EE1002 Lab2: Principle of Superposition (Online)

I. OBJECTIVES

1. To get familiar with the online simulator.
2. To simulate the voltages and currents of a circuit with the principle of superposition.
3. To understand the limitation of the superposition principle.

II. EQUIPMENT AND MATERIALS REQUIRED

1. Computer
2. Browser
3. Online simulator Circuit-Sandbox (https://spinningnumbers.org/circuit-sandbox/index.html)

III. THEORY

The superposition principle states that the overall voltage and current responses of a circuit due to multiple sources are equal to the sum of the individual voltage and current responses due to the individual source.

IV. PROCEDURE

Part A: Single DC Voltage Source

1. First pick a voltage source and resistors from the right column.

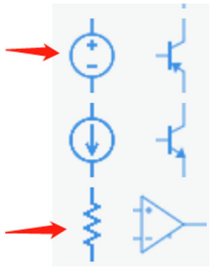


Fig. 1. Voltage source and resistor.

2. You can rotate the components by using the tool on the left. Double-click the voltage source and resistor to change their names and values.

(a) (b)

Fig.2. Settings of (a) voltage and (b) resistor.

3. Build the circuit in Fig. 3. Run the simulation with the "DC" solver (see Fig.4) and then the simulated results will be shown in the circuit directly. Please pay attention to the voltage direction. Fill in Table I (Column "$U1$ = 2.0V") with your simulated results.

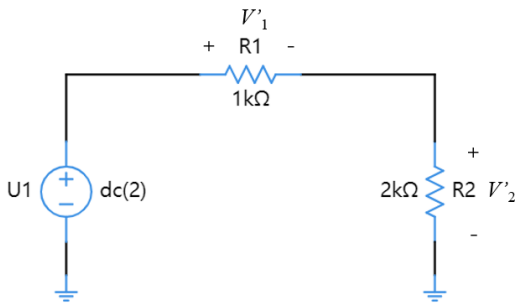


Figure 3. Circuit configuration with voltage source $U1$ = 2.0 V.

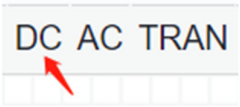


Fig. 4 Start the simulation with the "DC" solver.

Table I. The voltages in Part A.

DC Sources	$U1$ = 2.0V	$U2$ = 4.0V	Superposition	$U3$ = 6.0V	Errors
Voltage (V)	V'_1	V''_1	$V'_1 + V''_1$	V_1	$(V'_1 + V''_1) - V_1$
Simulation					
Calculation					
Voltage (V)	V'_2	V''_2	$V'_2 + V''_2$	V_2	$(V'_2 + V''_2) - V_2$
Simulation					
Calculation					

4. Change the voltage of the DC source to $U2$ = 4.0V, as shown in Fig. 5. Run the simulation with the "DC" solver. Please pay attention to the voltage direction. Fill in Table I (Column "$U2$ = 4.0V") with your simulated results.

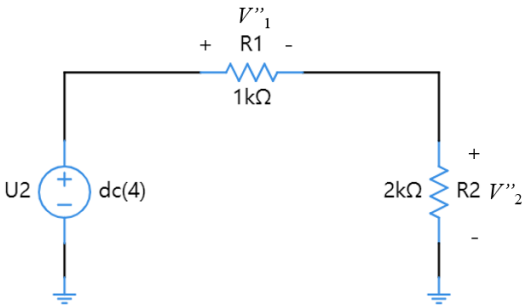


Figure 5. Circuit configuration with voltage source $U2$ = 4.0 V.

5. Change the voltage of the DC source to $U3$ = 6.0V, as shown in Fig. 6. Run the simulation with the "DC" solver. Please pay attention to the voltage direction. Fill in Table I (Column "$U3$ = 6.0V") with the simulated results.

6. Calculate the results using circuit theory and fill in the "Calculations" in Table I. Compare the calculated results with the simulated results. You are required to provide your detailed analysis in your lab report.

