

EGR 220: Engineering Circuit Theory

Lab 1: Introduction to Laboratory Equipment

Pre-lab

Read through the entire lab handout and complete the questions labeled as “PL Q#” in a manner similar to, but more relaxed than, homework (be neat, but do not worry about using EGR paper or putting problems on separate pages). Your pre-lab must be completed *before* you arrive for lab at 1:10pm. If you do not have a completed pre-lab you will not be allowed to do the lab, and will need to make it up on your own time. Every student must complete her own pre-lab.

Part I

GOAL: This exercise begins with an introduction to the electronic equipment that we will use throughout the semester. Figures 1 – 4 show of each of the four major pieces of equipment so that you can take helpful notes on how to operate each of them. You also have a Fluke handheld multimeter available at each lab station, and will use this throughout the semester. You will refer back to these notes and pictures in subsequent lab sessions, so take careful and neat notes.

- Agilent 33120A Function Generator
- Agilent E3631A Triple Output DC Power Supply
- Agilent 34401A Digital Multimeter & Fluke handheld multimeter
- Tektronix DPO3000 Oscilloscope

Take time to understand how to use each piece of equipment. You will be referred to the *User's Guides* and you are encouraged to ask questions. I have included a few reminders throughout the lab, for you to remember to record your results and observations – there are *reminders* that you need to be recording results and observations throughout – not only where I have commented.

Function Generator

The function generator generates a voltage that varies with time. Look through pages 2 – 4 of the *User's Guide*. Turn the function generator on and follow the steps on page 19 of the *User's Guide* to learn how to set the frequency of a sinusoidal voltage waveform. Check that the frequency initializes to 1000 Hz (*i.e.*, 1 kHz) and then set the frequency to 1,200,000 Hz (*i.e.*, 1.2MHz). Follow the steps on page 20 and generate a sinusoid with an amplitude of 50 mV (PP), where PP refers to peak-to-peak. Record notes that will be useful for you in the future.



Figure 1: Agilent Function Generator.

Oscilloscope

The oscilloscope allows you to display a voltage waveform (y-axis) as a function of time (x-axis). It displays your real-time data on a graph-paper-like screen. The Tektronix scope has many features and we will explore only the most basic features. To begin, use a BNC-to-alligator cable **and** an oscilloscope probe to attach the signal out of the function generator (OUTPUT), via the BNC cable, to channel 2 of the oscilloscope, **using the scope probe**. Set the function generator to generate a sinusoid of amplitude 1.0 Volt with a frequency of 1000 Hz. View the signal on the oscilloscope and confirm that the amplitude is 1.0 V, and the frequency is 1 kHz.

To explore the manual settings for scaling, displaying and measuring the signal, begin by pushing the 'menu' button in the 'trigger' area (far right) of the panel, and making sure that the scope is triggering from channel 2. (Check the menu buttons along the bottom of the display and use the upper left dial on the panel to select the channel.) Then use the vertical and horizontal position and scale knobs to create a pleasing display of the signal.

To confirm that the signal is what you expect (1.0 V with $f = 1\text{kHz}$) **use the cursors** (upper left section of the panel).

To use the automatic features, switch the BNC cable-to-scope probe setup to channel 3 on the oscilloscope and push 'Autoset' on the far right of the panel. You may need to make sure that channel 3 is showing on the display (read about how to do this *before* coming into lab.)

Q1: (To be answered for the lab memo, not necessarily during lab time.) What is the period of the sinusoid you measured on the oscilloscope? What is the relationship between a signal's period of oscillation, T , and its frequency in Hz, f .

In addition to sinusoids, other waveforms can be created with the function generator. If there is time, view them on the oscilloscope. Vary the signals in amplitude and frequency and observe effects on the oscilloscope. (Remember to briefly record what you did for future reference.)

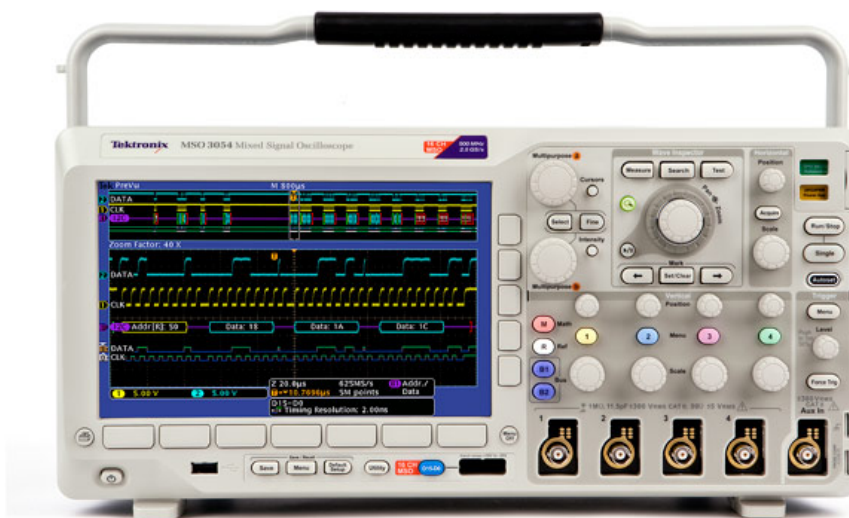


Figure 2: Tektronix DPO3000 Oscilloscope.

