ECEN326: Electronic Circuits
Spring 2022

Lecture 1: Introduction

Sam Palermo
Analog & Mixed-Signal Center
Texas A&M University
Analog Circuit Sequence

- Electronics I 325
  - Electronics II 326
- Operational Amplifiers 457
- VLSI Circuit Design 474
- Active Filter Analysis and Design 458
- Solid-State Devices 671
- Advanced-Analog Circuit Design 607
- Broadband Circuits 620
- High Frequency GaAs/SiGe Analog IC Design 650
- Integrated CMOS RF Circuits and Systems 665
- Active Network Synthesis 622
- Advanced Mixed-Signal Interfaces 669
- MM-Wave Integrated Circuits 625
- High-Speed Links Circuits & Systems 720

Money background image
Why is Analog Important?

- Naturally occurring signals are analog
- Analog circuits are required to amplify and condition the signal for further processing
- Performance of analog circuits often determine whether the chip works or not
- Examples
  - Sensors and actuators (imagers, MEMS)
  - RF transceivers
  - Microprocessor circuits (PLL, high-speed I/O, thermal sensor)
Integrated Circuits

- 4-core Microprocessor (45nm CMOS)
  - Mostly Digital
  - Noteable analog blocks
    - PLL, I/O circuits, thermal sensor

- Cellular Transceiver (0.13\(\mu\)m CMOS)
  - Considerable analog & digital

- Instrumentation Amplifier (0.5\(\mu\)m CMOS)
  - Mostly Analog
  - Some Digital Control Logic

[Bohr ISSCC 2009]

[Sowlati ISSCC 2009]

[Pertijs ISSCC 2009]
The Power of CMOS Scaling

- Scaling transistor dimensions allows for improved performance, reduced power, and reduced cost/transistor

- Assuming you can afford to build the fab
  - 32nm CMOS fab ~3-4 BILLION dollars
Course Topics

- BJT & MOSFET Review
  - Large signal model
  - Small signal model

- Differential Amplifiers
  - Large & small-signal analysis
  - Common-mode rejection

- Current Mirrors
  - Allows for accurate current sources
  - Output resistance & compliance voltage
Course Topics

• Active Loads
  • Allows for higher gain
  • Useful in IC design

• Frequency Response
  • What limits the bandwidth of our circuits
  • High-frequency transistor model

• Feedback
  • Allows for accurate gain

• Stability
  • In this class, we want to build amplifiers (not oscillators)
  • Phase & gain margin
Course Goals

- Learn how to analyze and simulate multi-transistor analog circuits
  - Large & small-signal analysis
  - Nodal impedance estimation
  - Develop “inspection-based” analysis capabilities
  - Extensive use of MultiSim
- Understand fundamental analog building blocks
  - Differential amplifiers, current mirrors, active loads
- Understand fundamental analog design concepts
  - Frequency response, feedback, stability
- Use circuit building blocks and design concepts to construct moderately complex analog circuits
  - “Build” component is emphasized in lab
Administrative

- **Instructor:**
  - Sam Palermo
  - 315E WERC Bldg., 979-458-4114, spalermo@tamu.edu
  - Office hours: M 10:00AM-11:30AM & F 1:00PM-2:30PM
    - Online via Zoom

- **Lectures:** TR 9:35AM-10:50AM, ETB 1037

- **Class web page**
  - [https://people.engr.tamu.edu/spalermo/ecen326.html](https://people.engr.tamu.edu/spalermo/ecen326.html)

- **Prerequisite**
  - ECEN 314 and 325
Class Material


• References
  • *Class Notes*, A. Karsilayan. *(Excellent Condensed Notes)*
  • Material is posted on website

• Lectures
  • ~100% slides, with previous semester’s notes posted on website
Lab

- Some details are TDB
- Lab kit details TBD
  - Use your 325 lab kit for now
- Preliminary plan is to use Analog Discovery 2, like in 325?
  - How many people have an AD2?
  - Tentative plan is for the department to supply them
- Primary circuit simulator is MultiSim
  - Follow instructions on website to get started
- Lab starts on Jan 26-27 with an orientation session
- Lab 1 is due on Feb 2-3
Grading

- **Exams (60%)**
  - Three midterm exams (20% each)

- **Homework (20%)**
  - Collaboration is allowed, but independent simulations and write-ups
  - Need to install MultiSim on your laptop/computer
  - Turn in via Canvas
  - No late homework will be graded

- **Laboratory (20% + 2%)**
  - Lab 11 is extra credit, with the total lab grade computed as a sum of the 11 lab grades divided by 10
Preliminary Schedule

<table>
<thead>
<tr>
<th>Topic</th>
<th>Week</th>
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<tbody>
<tr>
<td>I. Introduction/Amplifier review</td>
<td>Week 1-6</td>
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<tr>
<td>II. Differential amplifiers</td>
<td></td>
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<tr>
<td>Review session (30 min.)</td>
<td>Feb. 22</td>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; MIDTERM</td>
<td>Feb. 24</td>
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<td>III. Current mirrors</td>
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<td>IV. Active loads</td>
<td>Week 7-10</td>
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<td>V. Frequency response</td>
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<tr>
<td>Review session (30 min.)</td>
<td>Mar. 29</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; MIDTERM</td>
<td>Mar. 31</td>
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<td>VI. Stability</td>
<td>Week 11-15</td>
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<td>VII. Output stages</td>
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<tr>
<td>Review session (30 min.)</td>
<td>Apr. 28</td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; MIDTERM</td>
<td>May 5 (12:30PM-2:30PM)</td>
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- Dates may change with reasonable notice
Reading

- Razavi Chapter 5 & 7
  - The majority of this material should be 325 review