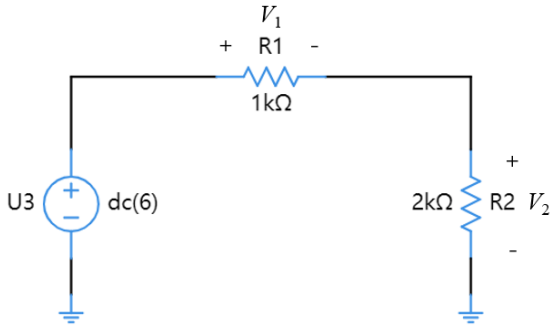


Figure 6. Circuit configuration with voltage source $U3$ = 6.0 V

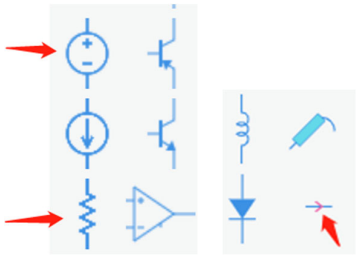
By using the data in Table I, calculate the powers in Table II.

Table II. The powers in Part A.

DC Sources	$U1$ = 2.0V	$U2$ = 4.0V	Superposition	$U3$ = 6.0V	Errors
Power (W)	P'_1	P''_1	$P'_1 + P''_1$	P_1	$(P'_1 + P''_1) - P_1$
Calculation					
Power (W)	P'_2	P'_2	$P'_2 + P''_2$	P_2	$(P'_2 + P''_2) - P_2$
Calculation					

Part B: Dual DC Voltage Source

1. Pick a voltage source, resistors and current probes from the right column (see Fig. 7).



(a) (b)

Fig. 7. (a) Voltage source and resistor. (b) Current probe in the component list.

2. Build the circuit in Fig. 8. Run the simulation with the "DC" solver. Please pay attention to the current direction. Fill in Table II (Column "Source V_1") with your simulated results.

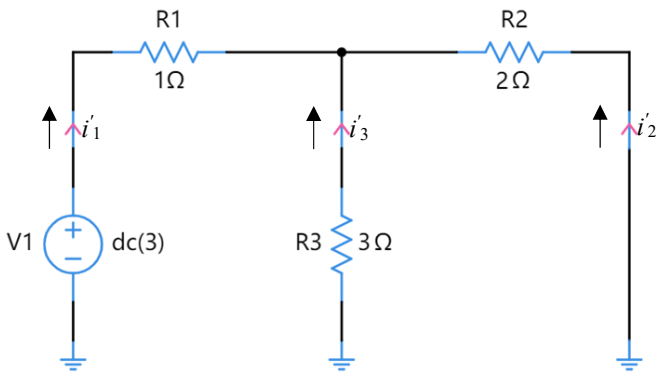


Fig.8. Circuit configuration with voltage source V1 (3.0V).

Table II. The currents in Part B.

	Source V_1	Source V_2	Superposition	Both V_1 & V_2	Errors
Currents (A)	i'_1	i''_1	$i'_1+i''_1$	i_1	$(i'_1+i''_1)-i_1$
Simulation					
Currents (A)	i'_2	i''_2	$i'_2+i''_2$	i_2	$(i'_2+i''_2)-i_2$
Simulation					
Currents (A)	i'_3	i''_3	$i'_3+i''_3$	i_3	$(i'_3+i''_3)-i_3$
Simulation					

3. Remove the voltage source V1 in Fig. 8 and add the voltage source V2 as shown in Fig. 9. Run the simulation with the DC solver and fill in Table II (Column "Source *V*2") with the simulated results.

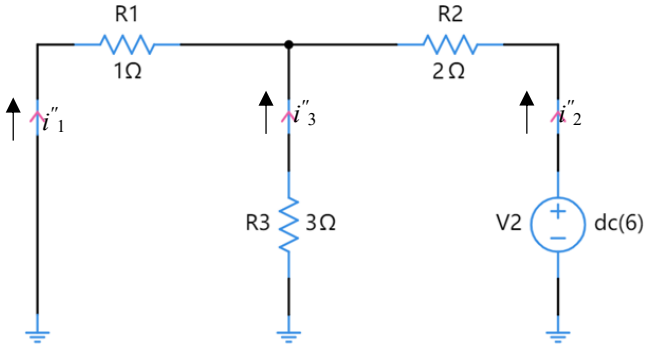


Fig.9. Circuit configuration with voltage source V2 (6.0V).

