EEE 433 Analog Integrated Circuits (4) [F,S]

Course (Catalog) Description:
Analysis, design, and applications of modern analog circuits using integrated field effect transistor technologies.
Lecture, lab. Technical Elective.

Prerequisite: EEE 335.

Textbook: Behzad Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2001.

Coordinators: S. Kiaei, Professor, David Allee

Prerequisites by Topic:
1. Circuit models of CMOS
2. Electronic circuit analysis
3. Circuit network analysis

Course Objectives:
1. Analysis, design, and applications of modern analog circuits using integrated field effect transistor technologies.
2. Introduce the principles of analog circuits and apply the techniques for the design of analog integrated circuit (Analog IC's).
3. Apply the methods learned in the class to design and implement practical projects
4. The class will have a lab (or projects for graduate students).
5. The final objective of the class is to implement a complete analog system. In each week's lab, the class will build parts of the system with an overall objective of completing the entire system by the end of the term.

Course Outcomes:
1. Students will demonstrate the use of analog circuit analysis techniques to analyze the operation and behavior of various analog integrated circuits.
2. Students will demonstrate their knowledge by designing analog circuits.
3. Design, simulation, and layout of Analog circuits.

Course Topics:
1. MOS device physics
2. Single stage amplifiers (CS, CG, CD, cascade amp)
3. Differential amplifiers
4. Current mirrors
5. Frequency response of amps and analog circuits
6. Feedback topology
7. Multi-stage Operational Amplifiers
8. Stability and frequency compensation
9. Output Stages, Audio Amp
10. Nonlinearity and mismatch
11. Analog layout

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Topics	Suggested Time
MOS device physics Review	1 week
Single stage amplifiers (CS, CG, CD, Cascode)	2 weeks
Differential Opamp, CM and DM operation, Active load.	1 week
Passive and active current mirrors	1 week
Frequency response for Amps	2 weeks
Feedback	2 week
Stability and frequency compensation	2 weeks
Output Stages	1 week
Operational Amplifiers, Multi-stage Opamp	2 weeks
Exams	1 Week

Computer Usage:
Use Cadence for Simulation Labs and homework problems.

Laboratory Experiments:
There will be weekly project/Lab. The labs will focus on developing a complete analog system. An example of this will be design of analog front-end for audio application, such as iPOD analog-front-end to interface iPOD to the headphone - This project will involve design of amplifier, analog filters, automatic gain control, and audio power amp to interface the iPOD to the headphone. The design, analysis, and simulations will be done using a CAD tool sycg as CADENCE, matlab for filter design and simulation of the system, and layout of Integrated Circuits (IC). Students could also develop the hardware on the board using the hardware lab. All hardware labs work will occur in GWC273 under an open lab system.
Note: For the students enrolled at 591 (graduate students), they will be performing projects and advance labs using the CAD tools.

Labs Topics:
Overall Project goal: development of a complete analog system with amplifier, analog filters, gains stages, feedback, and output stage. The project will be broken up into smaller labs which will involve design of the following blocks:

1. Design and Analysis of Single Stage Amplifier with Passive and Active Load
2. Frequency response of Single Stage Amplifier with Passive and Active Load
3. Current Mirror
4. Differential CMOS Amplifier with Active and Passive Load using Current Mirrors
5. Frequency Response of Differential CMOS Amplifier with Active and Passive Load
6. Design of feedback amplifier
7. Stability, Compensation, and Frequency Analysis of Feedback Amps.
8. (Optional Labs) Output Stage, Filters, Power Amplifiers.

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Course Contribution to Engineering Science and Design:
EEE433 contributes to engineering science through circuit analysis, problem solving, computer solutions, and applications of mathematics, physics, and electronics. Design occurs through weekly design projects as well as a four-week final design project.

Course Relationship to Program Outcomes:
a: Students with Analog/Mixed signal background are highly sought after upon graduation. All the design and computer tool skills taught as applications of math, physics and engineering principles and are used in modern analog/mixed signal industries.
k: Students completing 433 have basic knowledge of analog/mixed signal design. Students have extensive exposure to Cadence circuit analysis in 433. Cadence tools used for layout, simulation and extraction as well as contemporary methods in electronic circuit analysis. Cadence tools will be used in five years; course material geared toward analog electronics expected over next five years. Students are taught problem solving through circuit design, circuit analysis, layout of circuits, extraction of layout parameters, and design analysis.
Furthermore, there exist some contributions to **b** (3 hours of hardware and Cadence simulation required per week, which require students to design and conduct experiments), **c** (students design a complete analog system with amplification, energy blocks, input/output stages to interface with external systems),
e (solving engineering problems related to electronic circuits), **g** (both written and oral reports are required), **i** (literature surveys and develop references outside class for their projects),
j (Industry speakers give presentations on applications of course knowledge).

Person preparing this description and date of preparation: Sayfe Kiaei, K. Tsakalis, Apr. 2009.
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