Student's Name: Date:

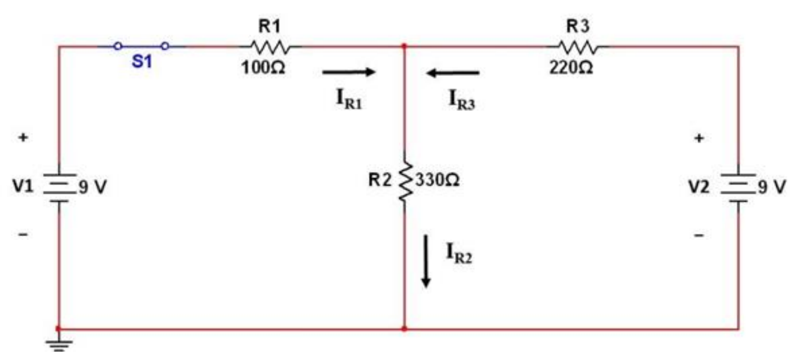
Introduction to Circuit Analysis Laboratory

Lab Experiment 10

Superposition Theorem Analysis in a Resistivity Circuit

Superposition-Two Energy Sources

In a scenery of complex circuits or circuits that have more than one sources (voltage and/or current) as shown in Circuit 10.1, regular method of series and parallel analysis is not enough to predict the voltage and current distribution within the circuit. One way to predict the currents and voltages for each resistor is to use **superposition theorem**. The method of superposition consists of finding the voltage and current contribution to each element by each source and then combining the effects.



Circuit 10.1 – Resistive circuit with two voltage sources (Original Circuit)

Appendix

$$\%\,\boldsymbol{difference} = \left(\frac{\textbf{Actual or calculated value} - \textbf{measured value}}{\textbf{Actual or calculated value}}\right) \times \mathbf{100}\%$$

Formula 10.1 – Percentage of difference formula

To find the contribution of one source, all of the other sources have to be removed from the circuit. Current sources are replaced by open circuits while voltage sources are replaced with short circuits. Once with one source active, find the voltage and current distribution through each of the resistors.

At the end of superposition, remember that currents in the same direction add, keeping the original direction. Currents in opposite directions subtract, keeping the direction of the larger current. Voltages with the same polarity add, keeping the original polarity. Voltages with opposite polarities subtract, keeping the polarity of the larger voltage.

Lab Experiment Procedure

Part 1: Original Circuit Measurement

1. Obtain 100 Ω, 220 Ω, and 330 Ω from your components' kit
2. Measure each resistor's value and record the measured resistance in Table 10.1

Resistor	Measured value (Include unit)
R1 = 100 Ω	
R2 = 330 Ω	
R3 = 220 Ω	

Table 10.1 – Resistance Measurement

3. Build Circuit 10.1 in a protoboard.
4. Prepare the circuit and the multimeter to measure current.
5. Measure the current through each resistor, I_{R1}, I_{R2}, and I_{R3}. Record measurement in Table 10.2, don't forget to include the direction of current flow for each resistor.

Current	Measured value (Include unit and direction of current flow)
$I_{R1(100\,\Omega)}$	
$I_{R2(330\,\Omega)}$	
$I_{R3(220\,\Omega)}$	

Table 10.2 – Current measurement through each resistor in Circuit 10.1

6. Prepare the circuit and the multimeter to measure voltage.
7. Measure the voltage across each resistor, V_{R1}, V_{R2}, and V_{R3}. Record measurement in Table 10.3, don't forget to include the voltage polarity for each voltage drop.

