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Testing Resistive Circuits with Varying Circuit Configurations, Experiment 1

Abstract:

In this experiment Edith and I were introduced to the use of a prototyping board, triple power supply, a digital multimeter and our component kits for this lab course. We used different circuit configurations to measure varying voltages and currents as well as familiarized ourselves to the color table for which resistors follow. Also using a LED at one point, through continual changes to the circuit setup, via different resistors and adding/changing components/elements, we were able to see the voltage-current relationship in several scenarios. Those scenarios included parallel v.s serie circuit setups, applying different levels of resistors and seeing changes in voltage/current with different output levels. Our results consisted of a stable relationship from currents and voltages in our configurations, varying numerical results for both when adding an LED, and an overall better understanding of our lab resources such as the power supply's and component kits.

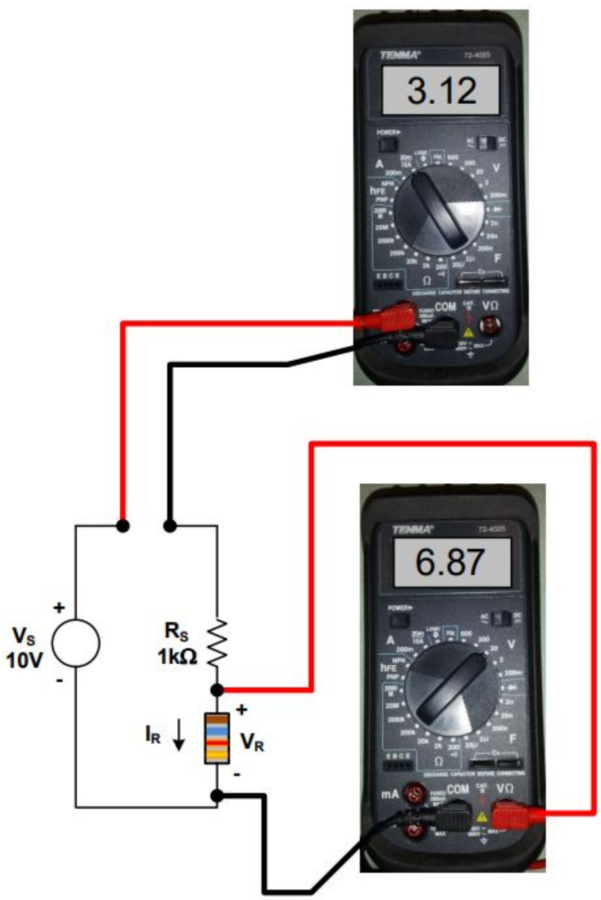
Results for part 1 concerning the circuit in series given 2 resistors had a varying V_r from -6.19V to a 6.19V measurement and -3.87mA to 3.87mA given a varying -10V to 10V input. Results for part 2 concerning the circuit with the LED had -1.95V to 1.95V and -8.16mA to 8.18mA through the same varying voltage input from -10V to 10V. Results for part 3 concerning our circuit with three resistors had voltages being 2.81V, 10.65V, and 1.54V through 2kΩ, 0.75kΩ, and 1.1kΩ resistors respectively. Results for part 4 concerning our parallel circuit had currents ranging from -1.53mA to -2mA.

Intro:

For each of our circuit configurations we had to find the correct resistor with given color (or given resistance). First we handled a circuit in series with a single power supply and two resistors. Second was a circuit with an LED and a given resistor. Third we handled a circuit in series again and fourth we handled a circuit in parallel. We found the respective currents, voltages and resistances for our varying circuits with circuit elements. We previously only discussed and solved for varying voltages and currents through a drawn circuit diagram, now we are making those diagrams.

Theory:

Circuit diagrams we followed:



