EE 110
Introduction to Engineering & Laboratory Experience
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Lab 0: Course Introduction

The primary goal of the one-unit EE110 course is to serve as a small window to allow the freshman electrical engineering students view the main categories of topics that they will encounter in the next few years of their electrical engineering studies at Sonoma State University. These topics include concepts in analog electronic components, Ohm’s law, DC and AC signals, rectifying diodes and LEDs, transistor switches and amplifiers, operational amplifiers and 555 timers. In addition, students are given an opportunity to learn about microcontrollers and a few simple applications. Finally, students become familiar with the basic ideas of circuit simulation. In order to achieve this goal, each topic is presented in a very simple fashion without treating the underlying foundations and theories of operation and circuit analysis. Our experience indicates that by a cursory treatment of various topics in electronics, students will experience a “flavor” for each topic and show a strong interest in one or more of the subjects. Students are required to build a final project based on what they have learned in this course. The project is not intended to be original and students can use a vast number of in-print and online resources available to them. It is required that the students present the projects at the end of the course and submit a comprehensive written document describing the operation of their project.

The experiments in this course are essentially divided into four parts, based on the type of equipment utilized in the experiments:

a. Standard laboratory equipment
b. Analog Discovery Scope
c. Arduino Uno R3
d. Multisim Circuit Simulation

Discovery Scope and Arduino devices are described below. At any given time students could use two or more of the above devices for a particular experiment. The idea of circuit simulation will be gradually introduced to the class during the semester. Multisim is an easy-to-use and powerful simulation application which is available on the laboratory computers. Initially, students are encouraged to use the application for drawing circuits for their reports. More detailed use of the “simulation” aspects of Multisim will be given during the “free style” Arduino lab experiments. Students are encouraged to use other circuit simulation programs if they wish. More advanced students who will finish the Arduino experiments ahead of the others are encouraged to become familiar with Multisim. Students may wish to use other online simulation software applications that are available for free. Circuits.IO is an example. The use of simulation software in this course is not mandatory. However, students are required to include computer-generated circuit diagrams in their reports. All students will simulate a simple circuit which involves a blinking LED powered by a low frequency AC source.
In lab 0, students are also given some advice on how to navigate through the department of engineering science websites. In particular, the 4-year road map for completion of the Electrical Engineering degree program is discussed. Additionally, the course syllabus will be discussed in some detail. The laboratory procedures including safety considerations, laboratory notebook, requirements for lab reports, attendance and final project will be discussed. A brief introduction to the equipment used in this laboratory will be given below:

1. Power Supply or Battery

2. Digital Auto Range Multimeter with Continuity Test

3. Keysight Oscilloscope

4. Digilent Discovery Scope (DS): These small and portable instruments will be loaned to students during the semester. The DS will help students carry measurements outside the laboratory (at home). DS units will be connected to students’ laptops, which will be used as input devices for writing codes and for monitoring the controls and results. The DS will be distributed among students in the beginning of lab 1, and the Arduino experiments will begin in lab 7. Students are urged to order their Arduino kits, a multimeter, lab books and
the text, Arduino for Dummies, immediately. It will be assumed that students will have the necessary tools (at the latest) for lab 2.

5. Arduino Uno microcontroller: Students are required to purchase a kit that includes the Arduino microcontroller boards as well as various electronic components including resistors, diodes, LEDs, transistors, motors, switches and wires and connectors (the price is about $50). For experiments on Arduino projects, students will follow the textbook “Arduino for Dummies”, which describes the software and hardware in detail, as well as principles of electronic components and instruments in a very simple language.

Students are required to submit four regular laboratory reports and a comprehensive report for their final project.

1. Diode Lab
2. Transistor Lab
3. Operational Amplifier Lab
4. 555 Timer Lab
5. Final Project

An important goal of this lab is to familiarize students with the traditional laboratory test and measurement instruments: Multimeter, DC power supply, Function generator, and oscilloscope. Each student will be provided with an Analog Discovery Scope (DS), which
includes all of the above instruments in one small box. The DS units will be connected to students’ laptops for viewing the data.

