438mcd2018

Master Course Description for EE-438 (ABET sheet)

Title: Instrumentation Design Project Capstone

Credits: 5 (4 lecture; 1 lab)

UW Course Catalog Description:

Coordinator: R. Bruce Darling, Professor, Electrical and Computer Engineering

Goals: To teach electronic circuit board level design techniques using contemporary surface mount technology and tools. Students will gain first-hand experience through the completion of a capstone design project involving an instrumentation system of their own choosing.

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

1. *Understand and apply* the specifications and limitations of commercially available printed circuit board manufacturing processes and commercially available integrated circuits for analog, digital, and mixed-signal circuits.
2. *Understand and apply* the principles of modern component management systems, parts libraries, component selection, failure mode analysis, and requirements validation.
3. *Design* integrated board-level systems for sensing and control applications.
4. *Design* printed circuit board physical layouts for performance, manufacturability, and testability.
5. *Create* industry standard documentation for board level electronic system designs.

Textbook: S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits, 4th Ed.*, McGraw-Hill, 2015. ISBN # 978-0-07-802816-8.

Reference Texts:

1. C. F. Coombs, Jr., *Printed Circuits Handbook, 3rd Ed.*, McGraw-Hill, 1988. ISBN # 0-07-012609.
2. J. S. Hwang, *Modern Solder Technology for Competitive Electronics Manufacturing*, McGraw-Hill, 1996. ISBN # 0-07-031749-6.

Prerequisites by Topic:

1. Analog circuit design (EE 433) or Medical Instrumentation (EE-436),
2. Analog simulator proficiency (SPICE; covered in EE-331 and EE-332),
3. Schematic capture proficiency (Capture, Multisim, Altium, or equivalent; covered in EE-331, EE-332, EE-433), and
4. Electronic device modeling (MOSFET and Bipolar; covered in EE-331 and EE-332).

Topics:

1. Design requirements, design research, and design documentation [1 session]
2. Failure modes and effects analysis (FMEA) [1 session]
3. Circuit miniaturization, integration, and surface mount technology [1 session]
4. The PCB design flow and eCAD tool options [1 session]
5. Industry standards for schematic capture and design documentation [1 session]
6. Power supplies, grounding, shielding, and interference rejection [1 session]
7. Controlled impedance lines and signal integrity [1 session]
8. Design for manufacturability (DfM) [1 session]
9. Practical PCB layout [1 session]
10. Design for testability (DfT) [1 session]

Course Structure: The class meets for four 50-minute contact sessions each week. Each week, one of the contact sessions will involve lecture-style presentation and discussion of the selected topics. The other three weekly contact sessions will take the form of student design review project presentations. Homework is assigned on alternate weeks for a total of 5 assignments over the quarter. The laboratory supports the completion of a quarter-long capstone design project. Laboratory time is open for the student groups to use as needed. The capstone design projects will involve groups of 3-4 students. Some of the design projects may originate from prior work carried out by the same student groups in previous courses.

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

Laboratory Resources: The main electronics laboratory in room 137 supports this class with benches equipped with oscilloscopes, power supplies, function generators, digital multimeters, test leads, and computers equipped with data acquisition pods. Laboratory parts kits are available from the EE Stores, with sales of individual components as needed for the design projects. Students often order components of their own choosing from mail-order/web-based vendors.

Grading: Capstone Design Project Documentation (75%), Design Reviews (15%), 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* **(H)** The homework and design projects deal with the application of circuit theory to electronic system analysis and design. Mathematical formulations are commonplace throughout the course. Both the homework and laboratory design projects involve a large component of solving engineering problems. The laboratory design projects are open-ended and additionally require the students to identify and formulate the principle issues associated with the engineering 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* **(H)** The homework problems and laboratory design projects are phrased in terms of realistic constraints such as cost, size, weight, power consumption, alignment ease, component variation, and manufacturability. Safety factors and green manufacturing processes are also emphasized in terms of producing safe, manufacturable and sustainable designs.

(3) *An ability to communicate effectively with a range of audiences* **(H)** Design project reports are required to be styled and formatted like an industrial research and development report. Emphasis is placed upon clear descriptions of circuit operation, illustrative block diagrams, industry acceptable schematic diagrams, a formal bill of materials with full component sourcing, and proper references to design standards. Regular design reviews also include oral presentations with supplemental visual graphics.

(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* **(L)** Professional standards for documentation and design conformance are emphasized throughout the course. Student teams are asked to consider and justify their design choices in terms of sustainable manufacturing practices and economic and environmental impact.

(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* **(M)** The design problems are addressed by teams of 2-3 students who must organize themselves and divide up the work among them.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions* **(M)** The course involves hands-on laboratory design work in which experimentation is a necessary component. Students must devise their own experiments to test their designs and make engineering judgments based on those outcomes to redesign the system.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies* **(M)** The course focuses on modern electronic circuit design which involves researching, selecting, and applying new components. Students are responsible for learning this on their own.

ABET Criterion 4 Considerations:

Engineering standards - Students must develop their capstone design project to meet specific performance specifications, some of which include benchmark testing or compliance testing against accepted standards for performance, compatibility, and safety.

Realistic constraints - The capstone design project, in addition to having explicit electrical performance specifications, is fundamentally phrased and graded in terms of the final solution's size, weight, cost, power consumption, alignment ease, component variability, and manufacturability criteria.

Prepared By: R. Bruce Darling

Last Revised: 12/10/2018