Master Course Description for EE-433 (ABET sheet)

Title: Analog Circuit Design

Credits: 5 (4 lecture; 1 lab)

UW Course Catalog Description

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

Goals: To teach modern analog system design techniques using the latest commercially available integrated circuit technology.

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

1. *Understand and apply* the specifications and limitations of commercially available operational amplifiers and other analog integrated circuits.
2. *Design* analog subsystems that employ feedback using operational amplifiers and other analog integrated circuits.
3. *Design* instrumentation and signal conditioning circuits using operational amplifiers.
4. *Design* active filters using operational amplifiers and other analog integrated circuits.
5. *Evaluate* the stability of operational amplifier systems and *design* frequency compensation circuitry.
6. *Design* signal generators and nonlinear circuits using operational amplifier circuits.

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. P. R. Gray, P. J. Hurst, S. H. Lewis, and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits, 4th Ed.*, John Wiley & Sons, 2001. ISBN # 0-471-32168-0.
2. J. Graeme, *Amplifier Applications of Op Amps*, McGraw-Hill, 1999. ISBN # 0-07-134642-2.
3. W. Jung, Ed., *Op Amp Applications Handbook*, Analog Devices / Newnes, 2005. ISBN # 0-7506-7844-5.

Prerequisites by Topic:

1. Devices and Circuits II (EE 332),
2. Analog simulator proficiency (SPICE; covered in EE-331 and EE-332), and
3. Electronic device modeling (MOSFET and Bipolar; covered in EE-331 and EE-332).

Topics:

1. Operational amplifier circuits (Franco Chapters 1 and 2) [2 weeks]

2. Static op amp limitations (Franco Chapter 5) [1.5 weeks]
3. Dynamic op amp limitations (Franco Chapter 6) [1.5 weeks]
4. Stability and compensation (Franco Chapter 8) [2 weeks]
5. Nonlinear circuits (Franco Chapter 9) [1 week]
6. Active filters (Franco Chapters 3 and 4) [1 week]
7. Signal generators (Franco Chapter 10) [1 week]

Course Structure: The class meets for four lectures a week, each consisting of 50-minutes. Homework is assigned weekly for a total of 9 assignments over the quarter. Laboratory work constitutes a significant focus of the class and is organized into smaller laboratory sections, typically 24 students divided into 8 groups of 3 each, which meet weekly.

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; Filter Wiz may be used for filter design; SWITCAP may be used for switched capacitor filter simulation; and National Instruments LabVIEW may be used for computer controlled data acquisition and instrument control. HSPICE, PSPICE, and MATLAB are available in all of the general purpose computing laboratories in the EE Department. Filter Wiz and SWITCAP are distributed to the students as needed. LabVIEW is available in the room 137 EE1 laboratory, integrated with hardware for data acquisition.

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.

Laboratory Structure: The laboratory consists of 3-4 design projects given across the quarter which emphasize the use of feedback and analog signal processing as applied to instrumentation systems. Examples of past design projects include:

1. CV/CC regulated power supply
2. Design of an active anti-aliasing filter
3. Design of a switched capacitor filter
4. Design of a function generator
5. Precision thermometer and voltage-to-frequency converter
6. Auto-ranging AC voltmeter
7. AC power and power factor meter
8. Synchronous capacitance meter
9. Digital atmospheric pressure meter and altimeter
10. Photographic exposure meter and bar graph
11. Wide range thermocouple digital thermometer

Grading: Laboratory Design Projects (75%), Homework (25%)

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 lectures, 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* **(M)** 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.

(3) *An ability to communicate effectively with a range of audiences* **(M)** 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 block diagrams, industry acceptable schematic diagrams, a formal bill of materials with full component sourcing, and proper references to design standards.

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

(5) *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.

(6) *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.

Prepared By: R. Bruce Darling

Last Revised: 12/05/2018