BRAC UNIVERSITY
Dept. of Computer Science and Engineering

CSE250L
Circuits and Electronics Laboratory

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Experiment No. 3

Verification of Superposition Principle

Objective

The aim of this experiment is to experimentally verify the Superposition theorem, which is an analytical technique for determining currents/voltages in a circuit with more than one emf source.

Theory

The Superposition Principle is a fundamental concept in electrical circuits that states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately, and all other sources are replaced by their internal resistance. The superposition theorem is used to solve networks where two or more sources are present and connected. The current or voltage through any component in a circuit is the sum of the effects of each individual source acting alone. In other words, the principle states that **the total response of a circuit with multiple sources is the sum of the responses of the circuit to each individual source acting alone.** This principle is widely used in circuit analysis to simplify complex circuits and solve them with ease.

In a **linear circuit** containing multiple independent sources and linear elements (e.g., resistors, inductors, and capacitors), the voltage across (or the current through) any element when all the sources are acting simultaneously may be obtained by adding algebraically all the individual voltages (or currents) caused by each independent source acting alone, with all other sources deactivated.

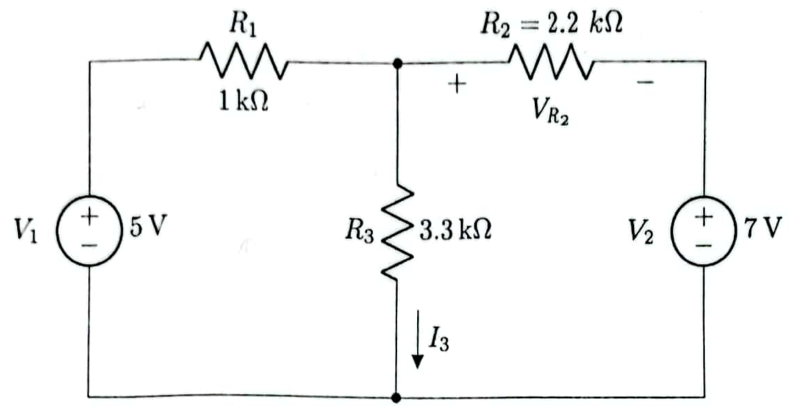
An independent **voltage source** is deactivated (made zero) by **shorting** it, and an independent **current source** is deactivated (made zero) by **open circuiting** it. However, if a dependent source is present, it must remain active during the superposition process.

Apparatus

- Multimeter
- Resistors ($1\ k\Omega,\ 2.2\ k\Omega,\ 3.3\ k\Omega$).
- DC power supply
- Breadboard
- Jumper wires

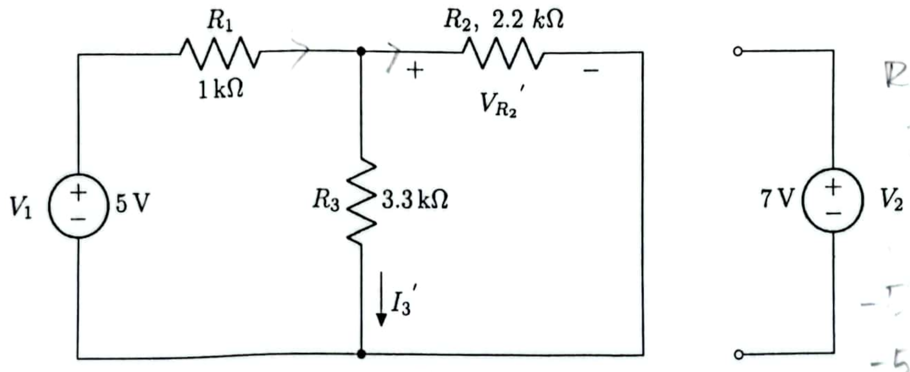
Procedures

- Measure the resistances of the provided resistors and fill up the data table (Table 1).
- Construct the following circuit on a breadboard. Try to use minimum number of jumper wires:



Circuit 1

- Measure the voltage across the resistors R_2, R_3 and current through the resistor R_3. Use a Multimeter for measuring the voltage and use Ohm's law to calculate the current (I_3) through R_3. Fill up the data tables.
- Render V_1 inactive (keeping V_2 active) and construct the following circuit.



