EXPERIMENT NUMBER 2
RESISTIVE NETWORKS

The resistors used in this laboratory are carbon composition resistors, consisting of graphite or some other type of carbon embedded in a filler material. Graphite is a moderately good conductor, so by varying the graphite-filler mix, a large range of resistance values can be obtained (the less graphite, the higher the resistance) [1]. Carbon resistors are cheap and reliable, however, their tolerances (5 to 20% deviation from nominal values) indicate that larger errors can be expected. Other types of resistors include wire wound, metal film, and carbon film [1]. The nominal value and tolerance of a carbon resistor can be determined from the color-coded stripes that appear on the resistor. The first two bands represent the two significant figures of the resistance, while the third band indicates the number of zeros that follow. If there are only three bands, the resistor has 20% tolerance. If the three color bands are followed by a silver band, the resistor has a 10% tolerance. A gold band following the three color bands indicates a 5% tolerance, and a red band indicates a 2% tolerance. For example, a resistor with bands of yellow, violet, red, and gold has a resistance of $4700 \, \Omega \pm 5\%$.

<table>
<thead>
<tr>
<th>First significant figure</th>
<th>Second significant figure</th>
<th>Number of zeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black 0</td>
<td>Green 5</td>
<td>Black 0</td>
</tr>
<tr>
<td>Brown 1</td>
<td>Blue 6</td>
<td>Brown 1</td>
</tr>
<tr>
<td>Red 2</td>
<td>Violet 7</td>
<td>Red 2</td>
</tr>
<tr>
<td>Orange 3</td>
<td>Gray 8</td>
<td>Orange 3</td>
</tr>
<tr>
<td>Yellow 4</td>
<td>White 9</td>
<td>Yellow 4</td>
</tr>
</tbody>
</table>

Resistor Color Code

The power rating of a resistor is the maximum power the resistor can handle. If this power is exceeded, the resulting current flowing in the resistor will transfer too much energy (in the form of heat) to the resistor material, causing damage to the resistor. A carbon composition resistor could warp, create an open circuit, and possibly explode.
when the power rating is significantly exceeded. Resistors should be visually inspected for existing warping or other damage, and resistance values should be measured with the DMM prior to use. The maximum power that a carbon composition resistor can handle is indicated by its size. Standard values are 1/8, 1/4, 1, and 2 watt ratings. A 2-watt resistor is over a centimeter in diameter, while a 1/8-watt resistor is a couple of millimeters in diameter.

To determine the power rating of a resistor for use in a circuit, estimate the maximum voltage or current that will pass through the resistor, and then compute the power from

\[ P = \frac{V^2}{R} = I^2 R \]

To be on the safe side, it can be assumed that the calculated value might possibly be exceeded by a factor of 4, and then use a resistor with an appropriate power rating.

**Lab Work**

In this lab you will construct resistance networks and perform voltage and current measurements to verify some of the basic network relationships you have learned, including Kirchoff's current law (KCL), Kirchoff's voltage law (KVL), the current divider relation, and the voltage divider relation. In performing the measurements, keep in mind the internal meter resistance for the DMM determined in the last lab. Note any instances where this resistance is a significant source of error.

1. Collect 1/4-watt resistors with values \( R_1 = 4.7 \, \text{k}\Omega \), \( R_2 = 3.3 \, \text{k}\Omega \), \( R_3 = 10 \, \text{k}\Omega \), \( R_4 = 1 \, \text{k}\Omega \), and \( R_5 = 10 \, \text{k}\Omega \). Using the ohmmeter feature of the digital multimeter (DMM), determine the actual values of the resistances. Record the measured resistance values. If any of the measured values are not close to the nominal values, double check the resistor labeling and replace the resistor.

2. Using a breadboard, assemble the network shown in figure 1. Using the DMM as a voltmeter, adjust the supply voltage, V, to obtain ten volts.
3. Measure and record the voltage across each resistor. Be sure to record the polarities of the voltages. Verify KVL for the center loop in the circuit (Loop A).

4. Using the DMM as an ammeter, measure the currents $i_1$ through $i_5$. You will have to insert the ammeter in series with the resistors one-by-one, and then replace the resistor to its original position prior to doing the next measurement. Keep track of the direction of the currents you measure. Verify KCL for node a.

5. Verify the current divider relation for the division of current $i_2$ as it passes through resistors $R_4$ and $R_5$. You can do this using the currents you measured in step 4 without doing any more measurements.

6. Remove resistors $R_3$ and $R_5$ from your circuit to create the circuit of figure 2. Measure the voltages across the three resistors, and verify the voltage divider relation for this circuit.

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Figure 1