Lab Experiment 12

Thevenin's Theorem and Maximum Power Transfer

Introduction

Part 1- Thevenin's Theorems

Thevenin's Theorem is applied to analyze a load does not care where it gets its energy from. As a matter of fact, as long as a load gets the same required energy, it "does not know" what circuit it is connected to. To this, Thevenin said that instead of using the original circuit to supply the required energy to the load, he will substitute the original circuit with a battery in series with a resistor, each of the proper value of course, and this combination will supply the load with the same required energy as the original circuit.

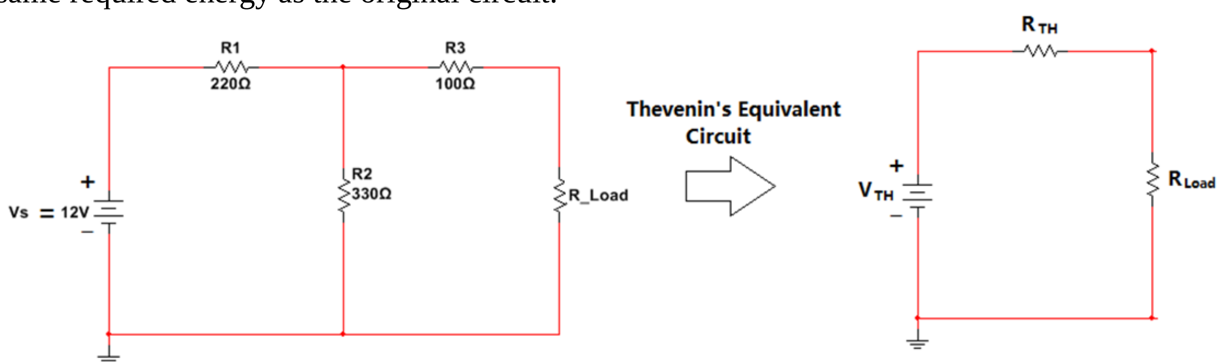


Figure 12.1 – Thevenin's Equivalent Circuit

Part 2 - Maximum Power Transfer

One important fact of circuit analysis is to find the conditions that should be imposed on the source and load resistance to ensure that it will deliver the maximum power to the load.

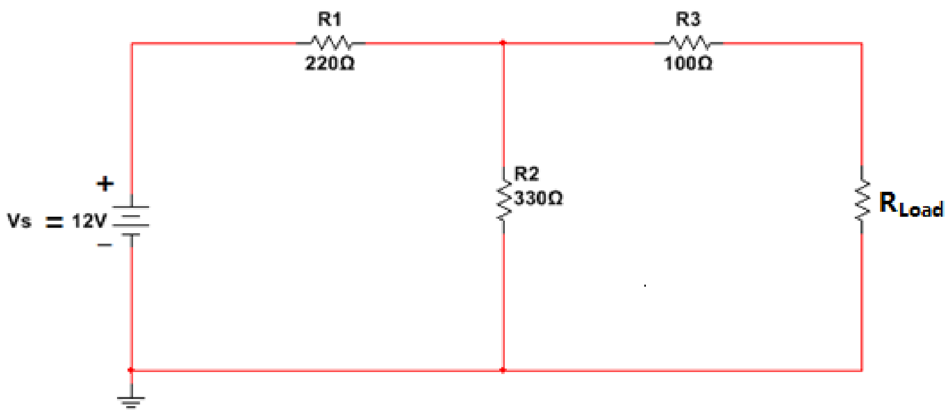
The maximum power transfer theorem states that *a load will receive maximum power from a network when its resistance is exactly equal to the Thevenin resistance of the network applied to the load.*

$$R_L = R_{TH}$$

Lab Experiment Procedure

Part I: Original Circuit Measurements

Circuit 12.1 shows a circuit with a 12V battery connected to a series parallel circuit consisting of R_1, R_2 and R_3. This circuit feeds energy to a load resistor R_L (1 kΩ potentiometer). The expected values of load current, load voltage and power to the load are also shown. You will be asked to confirm these values in your write-up.



