EE 2010 Circuit Analysis
Lab 09: DC Superposition and Thevenin Equivalent

Lab Section: **Printed Name (Last, First):**

Learning Objectives:

- Use Multisim to simulate and validate a two-source DC circuit
- Understand the notions of Superposition and Thevenin Equivalence
- Measure the voltage-current at the load of an original and simplified circuit
- Validate the concept of a Thevenin equivalent.

A. Before coming to lab:

1. Background

1.1 Read this article on Thevenin equivalent source and resistance.

1.2 Look over these examples of equivalent circuits.

2. A Dual DC Source Circuit Simulation

2.1 Construct a simulation of the circuit shown below:

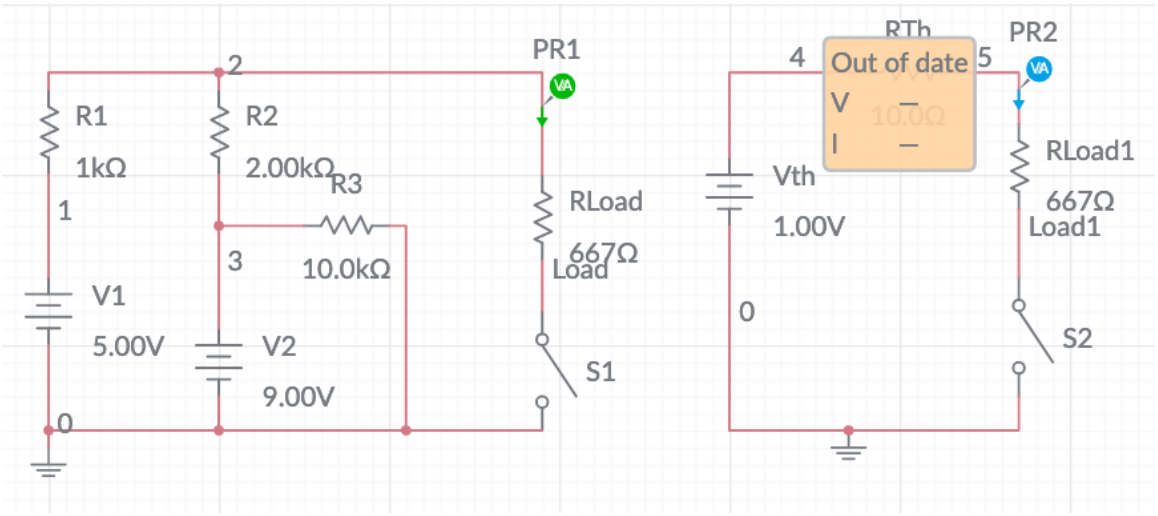


Figure 1: Dual source circuit and a simplified model.

2.2 Measure the "open-circuit" voltage of the circuit on the left by opening the switch.

2.3 Set the 5V source to 0V, and measure the open-circuit voltage. 3v

2.4 Turn the 5V source back on, and set the 9V source to 0V, and measure the open-circuit voltage.

2.5 Take note that voltage contributions add to the sum - a validation of "Superposition." 3+3.3333=6.3333v

2.6 Turn both voltage sources back on. 6.3333v

2.7 Adjust the source voltage for the circuit on the right to obtain the same open-circuit voltage. 6.3333v

2.8 This is the "Thevenin equivalent" voltage source simplified model.

2.9 Connect the load resistor (by closing the switch) in the circuit on the left.

2.10 Connect the load resistor (by closing the switch) in the circuit on the right.

2.11 Adjust the RTH resistor for the circuit on the right to obtain the same voltage and current as the circuit on the left. 666.66ohm

2.12 This is the "Thevenin equivalent" resistance for the simplified model.

2.13 Run the simulation and capture the results. Include the schematic and the grapher figures in your lab report.

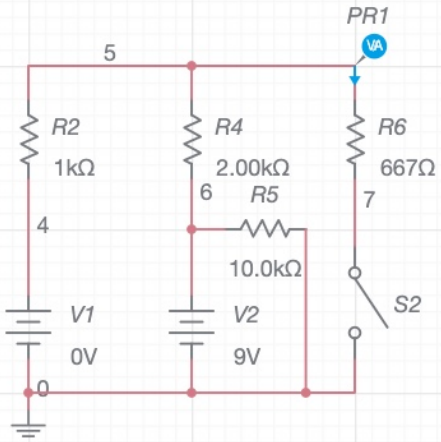
3. Observations

2.1.1 We have experimentally validated the principle of Superposition.

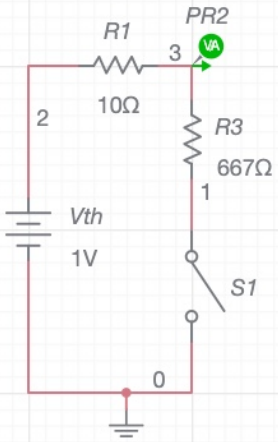
2.1.2 We have experimentally found the Thevenin equivalent source voltage.