4. Build the circuit in Fig. 10. Run the simulation with the DC solver and fill in Table II (Column "Both *V*1 *&* *V*2*"*) with the simulated results.

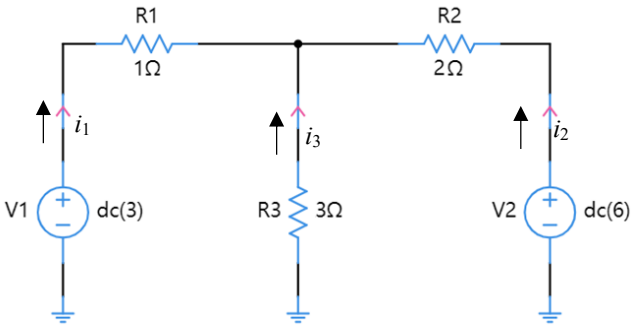


Fig.10. Circuit configuration with both voltage sources V1 (3.0 V) and V2 (6.0 V).

By using the data in Table II, calculate powers in Table III.

Table III. The powers in Part B.

	Source V_1	Source V_2	Superposition	Both V_1 & V_2	Errors
Power (W)	P'_1	P''_1	$P'_1+P''_1$	P_1	$(P'_1+P''_1)-P_1$
Calculation					
Power (W)	P'_2	P''_2	$P'_2+P'_2$	P_2	$(P'_2+P''_2)-P_2$
Calculation					
Power (W)	P'_3	P''_3	$P'_3+P''_3$	P_3	$(P'_3+P''_3)-P_3$
Calculation					

Part C: Dual DC Current Source

1. First pick a current source and resistors from the right column (see Fig. 11).

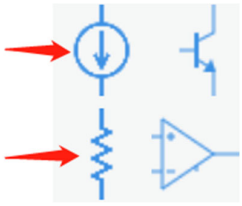


Fig. 11 Current source and resistor

2. Build the circuit in Fig. 12. Run the simulation with the "DC" solver. Please pay attention to the current direction. Fill in Table IV (Column "Source U_1") with the simulated results.

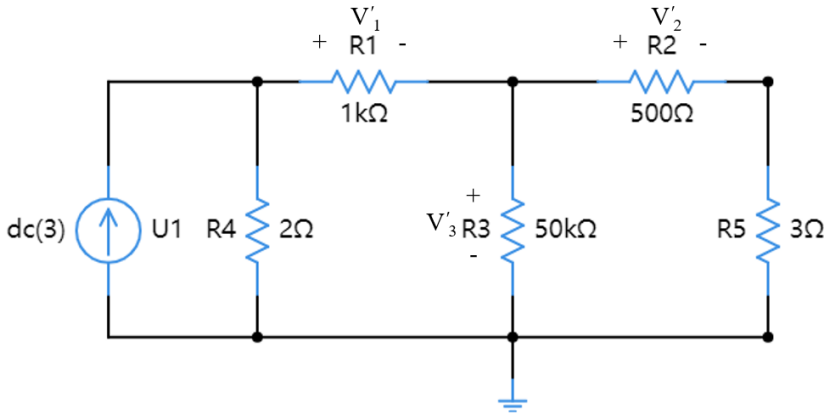


Fig.12. Circuit configuration with Current source U1 (3.0A).

Table IV The Currents in Part C

	Source U_1	Source U_2	Superposition	Both U_1 & U_2	Errors
Voltages (V)	V'_1	V''_1	$V'_1+V''_1$	V_1	$(V'_1+V''_1)-V_1$
Simulation					
Voltages (V)	V'_2	V''_2	$V'_2+V''_2$	V_2	$(V'_2+V''_2)-V_2$
Simulation					
Voltages (V)	V'_3	V''_3	$V'_3+V''_3$	V_3	$(V'_3+V''_3)-V_3$
Simulation					

3. Build the circuit in Fig. 13. Start the simulation with the "DC" solver and fill in Table IV (Column "Source U_2") with the simulated results.

