

Module 3

ELECTRICAL PRINCIPLES AND TECHNOLOGY

Objectives

- Investigate the application of the superposition theorem to multiple DC-source circuits
- Verify of nodal analysis and its usage in multi-source DC circuits
- Measure the current in the circuit using mesh analysis
- Prove the computed theoretical values and experimental values are almost the same.
- Learn various ways to measure Thévenin's voltage and resistance
- Construct an electric circuit with passive components and verify Norton's theorem

Tasks

- Superposition
- Mesh vs. Nodal Analysis
- Thévenin's and Norton's Theorems

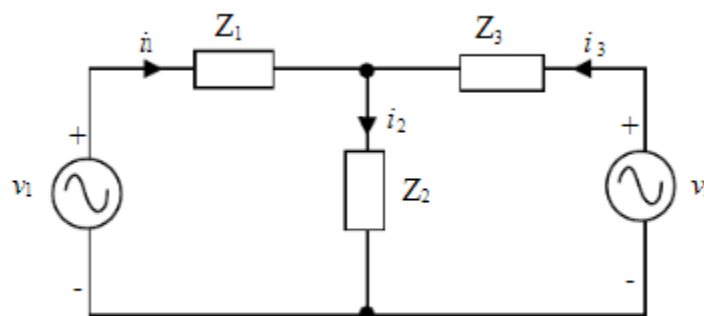
1. (Lab #8) Superposition

Objective:

The objective of this experiment 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.

Introduction:

The superposition principle allows us to calculate the combined effects of a multi-source circuit by looking at the individual effects of each source acting alone, then summing them. Particular attention must be paid to current directions and voltage polarities when applying superposition. The experiment uses a circuit with two voltage sources v_1 and v_2 Figure (8-1). The three currents i_1 , i_2 and i_3 can be calculated by taking the components due to v_1 acting alone, then v_2 acting alone, and adding them together. You will recall that the source not being considered is to be replaced with its internal resistance. This is the same as replacing it with a short circuit.



[Figure 8-1] Superposition Circuit

It is important to note that you must remove the power supply (or switch it off) before you replace it with a short circuit: never short-circuit a functioning power supply under these circumstances. Also, pay attention to the directions of the current components due to each source so that you algebraically sum them to get the totals.

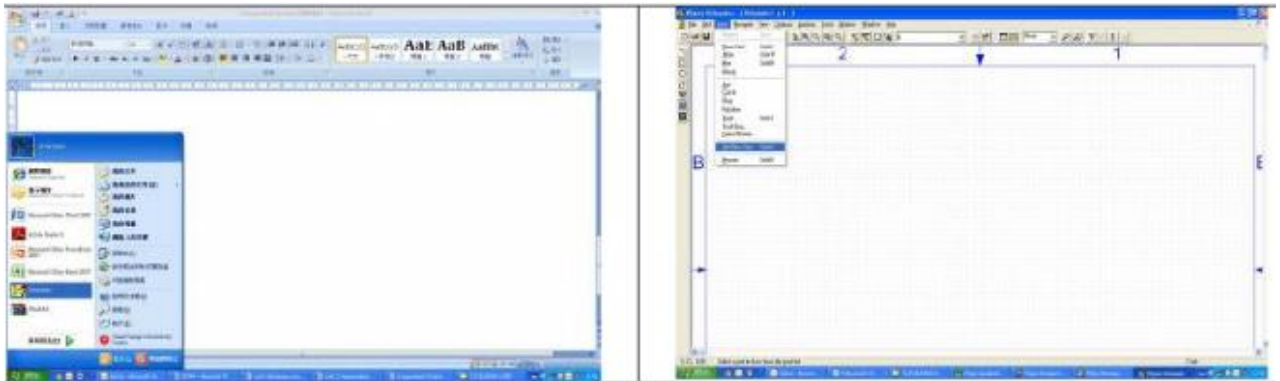
Equipment & Components

1. Adjustable Dual DC Power Supply,
2. Digital Multimeter
3. Resistors 4.7 k Ω , 6.8 k Ω , 10 k Ω , 22 k Ω and 33 k Ω .
4. PSpice Software

Tasks for the (Lab #8):

