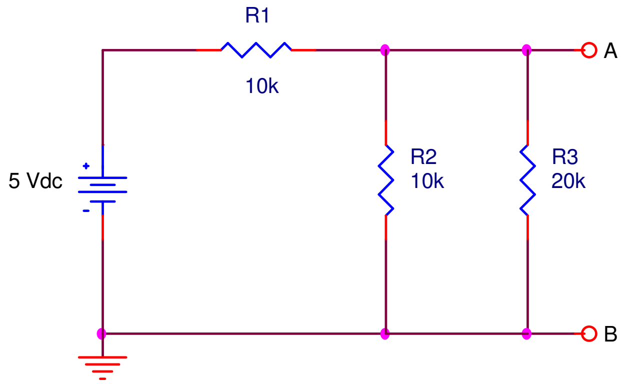
LAB #13: Thevenin's Theorem, Maximum Power Transfer, R-2R Ladders

In this lab the concepts of Thevenin's Theorem, the Maximum Power Transfer Theorem, and R-2R resistor ladder networks will be explored.

Part I: Thevenin's Theorem (30 pts)



To obtain the Thevenin Equivalent circuit as seen through nodes A and B, begin by calculating the Thevenin's Equivalent Voltage (V_{TH}).

Thevenin's Equivalent Voltage (V_{TH}) is the open circuit voltage between two points in a circuit. In this example, the open circuit voltage will be the voltage between A and B (V_{AB}).

1. Use the Series-Parallel analysis to calculate V_{AB}. (3 pts)

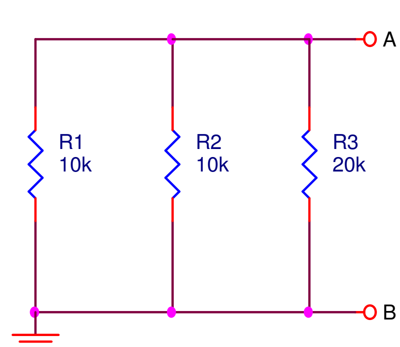
$V_{TH} = V_{AB} =$ ______________

The next step is to determine Thevenin's Equivalent Resistance (R_{TH}).

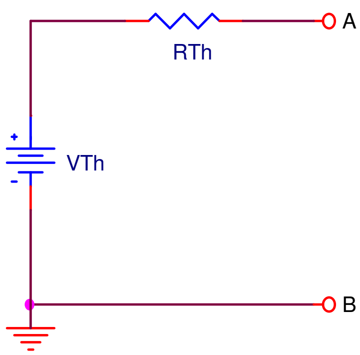
Thevenin's Equivalent Resistance (R_{TH}) is the total resistance appearing between two terminals. To find R_{TH}, short all the sources in the circuit and determine resistance between the two terminals. In this example, R_{TH} is the resistance that appears between A and B (R_{AB}).

2. Theoretically replace V1 with a **short** and calculate RAB. (3 pts)

$R_{TH} = R_{AB} =$ ______________



3. Complete the Thevenin schematic with the values calculated for V_{TH} and R_{TH}. (3 pts)



This circuit represents the Equivalent circuit. If we were to connect a load between A and B, the entire circuit would behave like this simpler circuit. Thevinizing a circuit is very useful for the purpose of observing how a load affects a circuit.

4. Build the complete circuit on page 1 to make the Thevenin measurements. (10 pts)

$V_{AB(\text{open circuit})}$ = ___________ $I_{AB(\text{short circuit})}$ = ___________

$R_{TH} = V_{AB} / I_{AB}$ = ___________

5. Turn OFF the power supply and measure the resistance at terminals A and B. (3 pts)

R_{AB} = ___________

6. Was this value equal to the resistance value calculated from the $V_{AB(oc)}$ and $I_{AB(sc)}$? If not how might this measurement be correctly performed? (3 pts)

Obtain a Potentiometer (POT) of at least 5 kΩ, and connect across (in parallel to) nodes A and B. The POT has three connections, but only two are needed in this circuit. Use the Top and Center, **or** the Center and Bottom terminals.

Connect a Voltmeter across A and B and turn ON the power supply.

Adjust the potentiometer until the voltmeter reads exactly HALF of V_{TH} ($V_{AB(\text{open circuit})}$ in this experiment).

