INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR

Introduction to Electronics Laboratory

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EXPERIMENT 1

A Look at Basic Circuit Theorems in Practice

PART 1:

Kirchhoff's Voltage Law (KVL):

Aim of the Experiment:

To verify Kirchhoff's Voltage Law (KVL)

Materials & Equipment:

- DC Power supply (10V)
- Bread board
- Digital Multi Meter
- Connecting wires
- Resistors : 4.7 KΩ (1 no.), 1.8 KΩ (3 no.s), 2.7 KΩ (2 no.s)

Theory:

Kirchhoff's Voltage Law states that for a closed loop series path the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero. This is because a circuit loop is a closed conducting path so no energy is lost.

In other words the algebraic sum of ALL the potential differences around the loop must be equal to zero as: $\Sigma V = 0$. Note here that the term "algebraic sum" means to take into account the polarities and signs of the sources and voltage drops around the loop. This idea by Kirchhoff is commonly known as the Conservation of Energy, as moving around a closed loop, or circuit, you will end up back to where you started in the circuit and therefore back to the same initial potential with no loss of voltage around the loop. Hence any voltage drops around the loop must be equal to any voltage sources met along the way

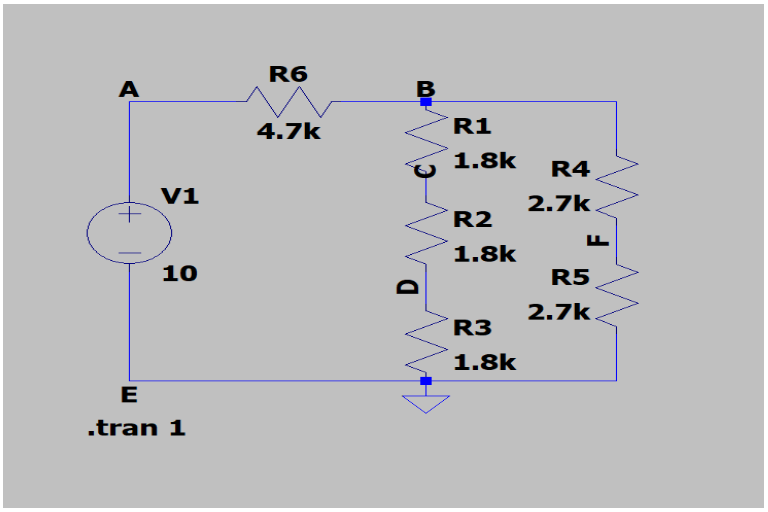
Procedure:

1. The following circuit was made on a stimulation software.
2. Three loops of the circuit were identified

Loop-1: A → B → C → D → E → A.
Loop-2: B → F → E → D → C → B.
Loop-3: A → B → F → E → A.

