ECE 203

ELECTRIC CIRCUITS AND SYSTEMS LABORATORY

SPRING 2020

Week of	Topic
Jan. 6	No labs meet this week
Jan. 13	Course introduction & lab safety
Jan. 20	No labs meet this week
Jan. 27	Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter *
Feb. 3	Lab II: Thevenin Resistance
Feb. 10	Lab III: Wheatstone Bridge Applications
Feb. 17	Lab IV: Inverting and Noninverting Amplifiers
Feb. 24	Lab V: Microphone Amplifier
Mar. 2	No labs meet this week
Mar. 9	Lab VI: Noise Canceling Headphones
Mar. 16	Lab VI: Noise Canceling Headphones (continued)
Mar. 23	Lab VII: Active Band-Pass Filter Lab VIII Parts' List must be emailed to your instructor 1 day before your next lab meeting.
Mar. 30	Lab VIII: Room Equalizer Design
Apr. 6	Lab VIII: Room Equalizer Design (continued) Lab VII Pspice exercise due at the start of lab
Apr. 13	Bench Exam - canceled
Apr. 20	**A Lab Exam will be given on Monday April 20th during your ECE 202 class time.** You should bring a pencil and ruler. *You will **NOT** be allowed to use a calculator for this exam.*
Apr. 20	Do lab course evaluations (worth 30 lab points)

* All lab lectures are video recorded and can be found on the ECE 203 YouTube channel at: https://www.youtube.com/user/ECE203msu

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ELECTRIC CIRCUITS AND SYSTEMS LABORATORY

MATERIALS: G.M. Wierzba, *ECE 203 Lab Manual and e-Notes*, *Spring 2020 Edition*, (free for all registered students)

PREREQ: ECE 202 or concurrently

GRADING:

LAB REPORTS*	60%
BENCH EXAM**	Pass/Fail
EXAM (M 4/20 in your ECE 202 classroom)	40%

* Your lab report grade consists of 60 points maximum. Your total lab report grade is multiplied by a scale factor at the end of the course such that all sections have the same average grade.
** *You must pass the bench exam to pass the course.*

OVERVIEW: Your project consultant 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.

It is very important that you are currently enrolled in ECE 202 while you are taking ECE 203. If you drop 202 you must also drop ECE 203.

This lab is intended to teach measurement techniques as well as reinforcing concepts taught in ECE 201 and ECE 202. As you complete each task in lab you will be asked to record, calculate and evaluate your data. You cannot go on to the next step or circuit unless each task is completed as stated in the lab experiment. This method emphasizes accuracy over speed. Your lab report is due at the **end of the period**. Your project consultant will return your graded lab at the beginning of the next lab period. If you come to lab unprepared you will probably be unable to finish all of the tasks in each lab. You must read the lab thoroughly before you come to lab and review past labs for measurement procedures.

POLICIES: Any copying of lab data from another group or section 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. If you are seriously ill you must contact your project consultant before you miss lab.

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

TARDINESS: Lab needs to start on time. Your project consultant 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 allowed to enter lab.*

Electrical Safety Considerations for ECE 203

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 203 Lab is primarily low voltage. There is no danger associated with this equipment when used as instructed. Care should always be taken not to touch the prongs of an electrical plug when inserting or removing it from an electrical outlet.

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. In such experiments warning boxes are placed in the experimental procedure and your project consultant will be required to check your wiring before you proceed.

We will 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.

Lastly, the ECE department does not allow any food or drink in any of the experimental labs at any time. This is for your safety. ***Anyone who brings food or drink into lab will be asked to leave the food or drink in the hallway outside of lab. If the student refuses they will receive a lab grade of zero for that lab.***

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 introduces the first time operation of these instruments.

The concepts covered are:
1. the resistor color code;
2. accuracy of components and the digital multimeter.

The laboratory techniques covered are:
1. voltage amplitude and time measurement with an oscilloscope;
2. measurement of resistors;
3. measurement of resistance using a 4-wire probe

2. **TITLE:** Lab II - Thevenin Resistance

PURPOSE: This lab looks at techniques for measuring a Thevenin resistance. It also introduces the use of a Proto-Board for the quick assembly of a circuit without the need to solder wires.

The concepts covered are:
1. accuracy of the Infiniium;
2. measuring source resistance in linear circuits;
3. poles and throws of switches;
4. battery performance and characterization;
5. microphone characterization.

The laboratory techniques covered are:
1. using the Infiniium's Toolbar to measure peak-to-peak voltages;
2. re-programming the function generator's calibration for High Impedance loads;
3. measuring DC voltage with a digital multimeter.