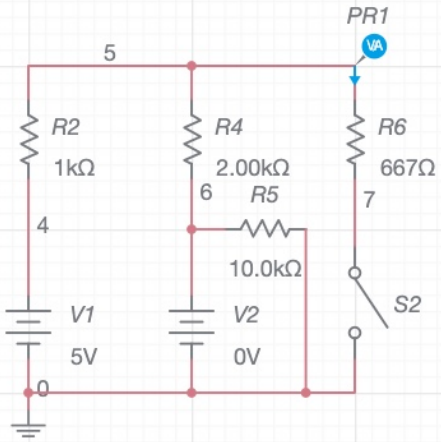
2.1.3 Note that this technique is applicable to ANY linear circuit.

2.1.4 We have also experimentally found the Thevenin equivalent resistance (internal to the system.)

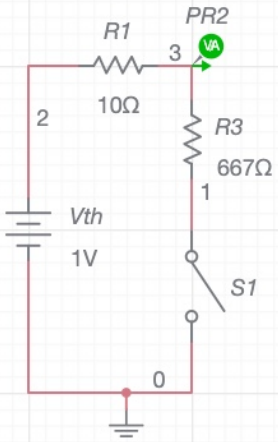


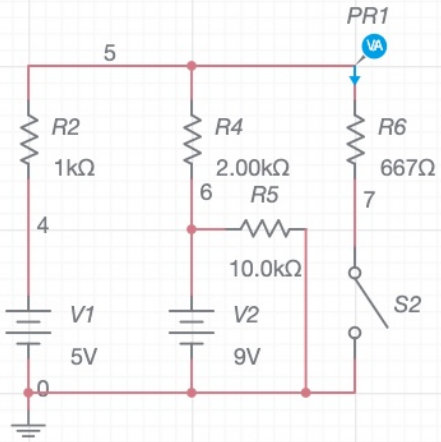
v 3.0000V
i 30.003nA



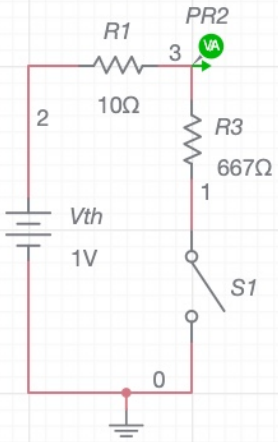


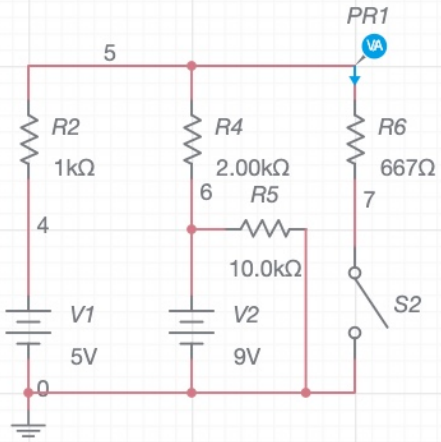
v 3.3333V
i 33.336nA



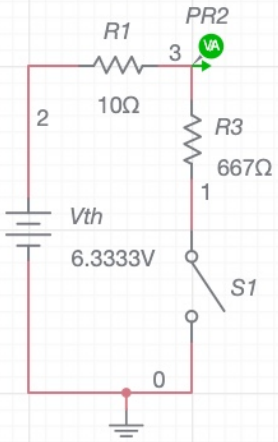


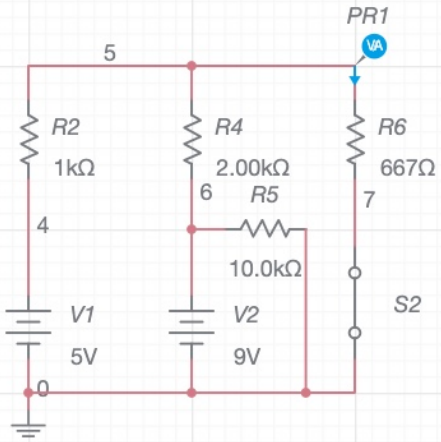
v 6.3333V
i 63.339nA



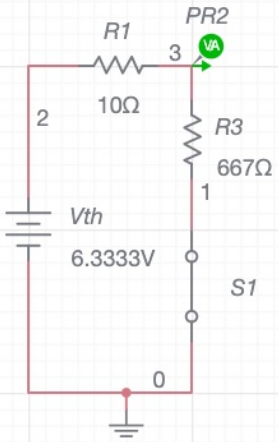


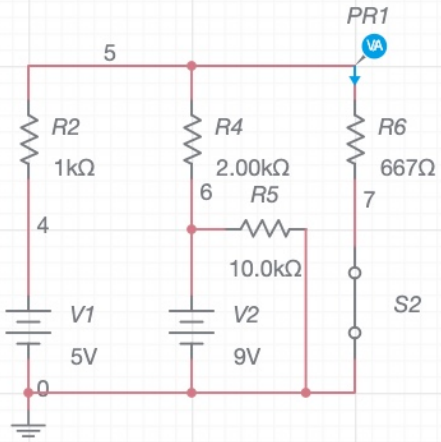
v 6.3333V
i 63.339nA

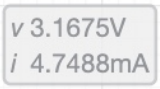


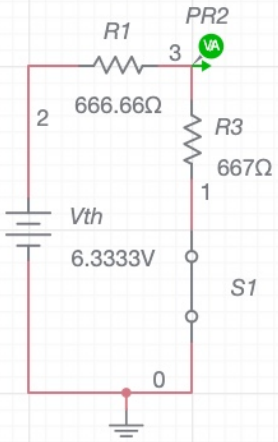


v 3.1675V
i 4.7488mA




PR1
5
R2
1kΩ
4
V1
5V
0
R4
2.00kΩ
6
R5
10.0kΩ
V2
9V
R6
667Ω
7
S2


v 3.1675V
i 4.7488mA


R1
PR2
3
666.66Ω
2
Vth
6.3333V
R3
667Ω
1
S1
0

B. In Lab Procedures

In this lab session you will experimentally determine the Thevenin equivalent for a dual-supply resistive circuit.

1. Construct the dual-supply resistive circuit simulated in the prelab

1.1 Assemble the circuit to resemble the simulated circuit below.

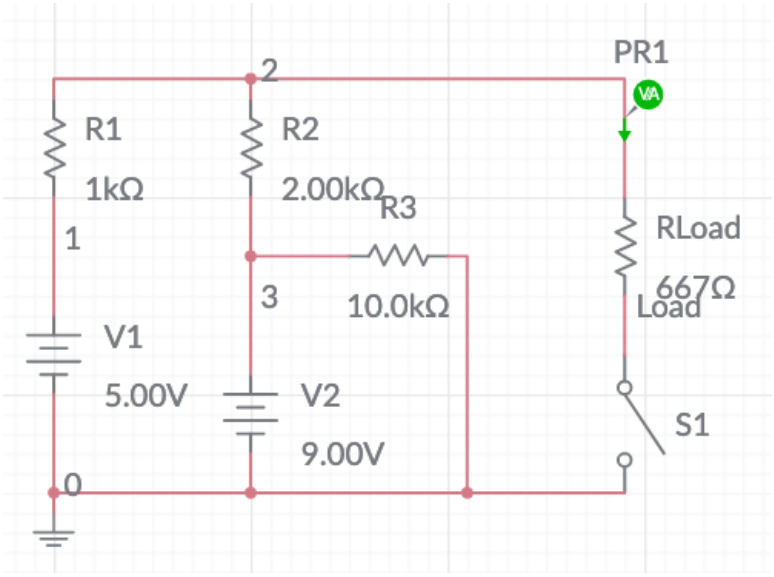


Figure 2: Dual-supply resistive circuit

1.2 Use the bench power supply to provide the 5V DC and 9V DC excitations

1.3 Measure the "open-circuit" voltage at Rload by opening the circuit