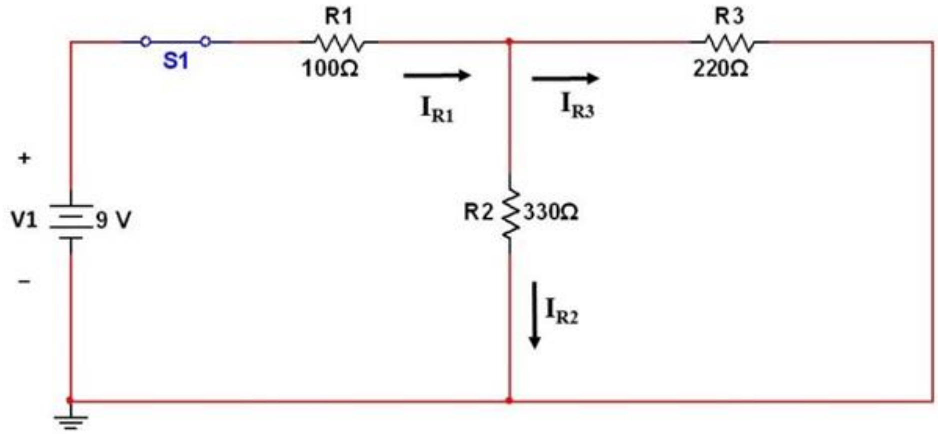
Voltage	Measured value (Include unit and voltage polarity)
$V_{R1(100\ \Omega)}$	
$V_{R2(330\ \Omega)}$	
$V_{R3(220\ \Omega)}$	

Table 10.3– Voltage Measurement of Original Circuit

Now, prepare to analyze Circuit 10.1 using superposition theorem. For this, each voltage source is active one at the time, and measurement of current and voltage through each resistor is done for each active source independently.

Part 2: Current and Voltage Measurement with "ONLY" V1 Voltage Source Active

8. To deactivate V2 voltage source, change the connection of R3 from the positive of the voltage source V2 to Ground ("-" of protoboard). This will ground the voltage source V2 and only V1 will be active. Check Circuit 10.2 for reference.



Circuit 10.2 – Original Circuit with V_{R1} active

9. Prepare the circuit and the multimeter to measure current.
10. Measure the current through each resistor, I_{R1}, I_{R2}, and I_{R3}. Record measurement in Table 10.4, don't forget to include the direction of current flow for each resistor.

Current	**Measured value (Include unit and direction of current flow)**
$I_{R1(100\ \Omega)}$	
$I_{R2(330\ \Omega)}$	
$I_{R3(220\ \Omega)}$	

Table 10.4 – Current Measurement of Original Circuit with ONLY V1 Voltage Source Active

11. Prepare the circuit and the multimeter to measure voltage.
12. Measure the voltage across each resistor, V_{R1}, V_{R2}, and V_{R3}. Record measurement in Table 10.5, don't forget to include the voltage polarity for each voltage drop. Hint: The polarity can be found by knowing the direction of the current flow through each resistor

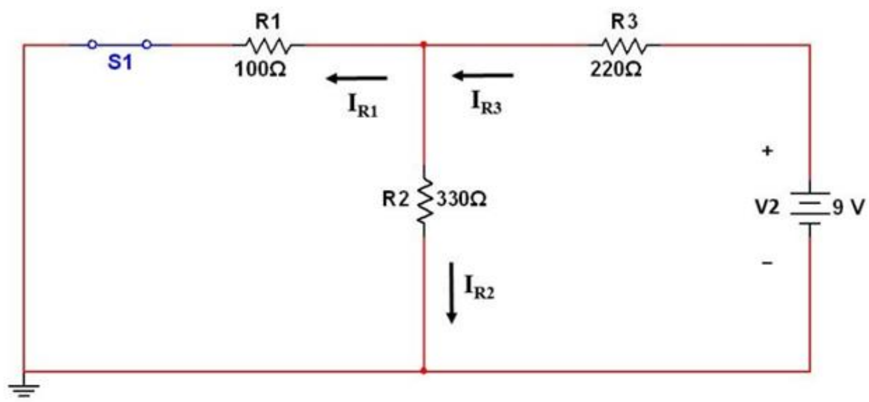
Voltage	**Measured value (Include unit and voltage polarity)**
$V_{R1(100\ \Omega)}$	
$V_{R2(330\ \Omega)}$	
$V_{R3(220\ \Omega)}$	

Table 10.5 – Voltage Measurement of Original Circuit with ONLY V1 Voltage Source Active

Part 3: Current and Voltage Measurement with "ONLY" V2 Voltage Source Active

13. Reconnect R3 from Ground to the positive polarity of V2. By doing this, you should have the original Circuit 1.

14. Change the connection of R1 from the positive of the voltage source V1 to Ground ("-" of protoboard). This procedure will ground the first voltage source, V1, and only V2 will be active. Check Circuit 3 for reference.