DC Power Supply

The power supply (see Figure 3) generates either a constant current (CC) or a constant voltage (CV). Here we focus on generating a voltage. Read through and play with the steps on page 36 of the *User's Guide* (except do not yet connect a load (step 1) – that is for Part II of this lab).

- *Always put the power supply in the disabled mode before making or changing the connections to it.*
- *When the power supply is enabled, do not let the positive and the negative leads touch each other, and do not **ever** connect them through a short circuit (i.e., a wire with no circuit element between).*

Q2: What the purpose of the “Output on/off” button? ... to be explored now, and fully answered in the lab memo, not necessarily now during lab time.



Figure 3: Agilent DC Power Supply.

Digital Multimeter

The multimeter, shown in Figure 4, is used to measure voltages, currents, and resistances. Refer to page 17 of the *User's Guide* to determine how to configure the multimeter to measure DC voltage.

With the power supply in the disabled mode, connect it to the multimeter. Once the connection is made, set the power supply to 5V, and confirm that the multimeter measures 5V as the output from the power supply. Try a few other voltages.

Q3: What are some important (and useful) differences between the voltage signal that is generated by the power supply and the voltage signal generated by the function generator? Ponder this question on your own, with your partner, and answer it for the lab memo (not necessarily now during lab time).



Figure 4: Agilent Digital Multimeter.

Part II

GOAL: This exercise is designed to familiarize you with creating simple circuits. You will also check experimentally some of the basic circuit laws as discussed in class. You will:

- Learn how to use a breadboard.
- Learn the color code for resistors, indicating their nominal value.
- Learn how to measure voltage and current in a circuit with the multimeter, and the voltage with the oscilloscope.
- Verify basic circuit laws experimentally.

Breadboard

Figure 5 shows the breadboard that you will use to wire your circuits. Each column of 5 contacts forms a node. The long rows across the top and bottom form “bus strips” that also form single nodes. These bus strips are typically used for power supply connections, but can also serve as nodes when many contact points are required.

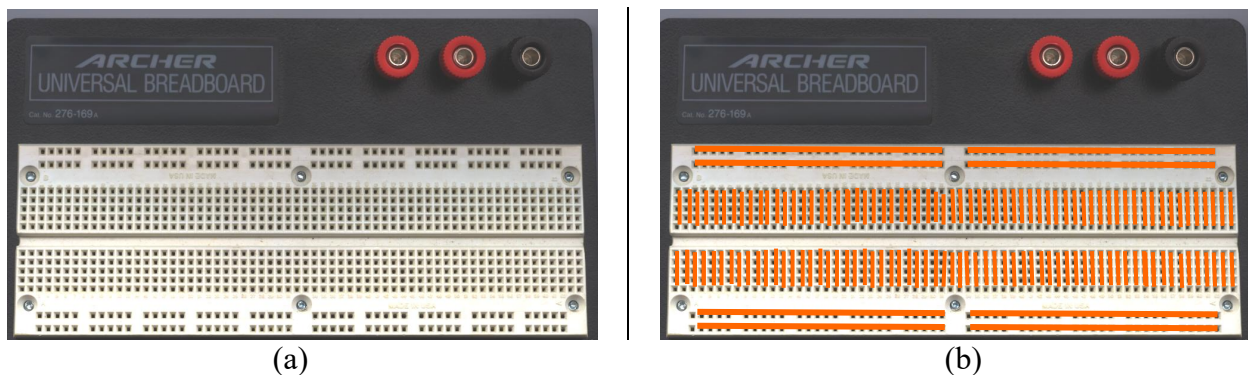


Figure 5: The breadboard you will use to wire your circuit. (a) as it appears, (b) indicating nodes connected with copper wire under the surface of the board.

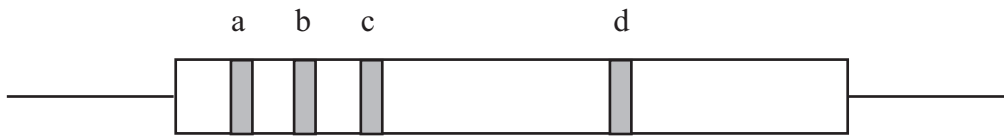
PL Q1 a: What will the color bands be for the $5.1\text{k}\Omega$ resistor (see below for information on resistor labeling)? Label the colors on the resistor figure on the next page.