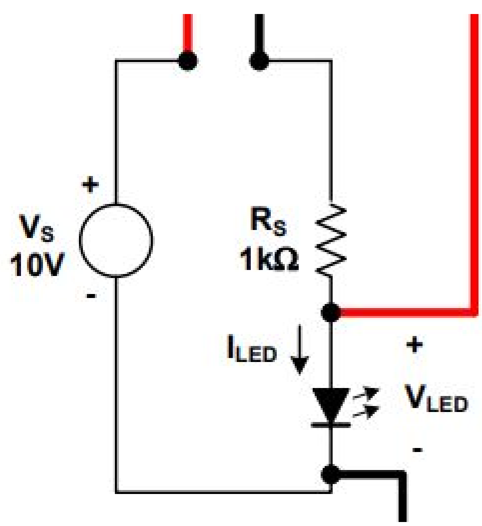
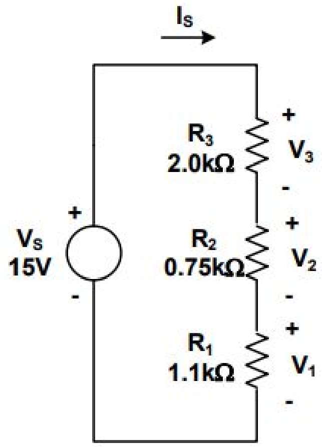
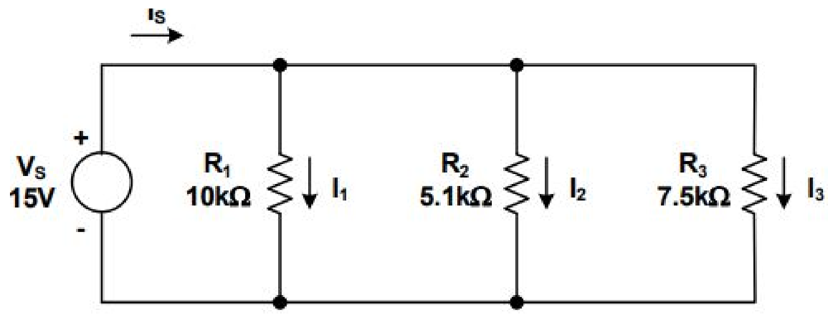


Figure 1 ↑ **Figure 2** ↑

Figure 3 ↓ **Figure 4** ↓





We used the series and parallel resistance equations to find our varying resistances.

Resistance in parallel: $R_{eq} = (1/R_1 + 1/R_2)^{-1} = R_1R_2/(R_1 + R_2)$

Resistance in series: $R_{eq} = R_1 + R_2$

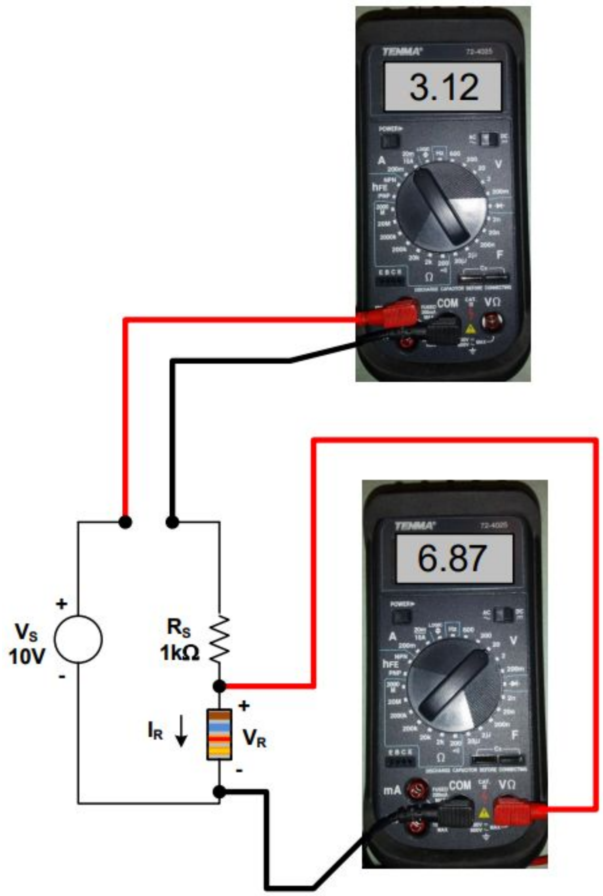
Voltage divider rule: $V_n = V_s * (R_n/(R_1 + R_2 + ... + R_n))$

Current divider rule: $I_n = I_s * (R_{eq}/(R_n + R_{eq}))$

R is the respective resistor, V_s *and* I_s are voltage and current sources respectively, and R_{eq} is the equivalent resistance.