1.4 Replace the 5V source with a short (jumper wire), and measure the open-circuit voltage at Rload: 3

1.5 Reconnect the 5V source

1.6 Replace the 9V source with a short (jumper wire), and measure the open-circuit voltage at Rload: 3.34

1.7 Take note that voltage contributions add to the sum - a validation of "Superposition."

1.8 Reconnect both voltage sources

1.9 Measure the open-circuit voltage at Rload: 6.34

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1.10 The Open Circuit voltage at Rload is the "Thevenin equivalent" voltage source simplified model

1.11 Reconnect the load resistor

1.12 Measure the loaded voltage across the load resistor: 3.21

1.13 Calculate the last equality in:

$$\begin{aligned} R_{Th} &= -\frac{V_{\text{OPEN}} - V_{\text{LOAD}}}{I_{\text{OPEN}} - I_{\text{LOAD}}} \\ &= \frac{V_{\text{OPEN}} - V_{\text{LOAD}}}{I_{\text{LOAD}} - 0} \\ &= \frac{V_{\text{OPEN}} - V_{\text{LOAD}}}{V_{\text{LOAD}}/R_{\text{LOAD}}} \end{aligned}$$

(6.34-3.21)/(3.21/680)=663.05

1.14 This is the "Thevenin equivalent" resistance for the simplified model.

1.15 Compare the In-Lab results with the simulation results of the Pre-Lab.

similar to prelab

C. Takeaways:

- Are there other techniques to determine the Thevenin equivalent resistance? What might these be?
- Does the Thevenin equivalent resistance depend on the value of the load resistor.
- Describe why the Thevenin model might be useful in analyses of circuit modules.