Circuit 12.1 Original Circuit Feeding Load Resistor

— Obtain 220 Ω, 330 Ω, and 100Ω resistor from your components kit. Measure their resistance individually, and record the measured values in Table 12.1.
— Obtain a 1 kΩ potentiometer and measure the highest resistance of the 1 kΩ potentiometer. Record measurement in Table 12.1
— Set the potentiometer to 500 Ω and record the measurement in Table 12.1

Given Resistance	Measured Resistance (Include unit)	Percent of difference $\left(\frac{Measured - \ldots Given}{Given}\right)$ *100%
R1 = 220 Ω		
R2 = 330 Ω		
R3 = 100 Ω		
R_{Load} = 1 kΩ pot		

Table 12.1 – Resistance measurement

— Build Circuit 12.1 in a protoboard.
— Prepare the DMM and circuit to measure current
— Measure the current through R_{Load}. Record measurement in Table 12.2

— Prepare the DMM and circuit to measure voltage
— Measure the voltage across R_{Load}. Record measurement in Table 12.2
— Multiply the voltage and the current through R_{Load} to obtain the power. Record the power in Table 12.2

	Voltage across the load resistance, V_L	**Current through the load resistance, I_L**	**Power dissipation at the load resistance, P_L**
Measured Value (Include Unit)			

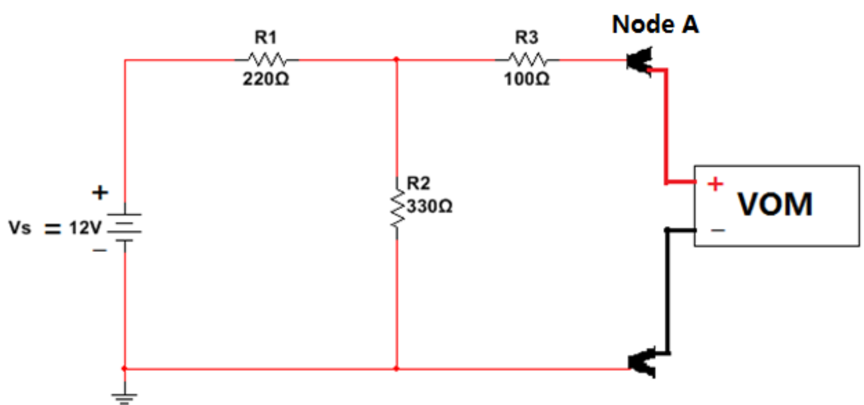
Table 12.2 Original Circuit Measurements

Part 2 - Thevenin's Equivalent Circuit

Circuit With R_{Load} Removed - Thevenin's Voltage

Circuit 12.2 shows the circuit with the load resistor removed. The open circuit voltage from Node A to ground is the Thevenin Voltage [V_{TH}].

— Remove the load resistor, 500 Ω (potentiometer), from the circuit and place jumper wires where the connections of R_{Load} were. Check Circuit 12.2 for reference
— Prepare the DMM to measure voltage (VOM)
— Measure the voltage across the open circuit where R_{Load} was connected, between Node A and ground. This voltage is known as the Thevenin's voltage.
— Record this measured value in Table 12.3

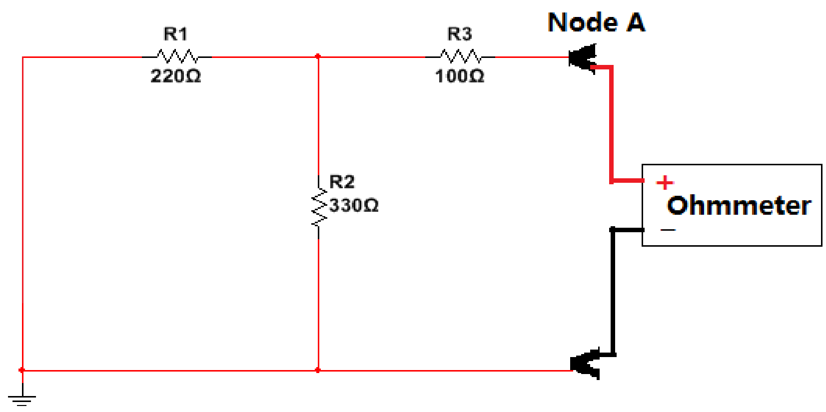


Circuit 12.2 Thevenin Voltage Measurement

Measuring the Thevenin's resistance

— Move one terminal of R1, the one that is connected to + power, to ground. Check Circuit 12.3 for reference.
— Prepare the DMM to measure resistance

