

ECE 303 - Sec 001, 004, 005

ELECTRONICS LABORATORY

FALL 2019

Week of	Topic
Aug. 26	No labs meet this week
Sept. 2	Course introduction & lab safety Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter *
Sept. 9	Lab II: Operational Amplifiers
Sept. 16	Lab III: Diode Curve Tracer and Digital Thermometer
Sept. 23	Lab does meet this week
Sept. 30	Lab IV: A Single and Dual Power Supply
Oct. 7	Lab V: A Sound-Level Booster for a Smoke Alarm
Oct. 14	Lab VI : SPICE Modeling and Simulation
Oct. 21	Lab VII: Low Distortion Sinusoidal Oscillators
Oct. 28	Lab VIII: Light Activated Exhaust Fan
Nov. 4	Lab IX: Touch Activated Alarm Lab VII Pspice exercise due at the start of lab
Nov. 11	Lab X: AM Optical Transceiver
Nov. 18	Lab XI: Dorm Entertainment System
Nov. 25	A Lab Exam on Labs I - X will be given on Monday Nov. 25th in your ECE 302 classroom. You should bring an approved calculator, pencil and ruler. You will not be allowed to use an unapproved calculator or share calculators.
Nov. 25	No labs meet this week
Dec. 2	Do lab course evaluations (worth 30 lab points)

* All lab lectures are video recorded and can be found on the ECE 303 YouTube channel at: <https://www.youtube.com/user/ECE303msu>

ECE 303 - Sec 002, 006, 007

ELECTRONICS LABORATORY

FALL 2019

Week of	Topic
Aug. 26	No labs meet this week
Sept. 2	Course introduction & lab safety
Sept. 9	Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter *
Sept. 16	Lab II: Operational Amplifiers
Sept. 23	Lab III: Diode Curve Tracer and Digital Thermometer
Sept. 30	Lab IV: A Single and Dual Power Supply
Oct. 7	Lab V: A Sound-Level Booster for a Smoke Alarm
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Nov. 25	No labs meet this week
Dec. 2	Do lab course evaluations (worth 30 lab points)

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ECE 303 - Sec 003

ELECTRONICS LABORATORY

FALL 2019

Monday	Topic
Aug. 26	No lab this week
Sept. 2	No lab this week
Sept. 9	Course introduction & lab safety
Sept. 16	Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter *
Sept. 23	Lab II: Operational Amplifiers
Sept. 30	Lab III: Diode Curve Tracer and Digital Thermometer
Oct. 7	Lab IV: A Single and Dual Power Supply
Oct. 14	Lab V: A Sound-Level Booster for a Smoke Alarm
Oct. 21	Lab VI : SPICE Modeling and Simulation
Oct. 28	Lab VII: Low Distortion Sinusoidal Oscillators
Nov. 4	Lab VIII: Light Activated Exhaust Fan
Nov. 11	Lab IX: Touch Activated Alarm Lab VII Pspice exercise due at the start of lab
Nov. 18	Lab X: AM Optical Transceiver
Nov. 25	A Lab Exam on Labs I - X will be given on Monday Nov. 25th in your ECE 302 classroom. You should bring an approved calculator, pencil and ruler. You will not be allowed to use an unapproved calculator or share calculators.
Nov. 25	Lab XI: Dorm Entertainment System
Dec. 2	Do lab course evaluations (worth 30 lab points)

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ECE 303

ELECTRONICS LABORATORY

MATERIALS: G.M. Wierzba, *ECE 303 Lab Manual and e-Notes, Fall 2019 Edition*, (free for all registered students)

PRE- & CO-REQ: ECE 202 & ECE 280, ECE 302

GRADING: LAB REPORTS* 60%
EXAM (M 11/25 in your ECE 302 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 lab report grade.

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.

It is very important that you are currently enrolled in ECE 302 while you are taking ECE 303. If you drop ECE 302 you must also drop ECE 303.

