North South University
Department of Electrical & Computer Engineering

LAB REPORT

Course Code : EEE 141L

Course Title: Electrical circuits lab

Course Instructor: Faculty Name M Abu Obaidah (Abo)

Experiment Number: 4

Experiment Name:

Objectives:

- To verify superposition theorem

Theory:

The Superposition theorem for electrical circuits states that for a linear system the response (voltage or current) in any branch of a bilateral linear circuit having more than one independent source equals the algebric sum of the responses caused by each independent source acting alone, where all other independent sources are replaced by their internal impedances.

The superposition theorem is used when the circuits having more than one sources.

Superposition theorem is applicable when we are to determine the current in one particular branch of a network containing several voltage sources and/or current sources.

Limitations of superposition theorem are as follows

- Not applicable to the branches which are coupled to the branch of circuit applicable to the branches of the circuit when the voltages and current of there branches are known.

- Not applicable to the network containing two or more sources that are not in series or parallel.
- Theorem can't be used to measure power.
- Applicable only to linear circuit.

Voltage divider rule is that rule if a series circuit has more than one resistor, the voltage across of each resistor is the ratio of resistor value multiplied with voltage source to total resistance value. Let us consider a circuit has three series resistors which are R_1, R_2, R_3 connected by series. Using voltage divider rule,

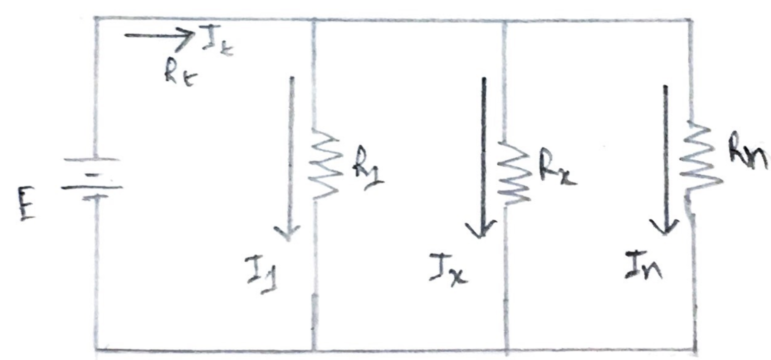
we get, $$V_1 = \frac{R_1}{R_1+R_2+R_3} V_s$$

$$V_2 = \frac{R_2}{R_1+R_2+R_3} V_s$$

$$V_3 = \frac{R_3}{R_1+R_2+R_3} V_s$$

Current divider rule states that the electric current entering the node of a parallel circuit is divided into the branches. Current divider rule is employed to calculate the magnitude of divided current in the circuits.

A parallel circuit with 'n' number of resistors and an input voltage source. We are interested to find the current which is flowing through R_x, $I_x = \frac{I_t}{R_x} R_t$



Apparatus List:

