Resistive DC Circuits

Laboratory 1

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Introduction

The purpose of this lab is to learn to use parts of our proto board and equipment given to us by UCSC BELS. Some of the equipment used in this lab would be the resistors, wires, voltage dividers, light bulbs, and proto board that helped establish and designed a circuit in order to determine unknown resistances. The goals of the experiment were to build a voltage divider and use theoretical laws learned, such as Kirchhoff's, Ohm's, and Resistive laws. Thus verifying each of the equations by experimental values. Kirchhoff's current law is when the net current entering a node is zero and alternatively, the sum of the currents entering a node equals the sum of the currents leaving a node. As for Kirchhoff's voltage law, it is when the algebraic sum of the voltages equals zero for any closed path (loop) in an electrical circuit. For circuits, there are two main ways to line resistors, in series or in parallel. For series circuit, we say that the resistors are in series, which mean current flows through one resistor and the output flows through the next resistor, or R1 + R2 = Req. For in parallel, the current flows through either resistor, which is 1/R1 + 1/R2 = 1/Req. For power dissipation, it is a measurement of the circuit in watts. We give the power dissipation by the equation P = VI or p = I^2*R

Part 1: Basic Resistive Circuits

Create the circuit displayed in Figure 1 using the signal function generator, two 1 kΩ resistors, and one 5 kΩ. It is important to note that R2 and R3 are in parallel to each other but in series to R1 as seen in Figure 1, also do not forget to ground so that the circuit is complete.

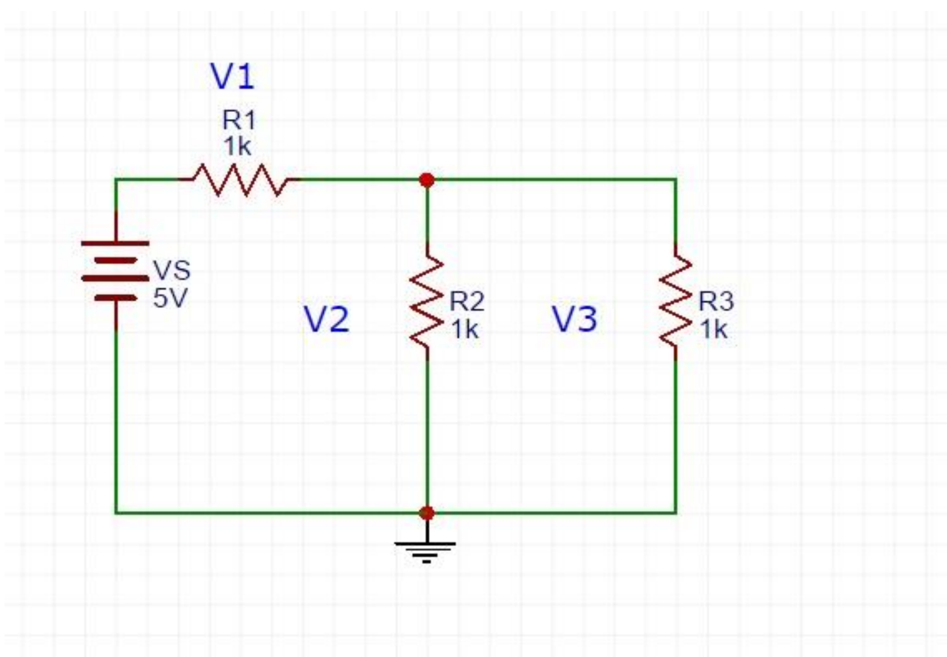

Figure 1

Circuit Schematic for the basic resistive circuit

As in Figure 1, the ideal resistors are labeled; however, after measuring them individually I realized that they weren't exactly precise. Note: these values were measured before making the circuit. R1 should be 1 kΩ, however, the experimental value is 0.9956 kΩ; R2 should be 1 kΩ, however, the experimental value is 0.996 kΩ, and lastly R3 should be 5 kΩ, however it was 5.06 kΩ. Taking the absolute difference in Ohms we got that R1 was 4.4 ohm's, R2 was 4 ohm's and R3 was 6 ohm's. Furthermore, the relative difference in percentage was R1 = 0.48%, R2 = 0.4%, and R3 = 0.0012%. Next, I was expected to measure the voltage drops for V1, V2, and V3. My results were, V1 = 2.7V, V2 = 2.27V, V3 = 2.27V. Finally, the last part of this circuit was to measure the current through the resistors. I ended up obtaining, I1 = 0.0025 A, I2 = 0.002299 A, and I3 = 0.000448 A. Verifying through KCL, we can see that I1 = I2 + I3; therefore, I2 = 0.002299 A + 0.000448 A = 0.002748 A. A slight difference from our experimental result which was 0.0025 A. As it can be seen with these values, the complete circuit is able to verify our theoretical values.

