

# EEE 231 – Advanced Analog & Mixed-Signal Integrated Circuit Design

## Elective Course

Date: 2/27/07

## Microelectronic Design area

Course Coordinator: Perry L Heedley and Thomas W Matthews

**Catalog Description:** A companion course to EEE 230, this course covers additional topics important in analog and mixed-signal integrated circuit design. Topics include traditional issues such as device matching and analog layout techniques, as well as important building blocks such as bandgap references and bias circuits. Also included are current-mode techniques such as high-speed current-mode logic (CML), and an introduction to noise in integrated circuits. Circuit and layout projects are assigned using CAD software..

**Prerequisites:** EEE 230 or consent of the instructor.

**Text (required):** “Design of Analog CMOS Integrated Circuits” by Behzad Razavi, McGraw Hill 2001

## **Additional Resources (optional):**

“Analysis and Design of Analog Integrated Circuits” by Paul Gray and Robert Meyer, John Wiley & Sons, Inc.

“Analog Integrated Circuit Design” by David Johns and Ken Martin, John Wiley & Sons, Inc. 1997”

**Course Objectives:** This class covers the practical side of mixed-signal design, such as how to achieve good device matching and how to draw successful mixed-signal integrated circuit layouts. Important circuit techniques such as supply & temperature independent biasing and current-mode design are covered as well. Detailed techniques needed to make real analog and mixed-signal integrated circuits work that many only learn after years on the job are covered, making this course invaluable to those serious about mixed-signal.

## **Prerequisites by Topic:**

1. BJT and MOS device models
2. Single-stage and differential amplifiers
3. Current sources and active loads
4. Operational amplifiers at the transistor level, including frequency response and compensation
5. Fully-differential circuits
6. Sampling and discrete time circuits

## **Topics Covered:**

1. Matching requirements for analog circuits and how to design for matching
2. Use of analog & mixed-signal layout techniques
3. Analysis and design of supply & temperature independent biasing circuits
4. Analysis and design of Current Mode Logic (CML) circuits
5. Analysis of noise in analog & mixed-signal circuits

**Evaluation:** Student performance will be evaluated using the following: Exams (60%), Projects (30%), and Homework (10%). Projects will be assigned to reinforce and expand upon classroom discussions on device matching and analog & mixed-signal IC layout techniques. Typical projects include designing a current DAC to achieve accuracy specifications and verifying it's performance using Monte Carlo simulations, and drawing the layout for a sub-1V bandgap reference circuit.

## EEE 231 Course Outline/Schedule

<u>Week</u>	<u>Topic</u>
1-3	Course introduction, Matching: area dependence, differential amplifiers, current mirrors, passive devices
4-5	Analog layout techniques: floorplanning, centrodng, mirror vs step symmetry, PLI, neighborhood matching
6-7	Supply & temperature independent biasing, PTAT and constant-gm bias circuits
8	Review, Mid-Term Exam
9-10	Bandgap references, bias & reference distribution
11-12	Current-mode techniques, CML logic
13-14	Noise in integrated circuits
15	Testing of mixed-signal circuits, Review for Final Exam