

Engineering: ELEC 3509 Electronics II

Instructor: Prof. John Rogers, email jrogers@doe.carleton.ca

Objective: To study the principles, design and analysis of analog electronic circuits.

Description: In this course, the student will learn both analysis and design of electronic circuits. Both discrete and integrated circuits will be discussed. This course builds on the concepts covering analysis of basic circuits and signals (covered in ELEC 2501) and also basic electronic devices and circuits, such as diodes, BJTS, MOSFETS and Amplifier/Rectifier/Regulator Circuits (covered in ELEC 2507). In this course, single transistor circuits will be extended to multiple transistor circuits made of Bipolar Junction Transistors. Various one and two transistor amplifier circuits will be studied, followed by an exploration of the opamp. Finally some opamp application such as design of filters and oscillators will be seen.

Grading:

Labs (5) 30%

In Class Participation 5%

Midterm Exam 15%

Final Exam 50%

Total 100%

- All labs must be completed with an average grade of 50% or better to pass the course. At least 50% on the final exam is required to pass the course.
- You are expected to attend and participate in all lectures in the course **especially** if you are repeating the course. During the lectures, work will be collected ten times during the term. In order to receive your 5% you must submit your work 8/10 times. **Anyone who misses handing in their work more than twice will automatically receive an FND in the course.**
Rational: Preparation and consistent hard work is required all term to be prepared to write the final exam. If you are not present for a large portion of the lectures you are not prepared to write the final exam.
- Assignments (and old exams) are on the web. Students are highly encouraged to solve them. Answers to many problems are found at the back of the book. Others will be provided.
- Academic accommodation for any reason must be sought as soon as possible, preferably early in the term. Verification will be required.

References:

1. *Microelectronic Circuits*, 4th or 5th Edition, A. Sedra and K. Smith, Oxford, 1998, 2004.
2. C.L. Alley and K.W. Atwood, *Microelectronics*, 1986, TK7874.A429.
3. P.R. Belanger et al, *Introduction to Circuits with Electronics*, 1985, TK7867.B37.
4. R. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, TK7867.B66.
5. P. Gray, *Analysis and Design of Analog Integrated Circuits*, TK7874.G688
6. H. Lam, *Analog and Digital Filter Design*, TK7872.F5L26.
7. J. Millman, *Microelectronics*, TK7874.M527.
8. C.J. Savant et al, *Electronic Circuit Design*, TK7876.S277.
9. R.J. Smith, *Circuits, Devices and Systems*, TK45.S616.
10. M.H. Rashid, *Microelectronic Circuits: Analysis and Design*, 1999.
11. M.N. Horenstein, *Microelectronic Circuits and Devices*, 1996.

Lecture Outline

Week 1: Review of Basic Electronic Devices and Circuits: p-n Junction, Diode Equation, Bipolar Junction Transistors (BJT): Concepts, Current Relations, Regions of Operation, Characteristics, Biasing, Small-Signal BJT model, Common Emitter Amplifier: AC analysis, Input and Output Resistance, Voltage/Current Gains, Frequency Response.

Week 2: Common Base Configuration and Cascode Amplifier, Common Collector Configuration, CC-CB Wideband Amplifier, Current Source/Sink Bias.

Week 3: Frequency Analysis of Transistor Amplifiers, Bode plots, Differential Amplifier Stage, CMG, DMG, CMRR, Analysis of 741 IC Op-Amp.

Week 4: Power Amplifiers: Class A, Class B, Class AB, Class C, Filters: RC filters theory, Second-order transfer functions.

Week 5: Filter Design Methodology: Types, Specifications, Approximations and Practical Circuit Topologies, Applications.

Week 6: Feedback Stability and Linear Oscillator Circuits, Applications, Review.

Notes on Lab Projects and Exercises

Goals: The laboratory portion of the course reinforces this theme through analysis and design of electronic circuits. As well, through the lab experiments, students will extend their previous experience of circuit design using a few discrete transistors, and will begin to use ICs as the basis for designs.

Topics: The lab topics form a coherent sequence following the lectures, beginning with BJT characteristics, followed by BJT amplifiers, op-amp circuitry, and, finally, the op-amp's use in filters and oscillators.

Organization: The labs are an integrated mixture of 10 multi-week exercises and projects. In order to complete all of the work, students attend the lab every week; there are no problem analysis sessions in the course. For every lab, students work in groups of two and provide one report per group. Groups of three or more are not allowed. Groups of 1 are allowed, but attempts will be made to find partners for all.

Exercises: For the lab exercises, students are expected to have completed any required preparation before they come to the lab, and, in the lab, to take notes which *must* be initialed by a lab demonstrator before they leave. For most of the exercises, a formal report is written after all the parts of the lab have been completed, and must be submitted by 3:00 p.m. seven days after the period in which the lab's last exercise was performed. The report must include the initialed lab notes as an appendix. The last exercise has an in-lab quiz and no formal report. (See attached schedule.) Submitted reports should be deposited in the stairwell filing cabinet.

Projects: As with the exercises, students are expected to have completed any required preparation before they come to a project lab. During one of the periods for each project, the student will be required to demonstrate a working circuit. If after the demonstration, the lab instructor or T.A. is satisfied that the circuit and the demonstration are acceptable, he will initial the student's de-

sign schematic. This initialed schematic *must* be submitted as an appendix to a formal engineering report fully analyzing and documenting the designed circuit(s). Sufficient data should be recorded to show that all the requirements have been satisfied. The final report is due in the stair-well filing cabinet by 3:00 P.M. 7 days after the student's last scheduled lab period for the project.

For the second project, the final demonstration will require some time and so will be made at an appointed time during the lab period. Thus, it is expected that the student will have his or her circuit functioning to meet the specification *before* the final period of this project. It is emphasized that full advantage should be taken of the scheduled laboratories and the advice available from faculty members and teaching assistants, as well as from laboratory demonstrations, during these periods.

Lates: Late reports and demonstrations are each penalized 30% if received within one week of the listed deadline, while later ones will receive a grade of 0. However, in order to pass the course, you must complete all labs

Laboratory Regulations: Food and drinks are not allowed in the laboratory at any time. Most importantly, students are expected to display a mature and professional attitude while in the lab.

Lab Equipment: The person responsible for most of the undergraduate electronics labs is Mr. Nagui Mikhail, and his room number is 5124 ME. Any mal-functioning equipment should be reported to the T.A.s who in turn will report problems to Nagui.

Health and Safety: students should be familiar with the locations of fire extinguishers, first-aid kits, the emergency phone number (4444), regulations and the University Health-And-Safety document. More information is provided on the course web page.

Components and Tools: Boards, component kits and tool sets can be purchased directly from the lab technician. Wire strippers, a small-tipped screwdriver and a pair of needle-nosed pliers are essential tools for performing the lab work.

Lab Outline

Lab 1: BJT A.C. and D.C. Operation

- BJT D.C. Characteristics and the current Mirror.
- BJT A. C. Characteristics

Lab 2: Amplifier Project

- Single Transistor and Two-Transistor Amplifiers
- Cascode Amplifier Design Review and Development
- Cascode Demonstration

Lab 3: Bipolar Op-Amp Simulation

- Design, Schematic
- To investigate the effect of various design parameters

Lab 4: Active Band-Pass Filter Project

- Introduction to Active Filters and Filter Simulations and Measurements
- Chebyshev Filter Design Review
- Chebyshev Filter Demonstration

Lab 5: Oscillators

- Wien Bridge and the Active-RC Phase Shift Quadratic Oscillators