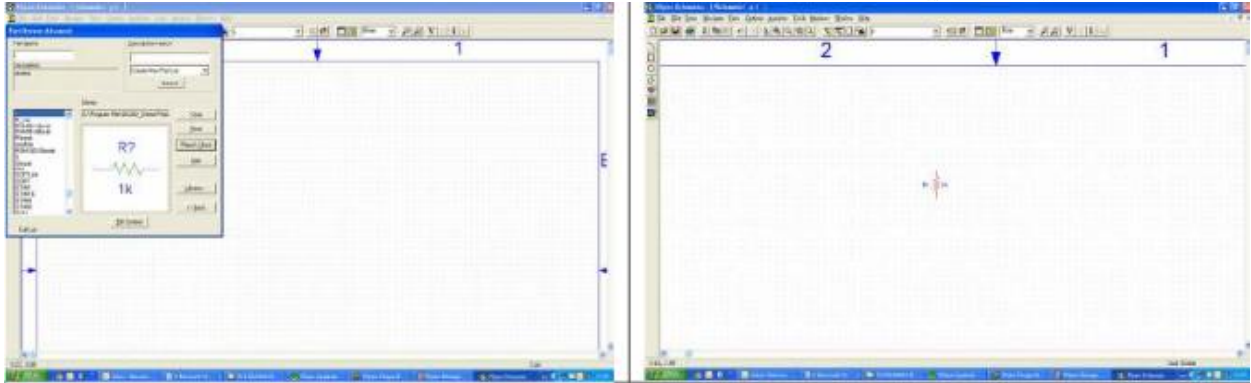
1) Simulate Superposition Theorem by PSpice

1. Double click on the Schematic icon in the PSpice in your PC.



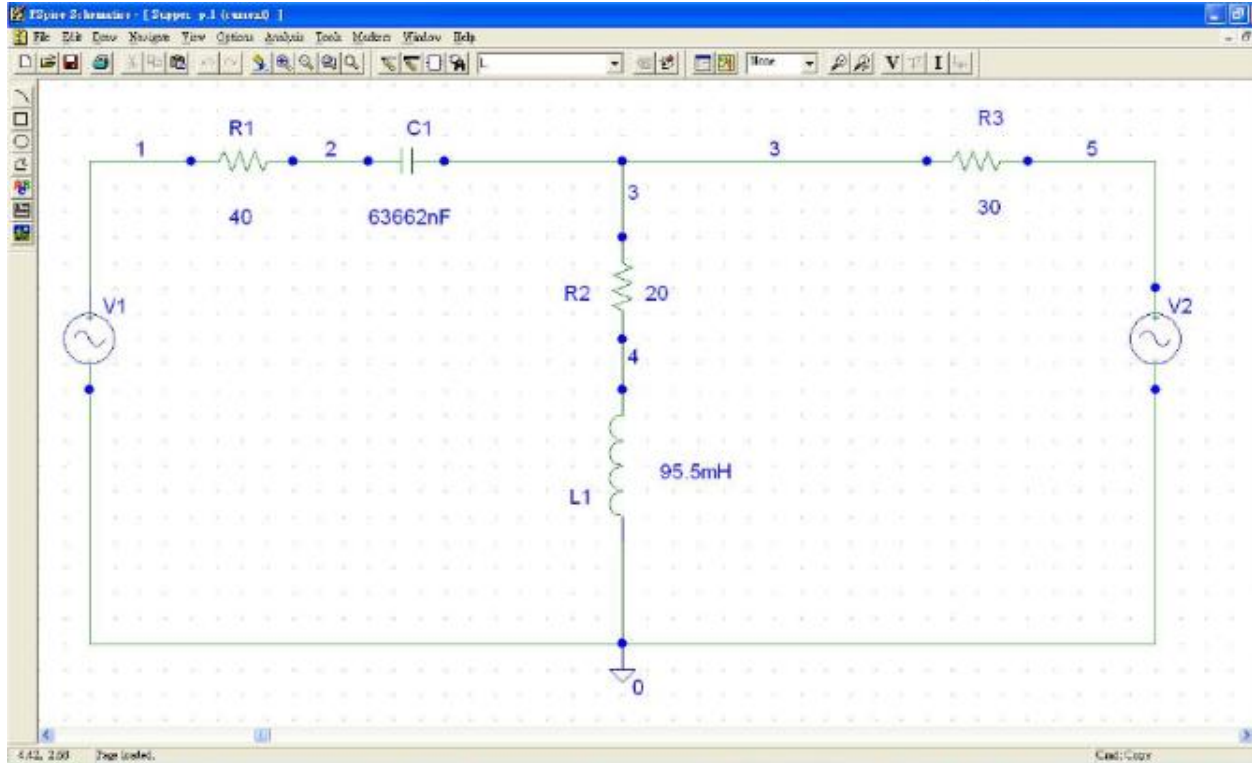
[Figure 8-2] Opening New Project on PSpice

