering (ECE) capstone fair in addition to a 20 minute class presentation.
- (4) 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 (M) The project design problems are addressed by teams of 3-4 students who must organize and divide up the work amongst themselves. Common partitions of work among students in a group include one student working on system definition, another working on circuit simulation, and another focusing on physical layout.
- (5) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions **(M)** The course involves direct experience with the design of semiconductor integrated circuits and experimentation with simulation software. Students must devise their own projects and define their

own simulations to verify their designs and make engineering judgments based on those outcomes of those simulations, then redesign the system/components as necessary.

(6) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies Ý(**M**) The course focuses on modern electronic circuit design which involves researching, selecting and designing components using prior state-of-the-art designs as a starting point. Students are responsible for learning this on their own.

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