This lab is intended to teach measurement techniques as well as reinforcing concepts taught in ECE 203 and ECE 302. 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 lab instructor 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 may 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 lab instructor 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 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 allowed to enter lab.*

Electrical Safety Considerations for ECE 303 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 303 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 lab instructor will be required to check your wiring before you proceed.

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.

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 along with the use of a compensated probe.

The concepts covered are:

1. equivalent circuits of the oscilloscope inputs, function generator output and digital multimeter inputs;
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. accuracy of components and instruments.

The laboratory techniques covered are:

1. voltage amplitude and time measurement with an oscilloscope;
2. a procedure for compensating an oscilloscope probe;
3. measurement of resistance including small values.

2. **TITLE:** Lab II - Introduction to Prototyping Electronic Circuits

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.

3. **TITLE:** Lab III - A Diode Curve Tracer and Digital Thermometer

PURPOSE: An instrument that displays the $V-I$ characteristics of a semiconductor is called a curve tracer. Our scope can be used to make such an instrument. Diodes are very temperature dependent in their $V-I$ characteristics. Although this usually causes problems in designs where large temperature swings occur, we can use this dependence on temperature to make a thermometer.

The concepts covered are:

1. $V-I$ characteristics of various types of diodes ;
2. designing a diode curve tracer using inverting amplifiers;
3. the Shockley equation for characterizing a diode;
4. the temperature dependence of diodes;
5. designing a digital readout thermometer using a diode sensor.

The laboratory techniques covered are:

1. using the Infinium's math function key to plot voltage transfer curves;

2. using the Infinium's Marker feature to measure points on a curve.

4. **TITLE:** Lab IV - A Single and Dual Power Supply

PURPOSE: Full-wave rectifiers are used to turn an ac voltage with an average voltage of zero into a voltage with a non-zero average value. Adding a large capacitor results in a fairly constant voltage with a small ac ripple voltage. The ripple can be greatly reduced with a Zener diode shunt regulator. By moving the ground and splitting the output voltage, we can make a dual complementary power supply, that is, $+V_{DC}$ and $-V_{DC}$.

The concepts covered are:

1. transformer turns ratio relationships
2. full-wave rectification;
3. full-wave rectification with capacitive smoothing;
4. ripple voltage estimation;
5. Zener diode shunt regulators;
6. creating complementary voltages by redefining ground.

The laboratory techniques covered are:

1. using the Infinium's Toolbar to measure average voltages, peak voltages, peak-to-peak voltages and frequency;
2. measuring capacitance with an LCR meter;
3. using the Infinium's Math Functions to differentiate a capacitor voltage to estimate maximum repetitive diode current.

5. **TITLE:** Lab V - A Sound-Level Booster for a Smoke Alarm

PURPOSE: Transformers can be used to step up an ac voltage but do not work for a dc voltage. A method for stepping up a dc voltage is presented using an astable oscillator and a voltage multiplier circuit. These circuits convert a dc source to an ac source and then back to a dc source and are usually referred to as dc-to-dc converters.

A voltage tripler is designed in this lab to increase the voltage of a 4 cell battery pack. This larger voltage is then used to power an alarm. As with most audio devices, more voltage results in more volume.

The concepts covered are:

1. astable operation of a 555 IC timer;
2. positive and negative clamping circuits;
3. positive and negative peak detectors;
4. designing dc-to-dc converters.

The laboratory techniques covered are:

1. using an external trigger to synchronize many waveforms with one reference signal.

6. **TITLE:** Lab VI - SPICE Modeling and Simulation

PURPOSE: PSpice is a general purpose circuit simulation program for dc, transient and phasor analyses. This allows the circuit designer to effectively build a circuit on a computer "Proto-Board," view the response of the circuit under a wide variety of test conditions and make design changes before touching the first piece of hardware.