- Measure the resistance in between the open circuit where R_{Load} was connected, between Node A and ground. This resistance is known as the Thevenin's resistance.
- Record this measured value in Table 12.3.
- Disassemble the circuit, turn off of lab equipment, organize the equipment leads, and organize the lab components.
- Proceed with calculations.



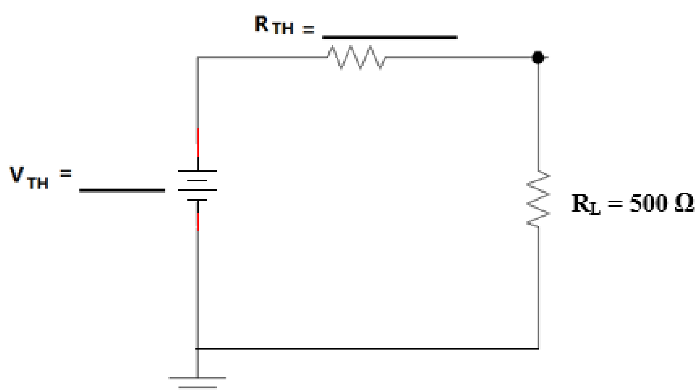
Circuit 12.3 Thevenin's resistance measurement

Thevenin's Equivalent Circuit Measurements		
	Voltage across the open circuit Thevenin's voltage, V_{TH}	Resistance between the open circuit Thevenin's resistance, R_{TH}
Measurements (Include all unit)		

Table 12.3 Thevenin Equivalent Circuit Measurements

Calculating the voltage, current, and power at the R_{Load} using the Thevenin's Equivalent circuit

Fill up the Circuit 12.4, which is the Thevenin's equivalent circuit, with measured values from Table 12.4.



Circuit 12.4 – Thevenin's equivalent Circuit

- Calculate the voltage, current, and power through $R_L = 500\Omega$
- Record calculation in table 12.4

Load Resistance calculation using the Thevenin's Equivalent Circuit			
	Voltage across the load resistance, V_L	**Current through the load resistance, I_L**	**Power dissipation at the load resistance, P_L**
Calculations (Include all unit)			

Table 12.4 – Load analysis from the Thevenin's Equivalent Circuit

- Use the information in Table 12.2 and Table 12.4, and calculate the percent of difference between the original circuit and the Thevenin's equivalent circuit in Table 12.5

Load Resistor Analysis			
	Voltage across the load resistance, V_L	**Current through the load resistance, I_L**	**Power dissipation at the load resistance, P_L**
Original Circuit Table 12.2			
Thevenin's Equivalent Table 12.4			
$\% = \left(\frac{\boldsymbol{Original} - \boldsymbol{Thevenin's}}{\boldsymbol{Original}}\right) \times \mathbf{100\%}$			

