Electric Circuits I
Laboratory 2: Circuits with Series and Parallel Resistors

Objective:

- To become familiar with the measurements in electric circuits.
- To determine the equivalent resistance of series and parallel combinations
- To use Kirchhoff's laws

A. Background & Theory

The equivalent resistance of N resistors connected in series is expressed as:

$$R_{eq} = R_1 + R_2 + \cdots + R_N = \sum_{n=1}^{N} R_n$$

The equivalent resistance of N resistors connected in parallel is expressed as:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N} = \sum_{n=1}^{N} \frac{1}{R_n}$$

Note: For only two resistors in parallel, the above equation reduces to:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

Also note that for resistors of the same value in parallel this reduces to:

$R_{eq} = \frac{R_1}{2}$ for two resistors

$R_{eq} = \frac{R_1}{3}$ for three resistors

$R_{eq} = \frac{R_1}{4}$ for four resistors

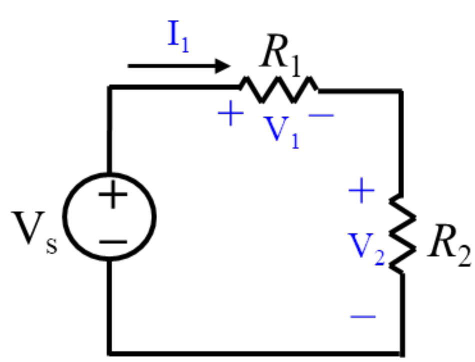
B. Prelab

1. Calculate by hand theoretical values for I_1, V_1, and V_2 for the circuit shown in Figure 1.
2. Calculate by hand theoretical values for I_1, I_2, I_3, V_1, V_2, and V_3 for the circuit shown in Figure 2.
3. Calculate by hand theoretical values for the currents through and voltages across each resistor of the circuit described in Laboratory Part 1 Step 9.
4. Calculate the equivalent resistance as seen by the voltage source in the circuit shown in Figure 3.
5. Calculate by hand theoretical values for I_1, I_2, I_3, I_4, I_5, V_1, V_2, V_3, V_4, V_5, and V_6 for the circuit shown in Figure 3.

Show all work and submit scanned copy of your work through Camino prior to the lab session.

C. Laboratory Part 1

Step 1. Build the simple voltage divider circuit shown below on your breadboard using the resistors shown and a DC power supply set to 20 V.



$R_1 = 2.2k\Omega$
$R_2 = 3.3k\Omega$

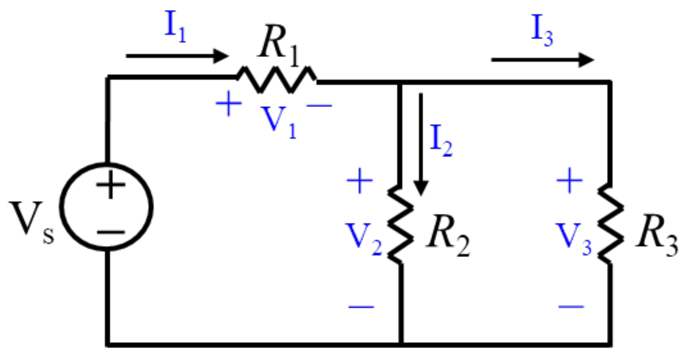
Figure 1

Step 2. Measure the current and the two voltages. Also, measure the resistance values.

Step 3. Compare your measurements to calculated values for the voltages and current. Make a table showing the measured and calculated values as well as the percentage difference.

Step 4. Compute the ratio of V_1 to V_2 and the ratio of R_1 to R_2. How are they related?

Step 5. Modify your circuit as shown below by adding a third resistor, R_3, connected in parallel to R_2.



$R_1 = 2.2k\Omega$
$R_2 = 3.3k\Omega$
$R_3 = 10k\Omega$

Figure 2

Step 6. Measure the three currents and the three voltages shown. Make a table showing the measured and calculated values, and the percentage difference. Also, measure the R_3 resistance value.

