Working Course Charter

ECE1341 Introduction to Electronics 4QH

Introduces the physical operation and circuit behavior of diodes, field-effect transistors and bipolar junction transistors as the basis for the design and analysis of modern electronic circuits. The focus is on the use of large and small-signal device models to understand how transistors operate as switches and amplifiers.

Prerequisite: ECE1215 Corequisite: ECE 1242.

Texts: 1. Sedra and Smith," *Microelectronic Circuits", 4th Ed . Oxford Press, 1995*
2. Roberts and Sedra," *SPICE for Microelectronic Circuits", 2nd Ed,* Oxford Press, 1996.
Optional? I think it should be. I don't think I'll ask students to buy it next time.

Course Objectives:
Upon completion of this course, a student should:
1. Understand and be capable of explaining the purpose and basis for electronic amplification
2. Understand and be capable of explaining the purpose and basis for electronic switching.
3. Be able to ascertain the behavior of a circuit from its transfer characteristic.
4. Understand and be capable of explaining the physical operation of junction diodes, field-effect transistors and bipolar transistors.
5. Understand the concept of a large-signal device model and be able to use these to determine the behavior of circuits containing diodes and transistors
6. be able to analyze and design simple switching circuits and develop their dc transfer characteristics?
7. Understand the concept of a small-signal model, its use and validity as a linearization about a bias point.
8. Be able to apply the small-signal model to evaluate the ac behavior of circuits containing diodes and transistors.
9. Be able to design the basic single-stage amplifiers to meet gain, impedance, power and dynamic range requirements.
10. Be able to use PSPICE for both DC and AC simulator and correlate simulated responses to pencil and paper calculations.
11. Be able to write coherent and lucid memoranda and executive summaries on relevant topics.
12. Understand and be capable of explaining the historical development of modern electronics as the basis for identifying the future trends in electronics and the issues that arise from these developments.

Topics Covered:

1. The nature of Electronics: An historical overview that introduces the concepts underlying modern Electronics.
2. Circuits and Devices: A cursory review of the basis elements introduced in ECE 1215.

The particular focus is on the controlled source and its applications as a switch and amplifier leading to the ideal op-amp.

3. Diodes: Use of the diode to introduce and develop many of the basic concepts used in electronics. The piecewise linear ideal diode model, the nonlinear diode equation and small signal approximations are developed. Diode models are used to determine the transfer characteristics of simple circuits.
   Rectifiers, Zener regulators, clippers and clamps are applications treated.

4. Bipolar junction Transistors(BJTs): The coupled-junction behavior of the BJT is developed and used to both describe the four models of operation and develop appropriate large-signal models. The BJT as a switch is analyzed. Single-stage BJT amplifiers are developed based on the small-signal model in each of the basic configurations: common-emitter(CE), common-collector(CC), common-base(CB) and common-emitter with emitter degeneration. Design methodologies are introduced to illustrate the relation of biasing and signal-processing performance. The high-frequency hybrid-π model is introduced.
5. Field-Effect Transistor(FETs): The physical operation and characteristics of MOSFETs are developed and used to introduce the FET as a circuit element (dependent source, variable resistance and capacitance). The FET as a switch is analyzed. Single-stage amplifiers based on the small-signal model are developed for common-source (CS), common-Drain common-gate (CG and common-source with source degeneration). High frequency models are described.

Class/laboratory Schedule: 3X weekly lectures 1X weekly recitation, 5X per quarter lab concurrent.

Meeting Professional Requirements:

Engineering topics: 4 QH
General engineering component: See relation to Program Objectives below.

Relationship of course to program objectives:

Program Objective	**Assessed**
1.1 Formulate and solve EE problems (specified in course objectives)	HE: One midterm and one final exam graded by instructor count 60% of grade. Homeworks graded by TA count 20% of grade.
1.2 Laboratory and computing tools	R: PSPICE used for circuit simulation in three projects. Reports submitted and graded. RH: MATLAB used, for homework problems ,and in PSPICE project
1.3 Design/conduct experiments, analyze data	N/A (see Charter for ECE1242BIntro to Electronics Lab)
1.4 Design systems, components, or processes	RH: Two homework problems each week involve circuit design. Design of amplifier.
2.1 Understand/apply mathematics	
2.1.1 Differential Calculus	HER: Evaluated in homework problems, exam questions, and project report.
2.1.2 Integral Calculus	H: Evaluated in homework problems. Not this time.

2.1.3 Complex algebra/analysis	R: Effect of by-pass and coupling capacitors calculated using pencil and paper (or MATLAB) for PSPICE reports.
2.1.4 Differential/Difference Equations	N/A
2.1.5 Linear Algebra	HE: Kirchkorff's laws for solving circuits expressed as matrix equation and solved in homework problems and exams.
2.1.6 Multivariate Calculus	CE. Small signal parameters developed as partial derivatives: g_m `=` {partial I_c} over {partial V_{be}} etc.
2.1.7 Probability/Stochastic Processes	N/A
2.2 Understand/apply physics	
2.2.1 Solid-state physics	H: Electrons/holes, and Boltzmann distribution used to explain p-n diode, BJT, and FET. Homework and exam question.
2.2.2 Electricity & Magnetism	HE: Electric field and current in devices. Homework and exam question.
2.3 Apply knowledge of programming	
2.3.1 Flow-charting/program design	N/A
2.3.2 Language syntax/debugging	HR: PSPICE language learned and used to analyze circuits in three projects. For homework problems, and in PSPICE project
2.3.3 Output analysis	R: Design and what-if analysis of circuits using PSPICE. Two PSPICE projects were designed to produce results the students could not expect. Their explanations of the results were graded.
2.4 Connect EE subfields	HEC: Circuit theory (Kirchkorff's laws, Thevinin and Norton equivalents, controlled sources) used extensively in class, homework, and exams. Photodiodes introduced in class and in midterm exam.
2.5 Information sources/literacy	R: Web and print sources accessed for pricing. Used as part of grading criteria for PSPICE report.Did not do this. R: Downloading of PSPICE student software. Use of PSPICE required for three projects C: E-mail communication encouraged ICs. Communications to students used a course web site.
2.6 Connect between theory and application	HE: Extensive use made of examples drawn from research laboratory instrumentation including photodiodes, mixers, amplifiers. C: Discussed effects such as dynamic range, noise, mixing, and saturation in applications such as hearing aids.
2.7 Connect between classroom and work/co-op	HE: Example from industry and co-op covered in class and used for homework and exam problems
3.1 Effective written communication	RV: Three written PSPICE project reports are required. Form and expression account for 30% of grade. One revision allowed to increase grade. Clear expression is a grading criterion.
3.2 Effective oral communications	N/A
3.3 Analyze information/compare alternatives	R: PSPICE project involves interpretation of design, selection of components, and discussion of cost/profit margin
3.4 Multidisciplinary teams	R: Teamwork is encouraged on PSPICE projects, although separate individual reports are required.
4.1 Professional/ethical issues	N/A
4.2 Lifelong learning	C: Final lecture reviewed history of electronics during the instructor's career, and encouraged students to think about future developments in that context.
4.3 Career management	C: Relevance of course material to different EE careers was emphasized.
5.1 Social/cultural context of EE	N/A
5.2 Historical/contemporary issues of EE	HE: History of electronic devices (tubes, BJTs, FETs, ICs) is reviewed.
5.3 Esthetics in engineering	C: Elegant simplicity of solutions to practical circuit problem.
5.4 Esthetics in written/oral expression	R: Project eports graded for succinctness, clarity of expression.

Prepared by Charles DiMarzio, September 29, 2000

Revised by Charles DiMarzio, January 16, 2001