3. The following observations were made.

<u>Circuit Diagram:</u>



<u>OBSERVATIONS:</u>

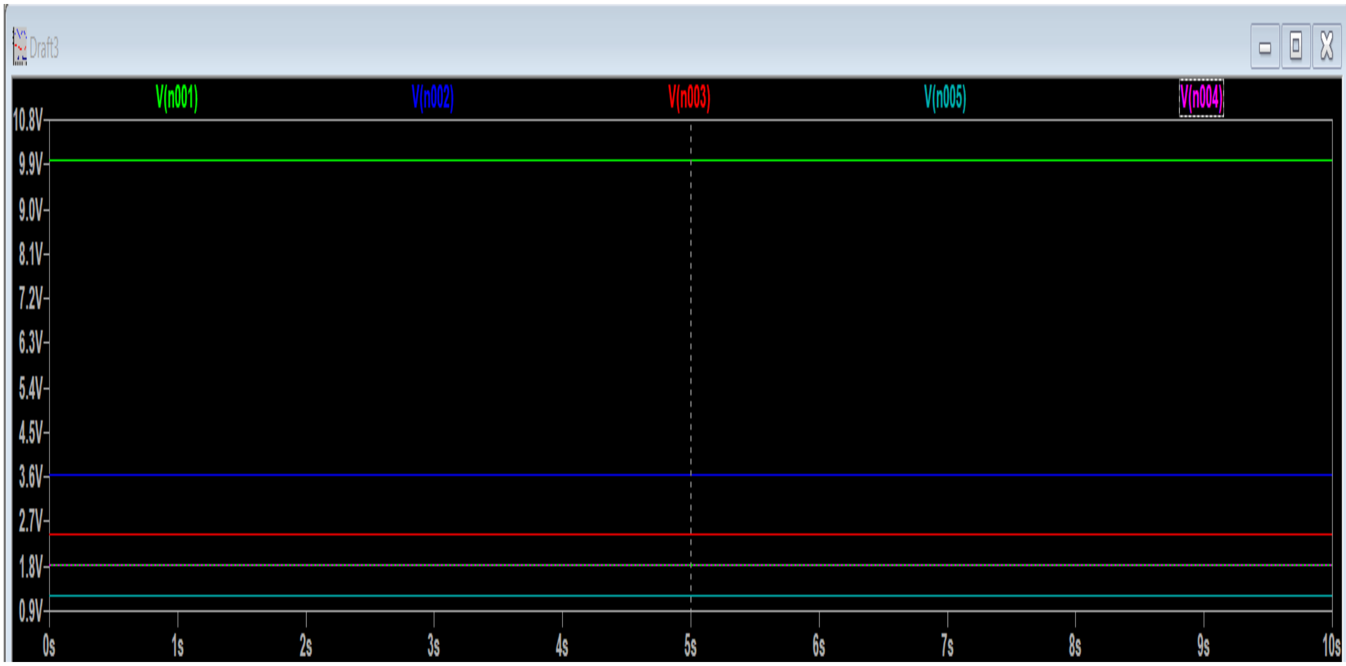
LOOP- ABCDEA

V(AB)	V(BC)	V(CD)	V(DE)	V(EA)	Sum
6.35V	1.22V	1.22V	1.21V	-10V	0V

LOOP-BFEDCB

V(BF)	V(FE)	V(ED)	V(DC)	V(CD)	SUM
1.824V	1.825	-1.216V	-1.216V	-1.217V	0V

GRAPHS:



CALCULATION-

1)LOOP-ABCDA:

6.35+1.22+1.22+1.21-10=0

2)LOOP-BFEDCB

1.824+1.825-1.216-1.216-1.217=0

Conclusion:

The purpose of this experiment was to verify Kirchhoff's Voltage Law. One can clearly see from the observations that the purpose was met. Hence, Kirchhoff's voltage law, which states that the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero, is verified.

PART 2: Kirchhoff's Current Law (KCL)

Aim:

To prove Kirchhoff's current law (KCL)

Materials required:

- DC Power supply:10 V and 7 V
- Bread board
- Digital Multi Meter
- Connecting wires
- Resistors : 3.3 KΩ (3 no.s), 1KΩ (2 no.s)

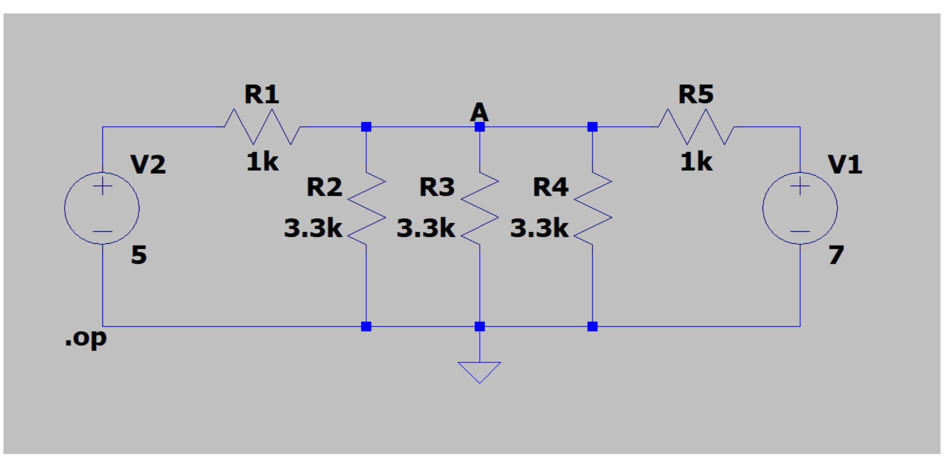
Theory:

Kirchhoffs Current Law or KCL, states that the "total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node". In other words the algebraic sum of All the currents entering and leaving a node must be equal to zero, $I_{(exiting)} + I_{(entering)} = 0$. This idea by Kirchhoff is commonly known as the Conservation of Charge.

Procedure:

1. The following circuit was made using a stimulation software.
2. It is assumed that the current flows away from A.
3. The following observations were made.