Part 2: Light Bulb Circuits

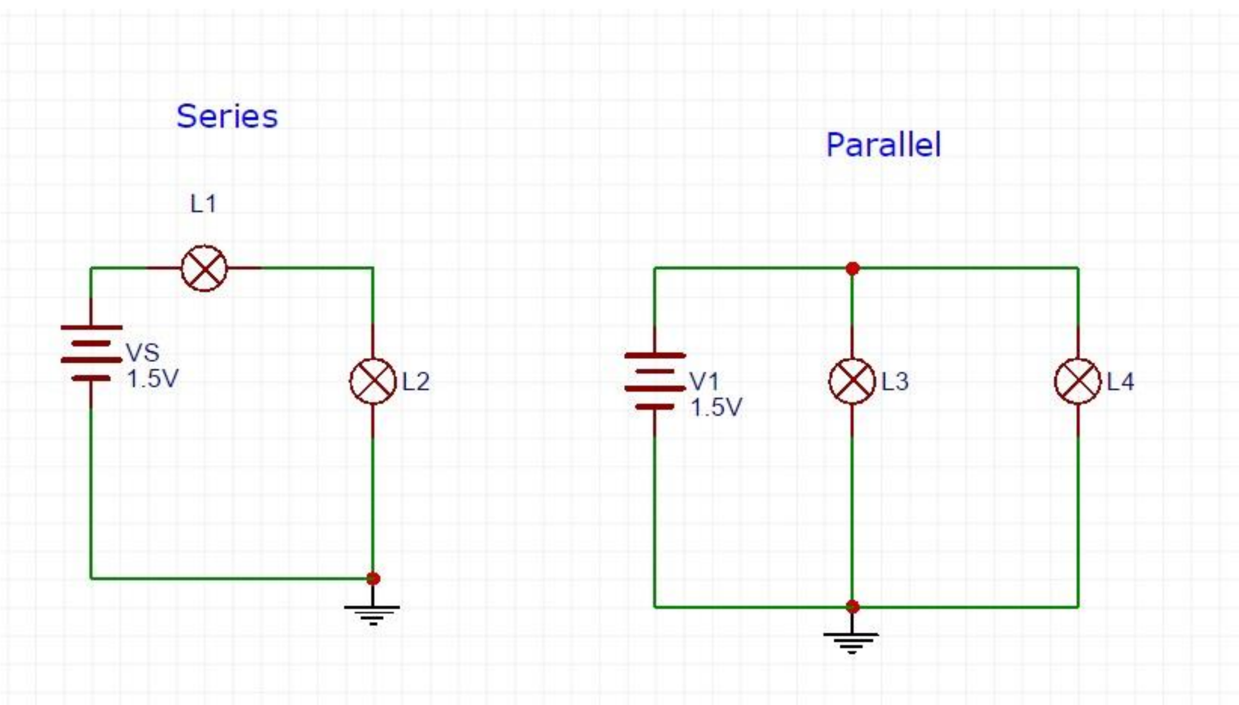

Figure 2

Circuit Schematic for the Light Bulb Circuits

** (L1 = L3, L2 = L4, and VS = V1) **

For this part of the lab, we were to build two circuits using the two light bulbs; however, one was in series and the other was in parallel. The first part of this was to measure the lightbulb resistance when they are cold (off); therefore, I obtained that L1 (L3 is the same light bulb just used in different schematic) to be 5.2 ohm's and L2 (same for L4) to be 5.1 ohm's. After connecting the light bulbs to a voltage source, in this case, 1.5 V, I compared the brightness between series and parallel. The brightness of the parallel has more light at the same voltage than the series. On the theoretical aspect, if we have resistors in series we would add for total resistance which would be more than parallel. Thus the series has more resistance and the conductance (1/R) is less than parallel, having parallel conducting more electricity. Now for part 3 of the light bulb circuit, I was to measure the resistance again while the bulbs were on. I did this by measuring the voltage and dividing it by the current through the lamps. For the series, Lightbulb 1 had voltage of 0.77V and Lightbulb 2 had voltage of 0.72 V. Then measuring the current, Lightbulb 1 had 21 mA and Lightbulb 2 had 0.19 mA. Using Ohm's law, we obtain that the Resistance of Lightbulb 1 had 34.2 ohm's and Lightbulb 2 had 37.9 ohm's. Next, we did the same approach for them in parallel. We had Lightbulb 1 voltage be 1.4 V and Lightbulb 2 voltage be 1.5V. The resistance of Lightbulb 1 was 28 ohm's and Lightbulb 2 be 31.1 ohm's. The difference between parallel and series is voltage drop between the Lightbulbs were more significant in the series, this had to do with not allowing as much current running through Lightbulb 2 resistor because of Lightbulb 1 resistor. Lastly, we determined the power dissipated in each light bulb. To do this I used the formula, P = VI. For series, Lightbulb 1 = (0.77V) (0.021A) = 0.01617 W, Lightbulb 2 = (0.72V) (0.019 A) = 0.01368 W. For parallel, Lightbulb 1 = (1.4V) (50 mA) = 0.07 W, Lightbulb 2 = (1.5 V) (45 mA) = 0.063 W. The comparison between the resistances of the lightbulb when cold (off) and hot (on) is V = IR: when off, there isn't any voltage potential or current flowing through the resistor. However, when we connect the current, there flows more current in each of the resistors which allows for the resistor to heat up and resist the flow of current.