Table 12.5 – Load Resistance Analysis

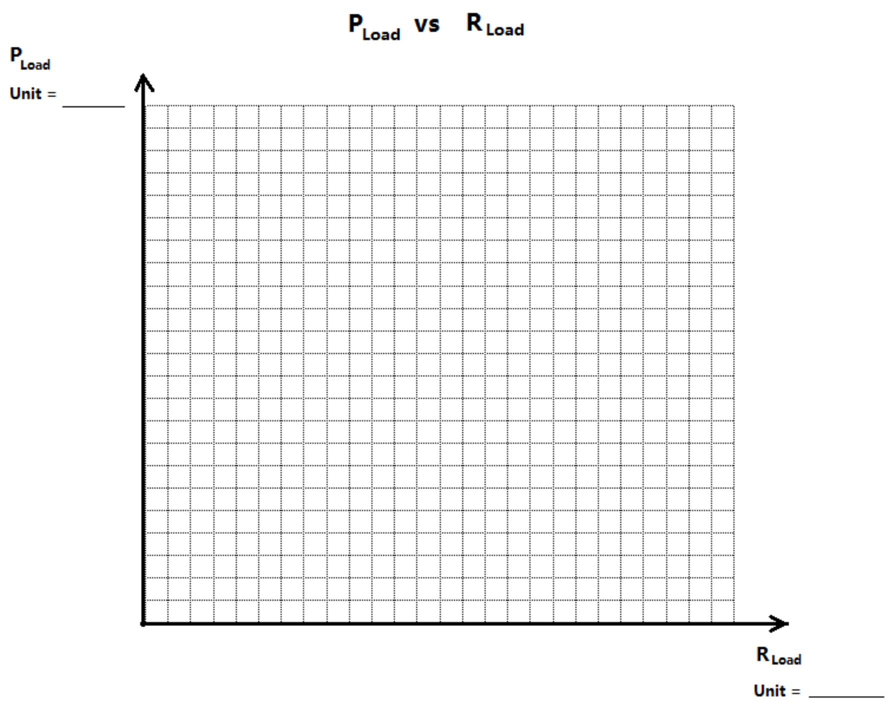
Part 3 – Maximum Power Transfer Analysis

- Build the Thevenin's equivalent circuit with its respective R_{TH} and V_{TH} values as shown in Circuit 12.4. Note: if you don't have the exact R_{TH} resistor in your components' kit, you can use another potentiometer and set it to the resistance of R_{TH}.
- Set the R_{Load} potentiometer to 0 Ω
- Prepare the multimeter and circuit to measure voltage.
- Measure the voltage across R_{Load} and record the measurement in Table 12.6
- Increment the resistance of R_{Load} according to Table 12.6, measure the voltage across R_{Load}, and record the measurement in Table 12.6.
- Once all data are recorded, disassemble the circuit, turn off of lab equipment, organize the equipment leads, and organize the lab components.

Power Analysis Through R_{Load}		
R_{Load} Ω	Measured V_{Load} (Include unit)	$Load\ Power, P_{Load} = \frac{(V_{Load})^2}{R_{Load}}$ (Include unit)
0 Ω		
50 Ω		
100 Ω		
175 Ω		
225 Ω		
275 Ω		
350 Ω		
375 Ω		
400 Ω		
500 Ω		
600 Ω		
800 Ω		
1000 Ω		

Table 12.6 – Power dissipation through R_{Load}

Using the measurements from Table 12.6, plot P_{Load} versus R_{Load}



Graph 12.1 – Maximum Power Transfer Plot - P_{Load} vs R_{Load}

- From Graph 12.1, estimate or measure the *Maximum Power Transfer* through load resistor, R_{Load} and record the measurement in Table 12.7
- Calculate the Maximum Power Transfer through the load resistor using Formula 12.1. Record calculation in Table 12.7

Maximum Power Transfer Analysis		
Measured Maximum Power from Graph 12.1 (Include Unit)	**Calculated Maximum Power using Formula 12.1 (Include Unit)**	**% of difference**

Table 12.7 – Maximum Power Transfer Analysis for Circuit 12.1

Questions

1. Does Thevenin's Equivalent supply the load with the same power as the original circuit? Explain your answer.
2. From the Thevenin's Equivalent circuit, Circuit12.4, would the polarity of V_{TH} affect the load voltage and current measurement? Explain your answer.
3. From Table 12.6, explain the power behavior with respect to the R_{Load}
4. Can you estimate the maximum power through the load by using the data from Table 12.6? How? Explain your answer.
5. Thevenin's equivalent circuit, Circuit 12.4, was used to obtain the power behavior for Table 12.6. If the original circuit, Circuit 12.1, was used instead of Circuit 12.4, would the power behavior be the same or different? Explain your answer.

Student's Name: ________________ Lab Instructor's Signature ____________________

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