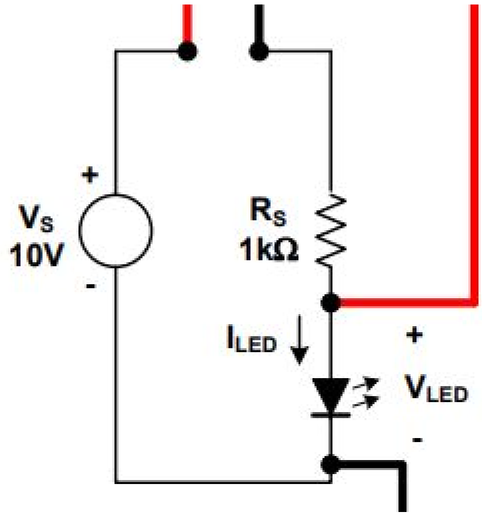
Experimental Procedures:

Part 1:



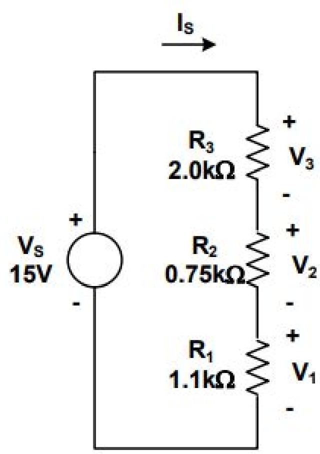
Creating the circuit diagram above in figure 1, we needed to record the varying voltage input change to our current and voltage values by our given points of interest. After creating the circuit on our protoboard we gave varying inputs of voltage between -10V and 10V. Using our digital multimeter's, we recorded the change in current and voltage at said given points.

Part 2:



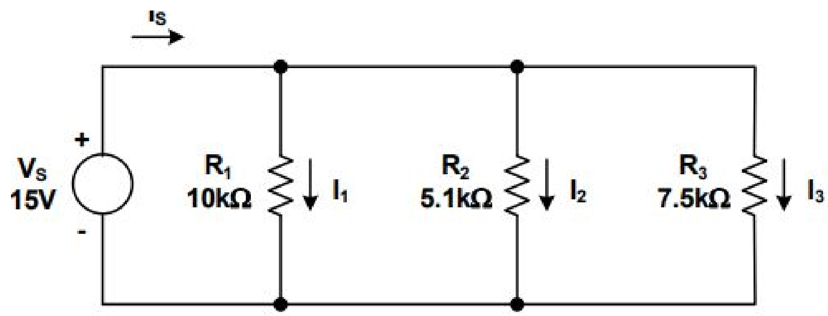
Just like part 1, we recorded the varying currents and voltages at the given points in the figure over the change in input voltage (-10V to 10V). This time however we replaced one resistor with an LED.

Part 3:



We then had to build figure 3, our circuit in series with three resistors. We had to find whether or not I_s, V_1, V_2, V_3 satisfy Kirchhoff;s voltage law. Then we had to find the equivalent resistance (R_{eq}) and compare to our expected value. Then we used the voltage divider rule and compared those results.

Part 4:



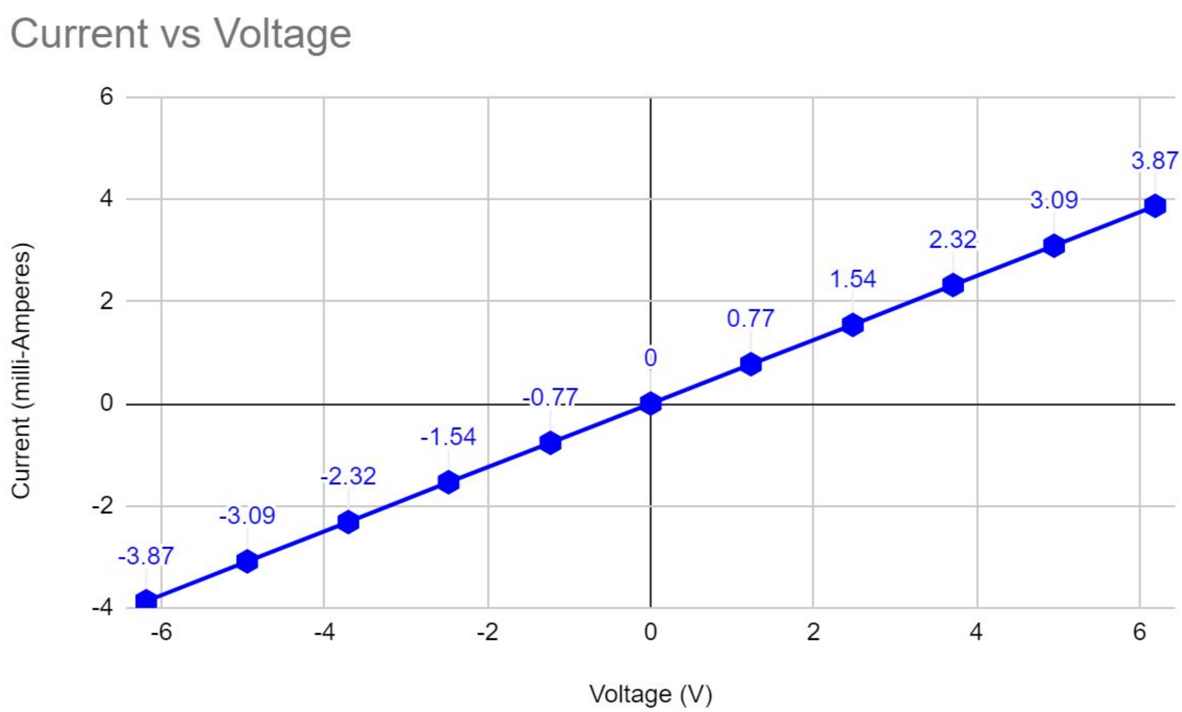
Our final circuit was the parallel circuit. After recreating it into our prototyping board we had to measure varying currents and the voltage (I_s , I_1 , I_2 , I_3 , $and\ V_s$). After getting the equivalent resistance we had to compare values just like part 3 but this time we were comparing currents rather than voltages.

