Basic DC circuit tools and measurements

Introduction

The primary goal of this first lab is to become familiar with the DC power supply and using the multi-meter for DC measurements. For building circuits, we need components, wires, a breadboard, and the DC power supply. For measurements, we use the digital multimeter. The components, wires, and breadboard are part of the lab kit that you will receive in lab. The power supply and multi-meter are part of the work benches in the lab.

There are short tutorials on: resistor color codes, the breadboard, potentiometers, the power supply and the multimeter. You should look at those prior to lab in order to have at least some cursory knowledge of how each thing works. (If you wait until lab time to look at the tutorial, you may run out of time.)

You should also read through the class notes (and do practice problems) up through Kirchoff's Laws.

One of the important things to realize about lab is that you can do good measurements on circuits even if you don't understand how the circuit works. In fact, building a circuit and measuring the behavior can be an important first step in "figuring out" a circuit that you may not yet understand.

1. Resistor tolerance

a. Select 20 resistors at random from your lab kit.
b. Determine the nominal values from the color bands.
c. Use the ohm-meter to measure the resistance each resistor.
d. Calculate the percentage error for each resistor: error = (nominal – actual)/nominal.
e. Determine an average error for the 20 resistors, using the *absolute values* of the percentage errors. Does this match the expected 5% tolerance for our resistors.

2. Resistor power rating

a. Pick a 100-Ω resistor from the lab kit. Say your good-byes to this resistor now. Measure the value with the ohm-meter so that you know the exact value. The resistors from the lab kit are rated for 0.25 W.
b. Using the breadboard, connect the +25-V DC supply across the resistor with voltage set initially to 0 V.
c. Increment the supply voltage to +1 V. Calculate the expected current and power dissipation.
d. Increment to +2 V and repeat the calculations.
e. Continue to increment the voltage in 1-V steps. Wait about 10 seconds after adjusting the voltage, and then put your finger on the resistor to see if you can detect a temperature

change. Note: Once you can detect that the resistor is becoming noticeably hot, STOP putting your finger on it! You don't want to any have any permanent scarring!

f. Continue to increment the voltage. (Now without the "fingertip temperature measurement".) Note the point at which you can begin to smell the hot resistor. Note the output current reading on the power supply.

g. Continue to increment the voltage up to maximum of 25 V. Note the current at each step. It is possible (or likely) that the resistor will burn out completely before you reach 25 V.

For the report, be sure to record the voltage and power at which the resistor became noticeably hot, the voltage and power at which you begin to smell the hot resistor, and the voltage and power at which the resistor burned out. For the future, remember the hot component and, in particular, remember the smell. When your circuits are getting hot and starting to smell, that probably means that something is wrong. In that case, it would probably be a good idea to turn off the power supply immediately!

3. Potentiometers

a. Plug a 10-kΩ potentiometer into your breadboard. Note the position of the 3 pins.

b. Use the ohm-meter to measure the resistance R_T between the outer two pins and confirm that is approximately 10 kΩ.

c. Use the trimming screwdriver to set the potentiometer dial about half-way between the two extremes. Measure the resistance between the left-hand pin and center pin (R_1). Then measure the resistance between the right-hand pin and the center pin (R_2). Confirm that $R_1 + R_2 = R_T$.

d. Variable resistor (rheostat). Connect the potentiometer so that one of the outer pins is shorted to the center pin, making it into a variable resistor. Connect it to a 5-V DC supply, a 100-Ω fixed resistor, and the ammeter, as shown in Fig. 1a (The fixed resistor is there to limit current.) Adjust the potentiometer dial through its full range so that the current varies from a maximum of about 5 V / 100 Ω = 50 mA to a minimum of about 5 V / (10 kΩ + 100 Ω) = 0.49 mA.

e. Variable voltage divider (volume control). Connect a 5-V DC voltage across the outer two pins of the potentiometer, as shown in Fig. 1b. Set the potentiometer dial so that it is about half-way between the two extremes. Use the voltmeter to measure the voltages across R_1 and R_2. Add the voltages to confirm that the potentiometer is functioning as a voltage divider. Sweep the potentiometer dial and show that the voltage across R_1 can be varied from 0 V to 5 V.