2. Click on the menu DRAW and then option GET NEW PART, whose instruction will then written as “draw/get new part” in the following procedures.
3. In the FULL LIST field, you will see the list of component. Move down and select “R”. Double Click to confirm your selection.



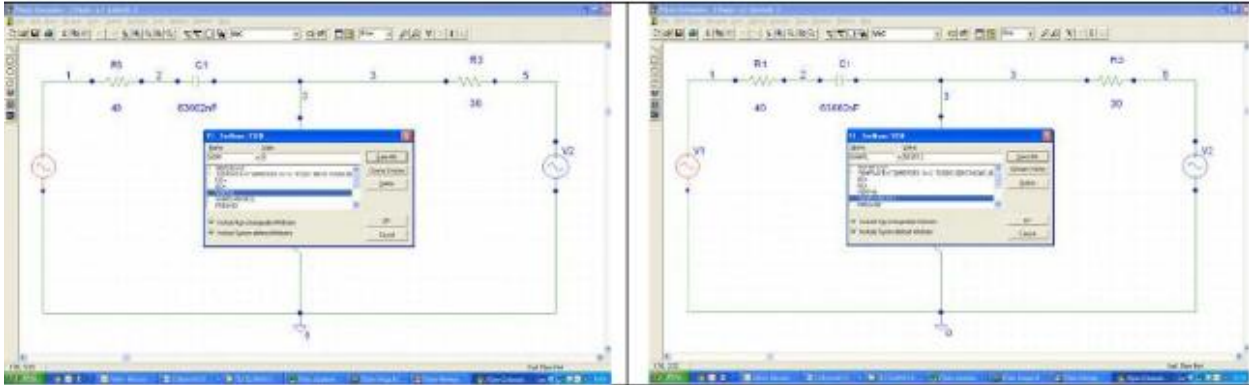
[Figure 8-3] Placing Resistors in PSpice

4. Press “Ctrl-R” to rotate the resistor and move the mouse to locate the resistor in appropriate position. Press the LEFT mouse button to place the R1 as shown in Figure (8-4). Then Press ESC button to terminate the placement.
5. Repeat step 3 and 4 for the rest components of the circuit as shown in Figure (8-4).
6. Select “draw/get new part” . In the FULL LIST field, you will see the list of component. Move down and select “VSIN”. Double Click to confirm your selection.
7. Move the mouse to locate the AC voltage source in appropriate position as shown in Figure (8-4). Press the LEFT mouse button to place the voltage source v1.
8. Move the mouse to locate the AC voltage source in another position as shown in Figure (8-4). Press the LEFT mouse button to place the voltage source v2. Then Press ESC button to terminate the placement.
9. Press “Ctrl-W” to place the wire. The cursor is now in pencil shape. Click on one side of the connecting node and move to another side of connecting node. Then “double click” on the destination node to place one connection.
10. Repeat step 9 for the rest of connection.
11. Make sure all wires are connected.



[Figure 8-4] Connecting Superposition Circuit in PSpice

12. Select “draw/get new part” . In the FULL LIST field, you will see the list of component. Move down and select “AGND”. Double Click to confirm your selection.
13. Move the mouse to locate the ground point in appropriate position as shown in Figure (8-4). Press the LEFT mouse button to place the reference point 0. Then Press ESC button to terminate the placement.
14. Double click the wire and give the label name as 1, 2, 3, 4 and 5 to the connections respectively as shown in Figure (8-4).
15. Double click the voltage source v1 and select attribute VOFF with mouse. Locate the cursor in the Value field with mouse, type in 0 and then press “Save Attri” button.
16. Select attribute VAMPL with mouse. Locate the cursor in the Value field with mouse, type in 50.9117 and then press “Save Attri” button