Results and Discussion:

Tables:

Part 1:

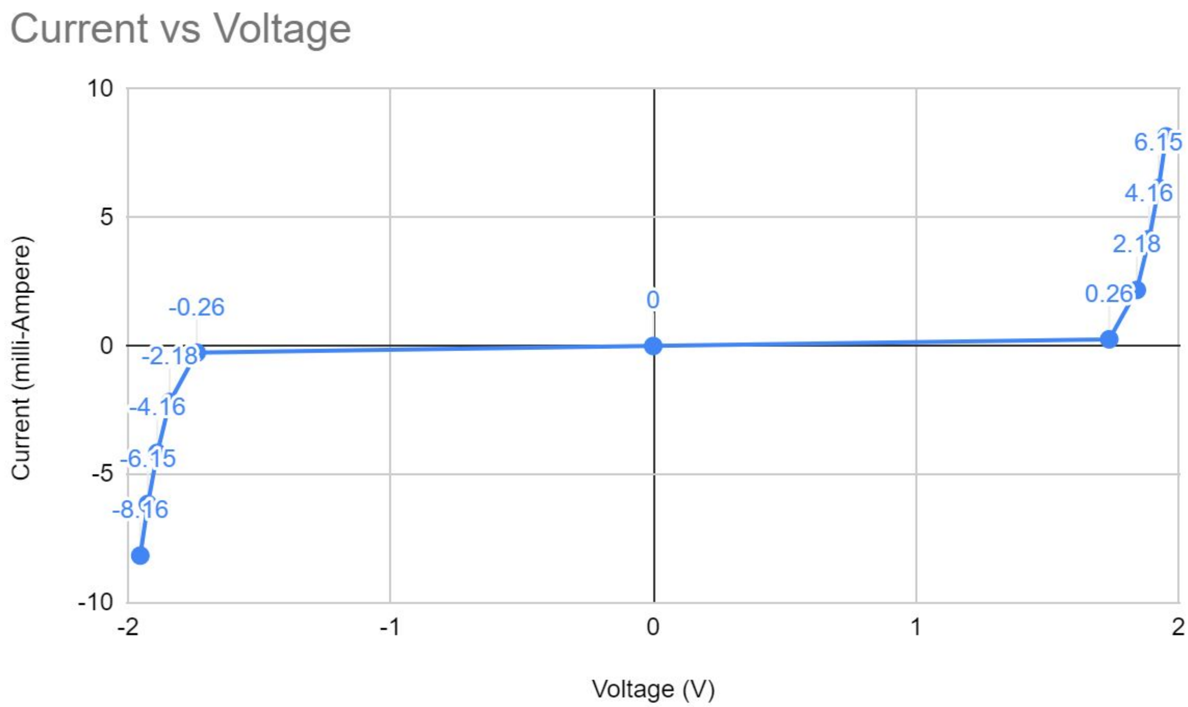
Volts input	-10V	-8V	-6V	-4V	-2V	0	2V	4V	6V	8V	10V
V_R **(V)**	-6.19	-4.95	-3.71	-2.48	-1.23	0	1.23	2.48	3.71	4.95	6.19
I_R **(mA)**	-3.87	-3.09	-2.32	-1.54	-0.77	0	0.77	1.54	2.32	3.09	3.87



We can see the relationship between the voltage and current output as a result of the change of voltage input. They are directly proportional, as one increases so does the other. One thing to keep in mind, the tolerance on the resistors were +/-5% and does seem to be within the 5% nominal resistance. Slope is equal to ~1.6.

