Background

The goal of this lab is to demonstrate the validity of Thevenin’s and Norton's theorems. These theorems are useful in analyzing complicated linear circuits by reducing them to a single independent source and resistor with respect to a pair of terminals where loads can be changed in and out.

![Circuit diagram](image)

Figure 1: Circuit for Thevenin and Norton Analysis

Given:
- $R_1 = 680 \Omega$
- $V_{S1} = 15 \text{ V}$
- $R_2 = 2200 \Omega$
- $V_{S2} = 20 \text{ V}$
- $R_3 = 1000 \Omega$
- $R_4 = 1500 \Omega$
- $R_5 = 2200 \Omega$
- $R_6 = 1000 \Omega$

Preliminary

Let’s suppose we are interested in determining the power dissipated by a load resistor $R_L$ connected between terminals $a$ and $b$ in the circuit shown above.

1) Assuming $R_L = 1500 \Omega$, use circuit analysis (e.g., nodal or mesh analysis) to find the voltage across and current through the load resistor. Then, calculate the power dissipated by the load resistor.

<table>
<thead>
<tr>
<th>$V_{RL}$</th>
<th>$i_{RL}$</th>
<th>$P_{RL}$</th>
</tr>
</thead>
</table>

2) Next, remove the load resistor and calculate the equivalent resistance seen at terminals $a-b$. (Hint: set voltage sources to zero by replacing with a short). This equivalent resistance is the Thevenin $R_T$ and Norton $R_N$ equivalent resistances.

3) Then, with the voltage sources active, calculate the open circuit voltage $V_{oc}$ seen at terminals $a-b$. This voltage is the Thevenin equivalent voltage $V_T$.

4) With the voltage sources active, calculate the short circuit current flowing from terminal $a$ to terminal $b$. This current is the Norton equivalent current $I_N$.

| $R_T$ | $V_T$ | $I_N$ |
5) Draw the Thevenin and Norton equivalent circuits.

6) If the load resistance is $R_L = 1500 \, \Omega$ in the Thevenin and Norton equivalent circuits, and find the voltage across and current through the load resistor. Also, calculate the power dissipated by the load resistor. Compare with the results in part 1).

<table>
<thead>
<tr>
<th>$V_{RL}$</th>
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<th>$P_{RL}$</th>
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</table>

7) Using either the Thevenin and Norton equivalent circuits, calculate the voltage across, current through, and power dissipated by the load resistor as it is varied $R_L = 150, 330, 470, 680, 1k, 1.5k, \text{ and } 2.2 \, k\Omega$.

**Table For Thevenin Circuit Calculations**

<table>
<thead>
<tr>
<th>$R_L$</th>
<th>$i_L$</th>
<th>$V_L$</th>
<th>$P_L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 $\Omega$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>330 $\Omega$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>470 $\Omega$</td>
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<tr>
<td>680 $\Omega$</td>
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<tr>
<td>1000 $\Omega$</td>
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<td></td>
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<tr>
<td>1500 $\Omega$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2200 $\Omega$</td>
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</tbody>
</table>

**Table For Norton Circuit Calculations**

<table>
<thead>
<tr>
<th>$R_L$</th>
<th>$i_L$</th>
<th>$V_L$</th>
<th>$P_L$</th>
</tr>
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<tbody>
<tr>
<td>150 $\Omega$</td>
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<tr>
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<tr>
<td>2200 $\Omega$</td>
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</table>
Experimental

1) Build the circuit shown in the figure **without** the load resistor.
   a) Measure and record the equivalent resistance.
   b) Measure and record the open circuit voltage.
   c) Measure and record the short circuit current.

\[
\begin{array}{|c|c|}
\hline
R_T & \ \ \\
\hline
V_T & \ \ \\
\hline
I_N & \ \ \\
\hline
\end{array}
\]

2) Measure and connect a 1000 \( \Omega \) load resistance. Measure the voltage across and current through the load resistor. Then, calculate the power dissipated by the load resistor.

\[
\begin{array}{|c|c|c|}
\hline
R_L & i_{RL} & P_{RL} \\
\hline
V_{RL} & \ \ \\
\hline
\end{array}
\]

3) Build the Thevenin equivalent circuit and repeat 2) for \( R_L = 150, 330, 470, 680, 1k, 1.5k, \) and \( 2.2 \) k\( \Omega \). Record results in table.

\[
\begin{array}{|c|c|c|c|}
\hline
R_L & i_L & V_L & P_L \\
\hline
150 \Omega & \ \ & \ \ & \ \\
330 \Omega & \ \ & \ \ & \ \\
470 \Omega & \ \ & \ \ & \ \\
680 \Omega & \ \ & \ \ & \ \\
1000 \Omega & \ \ & \ \ & \ \\
1500 \Omega & \ \ & \ \ & \ \\
2200 \Omega & \ \ & \ \ & \ \\
\hline
\end{array}
\]

4) Build the Norton equivalent circuit and repeat 2) for \( R_L = 150, 330, 470, 680, 1k, 1.5k, \) and \( 2.2 \) k\( \Omega \). Record results in table.

\[
\begin{array}{|c|c|c|c|}
\hline
R_L & i_L & V_L & P_L \\
\hline
150 \Omega & \ \ & \ \ & \ \\
330 \Omega & \ \ & \ \ & \ \\
470 \Omega & \ \ & \ \ & \ \\
680 \Omega & \ \ & \ \ & \ \\
1000 \Omega & \ \ & \ \ & \ \\
1500 \Omega & \ \ & \ \ & \ \\
2200 \Omega & \ \ & \ \ & \ \\
\hline
\end{array}
\]
Post-Lab

1) Plot power versus resistance for the measured results. Keeping in mind maximum power transfer, discuss your results. At what load resistance was the power transfer maximum?

2) Did the Thevenin and Norton Equivalent circuits produce the same voltages across and currents through the load resistor?