Circuit 2

$R_{eq} = 1.32$

$I = 3.788$

$= I_1$

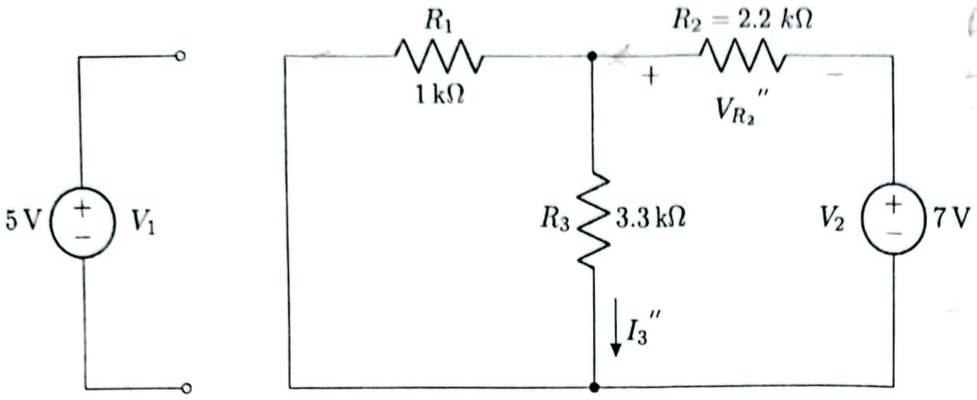
$-5 + I_1 + 2.2 I_2 = 0$

$I_2 = 0.5515$

I_3

- Measure the voltage across the resistors R_2, R_3 and current through the resistor R_3. Use a Multimeter for measuring the voltage and use Ohm's law to calculate the current (I_3') through R_3. Fill up the data tables.
- Render V_2 inactive (keeping V_1 active) and construct the following circuit.

-5



Circuit 3

$D = 2.096$

$I = V/R = I_2$

$= 2.358$

$7 + I_2 2.2 - I_3 3.3$

$I_3 = -3.69$

- ➢ Measure the voltage across the resistors R_2, R_3 and current through the resistor R_3. Use a Multimeter for measuring the voltage and use Ohm's law to calculate the current (I_3'') through R_3. Fill up the data tables.
- ➢ Verify if $I_3 = I_3' + I_3''$ which would validate the superposition theorem for the current through R_3.
- ➢ Verify if $V_{R_2} = V_{R_2}' + V_{R_2}''$ which would validate the superposition theorem for the voltage across R_2.

Data Tables

Signature of Lab Faculty: Asd' **Date:** 7.10.23

** ***<u>For all the data tables, take data up to three decimal places, round to two, then enter into the table.</u>***

Table 1: Resistance Data

For all your future calculations, please use the observed values only **(even for theoretical calculations)**.

Notation	Expected Resistance	Observed Resistance (kΩ)
R_1	1 kΩ	0.98
R_2	2.2 kΩ	2.164
R_3	3.3 kΩ	3.251

Table 2: Current through R_3 and voltage across R_2

In the following table, V_3 is the voltage drop across the resistor, R_3 and I_3 is the current through it. V_2 is the voltage drop across the resistor R_2. Similar syntax applies to the remaining resistors. Also, calculate the percentage of error between expected and observed values of $I_3' + I_3''$.

Observation	I_3 with both V_1 and V_2 active (mA)	I_3' with only V_1 is active (mA)	I_3'' with only V_2 is active (mA)	$I_3' + I_3''$ (mA)
Experimental	1.34	0.81	0.51	1.32
Theoretical	1.41	0.87	-0.54	1.41
Observation	V_{R_2} with both V_1 and V_2 active (V)	V_{R_2}' with only V_1 is active (V)	V_{R_2}'' with only V_2 is active (V)	$V_{R_2}' + V_{R_2}''$ (V)
Experimental	-2.35	2.882	-5.25	-2.36
Theoretical	-2.345	2.84	-5.189	-2345

- **Percentage of error** $= \left|\frac{Observed\ Value - Expected\ Value}{Expected\ Value}\right| \times 100\%$

N.B: Here, the Expected values are I_3, V_{R_2} *and the Observed values are* $I_3' + I_3''$ *and* $V_{R_2}' + V_{R_2}''$ respectively.

Hence, Percentage of error in $I_3' + I_3''$ calculation = 6.38 %

Hence, Percentage of error in $V_{R_2}' + V_{R_2}''$ calculation = 0.639 %

$$\boxed{\begin{matrix} V = IR \\ y = mx \end{matrix}}$$

Questions

1. Calculate the **power associated** with R_2 using the experimentally measured values of currents or voltages when:

   - Only V_1 source is active.
   - Only V_2 source is active.
   - Both V_1 and V_2 sources are active.