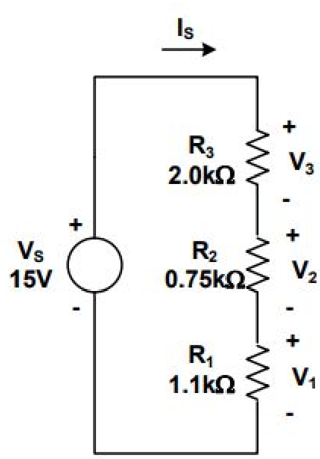
Part 2:

Volts input	-10V	-8V	-6V	-4V	-2V	0	2V	4V	6V	8V	10V
V_R **(V)**	-1.95	-1.92	-1.89	-1.84	-1.74	0	1.74	1.84	1.89	1.92	1.95
I_R **(mA)**	-8.16	-6.15	-4.16	-2.18	-0.26	0	0.26	2.18	4.16	6.15	8.16



Having the resistor replaced by the LED made a large difference, both circuit elements are adherently different and so our graphs are too. The LED uses up more energy to create the light.

Part 3:



Our results for I_s, V_1, V_2, V_3:

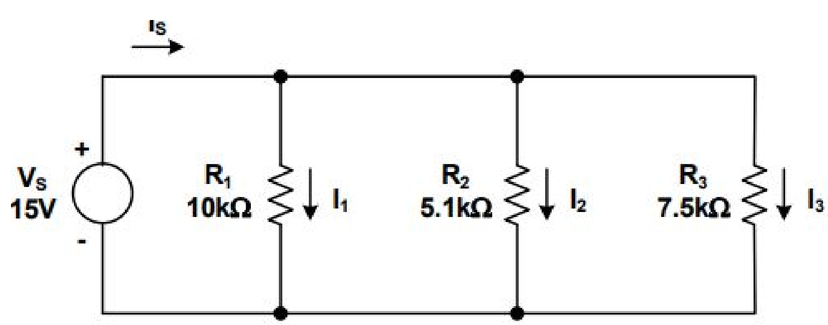
I_s	V_1	V_2	V_3
3.42mA	1.54V	10.65V	2.81V

In order to satisfy Kirchhoff's voltage law we get our voltages together, after subtracting the voltage source we should get 0. 1.54V + 10.65V + 2.81V - 15V = 0, which does satisfy the law. Our equivalent resistance ($R_{eq} = V_s/I_s$) results in 4.38kΩ as using the given Resistances we get 3.85kΩ. This difference may be due to an incorrect resistor or human error, possibly bad data as a result of faulty data gathering. The tolerances in the resistors could play a small role in difference as well. After we use the Voltage divider rule we get:

(V)	V_1	V_2	V_3
(V)	4.28V	2.92V	7.8V

Our data was inconsistent with the calculated results possibly due to human error or using the wrong circuit elements.

Part 4:



Our results for I_s, I_1, I_2, I_3, $and\ V_s$:

I_1	I_2	I_3	V_s (Volt source)
2.0mA	2.98mA	1.53mA	15V

Next we tested if these values follow Kirchhoff's current law. 1.53mA + 2.98mA + 2mA = 6.51mA. This is almost equal to the current source I_s = 6.5mA. The sum of the two are almost 0 meaning this does pass the law if you don't take account the 0.01mA difference. This could have been some sort of measuring issue or not accounting for tolerances. Comparing the equivalent resistances: $R_{eq} = V_s/I_s$ for our data ($R_{eq} = 15V/6.51mA = 2.304$kΩ) vs the nominal data ($R_{eq} = 15V/6.50mA =$ 2.307) we get that they are almost the same. This means our data is accurate and on point. Using the current divider rule we get:

(A)	I_1	I_2	I_3
(mA)	2.0mA	2.94mA	1.5mA

Which is very similar to our data.Our measured values seem to be correct, the small percent error may have been tolerance of resistors or human error.

Conclusion:

Voltage and current have a strong relationship, they are proportional to each other. We tested this relationship with several different circuit setups and different circuit components to get different results in said relationship. Even in series or parallel, more resistors or given LED, the relationship is apparent and our data differs between what is used and how.