Part 3: The Voltage Divider:

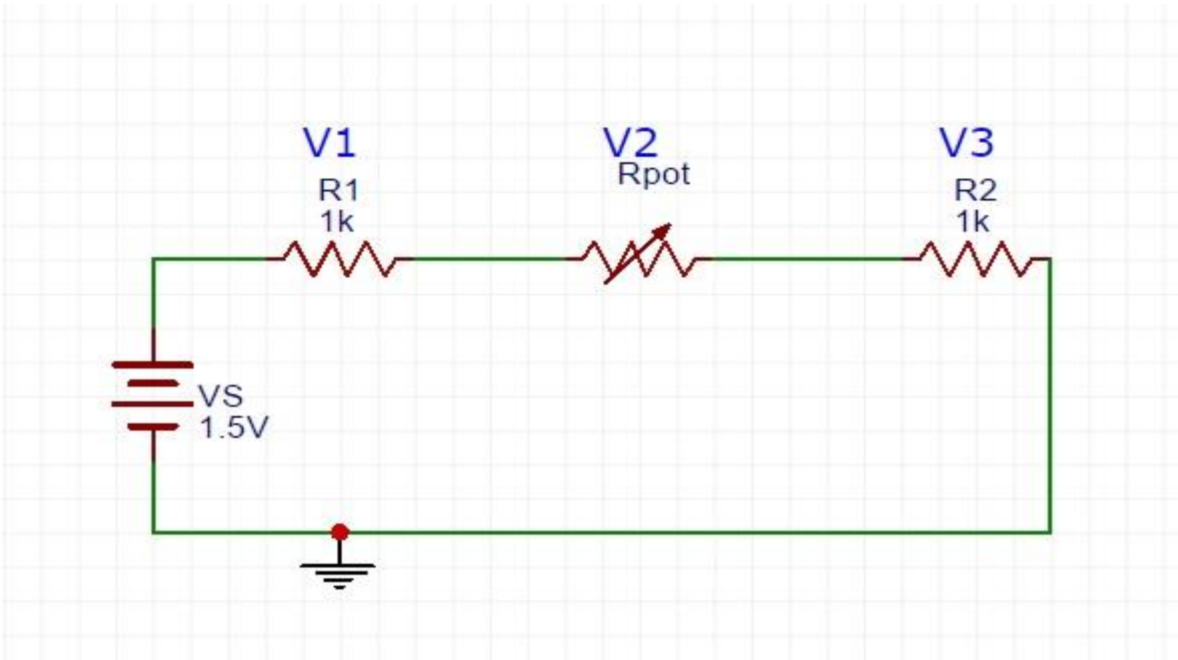

Figure 3

Circuit Schematic for the voltage divider

For this part of the lab I was to design a voltage divider which gives me a ratio of V2/ VS = 3/5. For the expected values, we use what was our knowns: VS= 1.5 V and V2Rpot which was (3/5) Vs = 0.9 V. Then we use KVL, VS = V1 + V2 + V3 and V1 + V3 = 0.6V. As for R2, V2 = R2* I = 0.9V/(1.28A) = 0.7 ohms.Using the two 1 kΩ and variable resistor, I was able to test out Figure 3. To verify my design experimentally, one can look at Figure 4 and compare; here I got my measurements of my resistor values, VS, V1, V2, and V3. For my resistor values I obtained R1 = 1 kΩ, Rpot = 0.65 kΩ, R2 = 1Ω VS =1.5V, V1 was 15.3 mV, V2 was 0.77V, and V3 was 15mV.

