EE P 538 Analog Circuits for Sensor Systems
University of Washington Electrical & Computer Engineering
Spring Quarter 2020

Course Syllabus

Lectures: TBD

Instructor: Jason Silver
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Teaching Assistant: TBD
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Required Textbook: P. Horowitz, *The Art of Electronics,* 3rd Ed, Cambridge University Press, 2015.

Additional References: P. Horowitz, *The Art of Electronics: The x Chapters,* 1st Ed, Cambridge University Press, 2020.

R. Jacob Baker, *CMOS: Mixed-Signal Circuit Design,* 2nd Ed, Wiley-IEEE Press, 2008.

Course Description:

In this course we will explore advanced topics in analog and mixed-signal circuit analysis and design, with an emphasis on concepts related to sensor interfacing. We will focus on discrete circuits, i.e. circuits comprising operational amplifiers and passive components such as resistors, capacitors, and inductors, as well as transistors (BJTs and MOSFETS). We will conduct an in-depth treatment on noise (Johnson, shot, flicker), and learn how to design circuits to achieve specific performance targets under realistic design constraints (e.g. power, cost, component availability). We will explore the concept of linearity and how devices with nonlinear characteristics (e.g. transistors, diodes, and opamps) can affect circuit and system performance. We will discuss the advantages (and drawbacks) of using feedback to design precision circuits. We will conduct an overview of data converters (ADCs and DACs) and explore various architectures (Nyquist, oversampling, Delta-Sigma) and their performance limitations (noise, linearity, power, speed).

During the last 4 weeks of the course, students will be assigned a design project in which they will design analog circuits to meet noise, bandwidth, linearity, and power specifications, and verify their designs in LTSpice.

Students should be comfortable with conducting basic linear circuit analysis (Kirchoff's and Ohm's laws, Thevenin/Norton equivalent circuits) on circuits containing resistors, capacitors, inductors, and operational amplifiers. Some understanding of transistor operation and transistor-based circuit analysis will be helpful. Familiarity with mathematical concepts related to engineering (Fourier/Laplace transforms, complex numbers) is essential.

After completing the course, students will have developed the insight and experience essential to the design and evaluation of analog circuits for mixed-signal data acquisition systems.

Weekly assignments will follow the lecture and (somewhat more loosely) the textbook. Supplemental references (typically engineering publications) will be provided as needed. Assignments will involve analysis, SPICE simulation, and a significant design component. Emphasis will be placed on conceptual understanding, "back-of-the-envelope" calculations/analysis, and circuit intuition. The use of MATLAB or other scripting languages (e.g. Python) is encouraged.

A single midterm exam, covering approximately half of the course material, will be administered halfway through the course. The exam will be "take-home," open-book, and open-notes.

Tentative Schedule:

Week	Topic	Reading
1	Foundations, sensor systems	AoE 1
2	Transistors: BJTs and MOSFETs	AoE 2,3
3	Operational Amplifiers	AoE 4
4	Precision Circuits	AoE 5
5	Filters	AoE 6
6	Low-Noise Techniques	AoE 8
7	Voltage Regulators	AoE 9
8	Data Converters	AoE 13
9	Data Converters	AoE 13
10	Digital Interfacing	AoE 12

Design Project:
A design project will be assigned toward the end of the quarter, and will take the place of weekly assignments. The project will involve the design and simulation (using LTSpice) of analog circuits toward written specifications. Students will submit a report detailing their design decisions, analysis, and simulation results.

Grading:
- Weekly Assignments: 40%
- Midterm Exam: 25%
- Design Project: 35%

Please submit your work by the assigned due dates.