   Fill out the Table given below and verify, whether the superposition theorem is verified or not in this case. If not, comment on the reasons. **You don't need to take any new readings for this task.** Use previous data from Table 2 to calculate the power. Remember, power consumed by a resistor, $P = VI = I^2R = \frac{V^2}{R}$

Observation	P_{R_2} when both V_1 and V_2 active $P_{R_2} = \frac{V_{R_2}^2}{R_2}$ (W)	P'_{R_2} when only V_1 is active $P'_{R_2} = \frac{V'^2_{R_2}}{R_2}$ (W)	P''_{R_2} when only V_2 is active $P''_{R_2} = \frac{V''^2_{R_2}}{R_2}$ (W)	$P'_{R_2} + P''_{R_2}$ (W)
Experimental	2.51	3.775	12.528	16.303
Theoretical	2.49956	3.666	12.2389	15.899

$V = IR$

$\frac{V}{R}$

Is the Superposition Principle applicable in the case of Power?

☐ Yes ☑ No

How would you relate your findings from this to the concept of linearity? Why does/doesn't it work when it comes to Power?

$P = VI$

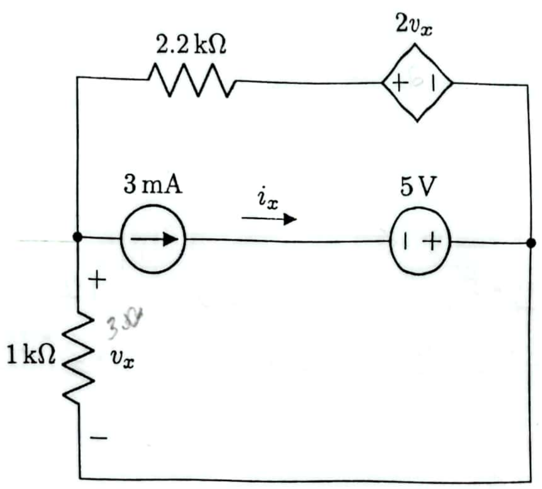
$= \boxed{\frac{V^2}{R}}$

The superposition principle shows that the total response of a circuit with multiple source is the sum of responses of the circuit to each individual source acting alone, which we proved by measuring earlier. But from the table we see, its not working in terms of power as it is a non linear quantity. We know, nonlinear quantities wont change based on V. We know, $P = V^2/R$. Power will change depending on V^2 but not V. So, Power is a non-linear quantity and superposition principle is not appliable for power.

2. Why was a short circuit wire required to be connected between the corresponding terminals while turning off a voltage source? Why wasn't simply turning off the power switch enough to deactivate the source?

Even if we switch off the power button, the potential point of two terminals will remain open creating an open circuit. If two terminals are not closed there will be a voltage drop. But we need to make sure there was no voltage difference on two point. That's why a short circuit was required after deactivating the voltage source

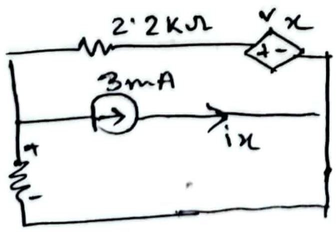
3. For the circuit shown below,



$- V_x + 2 \cdot 2 ... + 6$

(a) Show using the Superposition Principle that the 5 *V* voltage source has no effect on the current i_x.

case-1 - current source active, voltage deactive (shorted)



$i_x = \frac{V_{x1}}{10^3} \Rightarrow V_{x1} = i_x \times 10^3$

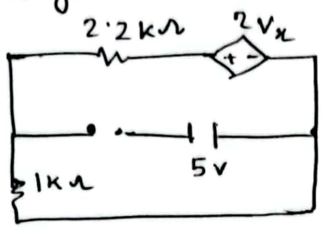
$+2V_{x1} - V_{x1} - 2 \cdot 2 i_1 \times 10^3 = 0$

$\Rightarrow (2 i_1 - i_1 - 2 \cdot 2) \times 10^3 = 0$

$\Rightarrow i_1 = 0$

only i_x current will flow

② Voltage source active, current source deactive



there will be no ix & 5 volt source will have no effect on ix, as it will be connected to a open circuit

(b) Why the 5 V voltage source does not contribute to the current i_x?

when we active voltage & deactivate current source, the will be no ix. So, 5V does not contribute to the ix.

The 5V source is no generating ix. Even when the 5v is removed with a shortcircuit wire, ix will still flow. Therefore, 5V source does not impact ix

(c) Can you draw any conclusions about the resistances of an ideal voltage and current source from this? If so, what are they?

while using superposition ~~theor~~ principle, we feel the need of a voltage source which maintains it's voltage perfectly no matter whats its connect to. So, internal resistance of a voltage source should be zero.

for an ideal current source, it needs to provide a fixed current even the voltage accross it can vary. So, it needs to have a infinite internal resistance..

Report

1. Fill up the theoretical parts of all the data tables.
2. Answer to the questions.
3. Discussion *[comment on the obtained results and discrepancies]*. Write in the next page.