(a) Trainer board

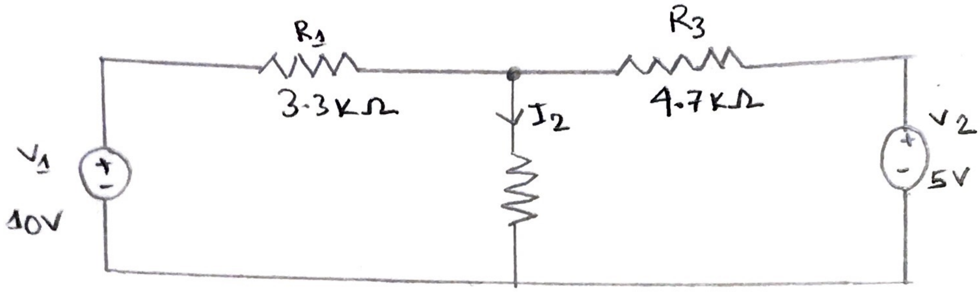
(b) DMM

(c) 1x 3.3 kΩ resistor

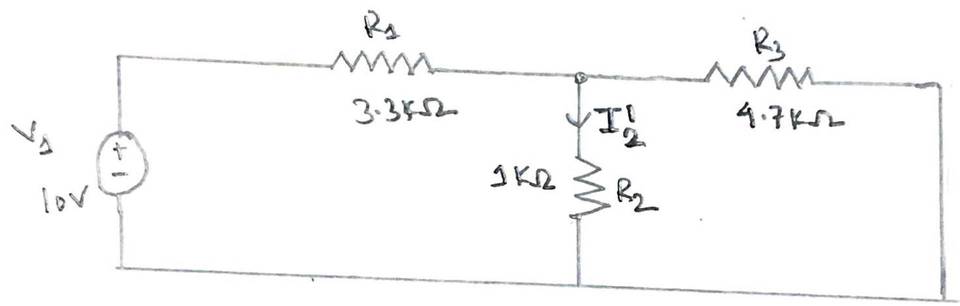
(d) 1x 4.7 kΩ resistor

(e) 1x 1 kΩ resistor.

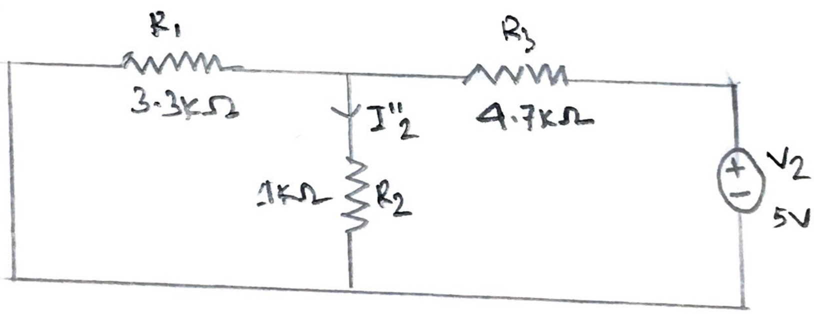
rcuit Diagram:



Circuit 1



Circuit 2



Circuit 3

Data and Results:

Table 1

I_2 (mA)	I'_2 (mA)	I''_2 (mA)	$I'_2 + I''_2$
2.63	1.992	0.587	2.579

Table 2

V_{R_1}	V'_{R_1}	V''_{R_1}	$V'_{R_1} + V''_{R_1}$
7.36	7.993	0.587	8.58

Table 3

V_{R_2}	V'_{R_2}	V''_{R_2}	$V'_{R_2} + V''_{R_2}$
2.63	1.992	0.587	2.579

Table 4

V_{R_3}	V'_{R_3}	V''_{R_3}	$V'_{R_3} + V''_{R_3}$
5.97	1.992	3.65	5.642

Calculation:

For Table 1, From Ohm's law,

$$I_2 = \frac{V_{R2}}{R_2} = \frac{2.63 V}{1\times10^3 \Omega} = 2.63 mA$$

$$I'_2 = \frac{V'_{R2}}{R_2} = \frac{1.992 V}{1\times10^3 \Omega} = 1.992 mA$$

$$I''_2 = \frac{V''_{R2}}{R_2} = \frac{0.587 V}{1\times10^3 \Omega} = 0.587 mA$$

Theoretical calculation:

For circuit-2,

$$R_T = R_1 + R_2 \parallel R_3$$

$$= 3.3K + 1K \parallel 4.7K$$

$$= 3.3K\Omega + 0.825 K\Omega$$

$$= 4.125 K\Omega$$

From Ohm's law ; $V = I'_{R_1} R_T$

$$\Rightarrow I'_{R_1} = \frac{V}{R_T} = \frac{10}{4.125\times10^3} = 2.424 mA$$

From CDR, $I'_{R_3} = \frac{I'_{R_1}}{R_2+R_3} \times R_2$

$$= \frac{2.424}{4.7+1} \times 1 = 0.43 mA$$

$$I'_{R_2} = \frac{I'_{R_1}}{R_1 + R_3} \times R_3$$

$$= \frac{2.424}{4.7+1} \times 4.7 = 1.998 \text{ mA}$$

From VDR,

$$V'_{R_1} = \frac{V}{R_T} \times R_1 = \frac{10}{4.125} \times 3.3 = 8V$$

$$V'_{R_2} = V'_{R_3} = \frac{V}{R_T} \times (R_2 \parallel R_3) = \frac{10}{4.125} \times (4.7 \parallel 1)$$

