Electronics II ─ Spring 2003
The University of North Carolina at Charlotte

Course Number:	ECGR 3132
Credit:	3 hrs, undergraduate
Time, Place:	M, W: 3:00 – 4:20PM Storrs 290
Text:	Adel S. Sedra and Kenneth C. Smith, *Microelectronic Circuits, Fourth Edition*, Oxford University Press, 1998, ISBN 0-19-511663-1 Paul W. Tuinenga, *SPICE: A Guide to Circuit Simulation and Analysis using PSPICE, Third Edition*, Prentice-Hall, 1995, ISBN 0-13-43049-4**?**
Prerequisite:	ECGR 3131, Fundamentals of Electronics, grade of C or better ECGR 2111, Network Theory I, grade of C or better ECGR 2112, Network Theory II, grade of C or better (recommended and will be required in the future) A solid understanding of dc circuit analysis is required.
Professor:	David M. Binkley Cameron Applied Research Center, 224 Office Hours: M, W: 5 – 6PM; T: 4 – 5PM
Teaching Assistant:	Matt Davis Email: matdavis@uncc.edu Office Hours: Smith 305, M, W: 2– 3PM, R: 1- 2PM

Welcome

Welcome to **Electronics II** here at the University of North Carolina at Charlotte. Analog electronic circuit design is one of the most in-demand areas of electrical engineering as wireless, broadband internet access, and other products utilizing analog circuitry gain a growing portion of the $200-billion international semiconductor market (2000). In my 20 plus years in industry, I designed the discrete and integrated circuit (IC) front-end electronics for positron emission tomography (PET) medical imaging scanners and other products. In fall 2000, I joined UNCC so I could teach analog circuit design and work with students in new circuit research.

I hope the circuit analysis, design, and measurement skills you learn in this course will help you in your chosen careers, whether you work in analog circuit design, digital circuit design, controls, communications, software, or any area of electrical engineering.

Topics Covered

This course begins with a review of bipolar and metal-oxide semiconductor (MOS) transistor single-stage amplifiers from ECGR 3131 (Fundamentals of Semiconductors and Electronics). Differential and multistage circuits are then presented followed by frequency response analysis. Finally, negative feedback is introduced to regulate gain and bandwidth. Throughout, DC bias and small signal analysis is presented for both bipolar and MOS transistor circuits. SPICE computer simulation is used to verify hand analysis, and projects are used to illustrate design methods and laboratory measurements.

Assistance

In order to maximally assist students in this course, my graduate teaching assistant, Matt Davis, and I will be holding separate office hours. I encourage you to see Matt or me during the office hours stated above. Additionally, Matt will hold special review sessions as requested by students.

Guest Lectures

My graduate research assistants and I are active in NASA research for micropower, low-noise CMOS preamplifiers for medical applications and deep space missions. Additionally, we are developing analog CMOS design methodologies and circuits as part of a large DARPA research grant. As a result, I will occasionally miss lectures because of research related travel. Class, however, will meet during all scheduled class times with my graduate research assistants or Matt giving lectures. These students have a strong background in undergraduate analog electronics and are currently studying advanced graduate topics.

Grading

We will have regular homework and some unannounced short quizzes to help students stay current with the lecture material and be prepared for major exams. Grading will generally consist of:

- Homework (check plus = 4, check = 3, check minus = 2, or zero = 0) for 15%
- Projects for 15%
- Unannounced short quizzes for 10% (one will be dropped)
- Three (or four) exams and a comprehensive final examination for 60%

Students are encouraged to start out well, continue learning well, build momentum (as evidenced by building a history of good grades), and then complete the course with mastery of the material. This is a much better way to learn and is much more enjoyable than trying to recover from poor performance earlier in a course.