1. DC Measurements

Electronic instruments and circuits are made up of individual and integrated electronic components. In this laboratory you will become familiar with some individual analog electronic components: switches, resistors, capacitors, diodes, and transistors. The picture below shows images of these components. In particular pay attention to the number of wires (legs, pins, leads) coming out of these devices. Generally the simple devices (resistors, capacitors, inductors, diodes) have two pins. Transistors and integrated circuits (ICs) have more than two pins. All electronic components are made up of one or more of the following materials: Conductors, semiconductors, semi-insulators, and insulators.

The electronic symbols for identifying some of these components are illustrated below. Each of these components has a specific function in a circuit. Today we will test the operation of traditional laboratory instruments. The functions and properties of the various components will be covered in the future sessions. Let us first talk about resistors which are the most basic component used in electronics. The resistance of resistors are measured in Ohms and the amount of electric current (I) going through them depends on their resistance (R) and the applied voltage (V). The relationship among I, R and V is expressed by Ohm’s law. The units of I, R, and V are Ohms, Amperes, and Volts, respectively.

Ohm’s Law

The single most important formula in electronics is described by the Ohm’s Law: \( V = I \times R \). This formula may be written in different forms and it can be used to derive expressions for other parameters such as electric power \( (P = V \times I = RI^2 = V^2/R) \). V is the voltage that is applied
to the device and I is the electric current that flows through the device due to the voltage difference at the two ends of the device. Voltage difference is sometimes referred to as the voltage drop or potential difference. The magnitude of I is determined by the electrical resistance R.

**DC Power Supplies**

A power supply is a device that provides the energy required to power up a circuit. In this section we will experiment with DC (Direct Current) power supplies. We will experiment with the AC (Alternating Current) power supplies or function generators in the future labs. Batteries are the most common types of DC power supplies. In this lab we will experiment with the Agilent E3630A power supply. The device output will be displayed on its front screen. However, multimeters are commonly used for measurement of basic electrical resistance, voltage, and current. Your station is equipped with a Fluke 179 multimeter. In this lab we will use both instruments. In order to become familiar with the use and accuracy of the DC power supply, try the following procedure.

**Assignment A:**

1. Set the function on Agilent E3630A to +6V. Adjust the voltage to 4.5 Volts. Measure the voltage using the provided multimeters. Write down the results. Make sure you turn the output power on.
2. Set the function to +20V. Adjust the voltage to +8 volts. Measure the voltage and record the result.
3. Set the function to -20V. Adjust the voltage to -10 volts. Measure the voltage and record the result.

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**Agilent E3630A DC Power Supply**

1. **Ohm's Law - A review**

Ohm's law states that the voltage drop across a resistor has a linear relationship to the current flowing through the resistor. Graphically this linear relationship is represented by a line when the current through the resistor is plotted against the voltage across it. This graph is termed I-V characteristic of the device. A linear I-V graph indicates that...
the resistance of the device remains constant over a wide range of currents and voltages. For many electronic devices the resistance is not a constant and varies with the applied voltage and current. These devices possess non-linear I-V characteristics. However, the slope of the curve at any given point determines the resistance of the device for that particular current and voltage.

The figure below illustrates a linear V (volts) vs. I (mA) graph. The slope of the graph indicates the device resistance. The resistance of the device is determined by calculating the slope: \( R = \frac{\Delta V}{\Delta I} \), which is approximately 1.1 kΩ.

The figure below illustrates a non-linear I-V curve for a diode. The device resistance, represented by the slope of the curve, varies with current and voltage. The resistance is very large near the origin (horizontal slope), and drops drastically for larger positive and negative voltages.

3. AC Instruments and Signals
The goal of this part of the experiment is to make students familiar with the basic operation of function generators and oscilloscopes. The output of the function generator is directly connected to one of the inputs of the dual channel oscilloscope. The idea is to become familiar with the concepts of frequency, period, amplitude, and other parameters of function generators and to learn to use the oscilloscope for viewing the signal output of the function generator and to confirm the values of frequency and amplitude using the oscilloscope screen and cursors. This part of the experiment is conducted mostly in a free style, exploring a wide range of frequencies and other parameters.

Students are required to carefully draw the waveform in their lab books as observed on the scope screen to scale. A more detailed description of traditional function generators and oscilloscopes, and the AC signals and oscilloscope function of the DS will be given in lab 3.

Your instructor will describe the concepts of signal period (frequency), and amplitude as illustrated in figure below, and will outline the measurement parameters.