American International University- Bangladesh
Department of Electrical and Electronic Engineering
EEE 1202: Introduction to Electrical Circuits Laboratory

Title: Study of Superposition Theorem for DC circuit.

Introduction:

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.

The objectives of this exercise are to-

1. investigate the application of the superposition theorem to multiple DC source circuits in terms of both voltage and current measurements.
2. examine the power measurement.

Theory and Methodology:

The principle of superposition is applicable only for linear systems. The concept of superposition can be explained mathematically by the following response and excitation principle:

$$i_1 \rightarrow v_1$$
$$i_2 \rightarrow v_2$$
$$i_1 + i_2 \rightarrow v_1 + v_2$$

Then, the quantity to the left of the arrow indicates the excitation and to the right, the system response. Thus, we can state that a device, if excited by a current i_1 will produce a response v_1. Similarly, an excitation i_2 will cause a response v_2. Then if we use an excitation $i_1 + i_1$, we will find a response $v_1 + v_2$.

The principle of superposition has the ability to reduce a complicated problem to several easier problems each containing only a single independent source.

Superposition theorem states that,
In any linear circuit containing multiple independent sources, the current or voltage at any point in the network may be calculated as algebraic sum of the individual contributions of each source acting alone.

When determining the contribution due to a particular independent source, we disable allthe remaining independent sources. That is, all the remaining voltage sources are made zero by replacing them with short circuits, and all remaining current sources are made zero by replacing them with open circuits. Also, it is important to note that if a dependent source is present; it must remain active (unaltered) during the process of superposition.

Action Plan:
(i) In a circuit comprising of many independent sources, only one source is allowed to be active in the circuit, the rest are deactivated (turned off).

(ii) To deactivate a voltage source, replace it with a short circuit, and to deactivate a current source, replace it with an open circuit.
(iii) The response obtained by applying each source, one at a time, are then added algebraically to obtain a solution.

Limitations: Superposition is a fundamental property of linear equations and, therefore, can be applied to any effect that is linearly related to the cause. That is, we want to point out that, superposition principle applies only to the current and voltage in a linear circuit but it cannot be used to determine power because power is a non-linear function.

<u>Pre-Lab Homework:</u>

Use PSpice and reference book for solving the following problem. Student must present the simulation results to the instructor before the start of the experiment.

HW 1: Find V_{out} using superposition theorem of Figure 6.0.

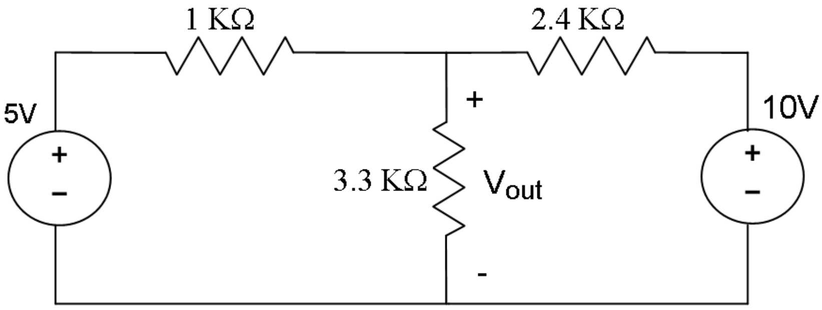
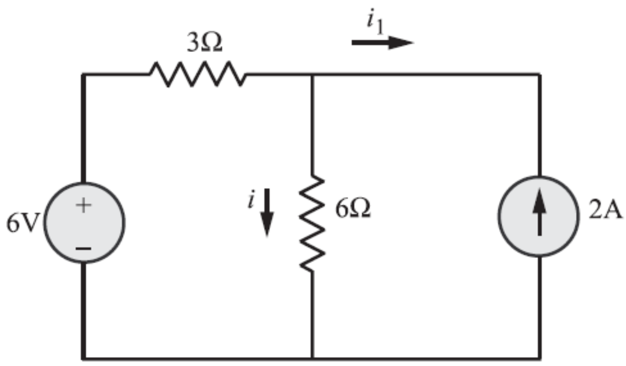


Fig 6.0

HW 2: Find the current in the 6Ω resistor using the principle of superposition for the following circuit:



<u>Apparatus:</u>

1. Trainer board
2. Digital multimeter
3. DC source
4. Resistors : 4.7k, 6.8k, 10k, 22k, 33k [1 pcs]
5. Connecting wires

<u>Precautions:</u>

To consider the effect of one voltage source the other must be replaced with a wire. Simply switching off the connection does not give the correct circuit configuration.

