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 resistances of series and parallel combinations
- To use Kirchhoff's laws

BACKGROUND & THEORY

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

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

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

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

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

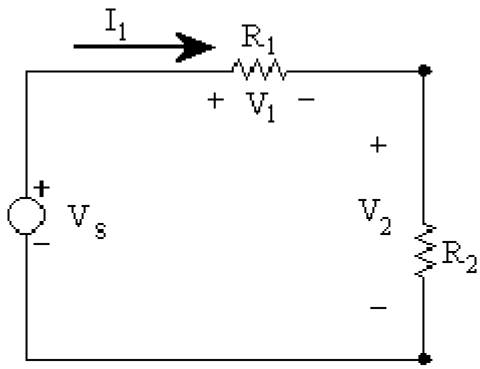
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 R_2}{R_1 + R_2}$$

Note also that for resistors of the same value in parallel this reduces to:

$R_{eq} = R_1/2$ for two resistors
$R_{eq} = R_1/3$ for three resistors
$R_{eq} = R_1/4$ for four resistors

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.



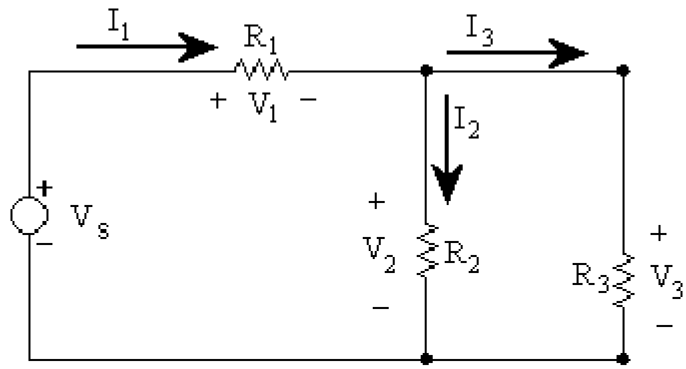
$R_1 = 4.7\ k\Omega$
$R_2 = 5.6\ k\Omega$

Step 2: Measure the current and the two voltages shown. 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 = 4.7 kΩ
R_2 = 5.6 kΩ
R_3 = 22 kΩ

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.

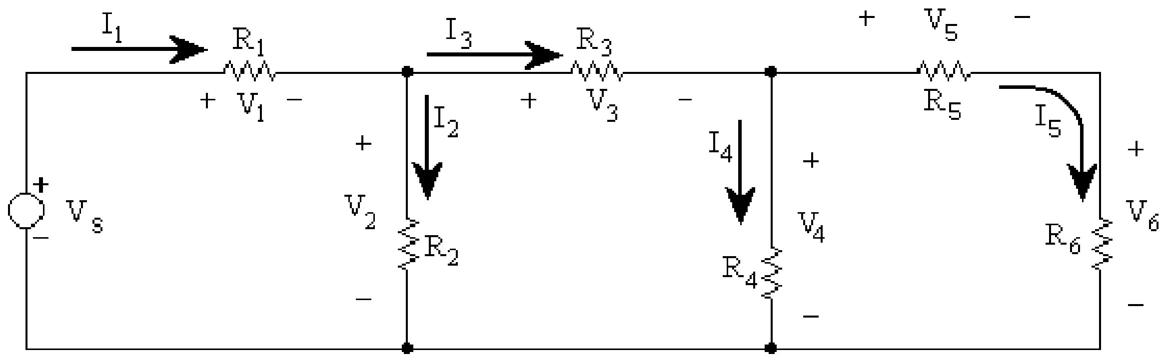
Step 7: Compute the equivalent resistance of the parallel combination of R_3 and R_2. How does this explain the values of I_1 and V_2 in this circuit compared to the values measured with the first circuit?

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 = 1.2 kΩ.

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?

Laboratory Part 2:



R_1 = 1.2 kΩ, R_2 = 5.6 kΩ, R_3 = 3.3 kΩ,
R_4 = 4.7 kΩ, R_5 = 2.7 kΩ, R_6 = 1.2 kΩ

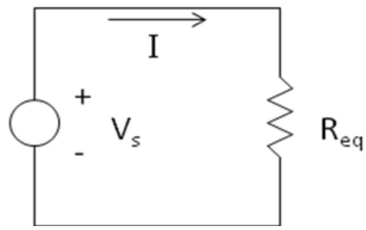
Step 1: Build the circuit shown above on the breadboard, using a DC power supply Vs set to 20V and leaded resistors for R_1, R_2, R_3, R_4, R_5, and R_6.

Step 2: Measure all the currents and voltages in the circuit, including Vs. 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.



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 measurement and calculation method?

Laboratory Report:

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

Pre-lab:

Read all steps in the lab procedure and complete the following theoretical calculations **<u>prior to coming to the lab</u>**. These calculations are based on the ideal component values given in the lab procedure.

- In Part 1
  - Step 2 - Calculate the theoretical values of the current and the two voltages specified in Step 2 of the lab procedure.
  - Step 4 – Calculate the ideal ratio of V_1 to V_2 and the ratio of R_1 to R_2.
  - Step 6 – Calculate the currents and voltages specified in Step 6.
  - Step 7 – Calculate the equivalent resistance of the parallel combination of R_3 and R_2.
  - Step 8 – Calculate the ratio of I_2 to I_3, and the ratio of R_2 to R_3.
  - Step 10 - Calculate the currents and voltages specified in Step 10, as well as the equivalent resistance of the three parallel resistors.
- In Part 2
  - Calculate all currents and voltages specified in Step 2.
  - Calculate the theoretical value of the equivalent resistance of the circuit from Part 2. To do this,
    - First calculate Req_{56}, the equivalent resistance of R_5 and R_6 connected in series.
    - Then calculate Req_{456}, the equivalent resistance of Req_{56} and R_4 connected in parallel.
    - Continue this process until you have the total equivalent resistance for the circuit shown in Step 5 of the lab procedure.