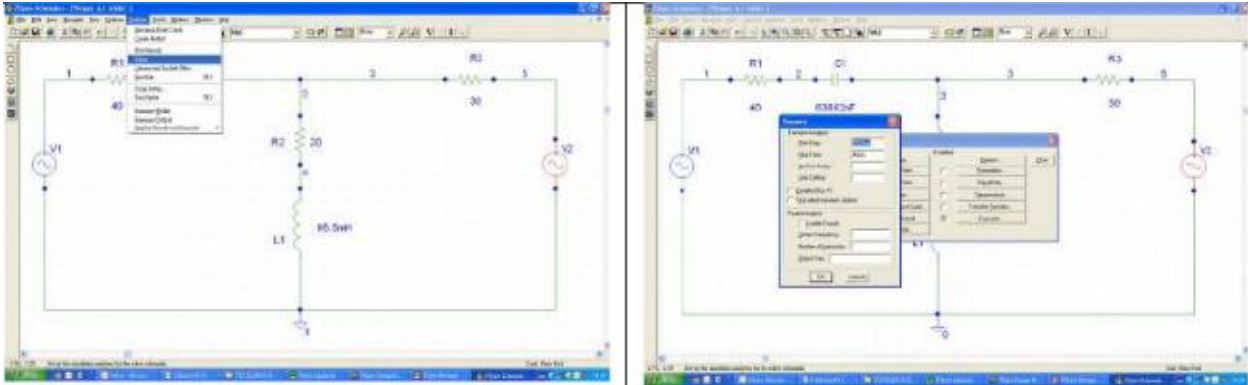


[Figure 8-5] Select The Voltage Amplitude

17. Select attribute FREQ with mouse. Locate the cursor in the Value field with mouse, type in 50 and then press “Source Attri” button.
18. Select attribute PHASE with mouse. Locate the cursor in the Value field with mouse, type in 30 and then press “Source Attri” button.
19. Click “ok” to confirm your setting. Now the attributes of v1 is $V_{off} = 0$, $V_{ampl} = 50.9117$, $F_{req} = 50$ and phase difference $= 30^\circ$
20. Repeat step 15 to step 19 for the voltage source v2 such that its attribute are as below

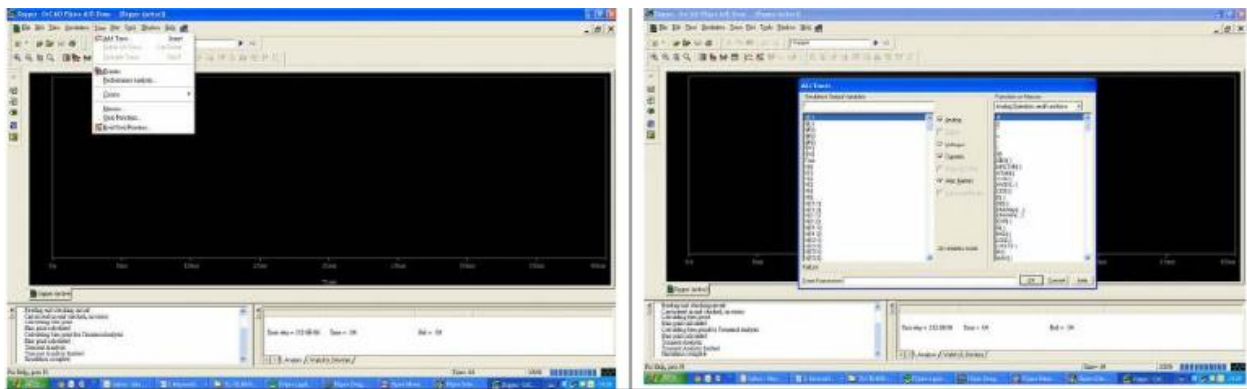
$$V_{off} = 0, V_{ampl} = 28.2843, F_{req} = 50 \text{ and phase difference} = 0^\circ$$

21. Now $v1 = 50.9117 \cdot \sin(\omega t + 30^\circ)[V]$ where $\omega = 2\pi f$ and $f = 50$, i.e., $V1 = 36 \angle 30^\circ [V]$ and $v2 = 28.2843 \cdot \sin(\omega t)[V]$ where $\omega = 2\pi f$ and $f = 50$, i.e., $V2 = 20 \angle 0^\circ [V]$.
22. Save your design in the TEMP/DEFAULT directory.
23. Select “Analysis/Setup” and then click the check box of Transient. → Click the “Transient” option and enter the Print Step to Ons and Final Time to 80ms. → Click “ok” to confirm. → Then click “close” to exit setup menu.



