

ECE 404L

RADIO FREQUENCY ELECTRONICS LAB

FALL 2019

Week of	Topic
Aug. 26	No labs meet this week
Sept. 2	Lab I: Introduction to the Oscilloscope, Function Generator and Digital Multimeter (Start Lab II)
Sept. 9	Lab II: AM/FM Radio - Audio Amplifier
Sept. 16	Lab II: AM/FM Radio - Audio Amplifier (continued)
Sept. 23	Lab III: AM/FM Radio - AM Radio
Sept. 30	Lab III: AM/FM Radio - AM Radio (continued)
Oct. 7	Lab IV: AM/FM Radio - FM Radio
Oct. 14	Lab IV: AM/FM Radio - FM Radio (continued)
Oct. 21	Lab V: RF Test Equipment and Applications
Oct. 28	Lab VI: Measurement of Passive Elements Using a Network Analyzer
Nov. 4	Lab VII: Introduction to Ansoft Designer
Nov. 11	Lab VIII: Filters and Impedance Matching
Nov. 18	Lab VIII: Filters and Impedance Matching (continued) (Lab course evaluation)
Nov. 25	No labs meet this week
Dec. 2	Lab IX: AM Voice Transmitter

* All lab lectures are video recorded and can be found on the ECE 404 home page at: <https://www.youtube.com/user/ECE404Lmsu>

ECE 404L

RADIO FREQUENCY ELECTRONICS LAB

MATERIALS: G.M. Wierzba, *ECE 404 Course e-Notes and Lab Manual, Fall 2019 Edition*, (free for all registered students)

Safety Glasses

GRADING: LAB REPORTS* 100%
(1/4)

**You must pass the lab to pass the course.*

OVERVIEW: Your lab instructor will give a quiz per experiment on the lab procedure you are about to perform and on the lab lecture video associated with that lab. This will count for 10 points of the maximum 60 points.

This lab is intended to teach measurement techniques as well as reinforcing concepts taught in ECE 404. 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 as indicated in the lab manual. 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. Your grade will be computed by dropping your lowest Lab Report grade.

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 404 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 a penalty for tardiness* will apply.

The equipment used in ECE 404 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 soldering in this lab. 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.***

*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.*

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 - AM/FM Radio - Audio Amplifier

PURPOSE:

Over the next few labs we are going to build an AM/FM radio. This lab will focus on soldering and testing of the Audio Amplifier portion of the radio.

The concepts covered are:

1. IC power amps
2. dc and ac models for bipolar transistors;
3. class AB complementary Darlington pair amplifier;
4. small-signal bandwidth;
5. efficiency.

The laboratory techniques covered are:

1. soldering;
2. troubleshooting by doing static measurements with a digital multimeter;
3. measuring gain and bandwidth with a scope;
4. measuring efficiency.

3. **TITLE:** Lab III - AM/FM Radio - AM Radio

PURPOSE:

This lab will focus on soldering and testing of the AM portion of the radio.

The concepts covered are:

1. amplitude modulation (AM);
2. superhetrodyne receiver;
3. AM detector and automatic gain control (AGC);
4. Intermediate Frequency (IF) transformers;
5. IF amplifiers;
6. AM oscillator and mixer.

The laboratory techniques covered are:

1. using the AM feature on the function generator;
2. troubleshooting by doing static measurements with a digital multimeter;

3. measuring gain, bandwidth and quality factor with a scope;
4. tuning.

4. TITLE: Lab IV - AM/FM Radio - FM Radio

PURPOSE:

This lab will focus on soldering and testing of the FM portion of the radio.

The concepts covered are:

1. frequency modulation (FM);
2. superhetrodyne receiver;
3. FM ratio detector and automatic frequency control (AFC);
4. Intermediate Frequency (IF) transformers;
5. IF amplifiers;
6. FM oscillator and mixer.

The laboratory techniques covered are:

1. using the FM feature on the function generator;
2. troubleshooting by doing static measurements with a digital multimeter;
3. measuring gain, bandwidth and quality factor with a scope;
4. tuning.

5. TITLE: Lab V - Radio Frequency Test Equipment and Applications

PURPOSE:

There have been many types of test equipment developed for high frequency applications. In this lab some of the more common RF test equipment are the spectrum analyzer and signal generator. The spectrum analyzer allows for the searching of sinusoidal signals at very high frequencies and very low power levels. The signal generator can create high frequency signals used to test other RF equipment.

Most RF signals are at very small power levels, so noise plays a large roll in any measurement done in an RF lab. This lab will focus on the common issues that appear when trying to measure radio frequencies. After a few of the equipment concepts are covered, the spectrum analyzer and signal generator are used to tune a Motorola pager receiver.

The concepts covered are:

1. amplitude modulation;
2. superhetrodyne receiver;
3. equivalent circuits of the spectrum analyzer inputs and function generator outputs;
4. noise temperature and noise floor.

The laboratory techniques covered are:

1. operation of a signal generator;
2. operation of a spectrum analyzer.

6. TITLE: Lab VI - Measurement of Passive Elements Using a Network Analyzer

PURPOSE:

Spectrum analyzers allow visualization of only the magnitude of RF signals. The network analyzer gives both magnitude and phase information. With the network analyzer, RF components can be measured at very high frequencies.

Resistors, capacitors and inductors have limitations at high frequencies. Models of these elements, in reality, are made up of all three elements which will resonate. With the network analyzer, this resonant frequency can be found and the upper useable frequency of any component can be identified.

The concepts covered are:

1. Phase plane adjustments;
2. Equivalent circuit of a resistor;
3. Equivalent circuit of a capacitor;
4. Equivalent circuit of an inductor;
5. Formula for winding an inductor.

The laboratory techniques covered are:

1. Calibrating the network analyzer;
2. De-embedding the test fixture;
3. Measuring the reflection coefficient;
4. Extracting impedance versus frequency.

7. TITLE: Lab VII - Introduction to Ansoft Designer

PURPOSE:

Ansoft Designer is a suite of design tools that fully integrate high-frequency, physics-based electromagnetic simulation, modeling, and automation into an environment for circuit and system analysis.

As with any robust software package, it is best to start with known examples and re-create these in simulation. In this way we can see how our existing knowledge meshes with the tools developed. It can also clear up misconceptions.

The concepts covered are:

1. first time use of Designer;
2. schematic creation and parameter adjustment;
3. creating and editing graphs.

The examples covered are:

1. Lab VI network analyzer plots;
2. Input impedance of a coaxial cable with load;
3. S-parameters of a two-port.

8. TITLE: Lab VIII - Filters and Impedance Matching

PURPOSE:

We will continue the use of a spectrum analyzer and network analyzer to evaluate RF circuits.

The concepts covered are:

1. Butterworth low-pass filter;
2. Scaling;
3. Scattering parameters;
4. Matching network for an antenna.

The laboratory techniques covered are:

1. Calibrating the network analyzer for two-port measurements;
2. De-embedding the test fixture;
3. Measuring the scattering parameters;
4. Measuring VSWR

9. TITLE: Lab IX - AM Voice Transmitter

PURPOSE: An oscillator is needed to make a transmitter. In this experiment we will make a radio frequency (RF) LC oscillator with a frequency of oscillation in the AM radio band (540 kHz to 1.7 MHz). By coupling an audio signal to the biasing current of the oscillator circuit, the transconductance of that transistor is varied. This causes the oscillator to partially collapse and restart with the audio signal. You will test your transmitter with your AM radio.