Master Course Description for EE-331 (ABET sheet)

Title: Devices and Circuits 1

Credits: 5 (4 lecture; 1 lab)

UW Course Catalog Description

Coordinator: Sajjad Moazeni, Assistant Professor, Electrical and Computer Engineering

Goals: To learn the physics, characteristics, applications, analysis, and design of circuits using semiconductor diodes and field-effect transistors with an emphasis on large-signal behavior and digital logic circuits. To understand and apply the principles of device modeling to circuit analysis and design. To gain hands-on experience with laboratory instrumentation and circuit troubleshooting.

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

1. *Calculate* conduction properties of materials and simple device structures.
2. *Explain* the operating principles of semiconductor diodes and field-effect transistors.
3. *Determine* the in-circuit operating state of the most common semiconductor devices.
4. *Perform* large signal analysis of circuits containing semiconductor diodes and field-effect transistors.
5. *Use* a modern schematic capture and computer-aided circuit analysis program, such as SPICE.
6. *Use* modern computer-based data acquisition and instrument control software and systems, such as LabVIEW.
7. *Calculate* the performance parameters for different MOS logic families.
8. *Design* circuits for switching load devices and simple logic functions.

Textbook: R. C. Jaeger and T. N. Blalock, *Microelectronic Circuit Design, 4th Ed.*, McGraw-Hill, 2011. ISBN # 978-0-07-338045-8.

Laboratory Handbook: R. B. Darling, *EE-331 Laboratory Handbook, Revision 7, September 2014*. Available from the class website.

Reference Texts:

1. P. W. Tuinenga, *SPICE: A Guide to Circuit Simulation Analysis Using PSPICE, 2nd Ed.,* Prentice-Hall, 1992. ISBN # 0-13-747270-6.
2. J. O. Attia, *PSPICE and MATLAB for Electronics: An Integrated Approach*, CRC Press,
3. ISBN # 0-8493-1263-9.
4. R. H. Bishop, *Learning with LabVIEW 2009*, Pearson/Prentice-Hall/National Instruments, 2010. ISBN # 978-0-13-214131-4.

Prerequisites by Topic:

1. Fundamentals of Electrical Engineering (EE-215),
2. Circuit Theory (EE-233),
3. Calculus and differential equations, and
4. Hands-on experience with laboratory instruments.

Topics:

I. The Physics of Electrical Conduction (Jaeger and Blalock Chapters 1 and 2) [2 weeks]

Single Carrier Conduction; Semiconductors and Energy Bands; Conduction Processes in Semiconductors; Effects at Junctions

II. Semiconductor Diodes (Jaeger and Blalock Chapter 3) [3 weeks]

Construction and Characteristics; Circuit Models; Circuit Analysis; Applications and Design

III. Field-Effect Transistors (Jaeger and Blalock Chapter 4) [3 weeks]

Construction and Characteristics; Circuit Models; Circuit Analysis; Applications and Design

IV. Digital Logic Families (Jaeger and Blalock Chapters 6,7, and 8) [2 weeks]

Characteristics and Parameters; nMOS and pMOS Logic; CMOS Logic; MOS Memory (as time permits)

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. Two exams are given at the ends of the 4th and 8th weeks, and a comprehensive final exam is given at the end of 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. The laboratory consists of an introductory meeting the first week, six planned experiments over the next six weeks of the quarter, and a comprehensive design project that occupies the last three weeks of the quarter. The experiments consist of between 6 to 10 procedures that are chosen from the laboratory handbook and which vary from quarter to quarter. A new design project is given each quarter which reinforces the concepts, theory, and practice presented in the lectures and laboratory experiments.

Computer Resources: SPICE is used for circuit simulation along with schematic capture for circuit entry and component parameterization. Two options are available, depending upon the instructor's preference. The older (free, but unsupported) legacy student evaluation version of OrCAD (Cadence) Capture and PSPICE is still made available; however, the more up-to-date National Instruments (Electronic Workbench) Multisim and Ultiboard are fully supported with a Departmental site license. National Instruments LabVIEW is used for computer controlled data acquisition and instrument control, and it is also supported by a College-wide educational site license. Capture, PSPICE, Multisim, Ultiboard and LabVIEW are available in all of the general purpose computing laboratories in the EE Department.

Laboratory Resources: The main electronics laboratory in room EEB 137 supports this class with benches equipped with oscilloscopes, power supplies, function generators, digital multimeters, test leads, and computers equipped with GPIB controller and data acquisition (DAQ) PCI cards. Laboratory parts kits are available from the EE Stores, with sales of individual components as needed for the design projects.

Grading: Laboratory (30%), Homework (20%), Exam-1 (15%), Exam-2 (15%), Final Exam (20%)

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, exams, and laboratory experiments require direct application of mathematics, scientific, and engineering knowledge, which includes component calculations, circuit analysis, device modeling, computer modeling, and an in-depth knowledge of modern semiconductor device operating characteristics.The solution to most of the homework and laboratory problems involves selecting appropriate devices and a circuit topology and then developing the design to meet the required performance needs.

(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)** Approximately one half of the homework problems are design oriented, requiring the students to specify components and a circuit topology to meet the given specifications. The laboratory concludes with a comprehensive, open-ended design project in which the students must design, prototype, and test a small electronic subsystem with considerations of cost, efficiency, and performance tradeoffs.

(3) *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 work in which experimentation is a necessary component, largely in the form of bench-top troubleshooting of circuits. Students must analyze and interpret the results of their own experiments to develop their understanding of device and circuit behavior and create properly functioning electronic systems.

Prepared by: R. Bruce Darling

Last revised: 12/05/2018