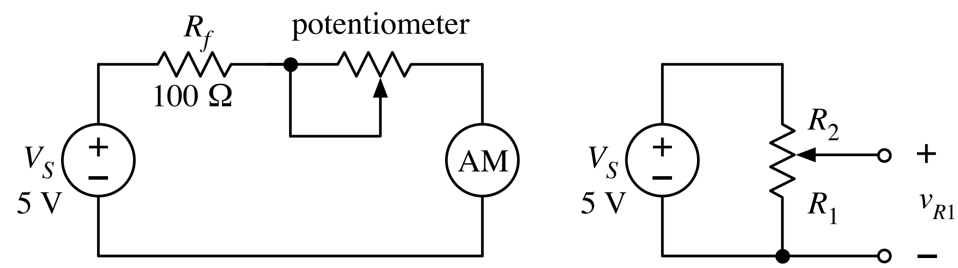


Figure 1.

(*a*) (*b*)

4. Kirchoff's Laws

a. Build the circuits shown below. As you are building the circuits, used the ohm-meter to measure the exact values of each resistor used in the circuit.

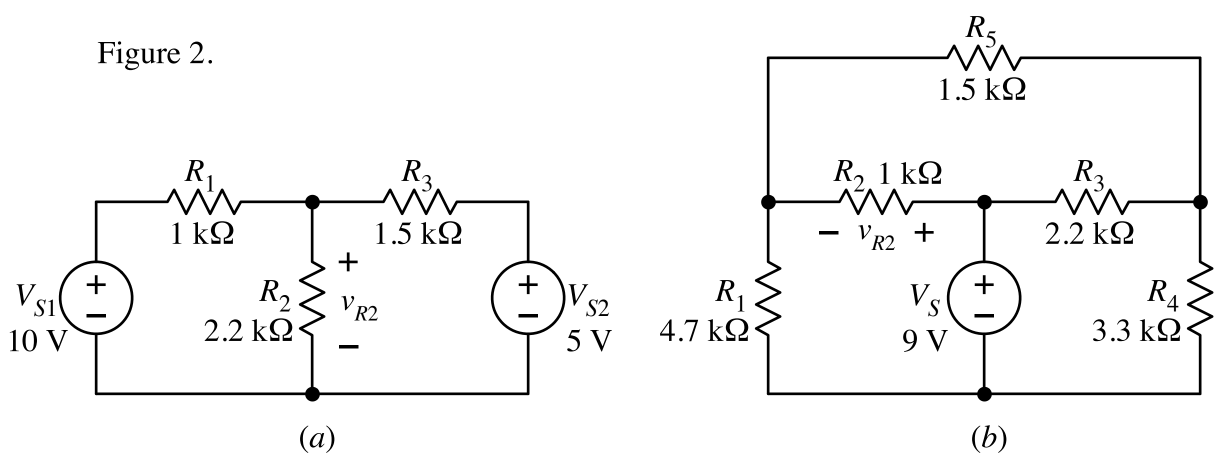
b. Use the voltmeter to measure the voltage across R_2 in each circuit.

c. Now knowing v_{R2}, use Kirchoff's Law to *calculate* the remains voltages and currents in the circuit, including DC source currents. (This should feel like a practice problem.)

d. Then use the voltmeter to measure all each voltages and use the ammeter to measure each current. (For this exercise, use the ammeter for each resistor — do not use the "voltmeter + Ohm's law" method for measuring resistor current.)

e. Record and compare the calculations and measurements.

Figure 2.



Reporting

Instructions and guidance on writing a report will be provided later. For now, make certain that you have completed as much of the work as possible and have recorded the data for all the measurements that you did complete.