Circuit 10.3 – Circuit 10.1 with V_{R2} active

15. Prepare the circuit and the multimeter to measure current.
16. Measure the current through each resistor, I_{R1}, I_{R2}, and I_{R3}. Record measurement in Table 10.6, don't forget to include the direction of current flow for each resistor.

Current	Measured value (Include unit and direction of current flow)
$I_{R1(100\ \Omega)}$	
$I_{R2(330\ \Omega)}$	
$I_{R3(220\ \Omega)}$	

Table 10.6 – Current Measurement of Original Circuit with ONLY V2 Voltage Source Active

17. Prepare the circuit and the multimeter to measure voltage.
18. Measure the voltage across each resistor, V_{R1}, V_{R2}, and V_{R3}. Record measurement in Table 10.7, don't forget to include the voltage polarity for each voltage drop.

Voltage	Measured value (Include unit and voltage polarity)
$V_{R1(100\ \Omega)}$	
$V_{R2(330\ \Omega)}$	
$V_{R3(220\ \Omega)}$	

Table 10.7 – Voltage Measurement of Original Circuit with ONLY V2 Voltage Source Active

19. Disassemble the circuit and place all components back to the lab kit. Also, turn off all equipment and organize all measurement leads. Now, you are proceed to analyze the measured data.

Part 4: Superposition Theorem Analysis

20. Record the measured current through each resistor from Table 10.2 to Table 10.8

21. Record the measured current through each resistor from Table 10.4 and Table 10.6 to Table 10.8.

22. Find the total current through each resistor using measured currents from Table 10.4 and 10.6. Remember, currents flowing in the same direction add and keep the direction of current flow; currents flowing in opposite direction subtract and keep the direction of the larger current. Record result in Table 10.8.

23. Find the percent of difference between the current from the original circuit, Table 10.2, and the total current from the superposition theorem (Step 22). Record the percent of different in Table 10.8.

Current	Measured current from Original Circuit (Table 10.2)	Superposition Theorem Analysis			% difference
		Measured current from Table 10.4	Measured current from Table 10.6	Total Current through each resistor (step 22)	
$I_{R1(100\ \Omega)}$					
$I_{R2(330\ \Omega)}$					
$I_{R3(220\ \Omega)}$					

Table 10.8 – Superposition Theorem Current Measurement and Analysis

24. Record the measured voltage across each resistor from Table 10.3 to Table 10.9

25. Record the measured voltage across each resistor from Table 10.5 and Table 10.7 to Table 10.9.

26. Find the total voltage across each resistor by using measured voltage from Table 10.5 and 10.7. Remember, voltages with the same polarity add and keep the original polarity; voltages with opposite polarity subtract and keep the polarity of the larger voltage. Record result in Table 10.9

27. Find the percent for difference between the voltage from the original circuit, Table 10.3, and the total voltage from the superposition theorem (step 26). Record the percent of different in Table 10.9.

Voltage	Measured voltage from Original Circuit (Table 10.3)	Superposition Theorem Analysis			% difference
		Measured voltage from Table 10.5	Measured voltage from Table 10.7	Total Voltage through each resistor (step 26)	
$V_{R1(100\ \Omega)}$					
$V_{R2(330\ \Omega)}$					
$V_{R3(220\ \Omega)}$					

Table 10.9 – Superposition Theorem Voltage Measurement and Analysis

28. Using the superposition current from Table 10.8 and superposition voltage from Table 10.9, calculate the power dissipation in each resistor. Record calculation in Table 10.10

Power Dissipation	Using current from Table 10.4 and voltage from Table 10.5		
	P_{R1}	P_{R2}	P_{R3}
	Using current from Table 10.6 and voltage from Table 10.7		
	P_{R1}	P_{R2}	P_{R3}
	Using I_{total} from Table 10.8 and V_{total} from Table 10.9		
	P_{R1}	P_{R2}	P_{R3}

Table 10.10 – Superposition Theorem Power Analysis

Notice that the total power to each resistor is neither the sum nor the difference of the power supplied by each source when considered separately. In other words, **power does not superimpose**.

Question

1. According to your measured voltage in Table 10.8 and the current in Table 10.9, does the measured data prove the superposition theorem? Explain your answer
2. According to the calculated power in Table 10.10, why the power calculation using superposition analysis does not superimpose? Explain your answer.

Answers:

Student's Signature: ______________ Lab Instructor's Signature _______________Date: ________

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