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Superposition Theorem

Objective

The objective of this exercise is to investigate the application of the superposition theorem to multiple DC source circuits in terms of both voltage and current measurements. Power calculations will also be examined.

Theory Overview

The superposition theorem states that in a linear bilateral multi-source DC circuit, the current through or voltage across any particular element may be determined by considering the contribution of each source independently, with the remaining sources replaced with their internal resistance. The contributions are then summed, paying attention to polarities, to find the total value. Superposition cannot in general be applied to non-linear circuits or to non-linear functions such as power.

Equipment

(1) Adjustable dual DC power supply model:________________srn:___________________
(1) Digital multimeter model:________________srn:___________________
(1) 4.7 kΩ __________________
(1) 6.8 kΩ __________________
(1) 10 kΩ __________________
(1) 22 kΩ __________________
(1) 33 kΩ __________________

Schematics

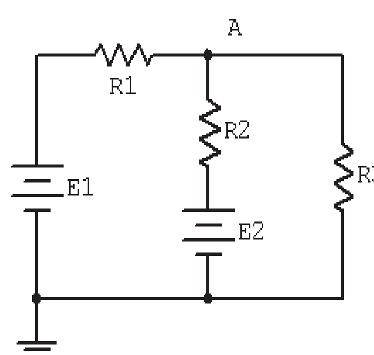

Figure 10.1

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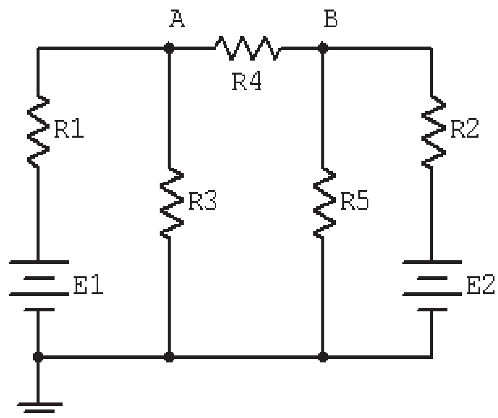

Figure 10.2

Procedure

Voltage Application

1. Consider the dual supply circuit of Figure 10.1 using E1 = 10 volts, E2 = 15 volts, R1 = 4.7 k, R2 = 6.8 k and R3 = 10 k. To find the voltage from node A to ground, superposition may be used. Each source is considered by itself. First consider source E1 by assuming that E2 is replaced with its internal resistance (a short). Determine the voltage at node A using standard series-parallel techniques and record it in Table 10.1. Make sure to indicate the polarity. Repeat the process using E2 while shorting E1. Finally, sum these two voltages and record in Table 10.1.

2. To verify the superposition theorem, the process may be implemented directly by measuring the contributions. Build the circuit of Figure 10.1 with the values specified in step 1, however, replace E2 with a short. Do **not** simply place a shorting wire across source E2! This will overload the power supply.

3. Measure the voltage at node A and record in Table 10.1. Be sure to note the polarity.

4. Remove the shorting wire and insert source E2. Also, replace source E1 with a short. Measure the voltage at node A and record in Table 10.1. Be sure to note the polarity.

5. Remove the shorting wire and re-insert source E1. Both sources should now be in the circuit. Measure the voltage at node A and record in Table 10.1. Be sure to note the polarity. Determine and record the deviations between theory and experimental results.

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6. Consider the dual supply circuit of Figure 10.2 using E1 = 10 volts, E2 = 15 volts, R1 = 4.7 k, R2 = 6.8 k, R3 = 10 k, R4 = 22 k and R5 = 33 k. To find the current through R4 flowing from node A to B, superposition may be used. Each source is again treated independently with the remaining sources replaced with their internal resistances. Calculate the current through R4 first considering E1 and then considering E2. Sum these results and record the three values in Table 10.2.

7. Assemble the circuit of Figure 10.2 using the values specified. Replace source E2 with a short and measure the current through R4. Be sure to note the direction of flow and record the result in Table 10.2.

8. Replace the short with source E2 and swap source E1 with a short. Measure the current through R4. Be sure to note the direction of flow and record the result in Table 10.2.

9. Remove the shorting wire and re-insert source E1. Both sources should now be in the circuit. Measure the current through R4 and record in Table 10.2. Be sure to note the direction. Determine and record the deviations between theory and experimental results.

10. Power is not a linear function as it is proportional to the square of either voltage or current. Consequently, superposition should not yield an accurate result when applied directly to power. Based on the measured currents in Table 10.2, calculate the power in R4 using E1-only and E2-only and record the values in Table 10.3. Adding these two powers yields the power as predicted by superposition. Determine this value and record it in Table 10.3. The true power in R4 may be determined from the total measured current flowing through it. Using the experimental current measured when both E1 and E2 were active (Table 10.2), determine the power in R4 and record it in Table 10.3.

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Simulation

11. Build the circuit of Figure 10.2 in a simulator. Using the virtual DMM as an ammeter, determine the current through resistor R4 and compare it to the theoretical and measured values recorded in Table 10.2.

Data Tables

Source	V_A Theory	V_A Experimental	Deviation
E1 Only			
E2 Only			
E1 and E2			

Table 10.1

Source	I_{R4} Theory	I_{R4} Experimental	Deviation
E1 Only			
E2 Only			
E1 and E2			

Table 10.2

Source	P_{R4}
E1 Only	
E2 Only	
E1 + E2	
E1 and E2	

Table 10.3

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Questions

1. Based on the results of Tables 10.1, 10.2 and 10.3, can superposition be applied successfully to voltage, current and power levels in a DC circuit?

2. If one of the sources in Figure 10.1 had been inserted with the opposite polarity, would there be a significant change in the resulting voltage at node A? Could both the magnitude and polarity change?

3. If both of the sources in Figure 10.1 had been inserted with the opposite polarity, would there be a significant change in the resulting voltage at node A? Could both the magnitude and polarity change?

4. Why is it important to note the polarities of the measured voltages and currents?