

ECE 402L

APPLICATIONS OF ANALOG INTEGRATED CIRCUITS

SPRING 2009

Week of	Topic
Jan. 12	No labs meet this week
Jan. 19	Course introduction & lab safety
Jan. 26	Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter *
Feb. 2	Lab II: DJ Mixer - Crossfader, Mic Preamp & Power Amplifier
Feb. 9	Lab III: DJ Mixer - RIAA Playback Equalizer
Feb. 16	Lab IV: DJ Mixer - Bass and Treble Tone Controls
Feb. 23	Lab V: DJ Mixer - Audio Spectrum Filters for a Color Organ
Mar. 2	Lab VI : Designing a Stabilizer for a Differentiator Circuit
Mar. 9 & 16	No labs meet this week
Mar. 23	Lab VII: PSpice Macromodeling an Op-Amp
Mar. 30	Lab VIII: Crossing Detectors
Apr. 6	Lab IX: DJ Mixer - Color Organ
Apr. 12	Lab X: Photo-Tachometer
Apr. 20	Lab XI: DJ Mixer - 40 Watt Power Amplifier
Apr. 27	Lab Evaluation

* All lab lectures are video recorded and can be found on the ECE 402 home page at: <http://www.egr.msu.edu/~wierzba>

ECE 402L: APPLICATIONS OF ANALOG INTEGRATED CIRCUITS

MATERIALS: G.M. Wierzba, *ECE 402 Course e-Notes and Lab Manual, Spring 2009 Edition*, available at <http://stores.lulu.com/willowepublishing>

Safety Glasses

GRADING: LAB REPORTS* 100%

* Your lab report grade consists of 60 points maximum.

OVERVIEW: Your teaching assistant will also give a weekly quiz on the lab you are about to perform including the lab lecture material. This will count for 10 points of the maximum 60 points.

This lab is intended to teach design as well as reinforce concepts taught in ECE 402. You will need for many labs to come with a completed design along with a SPICE simulation. In general these pre-labs are to be handed in at the beginning of lab and will constitute part of your lab grade. You should make an extra copy for use during lab.

As you complete each task in lab you should record, calculate and evaluate your data. Using your pre-lab as an aid you should be able to detect errors in your design.

POLICIES: Any copying of pre-lab reports or lab data from another group will result in a failing grade.

If you miss more than two labs you will receive a failing grade. There are no make up labs except for job interviews or plant trips. If you are seriously ill you must contact your lab instructor before you miss lab.

Since everyone in lab is trying to complete their work during lab you are not allowed to ask other lab groups for help. The lab instructor will try to help you but you are responsible for your own work.

TARDINESS: Lab needs to start on time. Your lab instructor will take attendance at the start of lab. Your lab report grade will be multiplied by 0.9 if you are tardy from 1 to 10 min., by 0.85 if you are tardy from 11 to 30 min. *If you are late more than 30 min you will not be allow to enter lab.*

Electrical Safety Considerations for ECE 402 Lab

G. M. Wierzba

Safety glasses are required. Minimally prescription glasses are ok but full wrap around glasses are preferred. If you fail to wear safety glasses or come to lab without a pair of safety glasses, you will be asked to leave. You can purchase another pair at the bookstore and return to lab but the penalty for tardiness described on the previous page will apply.

The equipment used in ECE 402 Lab is primarily low voltage. There is no danger associated with this equipment. Whenever specialized equipment is used that does pose a danger you will be notified.

In some lab experiments we are going to use polarized electrolytic capacitors. These elements must at all times have a positive voltage across their terminals with respect to an indicated polarity. Failure to do so can result in the component overheating which could cause severe burns.

We will also be cutting and stripping wires in most labs. This sometimes causes pieces of wire or plastic to fly through the air. This and the danger from capacitors is why we need safety glasses at all times.

EXPERIMENT DETAILS

1. **TITLE:** Lab I - Introduction to the Oscilloscope, Function Generator and Digital Multimeter

PURPOSE:

The oscilloscope, function generator and digital multimeter are the basic tools in the measurement and testing of circuits. This lab reviews the operation of these instruments along with the use of a compensated probe.

2. **TITLE:** Lab II - DJ Mixer - Crossfader, Microphone Preamp & Power Amp

PURPOSE:

Over the next several labs we are going to build a DJ Mixer. This is an instrument that allows simultaneous access to several sources of sound.