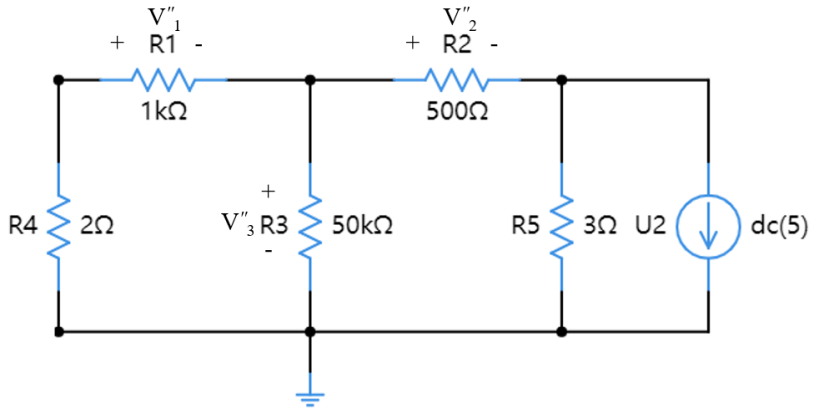


Fig.13. Circuit configuration with the current source U2 (5.0A).

4. Build the circuit in Fig. 14. Run the simulation with the DC solver and fill in Table IV (Column "Both U_1 & U_2") with the simulated results.

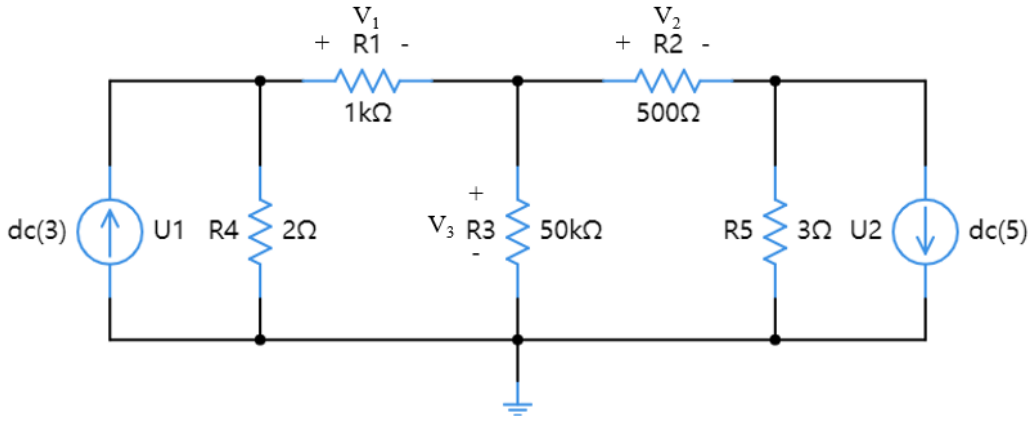


Fig.14. Circuit configuration with both voltage sources U1 (3.0 A) and U2 (5.0 A).

By using the data in Table IV, please calculate the powers in Table V.

Table V. The powers in Part C.

	Source U_1	Source U_2	Superposition	Both U_1 & U_2	Errors
Power (W)	P'_1	P''_1	$P'_1 + P''_1$	P_1	$(P'_1 + P''_1) - P_1$
Calculation					
Power (W)	P'_2	P''_2	$P'_2 + P'_2$	P_2	$(P'_2 + P''_2) - P_2$
Calculation					
Power (W)	P'_3	P''_3	$P'_3 + P''_3$	P_3	$(P'_3 + P''_3) - P_3$
Calculation					

V. DISCUSSION

1. Are there any limits for the number of sources in applying the principle of superposition?

2. Can the principle of superposition be applied to calculations of powers? Explain your answer.

REFERENCES

1. M. O. Sadiku, S. M. Musa and C. K. Alexander, Applied Circuit Analysis, McGraw Hill, 2012.
2. C. K. Alexander and M.O. Sadiku, Fundamentals of Electric Circuits, 5th Edition, McGraw Hill, 2012.