Georgia Institute of Technology
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 4430: Analog Integrated Circuits – Fall 2010
12:00 – 1:00 pm, Mon, Wed, Fri, Van Leer C240

http://www.ece.gatech.edu/academic/courses/ece4430/F10

Instructor: Maysam Ghovanloo, Ph.D. (mghovan@ece.gatech.edu), Phone: (404) 385-7048

Office Hours: Fridays 2:00-4:00 pm, other times with prior appointment

TA: N/A


Other References: (recommended)
1. CMOS Analog Circuit Design, P.E. Allen and D.R. Holberg
2. Design of Analog CMOS Integrated Circuits, B. Razavi
3. The Art of Analog Layout, A. Hastings

Prerequisites: Analog Electronics (ECE-3040 and 3050 or equivalent), Co-requisites: None

It is assumed that you are familiar with the following topics:
1. Circuit theory, frequency response, small signal analysis.
2. Solid-state devices and microelectronic circuits: P-type and N-type semiconductors, diodes, bipolar junction transistors, and MOS field-effect transistors (MOSFET).
3. Basic knowledge of MATLAB and available CAD tools such as SPICE or Cadence.

Course Description:
Analysis and design of the analog integrated circuits (ICs) using analytic techniques and CAD tools. This course emphasizes on circuit design and intuitive understanding of circuits, particularly those topics that are applicable to analog ASIC design.

Topical Outline:
Introduction, MOS Technology
CMOS and BJT Technologies, Layout and Design Rules
MOS models: dc, ac, capacitive effects, regions of operation, short channel effects, measurements
BJT models: diodes, high frequency, measurement
MOS analysis: large signal, small signal
SPICE simulations - MOS and BJT models
Switches and active resistors
Current sinks and sources
Current mirrors and amplifiers
Voltage and current reference generators
MOS inverting amplifiers
BJT inverting amplifiers, cascode amplifiers
Differential amplifiers
Output stage
MOS and BJT operational amplifiers

Course Projects:

Two projects will be assigned during this semester. The projects will sometimes include computer simulations using SPICE, MATLAB, or Cadence. You must use the transistor models associated with that specific project. Some projects need to be done individually and some need to be done in groups of two or three. The last project will be more comprehensive and has a higher grade percentage. If layout is part of the project, you should use Cadence for IC layout. There are online tutorials for learning how to use Cadence layout, such as:
http://www.eda.ncsu.edu/wiki/NCSU_EDA_Wiki

Some important details about the projects:

- You may discuss the questions in large groups, but each person must independently perform and write-up the required work unless indicated otherwise.

- MATLAB: We will use the computer program MATLAB for analyzing data; therefore your projects will require a simple understanding of MATLAB. We will use only a small fraction of MATLAB capability in this class.

- Format: For each project, you are required to develop a set of PowerPoint slides that describe your methods, simulation results, and regression data, and answers and solutions and explanations for the questions. One should use fonts that can be visible when projected. Please keep the number of slides to 15 or less. Minimize the number of slides with text only (preferably none other than the conclusion slide at the end). Graphs and diagrams should be computer generated using Cadence, Visio, etc (no hand drawn or scanned in).

- Each group will present their slides to the class, which are submitted to me before the deadline for that project. After the first or second presentations, it become clear that there is no need to repeat the problem statement (since others have), but rather focus on the results, and the approach.

- Slides are due by email to me (mghovan@ece.gatech.edu) at 10 am on the day that they are due. This rule gives me time to organize the presentations on my laptop so we can use the class time efficiently, and gives me a chance to take an early look at the presentations. In the e-mail please identify the names of all people in the project, as well as on the first slide, so I know who should get credit for the project. Projects handed in after this deadline and before the beginning of the class on the same day will be graded from 50% of the full grade. After the beginning of the class, no project will be accepted. So please do not fall behind… The
workload will not get any lighter later in the semester!

- Only one set of slides / one presentation will be accepted per group. To help me archive the presentation files, please use this naming convention: LastName1_LastName2_ECE4430_F10.ppt
- There is no need to show any MATLAB/SPICE code unless the project explicitly asks for it.
- Try to add a relevant title for each slide and a brief description so that your slides would be self explanatory. Also try to add one or two slides at the end as a conclusion and what you have learnt out of that specific project.

