Thevenin's Theorem and Max Power Transfer

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Abstract

In this lab we will construct a circuit and test to find the Thevenin voltage and resistance as seen by a load resistor and compare these measurements with the theoretical calculations of the same circuit. We will then determine the power across the resistor as resistance is varied and compare this to what we know about max power and it's relationship with the Thevenin resistance of the circuit.

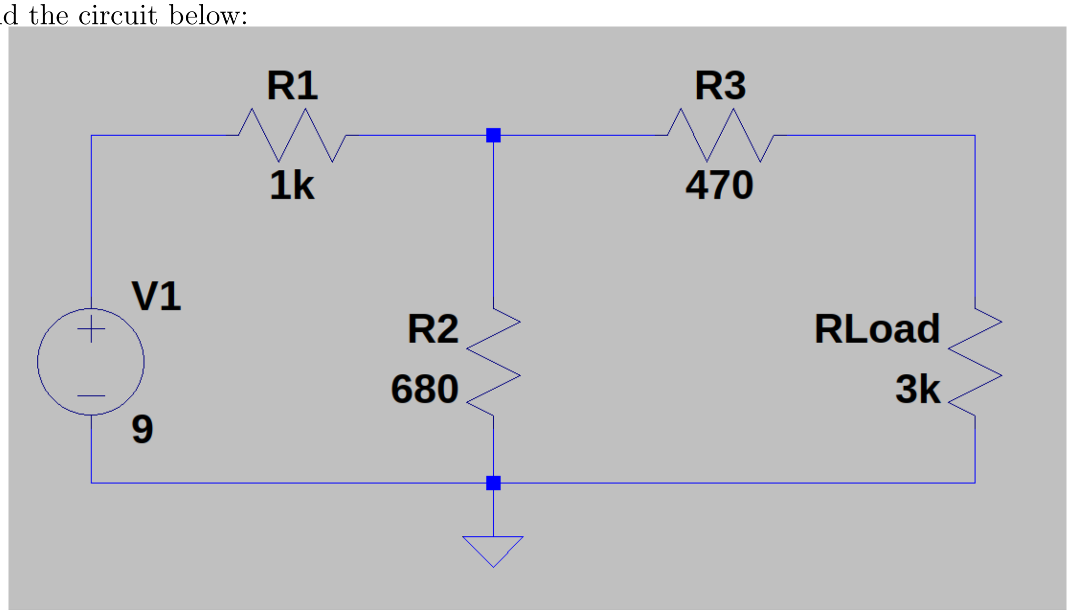
Equipment

- Extech EX330
- GWINSTEK GPE-3323 Serial: GER901738
- 470, 680, 1000 Ω Resistors
- RS-200 Resistance Substituter

Procedure

Part 1

1. Measure all resistors and record real values
2. Build the circuit below:



3. Remove the load and measure the open circuit voltage and the short circuit current.
4. Calculate the Thevenin resistance from $\frac{V_{oc}}{I_{sc}}$
5. Theoretically calculate the Thevenin voltage and resistance of the circuit. Compare the measured to the theoretical.
6. Replace the load resistor and measure the current and voltage across the load.
7. Build the Thevenin Equivalent circuit with the load in place and record the current and voltage across the load.
8. Compare the differences.

Part 2

9. Calculate the max power of this circuit.
10. Replace the load with the resistor substituter and record the voltage across the load from a range of resistance values. Calculate the power delivered to the load.
11. Graph the data and compare to the calculated max power from the Thevenin Circuit.