PL Q1 b: Sketch the circuit shown below in Figure 7 as an actual circuit on the breadboard (breadboard figure to use is on the next page), showing very clearly, and labeling as needed, where you will connect the resistor, the power supply and the VOLTMETER probes, to measure voltage **ACROSS** the resistor.

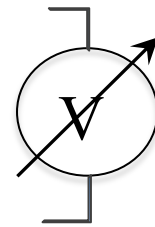
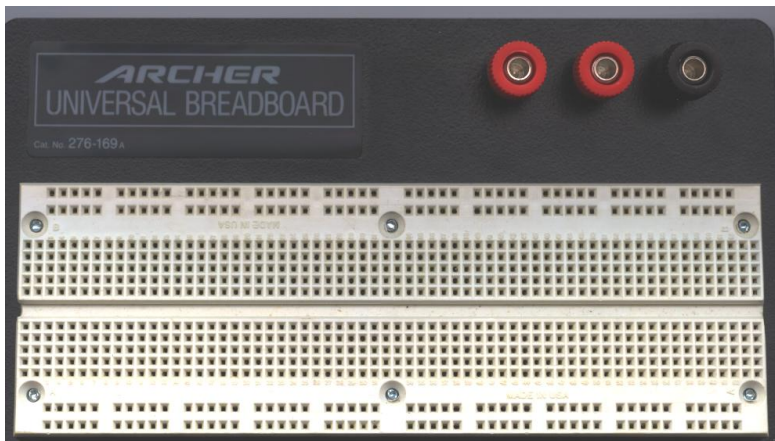
PL Q1 c: Sketch the circuit shown below in Figure 7 as an actual circuit on the breadboard (breadboard figure to use is on the next page), showing very clearly, and labeling as needed, where you will connect the resistor, the power supply and AMMETER probes to measure current **THROUGH** the resistor. (Read through the entire lab before completing this.)

(Note you label and hand in page 6 from the lab handout with your pre-lab.)

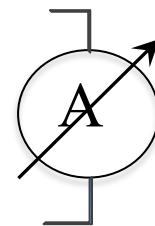
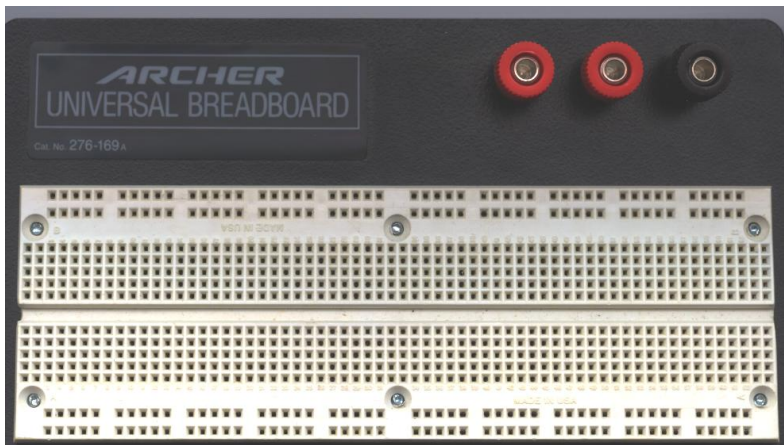
Label Color Bands for 5.1kΩ resistor:



Draw circuit for measuring VOLTAGE ACROSS the resistor (voltmeter symbol shown)



Draw circuit for measuring CURRENT THROUGH the resistor (ammeter symbol shown)



Resistors

The magnitude of the resistance of a resistor is color coded on the resistor via strips of colored bands. The resistors we use have 4 colored bands (the top resistor in Figure 6). Each color has a number associated with it, as defined in the figure. The first three colored strips indicate the numerical value of the resistance, so that $R = a b \times 10^c$. In other words, the first two bands define a two-digit number that is multiplied by the power of ten defined by the third band.

For example, suppose a resistor has the color code Brown-Black-Red. This color code corresponds to 10×10^2 or 1000Ω .

The fourth color band indicates the resistor's tolerance. A gold tolerance band indicates the actual resistance of the resistor will be within 5% of the nominal value. For example, a resistor labeled as 1000Ω with a 5% tolerance should have an actual resistance of $950 \leq R \leq 1050 \Omega$.