Grading is at least on the ten-point scale (A: 90-100%, B: 80-90%, C: 70-80%, D: 60-70%, and F: below 60%) with "curving" of individual assignments and the overall grade at the discretion of the professor. For Electronics II in the fall of 2002, grades consisted of:

- 12 A's (highest average was 98.5%) – general mastery of the material with little weakness
- 16 B's – good mastery of the material with some weakness
- 11 C's – adequate mastery of the material with moderate weakness
- 4 D's – little mastery of the material with substantial weakness
- 2 F's (lowest average was 29.4%) – general failure to comprehend material
- 2 W's

Since grading is based on the level of knowledge obtained, there is no limit to the number of A's (or F's) that can be earned. Note that there were considerably more A's and B's earned last semester in Electronics II compared to D's and F's. *The primary reason D's and F's were earned was poor class attendance for lectures, assignments, quizzes, and exams.*

General Information (Class Rules)

- If you plan on missing lectures, quizzes, exams, and assignments, please drop the course now to avoid getting a poor grade. Consider taking the course later when you are ready to apply yourself, or reevaluate if electrical engineering is what you are really interested in.
- Please remember the university permits dropping after the drop deadline only for extraordinary, documented circumstances. Professors do not make these rules.
- Homework one class period late will be marked down one grade. Homework more than one class period late will be given a grade of *zero* since homework solutions will normally be posted. The homework assignment before a major exam will not be accepted after the due date.
- Because of the massive class size and unannounced short quizzes, unfortunately no makeup quizzes can be given. However, the lowest quiz will be dropped.
- Major exams can be made up only under ***extraordinary*** circumstances when Matt and/or I are notified ***before*** the exam is given.
- Please take careful and complete class notes. Your notes, handouts, homework, projects, and previous quizzes and exams will be your best study guides. You are responsible for everything said in class, including material not included in the text or class handouts.
- All grades are ***earned***, not given. Grades are recorded in a large Excel spreadsheet where it is not possible (or fair) to "give" extra points to selected students requesting these. Grading, including any extra points or "curving", is applied uniformly for all students.
- Collaboration, not copying, on homework and the projects is encouraged as long as each student does his/her own work. Failure to do your own homework and projects will usually result in failing grades on quizzes, exams, and the course.
- Copying or cheating on the quizzes, exams, and final examination, is strictly prohibited. Students are responsible for understanding UNCC's strict policies on academic integrity and following these.

Electronic Circuit Design and Analysis, Some Comments

Many students find Electronics I (and Electronics II) distinctly different that their previous courses. Some students, especially those with electronics hobbies like amateur radio, will really like the material while others may find it frustrating. The hope is everyone will get a basic introduction to electronics, including the majority of students who will ultimately specialize in other areas such as digital IC design, controls, communications, power, and software design. Some comments and suggested are listed below.

- Electronic circuit analysis and design relies heavily on dc circuit analysis (and ac circuit analysis for Electronics II.) We will intensively review this background material at the beginning of the course.
- Circuit analysis is an intuitive process of looking at things and realizing cause-and-effect relationships. For example, if a certain voltage is present across a resistor, then we know there will be a resulting current. Learn to carefully look at a circuit and set up the simplest, cleanest relationships before beginning derivations and calculations.
- In practical circuits, there are rarely set formulas you can just plug values into for answers. Additionally, designers often create circuits or circuit variants that are new, so there are no formulas available. As a result, circuit analysis is essential.
- Circuit analysis is usually done symbolically where voltages, currents, resistances, etc., are identified symbolically by algebraic variables, followed by algebraic solution for the performance of interest. This allows the circuit designer to explore circuit behavior for

different component values, different component tolerances, etc. In some cases, the designer can even derive the optimum component values for desired circuit performance.