$$= \frac{10}{4.125} \times 0.825$$

$$= 2V$$

For Circuit-3,

$$R_T = R_3 + R_1 \parallel R_2$$

$$= 4.7 + 3.3 \parallel 1$$

$$= 4.7 + 0.767$$

$$= 5.467 \text{ k}\Omega$$

From Ohm's law, $V = I''_{R_3} R_T$

$$\Rightarrow I''_{R_3} = \frac{V}{R_T} = \frac{5}{5.467 \times 10^3} = 0.915 \text{ mA}$$

From CDR,

$$I''_{R_1} = \frac{I''_{R_3}}{R_1 + R_2} \times R_2$$

$$= \frac{0.915}{3.3 + 1} \times 1 = 0.213 \text{ mA}$$

$$I''_{R_2} = \frac{I''_{R_3}}{R_1 + R_2} \times R_1$$

$$= \frac{0.915}{3.3 + 1} \times 3.3 = 0.702 \text{ mA}$$

From VDR,

$$V''_{R_2} = V''_{R_1} = \frac{V}{R_T} \times (R_1 \parallel R_2)$$

$$= \frac{5}{5.647} \times (3.3 \parallel 1)$$

$$= \frac{5}{5.647} \times 0.767 = 0.679 \text{ V}$$

$$V''_{R_3} = \frac{V}{R_T} \times R_3 = \frac{5}{5.647} \times 4.7 = 4.162 \text{ V}$$

% of error:

$\%$ of error of $I'_2 = \frac{|1.998 - 1.992|}{1.998} \times 100 = 0.30$

$\%$ of error of $I''_2 = \frac{|0.702 - 0.587|}{0.702} \times 100 = 16.38$

$\%$ of error of $I'_2 + I''_2 = \frac{|(0.702 + 1.998) - 2.579|}{(0.702 + 1.998)} \times 100 = 4.48$

$\%$ of error of $V'_{R_1} = \frac{|8 - 7.993|}{8} \times 100 = 0.0875$

$\%$ of error of $V'_{R_2} = V'_{R_3} = \frac{|2 - 1.992|}{2} \times 100 = 0.4$

$\%$ of error of $V''_{R_1} = V''_{R_2} = \frac{|0.679 - 0.587|}{0.679} \times 100 = 13.55$

$\%$ of error of $V''_{R_3} = \frac{|4.162 - 3.65|}{4.162} \times 100 = 12.30$

From theoretical value,

$I'_2 + I''_2 = 0.702 + 1.998 = 2.7$

$V'_{R_1} + V''_{R_1} = 8 + 0.679 = 8.679$

$V'_{R_2} + V''_{R_2} = 2 + 0.679 = 2.679$

$V'_{R_3} + V''_{R_3} = 2 + 4.162 = 6.162$

So, % of error $V'_{R_1} + V''_{R_1} = \frac{18.679 - 8.581}{8.679} \times 100 = 1.14$

% of error of $V'_{R_2} + V''_{R_2} = \frac{12.679 - 2.5791}{2.679} \times 100 = 3.73$

% of error of $V'_{R_3} + V''_{R_3} = \frac{16.162 - 5.6421}{6.162} \times 100 = 8.44$

Report:

2. Theoretically calculate all values of table 1 to table 4. Show all steps in detail

Answer:

For circuit 2, $R_T = R_1 + R_2 \parallel R_3 = 3.3 + 1 \parallel 4.7 = 4.125\,k\Omega$

From Ohm's law, $V = I'_{R_1} R_T \Rightarrow I'_{R_1} = \frac{10}{4.125 \times 10^3} = 2.424\,mA$

From CDR, $I'_{R_3} = \frac{I'_{R_1}}{R_2 + R_3} \times R_2 = \frac{2.424}{4.7+1} \times 1 = 0.43\,mA$

