American International University- Bangladesh

Department of Electrical and Electronic Engineering

EEE 2109: Introduction to Electrical Circuits Lab

Title: Study of Superposition Theorem.

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 objective of this exercise is 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.

Pre-Lab Homework:

Use NI Multisim 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.

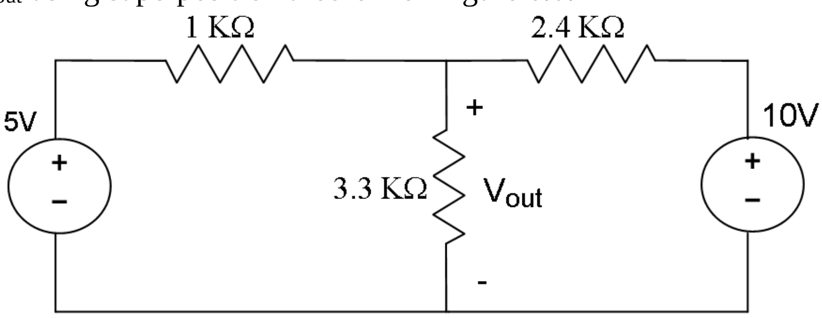

Fig 1

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

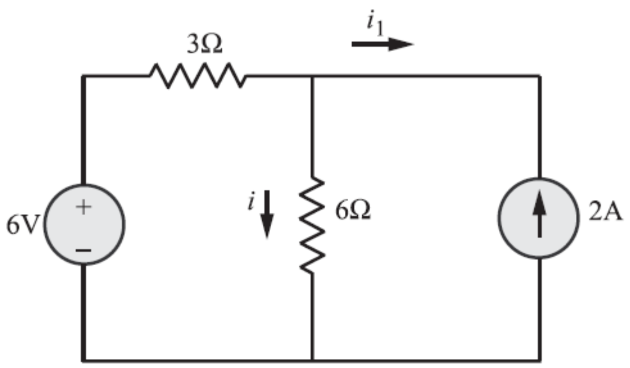

Fig 2

Apparatus:

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

Precautions:

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.

Experimental Procedure:

Circuit Diagram:

1. Implement the circuit of figure 12.
2. Remove the supply voltage E_2 by a short circuit.
3. Measure the node voltage V_A. Be sure to note the polarity.
4. Reconnect the supply voltage E_2.
5. Remove supply voltage E_1 by short circuit.
6. Measure the node voltage V_A. Be sure to note the polarity.
7. Reconnect the supply voltage E_1.
8. Measure node voltage V_A. Be sure to note the polarity.
9. Complete table 6.1 and check the deviation between experimental and theoretical values.

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

Table 6.1

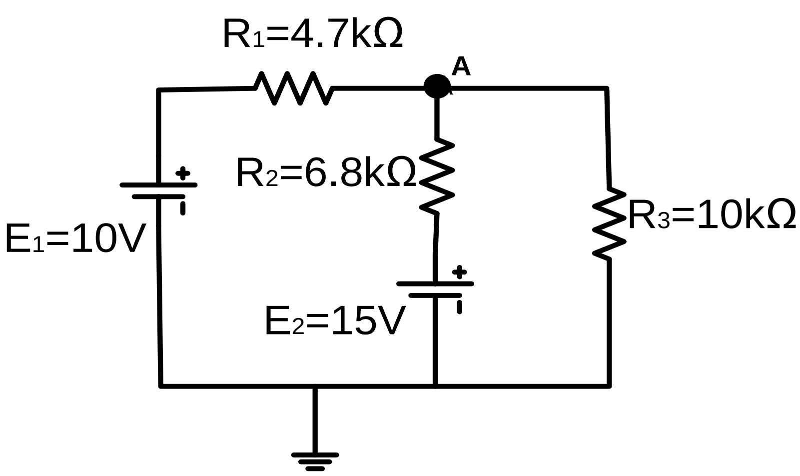

Fig 12

10. Implement the circuit given in figure 13.

11. Repeat procedure steps 2 to 9 but measure the I_{R4} current and P_{R4} power across R_4 resistor. Be sure to note the direction of I_{R4} current flow.
12. Complete table 6.2 and 6.3 and check the deviation between experimental and theoretical values.
13. Does power calculation maintain the superposition theorem? Explain your observation on table 6.3.

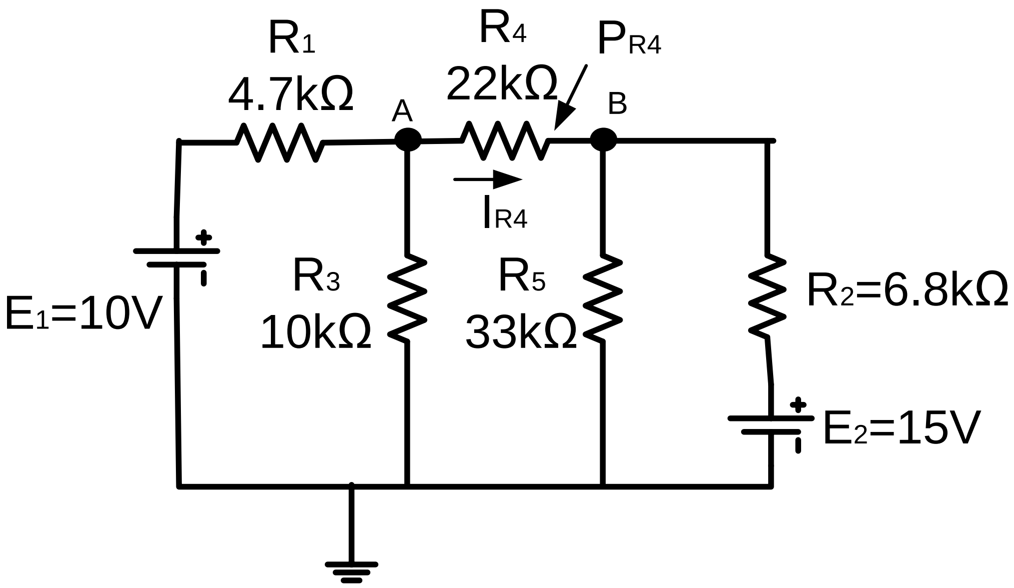

Fig 13

Results and Discussion:

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 (Voltages applied simultaneously)	

Table 6.3

Questions with answers for report writing:

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

Reference(s):

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

Teaching tips:

1. If there might be any problem measuring current, ask students to measure the voltage across that component and the corresponding resistances, and use $\frac{V}{R}$ relation to find the current.