# Laboratory Manual

**EE-153L – Introduction to Electrical Engineering**

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## Experiment 8

# Verification of Superposition Theorem

### 8.1 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. Moreover, power calculations will also be examined.

### 8.2 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.

#### 8.2.1 Pre-Lab Task

Before performing the experiment in the laboratory, complete the following tasks in LTspice to demonstrate your understanding of the theoretical concepts. These preparatory tasks will help you predict circuit behavior and verify your results during the lab session.

### 8.3 Equipment

- Adjustable DC Power Supply
- Digital Multimeter
- 4.7 kΩ, 6. 8kΩ, 10 kΩ, 22 kΩ, 33 kΩ

### 8.4 Schematics

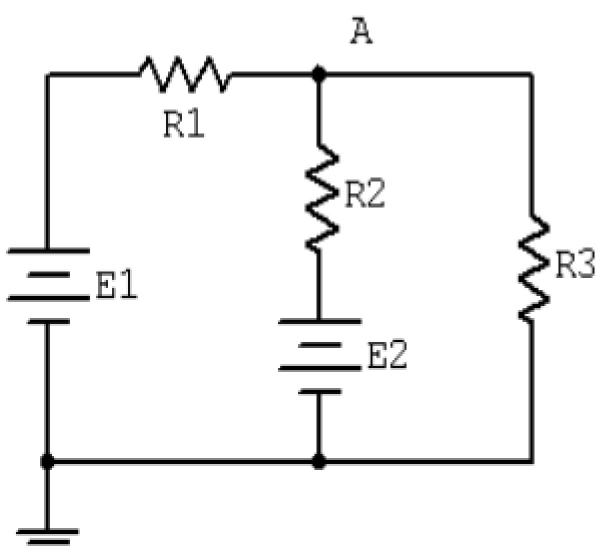


*Fig 8.1*

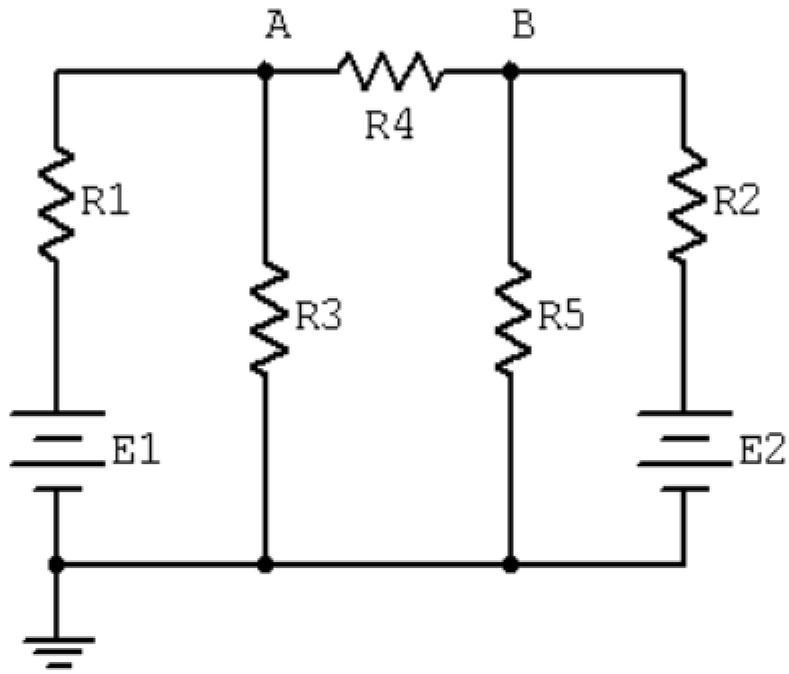


Fig 8.2

## 8.4 Procedure

**Voltage Application**

1. Consider the dual supply circuit of Figure 8.1 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 8.1. Make sure to indicate the polarity. Repeat the process using E2 while shorting E1. Finally, sum these two voltages and record in Table 8.1.

2. To verify the superposition theorem, the process may be implemented directly by measuring the contributions. Build the circuit of Figure 8.1 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 8.1. 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 8.1. 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 8.1. 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 8.2 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 8.2.

7. Assemble the circuit of Figure 8.2 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 8.2.

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 8.2.

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 8.2. 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 8.2, calculate the power in R4 using E1-only and E2-only and record the values in Table 8.3. Adding these two powers yields the power as predicted by superposition. Determine this value and record it in Table 8.3. 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 8.2), determine the power in R4 and record it in Table 8.3.

## 8.6 Data Tables

| **Source** | **$V_A$ Theory** | **$V_A$ Experimental** | **Deviation** |
|---|---|---|---|
| E1 Only | | | |

| | | | |
|---|---|---|---|
| E2 Only | | | |
| E1 and E2 | | | |

*Table 8.1*

| **Source** | **$I_{R4}$ Theory** | **$I_{R4}$ Experimental** | **Deviation** |
|---|---|---|---|
| E1 Only | | | |
| E2 Only | | | |
| E1 and E2 | | | |

*Table 8.2*

| **Source** | **$P_{R4}$** |
|---|---|
| E1 Only | |
| E2 Only | |
| E1 and E2 | |

*Table 8.3*

## 8.7 Questions

1. Based on the results of Tables 8.1, 8.2 and 8.3, can superposition be applied successfully to voltage, current and power levels in a DC circuit?

2. If one of the sources in Figure 8.1 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. Why is it important to note the polarities of the measured voltages and currents?

## 8.8 Conclusion

## Assessment

| Sr. No. | Specific Course Learning Outcomes | Knowledge Domains | Performance indicator |
|---|---|---|---|
| | Upon completion of this course, the students will be able to | | |
| **1** | **USE** electronic lab instruments including the digital multi-meter, function generator, oscilloscope and electronic circuit trainer. | P1 | • Proper wiring of the circuit<br>• Correct use of instruments (signal generator, oscilloscope)<br>• Data recorded in table |
| **2** | **CONSTRUCT** and **ANALYZE** basic circuits. | P2 | • Relate experiment with theoretical concept discussed in class.<br>• Describe relevant mathematical equations<br>• Discuss discrepancies between theoretical, simulation and experimental results<br>• Possible sources of discrepancies and ways to improve |
| **3** | **COMMUNICATE** clearly and effectively through presentation and/or report | A2 | • Report is structured properly<br>• Figures and Graphs annotated<br>• Language is clear |
| **4** | **DEMONSTRATE** teamwork and show commitment to the group in achieving the objectives of laboratory | A2 | • Does his/her part in the group<br>• Listen to other's ideas<br>• Does not argue |
| **5** | **DEMONSTRATE** punctuality, dress appropriately and comply with the standard safety procedures of the lab | A2 | • Wear proper dress to perform the tasks and Follow lab timing<br>• Follow safety instructions for handling the instruments. |