Sometimes the ammeters don't work properly so to determine current take the voltage drop across the resistor and divide by the resistance value to obtain the current passing through that particular element or branch. Always mention the units when taking the readings or doing the calculations.

<u>Experimental Procedure:</u>

Circuit Diagram:

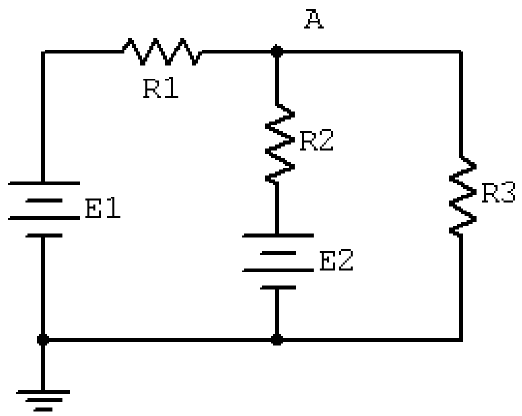


Figure 6.1

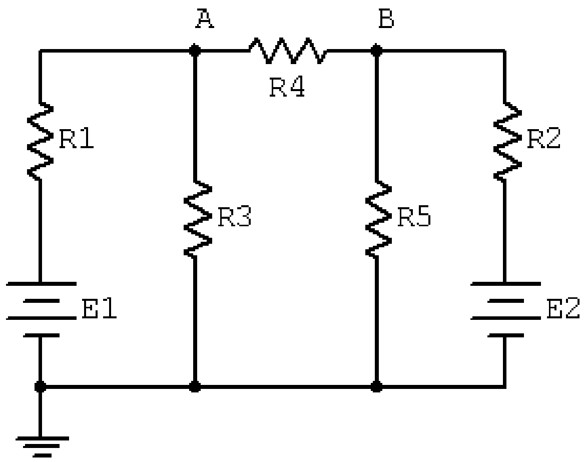


Figure 6.2

<u>Voltage Application</u>

1. Consider the dual supply circuit of Figure 6.1 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 6.1. Make sure to indicate the polarity. Repeat the process using E2 while shorting E1. Finally, sum these two voltages and record in Table 6.1.

2. To verify the superposition theorem, the process may be implemented directly by measuring the contributions. Build the circuit of Figure 6.1 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 6.1. 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 6.1. 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 6.1. Be sure to note the polarity. Determine and record the deviations between theory and experimental results.

Current and Power Application

6. Consider the dual supply circuit of Figure 6.2 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 6.2.

7. Assemble the circuit of Figure 6.2 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 6.2.

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 6.2.

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 6.2. 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 6.2, calculate the power in R4 using E1-only and E2-only and record the values in Table 6.3. Adding these two powers yields the power as predicted by superposition. Determine this value and record it in Table 6.3. 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 6.2), determine the power in R4 and record it in Table 6.3.

Simulation and Measurement:

1. Calculate the voltage across and current through R_5 as per the superposition theorem and show all the calculations clearly.
2. Compare the simulation results with your experimental data/ wave shapes and comment on the differences (if any).

Instructions for report writing:

1. Describe in words what the data means.
2. Compare your experimental values or findings with the theoretical values and analyze the result.

Data Tables:

Source	V_A Theory	V_A Experimental	Deviation
E1 only			
E2 only			
E1 & E2			

Table 6.1

Source	I_{R4} Theory	I_{R4} Experimental	Deviation
E1 only			
E2 only			
E1 & E2			

Table 6.2

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

Table 6.3

Discussion:

Determine whether or not the theorem was accepted. Discuss any mistakes you might have made while conducting the investigation and describe ways the study could have been improved.

Conclusion:

Summarize your experiment here and discuss whether the objectives were fulfilled or not within a short paragraph.

Reference(s):

1. Robert L. Boylestad, ”Introductory Circuit Analysis”, Prentice Hall, 12th Edition, New York, 2010, ISBN 9780137146666.