473mcd2018

Master Course Description for EE-473 (ABET sheet)

Title: Linear Integrated Circuits

Credits: 5

UW Course Catalog Description:

Coordinator: Chris Rudell, Associate Professor, Electrical and Computer Engineering

Goals: To learn the analysis, simulation and synthesis techniques and vocabulary of linear integrated circuits implemented in the two major integrated circuit technologies: BJT and MOS. Given the current industry and research trends, a strong emphasis is placed on MOS circuit design. To achieve expertise and experience in SPICE circuit simulation tools.

Learning Objectives: At the end of this course, students will be able to:

1. *Calculate* large-signal and small-signal parameters for BJT or MOS active devices.
2. *Analyze, simulate and synthesize* single-stage MOS amplifiers.
3. *Analyze, simulate and synthesize* MOS current mirror circuits for DC bias and active-load applications.
4. *Analyze, simulate and synthesize* MOS amplifier frequency responses.
5. *Analyze, simulate and synthesize* MOS operational amplifiers.
6. *Analyze, simulate and synthesize* MOS amplifier output stages.

Textbook:ÝP. Gray, P. Hurst, S. Lewis, and R. Meyer, *Analysis and Design of Analog Integrated Circuits*, 5th Ed., John Wiley & Sons, 2009.

Reference Textbooks:

1. B. Razavi, *RF Microelectronics*, 1st Ed., Prentice Hall, 1998.
2. M. E. Van Valkenburg, *Analog Filter Design*, Oxford University Press, 1982.
3. D. Johns and K. Martin, *Analog Integrated Circuit Design*, John Wiley & Sons, 1997.

Prerequisites by Topic:

1. Continuous-time signal analysis
2. Fourier series and transforms in continuous time
3. Physics, characteristics, applications and analysis of circuits using semiconductor diodes, BJT, and MOS devices
4. Background on small-signal modeling and circuit analysis using BJT and MOS devices
5. Background on low and high frequency analysis of basic linear DC bias and simple gain stages
6. Familiarity with stability considerations and frequency compensation in operational amplifiers

Topics:

1. Large- and small-signal integrated circuit active device models (3 lectures)
2. Single-stage amplifiers (3 lectures)
3. Current mirrors (2 lectures)
4. Frequency response (4 lectures)
5. Operational amplifiers (4 lectures)
6. Output stages (2 lectures)
7. Circuit stability (2 lectures)
8. Feedback analysis and compensation (4 lectures)

Course Structure: The class meets for two lectures a week, each consisting of a 110-minute session. Additionally, the class offers a 50-minute TA- or professor-led discussion session to emphasize course fundamentals and present examples. There are approximately six homework assignments that include small SPICE simulation projects. There are multiple design projects that require SPICE simulation for verification of specifications; the projects include written presentations. There is a written midterm examination and a written final examination.

Computer Resources: The computer simulations (HSPICE, PSPICE, or SPECTRE) can be done on any laptop with VNC installed (or equivalent virtual desktop) and logging into the instructional machines found in the Sieg Hall Linux lab, currently serving as the ECE Department educational machines.

Laboratory Resources: None.

Laboratory Structure: Mainly one project that uses simulation software to design and verify two projects throughout the course:

1. Bias circuit design project on the transistor level.
2. Op amp design with compensation with gain, bandwidth, power, noise and stability as the target specifications.

Grading: 15% Homework, 45% projects, 20% for 2 midterm examinations (10% each), 20% final examination.

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(H)** The vast majority of the lectures, homework and projects deal with the application of circuit theory and control theory to specific linear integrated circuit operation. Large- and small-signal semiconductor device characteristics are included in the formulations. Linear circuit analysis formulations are commonplace throughout the course. The homework and examinations involve solving engineering problems identified by the assignments and exemplified by class discussion. The design projects challenge the students to identify

the issues and formulate their individual solutions. The projects are conducted in teams of two. Since both MOS and BJT technologies offer two major device options, each team member chooses one of the two options. The team submits a written report describing the individual designs and comparing the two alternative implementations.

(2) *An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.* **(L)** The course covers analysis and with emphasis on synthesis of linear integrated circuits, with associated homework and examination problems. To incorporate realistic constraints, a module on integrated circuit process variations and yield is taught.

(3) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions*. **(L)** Students use SPICE to simulate homework problems and to support the design projects.

Prepared By: J. Christophe Rudell

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