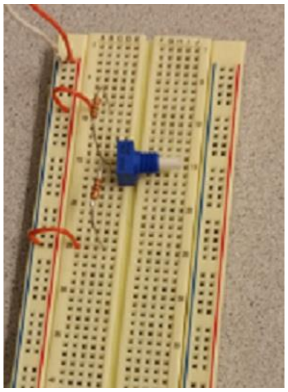

Figure 4

Circuit Schematic of the experimental design

Part 4: The Wheatstone Bridge

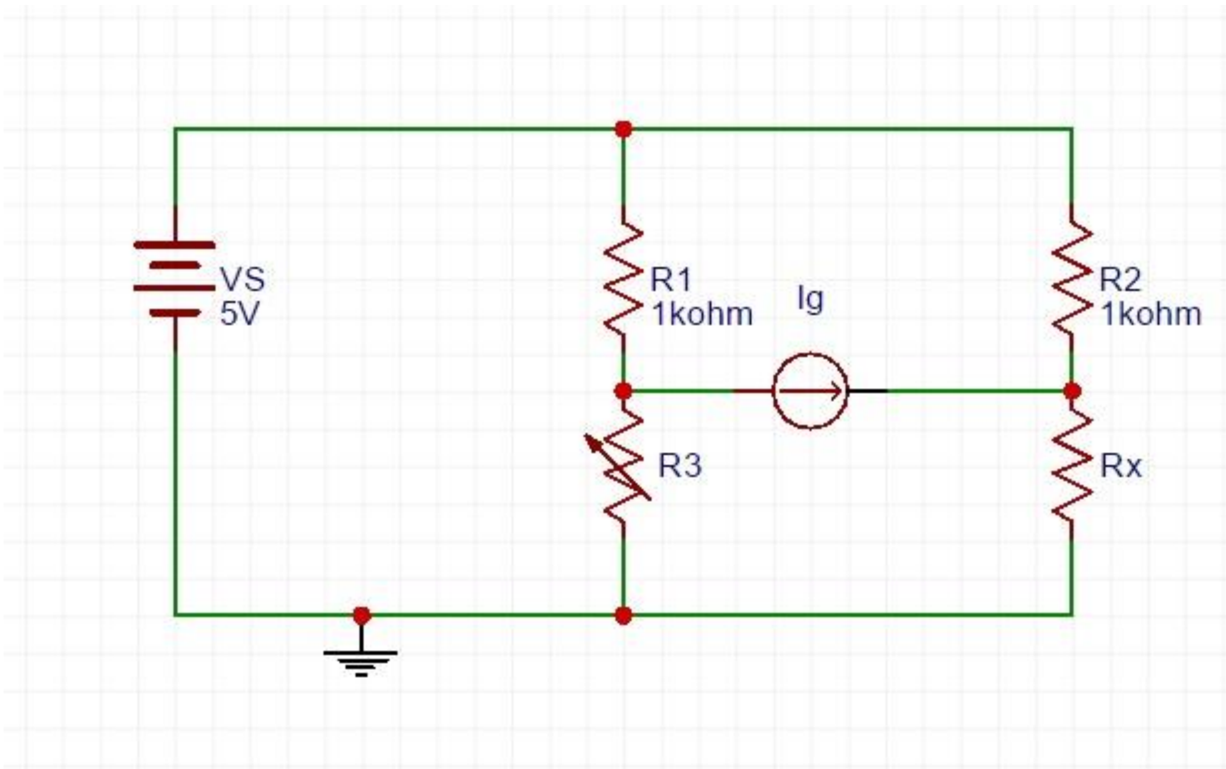

Figure 5

Circuit Schematic for the Wheatstone Bridge

For the last part of the lab, we were to build a circuit that consist of a Wheatstone bridge to measure unknown resistances. First we build the following circuit, in Figure 5. Then we balanced the bridge by tuning R3 until the current of Ig was zero. We then measured R3, and added a small resistor in series with it to make sure that there wasn't a shortage. R3 results came out to be 3.305 kΩ. Using the theoretical value Rx = R2R3/R1, we obtained Rx to be 3.5 kΩ, a difference of 195 ohm's or 5.57% difference.

Conclusion

Overall, this lab was successful. It familiarized myself with how circuits are experimentally calculated and designed. By being able to measure and see the results, I believe it helps verify the basic laws in electrical engineering. In this lab, we were also able to determine that we can find unknown values through other known values in our board. The percentage of errors were displayed and although, we did not get the ideal values, we were around the +/- 5% error, which is sufficient enough to rely on our statistics.