[Figure 8-6] Start Circuit Analysis

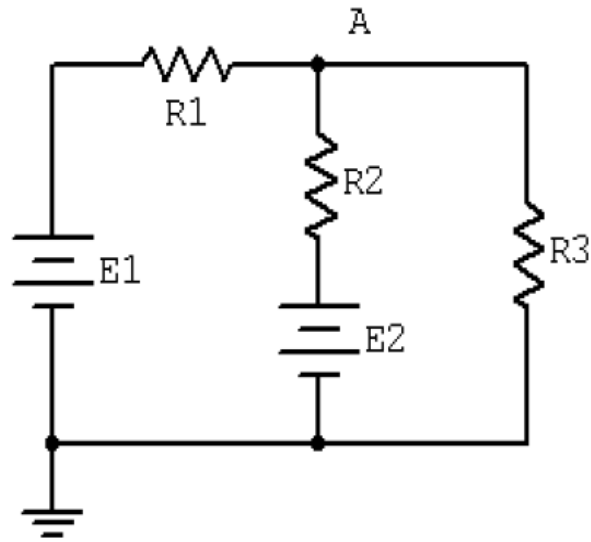
24. Select “Analysis/Simulate” and then wait for the completion of simulation. (Note: it takes a few minute to complete the simulation)
25. The simulator brings you to a “Probe” window. Select “Trace/Add” and then click on I(R1), I(R2) and I(R3) sequentially. Click “ok” to confirm your selections.



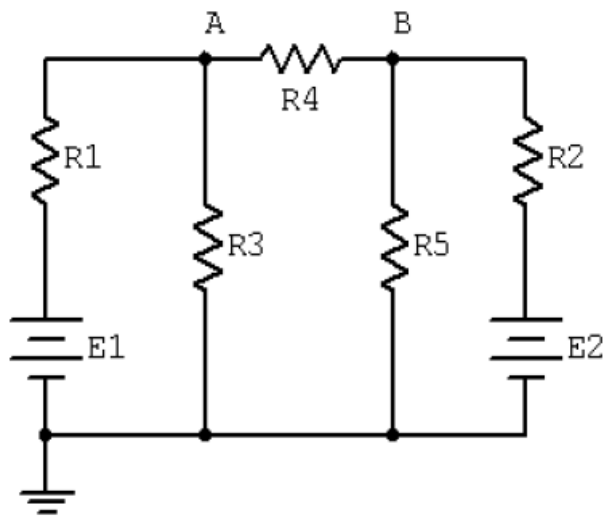
[Figure 8-7] Start Current Tracing

26. Record the waveforms of I(R1), I(R2) and I(R3).

2) Building and analysis of Superposition Theorem



[Figure 8-8] Connecting first Superposition Circuit



[Figure 8-9] Connecting Second Superposition Circuit

Procedure

Voltage Application

1. Consider the dual supply circuit of Figure 1 using $E1 = 10$ volts, $E2 = 15$ volts, $R1 = 4.7k\Omega$, $R2 = 6.8k\Omega$ and $R3 = 10k\Omega$. To find the voltage from node A to the 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, build the circuit of Figure (8-8) 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 2 using $E1 = 10$ volts, $E2 = 15$ volts, $R1 = 4.7k\Omega$, $R2 = 6.8k\Omega$, $R3 = 10k\Omega$, $R4 = 22k\Omega$ and $R5 = 33k\Omega$. 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 (8-9) using the specified values. 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 calculated 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).

[Table 8-1] Recode Voltage V_A on Superposition Circuit

Source	V_A Calculated	V_A Experimental	Deviation
E1			
E2			
E1&E2			

[Table 8-2] Recode Current I_{R4} on Superposition Circuit

Source	I_{R4} Calculated	I_{R4} Experimental	Deviation
E1			
E2			
E1&E2			

[Table 8-3] Recode Power P_{R4} on Superposition Circuit

Source	P_{R4}
E1	
E2	
E1+E2	
E1&E2	

Questions

1. Based on the results of Tables (8- 1, 2 and 3), can superposition be applied successfully to voltage, current and power levels in a DC circuit?
2. If one of the sources in Figure (8-8) 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 (8-8) 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?