EE 538 Analog Circuits for Sensor Systems I

University of Washington Electrical & Computer Engineering

Autumn Quarter 2021

Lectures: Thursdays, 6:00-9:50p, ECE 003 Rushmer Room, Zoom (https://washington.zoom.us/j/93459373099Links to an external site.)

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Background Material:

A. Sedra and K. Smith, *Microelectronic Circuits*, 8th Ed, Oxford University Press, 2019.

Recommended Textbooks:

P. Horowitz, *The Art of Electronics,* 3rd Ed, Cambridge University Press, 2015.

C.D. Motchenbacher and J.A. Connelly, *Low Noise Electronic System Design*, 1st Ed, Wiley-Interscience, 1993.

Additional References:

J. Fraden, *Handbook of Modern Sensors*, 5th Ed, Springer, 2016.

Course Description:

In this course we will explore advanced topics in analog circuit analysis and design, with an emphasis on concepts related to sensor interfacing. We will focus on discrete and opamp-based circuits, i.e. circuits comprising operational amplifiers and passive components such as resistors and capacitors, 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 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 second half 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 highly recommended.

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

Tentative Schedule:

Week	Topic	Sedra/Smith	Horowitz/Hill
1	Signals & Amplifiers, Foundations	Chapter 1	Chapter 1
2	Bipolar Transistors	Chapter 6	Chapter 2
3	MOSFET Transistors	Chapter 5	Chapter 3
4	Operational Amplifiers	Chapter 2	Chapter 4
5	Precision Design	Chapter 2	Chapter 4, 5

6	Noise	lecture notes	Chapter 8
7	Noise	lecture notes	Chapter 8
8	Filters	Chapter 14	Chapter 6
9	Sampling/Quantization	lecture notes	Chapter 13
10	Data Converters	lecture notes	Chapter 13

Assignments:

Weekly assignments will follow the lectures. 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.

Design Project:

A design project will be assigned midway through the quarter. The project will involve the design and simulation (using LTSpice) of analog circuits toward written specifications. Students will be asked to submit weekly to biweekly deliverables that will take the place of weekly assignments. At the end of the course, students will submit a report detailing their design decisions, analysis, and simulation results.

Grading:

- Weekly Assignments: 50%
- Design Project: 50%

Please submit your work by the assigned due dates!