Master Course Description for EE-331 (ABET sheet)

Title: Devices and Circuits

Credits: 4 (3 lecture; 1 lab)

UW Course Catalog Description

Coordinator: Scott Dunham, 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. *Calculate* the performance parameters for different MOS logic families.
7. *Design* circuits for switching load devices and simple logic functions.

Textbook: Sedra and Smith, Microelectronic Circuits, 8th edition, Oxford University Press 2020. We will be covering Chapters 3, 4, 5, 7 (excluding 7.3 and 7.5), 16, 17 and 18..

Laboratory Handbook: Revised from EE-331 Laboratory Handbook (R. B. Darling) by Stephany Ayala-Cerna and Tai Chen. Available from the class website.

Prerequisites by Topic:

1. Fundamentals of Electrical Engineering (EE-215),
2. Semiconductor Device Physics (EE-280),
3. Calculus and differential equations.
4.

Topics:

I. Review of Semiconductor Physics [1 weeks]

II. Semiconductor Diodes [1.5 week]

Construction and Characteristics; Modes (On, Off, Breakdown) and Circuit Models; Circuit Analysis; Charge Storage; Schottky Diodes

III. Diode Circuits [1.5 weeks]

Rectifiers, Regulators, Transient Response

IV. Field-Effect Transistors [1.5 weeks]

Construction and Characteristics; Circuit Models; Circuit Analysis;

IV. Field-Effect Transistor Applications [3 weeks]

Characteristics and Parameters; nMOS Inverters; Logic Gate Design; CMOS Logic; Transmission Gate Circuits; Power and Switching Speed

V. MOS Memory [1.5 weeks]

Latches, SRAM, and DRAM; Sense Amps; Address Decoders; Flash Memory

Course Structure: The class meets for three 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, generally 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, four 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 LTSPICE is still made available; however, the more up-to-date National Instruments (Electronic Workbench) Multisim is fully supported with a Departmental site license.

Laboratory Resources: The main electronics laboratory in room EEB 137 supports this class with benches equipped with oscilloscopes, power supplies, function generators, digital multimeters, and test leads.

Grading: Laboratory (20%), Homework (16%), Exam-1 (17%), Exam-2 (17%), Final Exam (30%)

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: Scott Dunham

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