Reading Assignments:

Reading assignments include sections of the textbooks, supplementary notes, and online articles that are relevant to the course topics. Class notes and supplementary materials, which topics may or may not be included in the textbook, will be posted on the class webpage and **it is your responsibility to print them out and bring to the class with you.** These materials will not be handed out during lectures. Students are responsible for both lecture material and reading assignments for the midterms, projects, and final examination.

Homework:

Homework will be assigned, as seen on the course webpage. The homework will include designs, hand calculations, and computer simulation problems using SPICE/Cadence. Homework will be collected and randomly graded only after each midterm. You are expected and highly encouraged to complete the problems.

Exams:

- There will be three, closed book examinations, each of 50 minute duration, other than the final exam: Diagnostic, Midterm-1, and Midterm-2
- Diagnostic exam is only meant to tell me the average level of the class and has neither positive nor negative impact on your final grade.
- Rules of exam: One new sheet of notes, last exam's sheet of notes, and a calculator.
- Each exam is cumulative: Every unit builds on all the previous units.
- Expect the unexpected: The exam will be over material covered in lectures (primarily), handouts, and in the textbook, but I reserve the right to make any / all problems not look like homework problems. I expect that you get the intuition of the key concepts from the homework. In the exam, you should be able to apply these concepts to slightly different problems.
- All grades become final one week after the graded exams are returned in class.

Missed Exam:

If you miss a midterm exam or do not attend your project presentation without a certified medical excuse or my prior approval, a zero will be averaged into your grade. Certified excuses and prior approval will be dealt with individually. Generally, only one makeup exam will be held at a designated time near the end of the semester and before the final exam. This means that there
will be only one make-up test, independently from which exam/presentation you miss. Thus, the
make-up test will be comprehensive. To request an excused absence, 1- write a formal letter to
me (typeset), dated and signed, stating your specific request and the reason you are asking for an
excused absence; 2- provide documentation supporting your request; 3- bring this letter and the
documentation to me in person before the requested date (if an absence is foreseeable) or within
one week after the absence (if it is of unforeseeable nature), at which time your request will be
discussed. Special cases will be dealt with individually.

**Academic Integrity:**

It is the responsibility of the instructor to encourage an environment where you can learn and
your accomplishments will be rewarded fairly. Any behavior which compromises the basic rules
of academic honesty as described in the General Catalog will not be tolerated. It is the
instructor’s understanding that the student’s signature on any test or assignment means that the
student neither gave nor received unauthorized aid. For more information please visit:
http://www.deanofstudents.gatech.edu/integrity/

**Disabilities:**

Reasonable accommodations will be made for students with verifiable disabilities. To qualify for
these accommodations, students must register with Access Disabled Assistance Program for
Tech Students (ADAPTS). For more information: http://www.adapts.gatech.edu/

**Grading Policy:**

<table>
<thead>
<tr>
<th>Homework</th>
<th>10%</th>
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<tbody>
<tr>
<td>Quizzes</td>
<td>10%</td>
</tr>
<tr>
<td>Midterms (2)</td>
<td>20%</td>
</tr>
<tr>
<td>Projects (2)</td>
<td>20% + Possible extra credits up to 10%</td>
</tr>
<tr>
<td>Final</td>
<td>40%</td>
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A: 90.0 – 100.0    B: 80.0 – 89.9    C: 60.0 – 79.9    D: 50.0 – 69.9    F: 0.0 – 49.9

**Auditing Criteria:**

To audit this course you will need to:

1- Attend all sessions
2- Do the projects

Basically you just do not need to participate in any of the exams. Everything else would be the
same as taking the course for credit.

**Exams Schedule (Tentative):**

<table>
<thead>
<tr>
<th>Exam/Project</th>
<th>Date</th>
<th>Time</th>
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<tbody>
<tr>
<td>Diagnostic Exam</td>
<td>Wednesday 8/25/10</td>
<td>In class</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>Monday 10/11/10</td>
<td>In class</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>Monday 11/8/10</td>
<td>In class</td>
</tr>
<tr>
<td>Final</td>
<td>Monday 12/13/10</td>
<td>11:30am - 2:20pm</td>
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