3. **TITLE:** Lab III - Wheatstone Bridge Applications

PURPOSE: The Wheatstone Bridge has a very unique cancellation property. This lab looks at some of the properties of the Wheatstone Bridge and one application in the use of a compensated scope probe.

The concepts covered are:
1. Wheatstone Bridge with resistive and reactive components;
2. the use of a balanced bridge to compensate for the stray capacitance of a measuring cable and the equivalent impedance of the oscilloscope;
3. capacitor coding.

The laboratory techniques covered are:
1. use of an LCR meter to measure resistance and capacitance;
2. measurement of resistance and capacitance with a Wheatstone Bridge;
3. a procedure for compensating an oscilloscope probe.

4. **TITLE:** Lab IV - Inverting and Noninverting Amplifiers

PURPOSE: The operational amplifier is a basic building block used in many electronic circuits.

The concepts covered are:
1. accuracy of components and instruments;
2. the properties of the ideal operational amplifier;
3. inverting and noninverting amplification.

The laboratory techniques covered are:
1. the measurement of true RMS voltage using a digital multimeter;
2. the use of the dual trace feature of an oscilloscope for measuring gain and phase of an amplifier.

5. **TITLE:** Lab V - Microphone Amplifier

PURPOSE: Long wires in electronic circuits cause problems. In power supply connections they can cause oscillations on the wires to our integrated circuits. In microphones they pick up unwanted signals that also get amplified. We will look how to address these problems in this lab.

The concepts covered are:
1. differential amplification;
2. power supply stability;
3. common-mode noise cancellation;
4. power boosting stage for an op-amp.

The laboratory techniques covered are:
1. measuring RMS voltage with the oscilloscope;
2. one shot triggering.

6. **TITLE:** Lab VI - Noise Canceling / Eavesdropping Headphones

PURPOSE: The popularity of very small portable music players is evident as you walk around campus. A real problem and danger is that the listener may attempt to cancel background noise by increasing the volume of the music. Besides making the user less aware of their surrounding, high sound levels over time can damage hearing.

The nature of the problem is that your ear is picking up two sources of sound, the music and the background noise. To cancel the background noise, all we would need to do is to sense it and create the same amplitude but the opposite sign. This would mean adding a microphone to each of our headphones. By adding the noise with an opposite sign to the music from our player, we can let our ear drum add these two sounds to the background noise. The net result ideally is a cancellation of the background noise but not the music.

In this lab, you will build a circuit to cancel background noise without increasing the volume of the music. We will investigate which types of background noise we can cancel and we will modify the circuitry to turn the noise canceling headphones into eavesdropping headphones.

The concepts covered are:

1. bandwidth limiting to reduce noise;
2. using low noise op-amps to reduce noise;
3. using ganged pots to vary two gains simultaneously;
4. using a double-pole-double-pole (DPDT) switch to change the noise canceling headphones into eavesdropping headphones;
5. dispelling myths about noise canceling headphones through testing.

7. **TITLE:** Lab VII - Active Band-Pass Filter

PURPOSE: Active filters are used extensively in audio preamplifier circuits and test instruments. Active filters consist of resistors, capacitors and op-amps and can realize filter functions similar to that of circuits using resistors, capacitors and inductors.

The concepts covered are:

1. multiple loop feedback filters;
2. developing a design procedure for component selection;
3. using a Fourier series to model a periodic wave form;
4. the effects of capacitor quality factor on filter response.

The laboratory techniques covered are:

1. using the x-y feature of the scope to display a Lissajous pattern for tuning;
2. measuring the quality factor of a capacitor using an LCR meter.

8. **TITLE:** Lab VIII - Room Equalizer Design

PURPOSE: Furniture, drapes, walls and rugs cause amplitude and phase distortion when playing music in a confined space. Some tones are suppressed and some tones are enhanced by the room acoustics. One way to compensate for this is to amplify or attenuate the frequencies that are affected, respectively. This is done by dividing up the audio band (20 Hz to 20 kHz) into smaller bands which can be amplified, attenuated or just passed. We will do this with three band-pass active filters. By summing the results we can then put the audio band back together with the compensated music and play this through a power amplifier.

In lab, we have one high quality speaker per lab bench so to play a stereo source of sound we need to add the two channels creating a monaural source of sound.

The concepts covered are:

1. designing a stereo-to-monaural converter;
2. determining design constraints and component selection for the band-pass filters of the equalizer;
3. designing a variable summer.