Measurements

Resistor Measurements:

$$R_1 = 986\Omega \qquad R_2 = 670\Omega \qquad R_3 = 462\Omega \qquad R_{Load} = 2944\Omega$$

Open Circuit Voltage, Short Circuit Current, Measured Total Resistance (Power Supply set to 0v):

$$V_{oc} = 3.65V \qquad I_{sc} = 4.19mA \qquad R_{measured} = 903\Omega$$

R_{Th} calculated from V_{oc} and I_{sc}:

$$R_{Th} = \frac{V_{oc}}{I_{sc}} \Rightarrow R_{Th} = 871.12\Omega$$

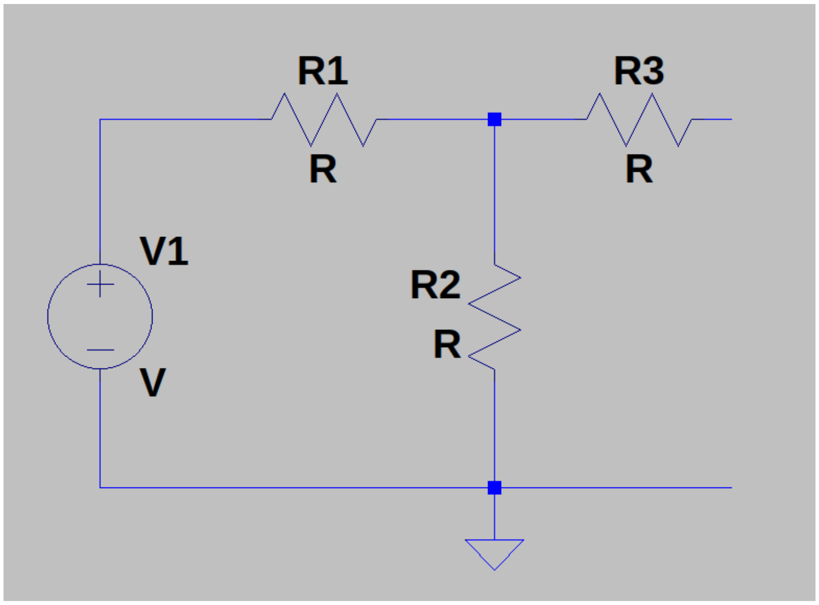
Current and Voltage Across R_{Load}:

$$I_L = 4.16mA \qquad V_L = 2.814v$$

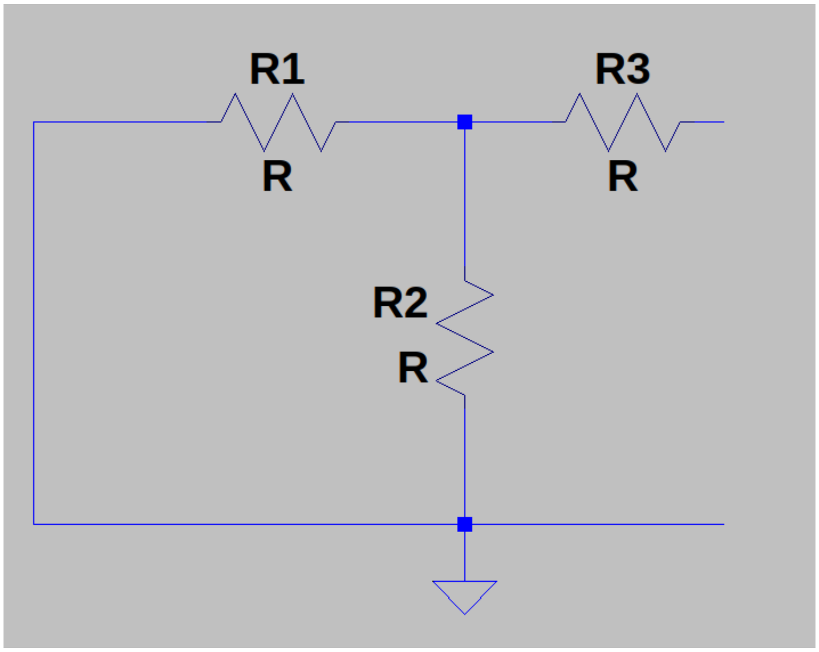
Current and Voltage Across R_{Load} with the Thevenin Equivalent Circuit:

$$I_L = 4.12mA \qquad V_L = 2.809v$$

Theoretical

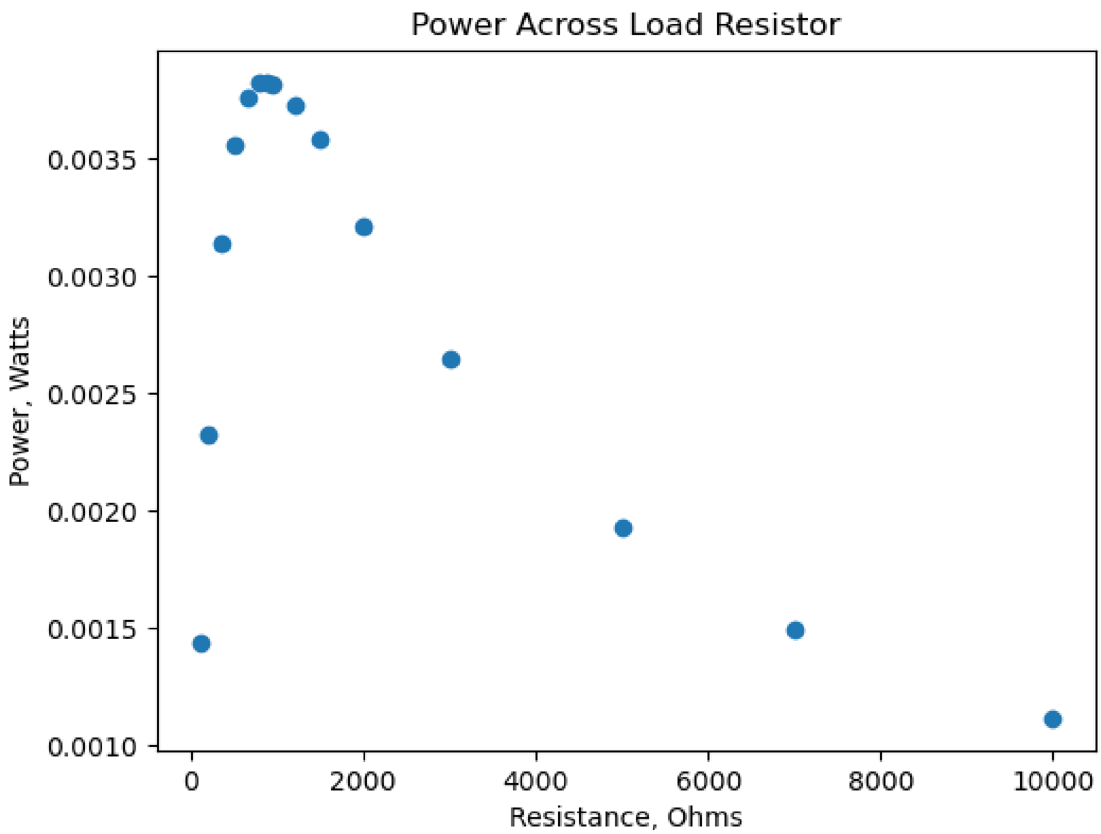


$$V_{Th} = 9v * \frac{670\Omega}{986\Omega + 670\Omega} \Rightarrow V_{Th} = 3.64v$$



$$R_{Th} = \frac{986\Omega * 670\Omega}{986\Omega + 670\Omega} + 462\Omega \Rightarrow R_{Th} = 865.93\Omega$$

Part 2



As the load resistance increased the power across the load increased until a max was met. The max power occurred when $R_{Load} = 871$. Power decreased as resistance increased past this peak. This supports the theory that max power occurs at the Thevenin Resistance of the circuit.

Theoretical Max Power of the circuit:

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} \Rightarrow P_{max} = \frac{3.64^2}{4 * 865.93} \Rightarrow P_{max} = .00383W$$

Max Power of the circuit:

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} \Rightarrow P_{max} = \frac{1.825^2}{871} \Rightarrow P_{max} = .00382W$$

Conclusion

By comparing our measured values of this circuit with the theoretically calculated values we find that there to be a .01 v difference between the Thevenin voltage across a load resistor compared to the measured value and a 5.19 Ω difference between the Thevenin resistance and the measured resistance of the circuit as seen by the load resistor. We also found that the max power of the circuit occurs when the load resistor is equal to the Thevenin resistance.