# EEE 230 - Analog & Mixed-Signal Integrated Circuit Design

**Elective Area Core Course** **Date:** 2/28/07

**Microelectronic Design area**

**Course Coordinators:** Perry L Heedley and Thomas W Matthews.

**Catalog Description:** This course covers core topics and circuits important for analog and mixed-signal integrated circuits. Topics include: device structures and models, single-stage and differential amplifiers, current mirrors and active loads, operational amplifier design, stability and compensation, fully-differential circuits and common-mode feedback. An introduction to sampled-data systems and switched-capacitor circuits is also included. Design projects are assigned using SPICE software. 3 units.

**Prerequisites:** EEE 109 or consent of the instructor

**Text (required):** "Analysis and Design of Analog Integrated Circuits", 4th Edition, by Gray, Hurst, Lewis and Meyer, John Wiley & Sons, Inc. 2001

**Additional Resources (optional):**
"Analog Integrated Circuit Design" by David Johns and Ken Martin, John Wiley & Sons, Inc. 1997
"Design of Analog CMOS Integrated Circuits" by Behzad Razavi, McGraw Hill 2001

**Course Objectives:** As the core course in the microelectronic design area, this class begins with a review of basic material such as MOSFET and BJT devices and models and single transistor amplifiers. Analog building block circuits such as differential amplifiers and currents mirrors are then covered, building up to coverage of several different operational amplifier topologies including two-stage, telescopic, folded-cascode and current mirror op amps. Frequency response and stability of op amps is covered including compensation techniques. Fully differential op amps and common-mode feedback are also covered as well as an introduction to sampled-data systems and switched capacitor circuits. The primary goal of this class is to teach students how to design and compensate operational amplifiers to meet various specifications, using basic analog building blocks such as differential amplifiers and current mirrors. A secondary goal is to introduce them to sampling and switched-capacitor concepts in preparation for advanced topics coverd in follow-on classes such as EEE 231 and EEE 232.

**Prerequisites by Topic:**

1. MOSFET and BJT devices and models
2. Single and multistage amplifiers, including differential amplifiers
3. Frequency response concepts, including Bode plots
4. Feedback concepts, including the use of ideal op amps

**Topics Covered:**

1. Integrated circuit devices and models
2. Analysis and design of single-stage and differential amplifiers
3. Analysis and design of current sources and active loads
4. Analysis and design of operational amplifiers, including frequency response and compensation
5. Analysis and design of fully-differential op amps, including the use of common-mode feedback
6. Introduction to sampled-data systems and switched-capacitor circuits

**Evaluation:** Student performance will be evaluated using the following: Exams (60%), Projects (30%), Homework (10%). Projects will be assigned to reinforce and expand upon classroom discussions on device characteristics and analog circuits such as current mirrors and operational amplifiers. Typical projects include designing a wide-swing current mirror and an op amp to achieve a desired set of specifications, and verifying the performance of each circuit using PSpice simulations.

# EEE 230 Course Outline/Schedule

| Week | Topics covered | Text reference |
|---|---|---|
| 1 | Course introduction, the role of analog in modern integrated circuits, P-N junction basics | 1.1 – 1.2 |
| 2 | BJT & MOS device structures, large and small-signal models | 1.3 – 1.9 |
| 3, 4 | Single-stage amplifiers, multi-stage amplifiers, cascodes | 3.1 – 3.4 |
| 5 | Differential amplifiers, differential and common-mode half-circuit analysis, CMRR and PSRR | 3.5.1 – 3.5.5 |
| 6 | Discrete vs integrated circuit biasing, Current sources and active loads | 4.1 – 4.3 |
| 7, 8 | Operational amplifiers: two-stage, telescopic, folded-cascode, current mirror | 6.1 – 6.7 |
| 9 | **Review, Mid-Term Exam** | |
| 10 | Frequency response of op-amps, slew rate | 7.1 – 7.3, 7.5 |
| 11 | Stability and compensation of feedback amplifiers, pole-splitting, relation between frequency and time response | 9.1 – 9.4, 9.6 |
| 12 | Fully-differential amplifiers, common-mode feedback | 12.1 – 12.8 |
| 13, 14 | Sampled-data systems and switched-capacitor circuits | notes |
| 15 | Analog design methodology, **Review for Final Exam** | notes |