ECE 4930/6930 Course Specific Syllabus Spring 2020

Course Description

ECE 4930/6930 Analog Design with Applications in Music Synthesis: 3 credits (2,2)

An introduction to the use of operational amplifiers and operational transconductance amplifiers in analog circuit design. Other devices introduced may vary each semester. Emphasis will be on ideal devices, although non-ideal characteristics of real devices will be considered, when these limitations are important, and how to design around them. Numerous simple circuits will be analyzed and used as building blocks in more complex systems. Various case studies will illustrate designs for most of the standard modules found in an analog music synthesizer. The lab work will be based on these case studies.
Preq: ECE 3200 and ECE 3300, each with a C or better.

Course Objectives

At the completion of this course, students should be able to:

- Analyze circuits containing operational amplifiers
- Design basic operational amplifier circuits to specifications. This includes, but is not limited to
  - Amplifiers
  - Filters
  - Oscillators
  - Comparators
- Use basic operational amplifier circuits as building blocks to implement more complex functions
- Specify an appropriate operational amplifier for a specific application
- Understand the fundamentals of voltage control using operational transconductance amplifiers
- Understand the basic uses of analog switches and the 555 timer
- Design an analog music synthesizer
- Other objectives will vary from semester to semester, depending on additional topics covered.

Course Meeting Times and Instructor Information

Section	Day	Time	Room	Instructor	Email	Office
TBA	ONLINE			Dr. William Park	parkw@clemson.edu	Edisto Beach, SC (no foolin')
LAB	Tuesdays 2-4		B12 Riggs	Jeff Osterberg	josterb@g.clemson.edu	311 Fluor Daniel

Course Textbooks

- **Operational Amplifiers with Linear Integrated Circuits – 4th Edition ISBN** 9780130320131 **- William D. Stanley**
- **The Musical Engineer's Handbook – Bernard M. Hutchins** (NOTE: Bernie has graciously offered to allow me to distribute an electronic copy of the Musical Engineer's Handbook free to all students enrolled in the course.)

Getting Help

Since this is an online course and I am about 5 hours from campus, I will not have office hours in the usual sense.
If you need my help, you have the following options.

- Post your question(s) in the appropriate discussion forum on CANVAS. (Preferred method.)
- Send me an email.
- If necessary, we can arrange a time to talk via phone or FaceTime or Skype.

I will normally check the discussion boards and my email several times each weekday except on days (typically Wednesday) when I have to make off-island excursions (Charleston) to obtain necessary groceries and other supplies.

Important Course Dates

A full academic calendar is available at this link, but summarized below are the important dates for Spring 2020.

- ⇒ Official first day of class ..... Wednesday, January 8
- ⇒ Last day to add a course ..... Tuesday, January 14
- ⇒ Last day to drop a course without receiving a W on your academic record ..... Wednesday, January 22
- ⇒ **Test 1** ..... **TBA about Feb 18**
- ⇒ Midterm grade deadline ..... Friday, February 28
- ⇒ Last day to drop a course ..... Friday, March 13
- ⇒ Spring Break ..... Week of March 16
- ⇒ **Test 2** ..... **TBA about April 1**
- ⇒ Last day of class ..... Friday, April 24
- ⇒ **Final exam** ..... **TBA Week of April 27**

Grading

Test 1 and 2 (@ 15%)	**30%**
Final Exam	**20%**
Module Completion	**25%**
Laboratory	**25%**

Late Policy

A 25% penalty will be assessed for each module that is not completed by the due date. Modules will not be accepted for credit more than one week late nor after the test covering the material in that module. If there are extenuating circumstances warranting extra time, the professor MUST be informed in a timely manner for approval of an extension.

Return of Graded Work

Modules will hopefully be graded within three days.

Tests will hopefully be graded within one week.

Additional Components for Graduate Credit (6930)

Students enrolled in ECE 6930 will have additional requirements, both in assigned problems and test questions.