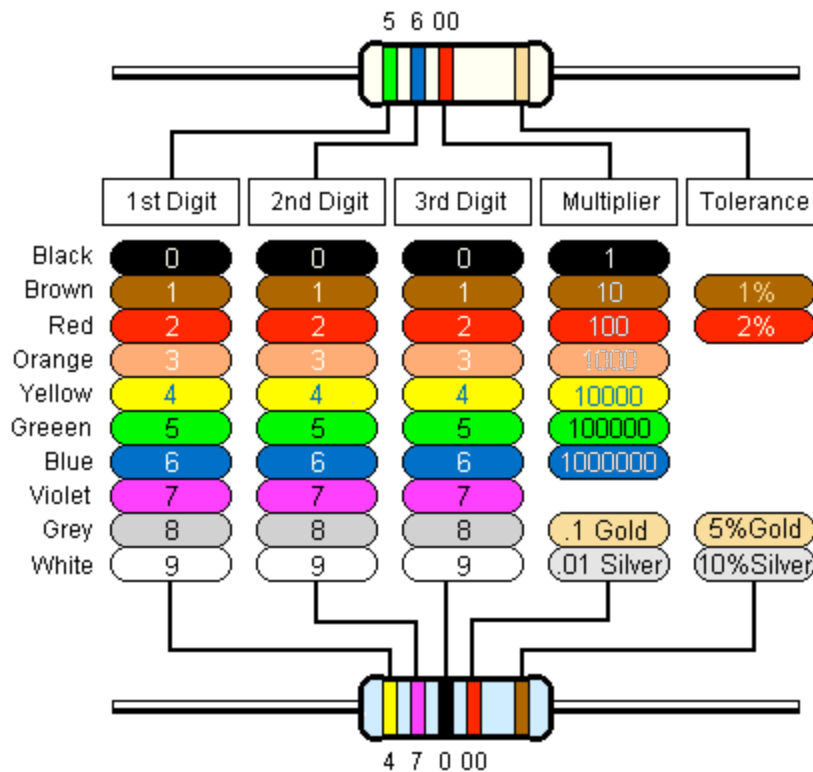


Figure 6: Resistor Color Bands,
<http://www.educylopedia.be/electronics/electroniccalculatorsresistor.htm>

Measuring currents and voltages within a circuit

Build on your breadboard the circuit shown in Figure 7. First, place the resistor in your breadboard so that it connects between two different nodes. If you cannot find a $5\text{k}\Omega$ resistor, use something close (e.g., $5.1\text{k}\Omega$).

Use the multimeter (configured as an Ohmmeter, perhaps use the Fluke handheld for this) to measure the actual resistance (see page 17 of the *User's Guide* if you use the Agilent multimeter).

Q4: How different is the actual value of R from its nominal value?

Next, connect 5 Volts from the DC power supply across the resistor. **Remember to keep the power supply in the “disabled” mode while you are making connections.** Once the circuit is completed you will measure both v , the **voltage across**, and i , the **current through** the resistor.

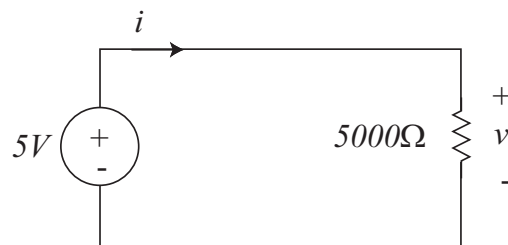


Figure 7: Voltage measuring circuit.

Measuring Voltage

First, measure the voltage v across the resistor in two different ways: (1) Using the digital multimeter and (2) Using the oscilloscope. Again, while you are connecting the oscilloscope and the multimeter to the circuit, make sure the power supply is disabled. Remember to record *briefly* any significant observations and your results.

PL Q2: To measure voltage with either instrument, you should place the relevant probes in *parallel* with the element whose voltage you wish to measure. Why?

PL Q3: What do you expect to find for the voltage measurement? Why?

Q5: What is the voltage value actually measured by the multimeter? by the oscilloscope?

Q6: Are the values reasonable? Which appears to be the most accurate? Why?

Measuring Current

Second, measure the current i through the resistor. In this case, you will use the AGILENT digital multimeter. (Refer to page 18 of the *User's Guide* for the multimeter and configure your multimeter to measure current and remember to disable the power supply while you are making connections to the multimeter. Also, see the notes below.)

PL Q4: To measure current through an element, you should place the ammeter in *series* with the element whose current you wish to measure. Why?

PL Q5: What do you expect for the current measurement? Why?

Q7: What is the current value measured by the multimeter? Does this seem reasonable?

Q8: Is Ohm's law satisfied in your circuit? How do you know?

To Measure Current, you will use the AGILENT multimeter to measure current. Do the following:

- On the top right of the multimeter, connect the red probe to the bottom 'hot' (red) position, which is labeled as the one to use for current (with a red "I"). Use the same ground, or common, connection as you did to measure voltage, with the black probe.
- Press the 'shift' key (lower right) with the "DC I" key (upper left) to set the display to show DC current
- Connect the multimeter so that the current that flows through the resistor is *the same* current that will flow through the meter. **To do this you must break your circuit and insert the multimeter into the circuit.** It will take some thought and careful wiring to do this correctly... It is odd to think of the lab equipment as being an element in your circuit, but this is what you need to do.