$I'_{R_2} = \frac{I'_{R_1}}{R_2 + R_3} \times R_3 = \frac{2.424}{4.7+1} \times 4.7 = 1.998\,mA$

From VDR, $V'_{R_1} = \frac{V}{R_T} \times R_1 = \frac{10}{4.125} \times 3.3 = 8V$

$V'_{R_2} = V'_{R_3} = \frac{V}{R_T} \times (R_2 \parallel R_3) = \frac{10}{4.125} \times (4.7 \parallel 1) = 2V$

For circuit 3, $R_T = R_3 + R_1 \parallel R_2 = 4.7 + 3.3 \parallel 1 = 5.467\ k\Omega$

From Ohm's law, $V = I''_{R_3} R_T \Rightarrow I''_{R_3} = \frac{5}{5.467 \times 10^3} = 0.915\ mA$

From CDR, $I''_{R_1} = \frac{I''_{R_3}}{R_1 + R_2} \times R_2 = \frac{0.915}{3.3+1} \times 1 = 0.213\ mA$

$I''_{R_2} = \frac{I''_{R_3}}{R_1 + R_2} \times R_1 = \frac{0.915}{3.3+1} \times 3.3 = 0.702\ mA$

From VDR, $V''_{R_2} = V''_{R_1} = \frac{V}{R_T} \times (R_1 \parallel R_2) = \frac{5}{5.697} \times (3.3 \parallel 1) = 0.679\ V$

$V''_{R_3} = \frac{V}{R_T} \times R_3 = \frac{5}{5.697} \times 4.7 = 4.162\ V$

So, $I'_2 + I''_2 = 0.702 + 1.998 = 2.7\ mA = I_2$

$V'_{R_1} + V''_{R_1} = 8 + 0.679 = 8.679\ V = V_{R_1}$

$V'_{R_2} + V''_{R_2} = 2 + 0.679 = 2.679\ V = V_{R_2}$

$V'_{R_3} + V''_{R_3} = 2 + 4.162 = 6.162\ V = V_{R_3}$

3. Find the % of error between each value

Answer:

% of error of

$$I'_2 = \frac{|1.998-1.992|}{1.998}\times 100 = 0.30$$

$$I''_2 = \frac{|0.702-0.587|}{0.702}\times 100 = 16.38$$

$$I'_2 + I''_2 = \frac{|2.7-2.579|}{2.7}\times 100 = 4.48$$

$$V'_{R_1} = \frac{|8-7.993|}{8}\times 100 = 0.0875$$

$$V'_{R_2} = V'_{R_3} = \frac{|2-1.992|}{2}\times 100 = 0.4$$

$$V''_{R_1} = V''_{R_2} = \frac{|0.679-0.587|}{0.679}\times 100 = 13.55$$

$$V''_{R_3} = \frac{|4.162-3.65|}{4.162}\times 100 = 12.30$$

$$V'_{R_1} + V''_{R_1} = \frac{|8.679-8.58|}{8.679}\times 100 = 1.14$$

$$V'_{R_2} + V''_{R_2} = \frac{|2.679-2.579|}{2.679}\times 100 = 3.73$$

$$V'_{R_3} + V''_{R_3} = \frac{|6.162-5.642|}{6.162}\times 100 = 8.44$$

4. Show that your circuit followed superposition theorem.

Answer: From experiment, we got $I_2 = 2.63$ mA. Also we got $I'_2 = 1.992$ mA and $I''_2 = 0.587$ mA. When both I'_2 and I''_2 were added, the calculated value of I_2 was 2.579. With difference of 0.051 mA, the formula of $I_2 = I'_2 + I''_2$ was verified. So, our circuit followed superposition theorem.

Result Analysis and Discussion:

We observed that our circuit had two voltage sources, 10V and 5V. So superposition theorem is ~~in~~ applicable in the circuit.

The superposition theorem states that the voltage across or current through an element in a linear circuit is the algebraic sum of the voltages across or current through that element due to each independent source active alone.

So ~~we~~ for each independent source, we put 5V source active and took all values. And again we put 10 V

Sounce active and taok all values.

from taking all values