Laboratory

The laboratory will be supervised by a Graduate Teaching Assistant and will be on the Clemson main campus. If you are unable to attend the lab each week, you must make arrangements to obtain the necessary equipment wherever you are and complete the labs on your own. THE LECTURE CANNOT BE TAKEN FOR CREDIT WITHOUT THE LAB.

Tentative List of Laboratory Experiments

1. Equipment Familiarization
2. Mixer
3. Noise Source
4. Simple Oscillator: Integrator-Schmitt Trigger
5. Voltage Controlled Amplifier
6. Transient Generators
7. Sample and Hold
8. Voltage Controlled Oscillator
9. Voltage Controlled Filter

Exam Schedule

⇒ Test 1 TBA about Feb 18

⇒ Test 2 TBA about Apr 1

⇒ Final Exam TBA week of April 27

Since I will almost certainly not be in Clemson on test days, there will be a proctor monitoring the exams.

If you require special accommodations on exams, I MUST have a copy of your letter from SDS AT LEAST 2 weeks prior to the first exam. Please scan the letter and email to me (parkw).

The schedule, policies, procedures and assignments in this course are subject to change in the event of extenuating circumstances, by mutual agreement, and / or to ensure better student learning.

TENTATIVE Course Outline

The course is divided into modules. The specific goals of each module are given in CANVAS, along with the chapters covered in the textbook. The topical outline below includes the approximate number of weeks devoted to each module in brackets.

Module 1: OpAmp Basics [1]
- The Ideal OpAmp and Negative Feedback
- Simple Amplifier Circuits

Module 2: More Simple Negative Feedback Circuits [1]
- Summing Amplifier
- Differential Amplifier
- Dependent Sources
- Case Study: Mixer

Module 3: Real (Non-Ideal) Opamps [1.5]
- Non-ideal Characteristics
  - Input Bias Current
  - Input Offset Current
  - Input Offset Voltage
  - Input Impedance
  - Output Impedance
- Real Device Examples
  - 741 family
  - TL07X/TL08X family
- Dealing With Non-Ideal Characteristics
- Slew Rate
- Bandwidth
- Noise
- Case Study: Noise Generator

Module 4: More Basic Circuits [1]
- Instrumentation Amplifier
- Integrators and Differentiators
- Simple Filters
- Simulated Inductor
- Case Study: Simple Bandpass FIlter

Test 1

Module 5: Circuits Without Negative Feedback {1}
- Simple Comparators
- Positive feedback and Hysteresis
- Dealing with noisy signals
- Multilevel Comparators
- A Simple Oscillator
- Case Study: Low Frequency Oscillator

Module 6: Operational Transconductance Amplifiers [1.5]
- Basic concepts
- Controlling circuit parameters with a voltage
- Voltage Controlled Amplifier (VCA)
- Case Study: Voltage Controlled Amplifier

Module 7: Basic Oscillators [1]

- Astable Multivibrator
- Wien Bridge
- Phase Shift
- Case Study: A Simple Voltage Controlled Oscillator

Module 68: Analog Switches and 555 Timer [1]

- Analog Switches
- The 555 timer as a monostable
- The 555 timer as an astable multivibrator
- Case Study: ADSR Transient Generator

Test 2

Module 9: OpAmp Circuits Using Discrete Semiconductors [1.5]

- Diode Circuits
  - Precision Diode
  - Peak Detectors
- Transistor Circuits
  - Current Sources
  - Exponential and Logarithmic Converters
  - Increasing Output Power
  - Sample and Hold
- Case Study: Sample and Hold

Module 10: Filters [1]

- Filter Classification
- Design Procedures
- Voltage Controlled Filters
- Case Study: VCF with 1 V/Octave response

Module 11: Voltage Controlled Oscillators [1.5]

- Choosing a basic oscillator for voltage control
- Exponential Converters Revisited
- Temperature Compensation
- Case Study: VCO with 1 V/Octave response

Final Exam