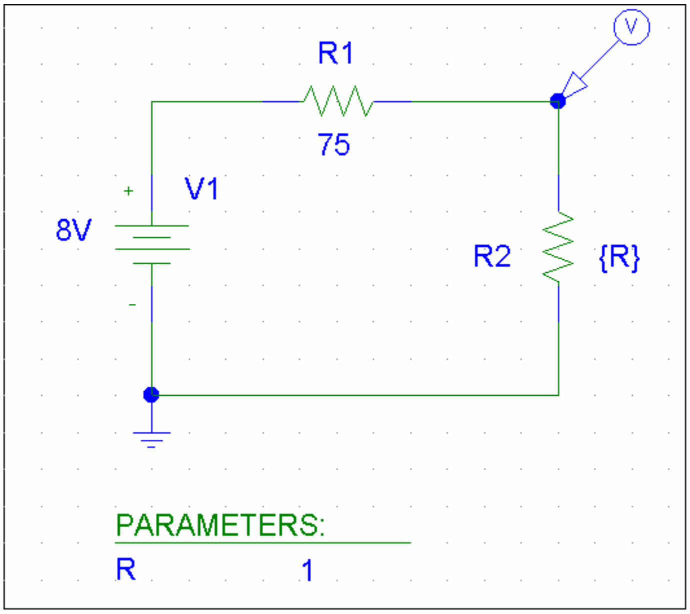
Turn OFF the power supply and remove the potentiometer WITHOUT adjusting it.

7. Use the multi-meter to measure the resistance between the two connections of the potentiometer that were connected to the circuit. (5 pts)

R_{POT} = ______________ This should also be the Thevenin Resistance.

PART II: The Maximum Power Transfer Theory (25 pts)

Given:



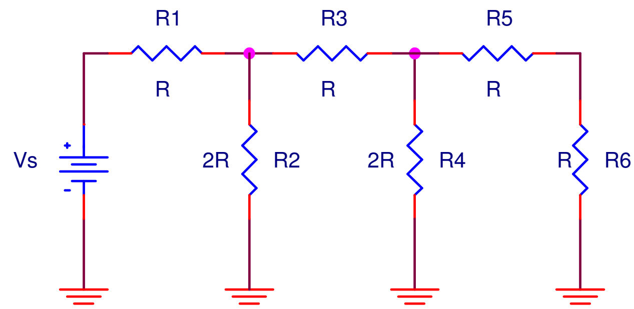
In this part, the **Maximum Power Transfer Theorem** will be explored by simulating the circuit in Pspice. The result will be a graph that shows how the power at the load changes with different load resistors. The graph should look similar to the one on page 244 of the textbook.
(The following directions must be followed very closely to successfully create the graph.)

1. In Pspice Schematics draw the circuit above, initially ignoring the "PARAMETERS" and the "V arrow marker".
2. For the value of R2 enter {R} rather than a numeric value like normal.
3. Select the Voltage/Level Marker and place a marker above R2 as shown in the diagram.
4. Now, select the ***DRAW>GET NEW PART*** menu.
5. In the field under PART NAME, enter PARAM. Click ***Place & Close***.
6. Double click on the PARAM. In the popup window enter R in the NAME1 box, and 10 in the VALUE1 box. Click ***SaveAtr*** and close the window.
7. From the Dropdown menu select ***Analysis>Setup***.
8. Check the ***DC SWEEP*** box, and open the ***DC SWEEP Options***.
9. Under ***Sweep Var. Type*** select ***Global Parameter***.
10. In the ***Name*** box enter R. In the ***Start Value*** box enter 1. In the ***End Value*** box enter 150. In the ***Increment*** box enter 1.
11. Select ***OK*** to close the window.
12. Now ***Run*** the simulation. There are only a few more steps.
13. In the plot window double click on the text label ▫`V(R2:2)` or ▫`V(R2:1)`. The **Modify Trace** window should open.
14. If the trace expression shows `V(R2:2)` change it to `-V(R2:2)*I(R2)`; if it shows `V(R2:1)` change it to `V(R2:1)*I(R2)`.
15. If the graph shows a peak at 75Ω use the ***Window>Copy to Clipboard…*** menu to include it in your lab report. Otherwise check your work or ask for assistance.

DESIGN I: Resistive Ladder Networks (35 pts)

R-2R resistor networks (also called ladders) have a very unique property that divides the source voltage by 2 for each rung of the ladder that is crossed. R-2R ladders are often used when converting digital signals to analog and analog signals to digital. Because only two resistor values are needed the circuits can be made more accurately than some other circuits.

Use Pspice to design a R-2R Resistive Ladder Network that obeys the following constraints:



1. R1, R3, R5, & R6 are all the same.
2. R2 & R4 are the same and twice R1.
3. Choose any standard value resistors. (5 pts)
4. Is cannot exceed 1mA. (5 pts)
5. V_{R2} = 5 V. (5 pts)
6. V_{R4} = 2.5 V. (5 pts)
7. V_{R6} = 1.25 V. (5 pts)

Simulate your circuit in Pspice, and include the results to your lab report.

6. Build the circuit, show it to the lab instructor, and measure the following: (10 pts)

	R	V	I
R1			
R2			
R3			
R4			
R5			
R6			
	RT =	Vs =	Is =