The concepts covered are:

1. SPICE coding of schematics;
2. Transient and DC analyses;
3. SPICE model for a diode.

The laboratory techniques covered are:

1. Running PSpice;
2. Obtaining a hard copy of output;
3. Using cursor control to read data points.

7. **TITLE:** Lab VII - Low Distortion Sinusoidal Oscillators for use in Audio Test Equipment

PURPOSE: Audio amplifiers need to produce true replicas of their inputs over the audio band of frequencies. Testing audio amplifiers for distortion requires a sinusoidal source of exceptional purity. Our lab function generator has a diode shaping circuit which forms a sine wave from a triangle wave. This technique is capable of generating very low frequency sinusoids but unfortunately not with low distortion. We will look at another method for generating sinusoids which does result in low distortion over the audio band of frequencies.

The concepts covered are:

1. modeling of the inverting and non-inverting amplifiers;
2. determining conditions for sinusoidal oscillation;
3. Phase Shift and Wien Bridge oscillator circuits;
4. automatic gain control for oscillator stabilization.

The laboratory techniques covered are:

1. capacitance dissipation factor measurement with an LCR meter;
2. measuring phase shift using the dual trace feature of an oscilloscope.

8. **TITLE:** Lab VIII - A Light Activated Exhaust Fan

PURPOSE: One use of bipolar junction transistors (BJTs) is to switch circuits on and off. Switching various loads on or off can cause problems especially when the load is inductive. Sometimes the load contains a large amount of energy and isolating this from the control circuitry is very important especially in the case of a component failure. Sensors play a role in many electronic circuits. In this lab we will use a light sensitive resistor to sense a smoke filled room and turn on an exhaust fan. When the room is again clear of smoke it will turn off the fan. This type of photo-resistor is also used in auto-focus cameras, street lamp switches and contrast controls for TVs.

The concepts covered are:

1. the bipolar logic inverter;
2. switching resistive, capacitive and inductive loads;
3. using a damping diode to discharge a coil;
4. using a relay for load isolation;
5. using a photo-resistor as a sensor;
6. using a magnet to activate a circuit.

The laboratory techniques covered are:

1. Using a x10 probe to measure a BJT's breakdown voltage;
2. Using the Infinium's Marker feature to measure the difference of two points on a trace.

9. **TITLE:** Lab IX - A Touch Activated Alarm

PURPOSE: Mechanical switches over extended use wear out. A touch switch has no moving parts and ideally has an unlimited life. There are many techniques for designing touch activated switches. This lab will use the fact that your body resistance, although on the order of hundreds of kilohms, can create a small base current which in turn can saturate a BJT.

The concepts covered are:

1. using body resistance to activate a BJT inverter;
2. using feedback to latch a circuit.

10. **TITLE:** Lab X - An Amplitude Modulated Optical Transmitter and Receiver.

PURPOSE: Op-amps, like most amplifiers, have a limitation of a maximum gain times bandwidth, called the gain-bandwidth-product (GBP). For a 741 op-amp this is 1MHz, that is, to have a gain of 5000 means that the largest useable frequency is $1\text{M}/5000$ or 200 Hz. Bipolar transistors (BJTs) have GBPs around 100MHz. This lab will investigate using BJTs to design a high-gain wide-bandwidth microphone pre-amplifier. An LED is then used as a load so that the amplitude of our voice modulates the current in the LED. A photo-transistor receives this transmitted signal as a base current consisting of a constant light level plus a time-varying light level. The constant (dc) level is blocked and the time varying level is amplified with a power amplifier.

The concepts covered are:

1. dc analysis of BJTs and a photo-transistor
2. ac models for BJTs and a photo-transistor
3. ac analysis of a multistage and optical amplifier

Laboratory techniques covered are:

1. measuring -3dB bandwidth

11. **TITLE:** Lab XI - Designing a Dorm Entertainment System: MP3 Player Power Amplifier, PA System, Karaoke Machine and AM Radio

PURPOSE: Most students have a portable MP3 player or Smart Phone. Docking this portable player into an entertainment system would be desirable for many students. The design criteria for this project are considering that our target consumer is living in a limited space environment and is on a even more limited budget.

The concepts covered are:

1. current limit of an op-amp
2. complementary Class B power amplifier
3. crossover distortion
4. mixing
5. parallel resonance
6. amplitude modulation and detection

Laboratory techniques covered are:

1. measuring efficiency