A crossfader is a circuit which allows two sources of sound to be mixed together. Using a single pot we can select more from one source of sound while having less from the second source of sound. This is used to fade from one song to another while both are being played.

In this lab, you build a crossfader for your DJ Mixer to mix a CD player output with a phonograph output (which will be built in the following lab). We will also add a microphone amplifier with noise cancellation to allow the DJ to address the audience.

3. **TITLE:** Lab III - DJ Mixer - RIAA Playback Equalizer

PURPOSE:

With this lab we are going to add to our DJ Mixer an input for a phonograph record.

Phonograph playback preamplifiers require special frequency shaping circuits in their feedback paths in order to equalize or correct for the signal coming off the phonograph cartridge.

In this lab, you will design an RIAA Phonograph Playback Equalizer to undo the recording process. This will then be connected to one of the inputs of the crossfader of Lab II.

4. **TITLE:** Lab IV - DJ Mixer - Bass and Treble Tone Controls

PURPOSE:

Adding bass and treble controls to our mixer will allow us to match the sound to the room acoustics and personal preferences.

In the course notes of Ch. 2, pp 24 - 32, we approached the design of bass and treble control circuits from scratch. That is, we started with the specifications of our

circuit and then began putting configurations of components together that could realize these specifications.

In this lab, you will reconsider the design of the bass and treble tone control circuit we did in class. You will also consider lowering the cost of the design by trying to combine functional blocks.

5. TITLE: Lab V - DJ Mixer - Audio Spectrum Filters for a Color Organ

PURPOSE:

A color organ is a system which causes a set of lights to change dynamically with music tones and levels. It consists of four active filters which divide the audio spectrum into distinct color bands. Each band triggers a set of lights which in our design will be red, yellow, green and blue LEDs. In commercial designs these are sometimes flood lights.

In this lab, you will design the active filters for the color organ and add this to our DJ Mixer. In a later lab, we will add the comparators and LEDs.

6. TITLE: Lab VI - Designing a Stabilizer for a Differentiator Circuit

PURPOSE:

Stability is considered by many to be one of the most common problems in getting a design to work. In this lab you will investigate the properties of a differentiator circuit, i.e. a circuit whose output is the derivative of the input times a scalar. This circuit suffers from excessive ringing.

Your main design task is to modify the differentiator circuit to eliminate the ringing while maintaining function.

7. TITLE: Lab VII - PSpice Macromodeling of an Op-Amp

PURPOSE:

Macromodels attempt to capture the linear and nonlinear performance of an IC using a much simplified equivalent circuit of the IC. Macromodeling is an area of virtual design where Spice components are the parts and the design task is to re-create reality.

Your tasks are to measure some of the parameters needed for the PSpice macromodel of an op-amp.

8. TITLE: Lab VIII - Crossing Detectors

PURPOSE:

Comparators are high speed switching circuits which compare two inputs and produces an output state high or low. One advantage of a comparator is that it requires

a very small drive current.

Your tasks are to test and measure some of parameters of crossing detectors and crossing detectors with hysteresis. You will also be asked to design a detector in a noisy environment.

9. TITLE: Lab IX - DJ Mixer - Color Organ

PURPOSE:

A color organ is a system which causes a set of lights to change dynamically with music tones and levels. It consists of four active filters which divide the audio spectrum into distinct color bands. Each band triggers a set of lights which in our design will be red, yellow, green and orange LEDs. In commercial designs these are sometimes flood lights.

In this lab, you will build the comparator and LED circuit for the color organ and add this to the audio spectrum filters on our DJ Mixer.

10. TITLE: Lab X - Photo-tachometer

PURPOSE:

Measuring the rotations per minute of a shaft is a common measurement problem. Flashing a constant light source on a shaft will produce a light pattern proportional to the frequency of rotation.

In this lab you will design a photo-tachometer which will take the a pulsing light source and convert it to an average value proportional to frequency of the pulses. Issues of noise and interference will be addressed.

11. TITLE: Lab XI - DJ-Mixer - 40 Watt Power Amplifier

PURPOSE:

A current power booster is added to the basic 2 Watt power amplifier used previously in the DJ-Mixer. Heat sinks are used to handle the added power dissipation.

Feedback is again used to lower distortion. However, the added transistors cause the open-loop gain of the power amplifier to have a poor phase margin. Using β networks, you will design a compensation scheme to make the power amplifier stable.