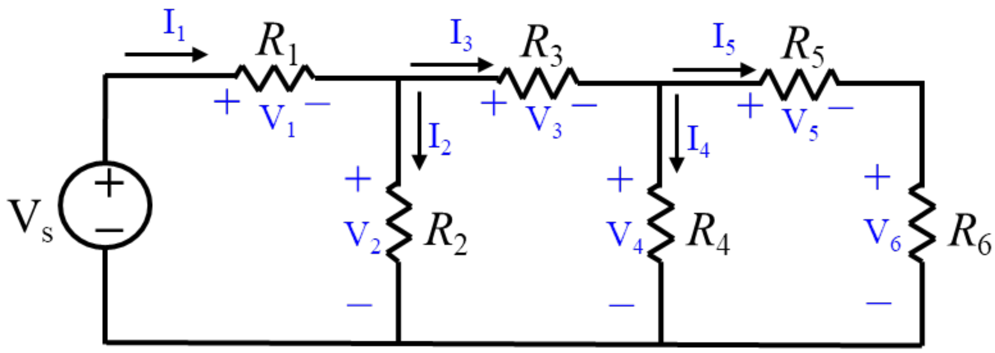
Step 7. Compute the equivalent resistance of the parallel combination of R_3 and R_2. How does this explain the values of I_1 and V_2 in this circuit compared to the values measured with the first circuit?

Step 8. What is the ratio of I_2 to I_3? What is the ratio of R_2 to R_3? How are they related?

Step 9. Modify your circuit by adding a fourth resistor, R_4, connected in parallel to R_2 and R_3 with $R_4 = 1.2k\Omega$.

Step 10. Measure the currents through and voltages across each resistor. Make a table showing the measured and calculated values, and the percentage difference. Compute the equivalent resistance of the three measured resistors connected in parallel. How is the current I_1 divided by the three resistors connected in parallel?

D. Laboratory Part 2



$$R_1 = 2.2k\Omega, R_2 = 3.3k\Omega, R_3 = 4.7k\Omega$$

$$R_4 = 5.6k\Omega, R_5 = 2.7k\Omega, R_6 = 1.2k\Omega$$

Figure 3

Step 1. Build the circuit shown above on the breadboard, using a DC power supply V_s set to 20V and leaded resistors for R_1, R_2, R_3, R_4, R_5, and R_6.

Step 2. Measure all the currents and voltages in the circuit, including V_s. Make a table showing the percentage difference between measured and calculated values.

Step 3. Write Kirchhoff's Current Law for each node, and from your measurements, verify that KCL is satisfied at each node. If there is any discrepancy, recheck your measurements.

Step 4. Write Kirchhoff's Voltage Law for each loop, and from your measurements, verify that KVL is satisfied for each loop. If there is any discrepancy, recheck your measurements.

Step 5. With the ohmmeter, measure that equivalent resistance of the circuit as shown in the figure below. Compare it to the theoretical value calculated in the pre-lab.

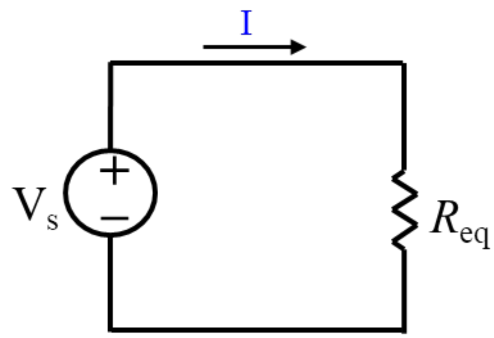


Figure 4

Step 6. Use the measured value of the voltage V_S and the current I_1 from Step 2 to calculate the equivalent resistance. Compare this value to your measurement from Step 5.

Step 7. If R_6 were replaced by an unknown resistor value, how could you find the value of R_6 from the measurement and the calculation method?

E. Laboratory Report:

Include all measurements, computations, tables, and answers to all questions from the laboratory procedure. Clearly label all steps.