- Most practical electronic components have wide tolerances. Standard discrete resistors have a tolerance of ±5% while integrated circuit resistors often have tolerances exceeding ±20%. Bipolar transistor current gain (β) may have a nominal value of 100 but vary from 20 – 500. Because of component tolerances, you will find normal disagreement between hand calculated, SPICE simulated, and measured values of voltages and currents.
- Always consider and record units in your answers. In derivations, continually look for consistency in units. For example, you know something is wrong if you are adding two variables where one is a resistance and the other is a voltage.
- Always think practically about circuits you are designing or analyzing. If you have a simple circuit powered by a single 5-V power source, would you expect to find any voltages above 5 V? What effect would changing a particular resistor value in an amplifier have?
- In order to rapidly design or analyze circuits we must often make reasonable approximations. These may include assuming a 0.7-V forward drop for silicon diodes or the base-emitter junction of a bipolar transistor, neglecting the base current of bipolar transistors, assuming a MOSFET threshold voltage, etc. Learn how to make reasonable approximations and understand the limitations of these approximations. For example, what is the approximate resistance of a 100-kΩ resistor in parallel with a 1-kΩ resistor? How good is this approximation?
- Remember, you can consider a capacitor an open circuit for dc bias analysis. You can consider it a short circuit for high frequency ac signals.
- Remember the notion of linear superposition. In most amplifiers, an ac small signal voltage "rides" on top of dc bias voltages. There are two analyses done: the dc bias analysis and the ac small-signal analysis. The total answer is the sum of the dc bias levels and the ac small signals.
- Circuit design is a creative and intuitive process of creating different possibilities and analyzing them to see if they work. Circuits consist of both topology (the arrangement of transistors, resistors, etc.) and the choice of values for all components. There may be many circuits that meet a design requirement. However, some circuits will be simpler, more reliable, consume less power, take less space, cost less, have less sensitivity to component variations, etc. Creativity, analysis, and experience are required for an optimal, elegant design.
- Many students enjoy the projects and really get a feel for electronics from these projects. Allow yourself some time for these projects. Much time is saved by careful hand circuit analysis first, then SPICE simulation, then building up a circuit, then carefully proofing your connections and component values before applying power, then applying power and verifying bias voltages, and then beginning to look at circuit performance.

Electronics II, ECGR 3132, Spring 2003, Storrs 290 ─ Course Outline
The University of North Carolina at Charlotte

Dr. David M. Binkley, Cameron 224, office hours MW: 5– 6PM, T: 4– 5PM
Matt Davis, matdavis@uncc.edu, office hours, Smith 305, MW: 2– 3PM, R: 1– 2PM

Week	Topics	Reading[1]	Homework[1]
Review of Single-Stage Bipolar and MOS Transistor Amplifiers			
Jan. 13, 15	Bipolar models, biasing, and small-signal analysis	4.4 – 4.11	HW-1
Jan. 20 (holiday), 22			HW-2
Jan. 27, 29	MOS models, biasing, and small-signal analysis	5.2 – 5.7	
Feb. 3, 5 (Exam 1)			HW-3
Differential and Multistage Amplifiers			
Feb. 10, 12	Bipolar transistor differential amplifier	6.1, 6.2	
Feb. 17, 19	Transistor biasing, current mirrors, active loads	6.4, 6.5	
Feb. 24, 26	MOSFET differential amplifier, current mirrors	6.6	
Mar. 3, 5 (Exam 2)	Multistage amplifiers	6.9	
Mar. 10 – 15 (break)			
Frequency Response			
Mar. 17, 19	s-domain analysis, bode plots, cascade analysis	7.1, 7.2	
Mar. 24, 26	Common source (emitter) amplifier, Miller effect	7.3, 7.4	
Mar. 31, Apr. 2	Common gate (base) amplifier, followers	7.5, 7.6	
Apr. 7, 9 (Exam 3)	Differential amplifier, cascades	7.8	
Negative Feedback			
Apr. 14, 16	Negative feedback, properties and topologies	8.1 – 8.6	
Apr. 21, 23	Loop gain, feedback stability and compensation	8.7 – 8.11	
Apr. 28, 30 (Exam 4)			

Homework Assignments and Due Dates

Assignment	Topic	Problems[1]
HW-1	Bipolar transistor small-signal derivations	HW-1.1 to 1.7 on pages 2-4 to 2-10 of "Bipolar Transistor Small-Signal Analysis Handout" (*Due 1/27*); 1.7 is optional.
HW-2	Bipolar transistor single-stage amplifiers	4.76, 77, 78, 84, 87, 89, 90, 91, and 92 (*Due 2/3*)
HW-3	MOS modeling and single-stage amplifiers	Fill out MOS parameter table in MOS handout; (*Due 2/10**) 5.48, 55, 57, 73, and 80; (*Due 2/10**) 5.8, D11, 15, 17, 23, 24, D34, 41 b, e, g, h (MOS bias review problems, *not due*)

* These homeworks cannot be accepted after the due date because solutions will be posted immediately on the web to help students review for the exams.

[1] Homework from Sedra and Smith, *Microelectronic Circuits*, Fourth Edition, Oxford University Press, 1998, ISBN 0-19-511663-1, unless otherwise specified.