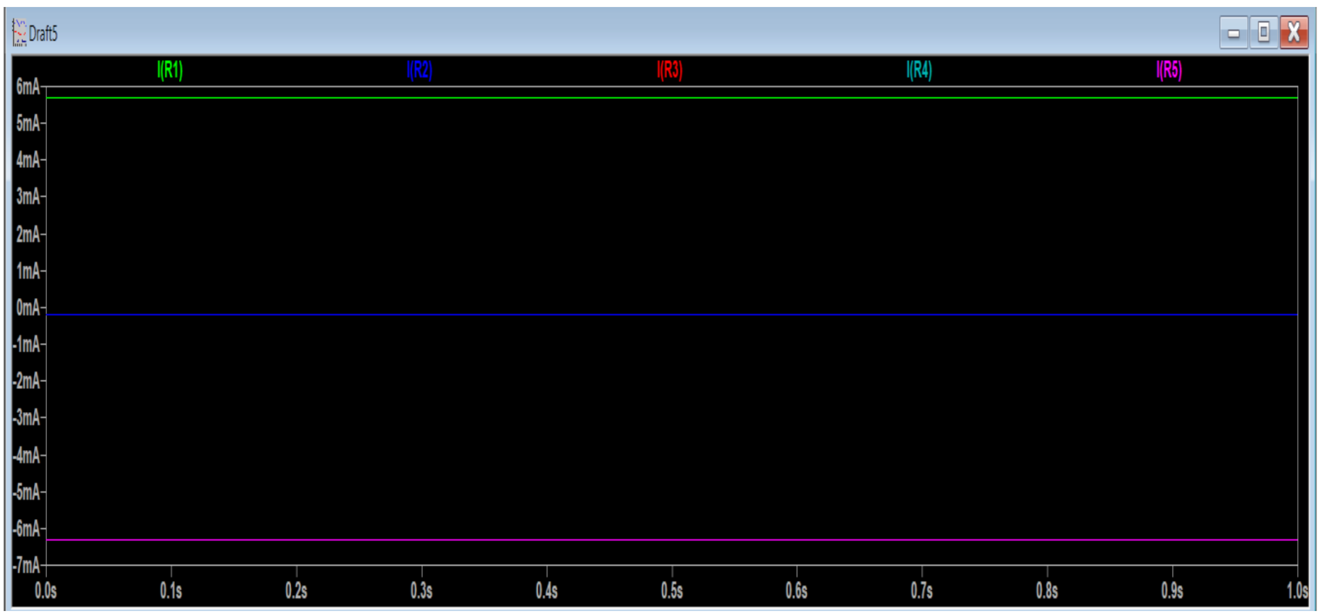
Circuit Diagram:



Observations:

Rheostat	**Current**
R1	-5.687mA
R2	-0.208mA
R3	-0.208mA
R4	-0.208mA
R5	6.312mA
Sum	0.001mA

GRAPHS:



Calculations:

sum of all the current at node A I = i1 + i2 + i3 + i4 + i5
=5687.4999 + 208.33334*3 - 6312.5002
=0.

Conclusion:

The purpose of this experiment was to verify Kirchhoff's Current Law. One can clearly see from the observations that the purpose was met. Hence, Kirchhoff's Current law, which states that all the currents entering and leaving a node must be equal to zero, is verified.

Part 3: Finding Current using Superposition Principle

Aim:

To find current using superposition principle.

Materials required:

- DC Power supply:5 V and 7 V
- Bread board
- Digital Multi Meter
- Connecting wires
- Resistors : 3.3 KΩ (3 no.s), 1KΩ (2 no.s)

Theory:

Superposition theorem states that in a linear circuit with several sources the voltage and current responses in any branch is the algebraic sum of the voltage and current responses due to each source acting independently with all other sources replaced by their internal impedance.

Procedure:

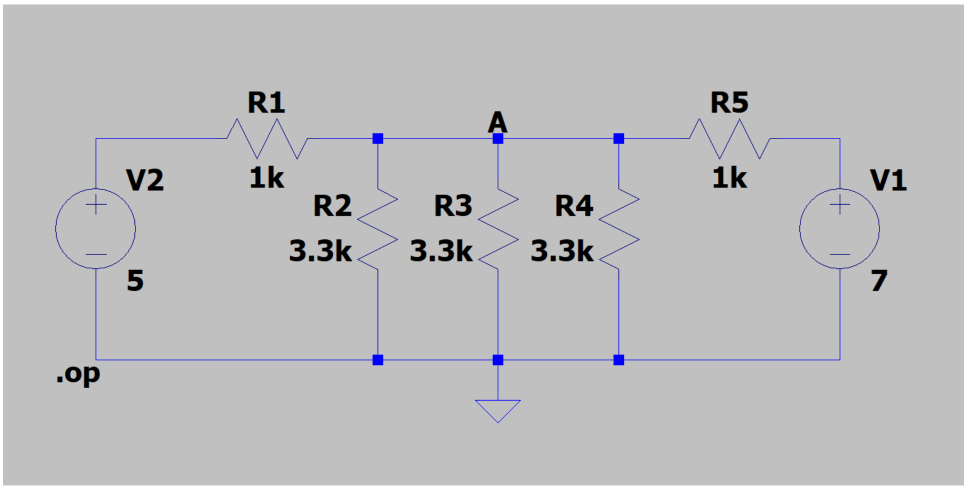
1) The circuit is wired up using the software and given values are assigned to the components of the circuit.

2) After disabling the 5V source, current across the R2 (i.e., R5) is checked and noted.

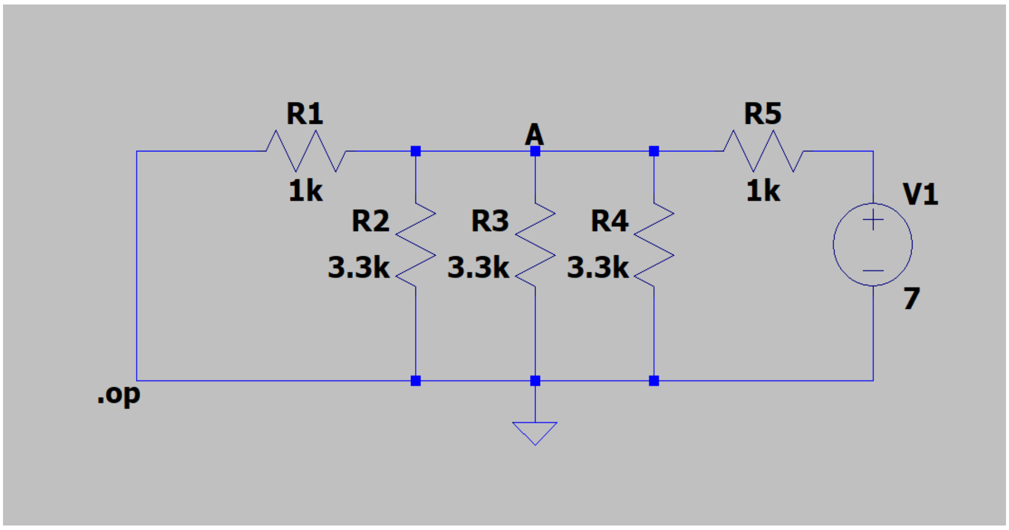
3) Next, after disabling the 7V source, current across R2 (i.e., R12) is checked and noted.

Circuit Diagram:

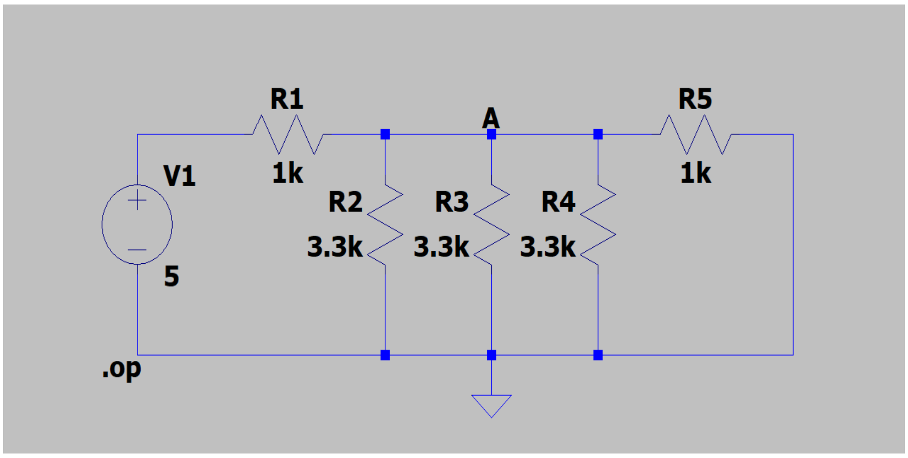
- Original Circuit:



- After short circuit of 5V source:



- After short circuit of 7V source:



Observations:

Current	Value
I_1	729.17µA
I_2	-520.83µA
I_{R3}	208.33µA
I_1+I_2	208.33µA

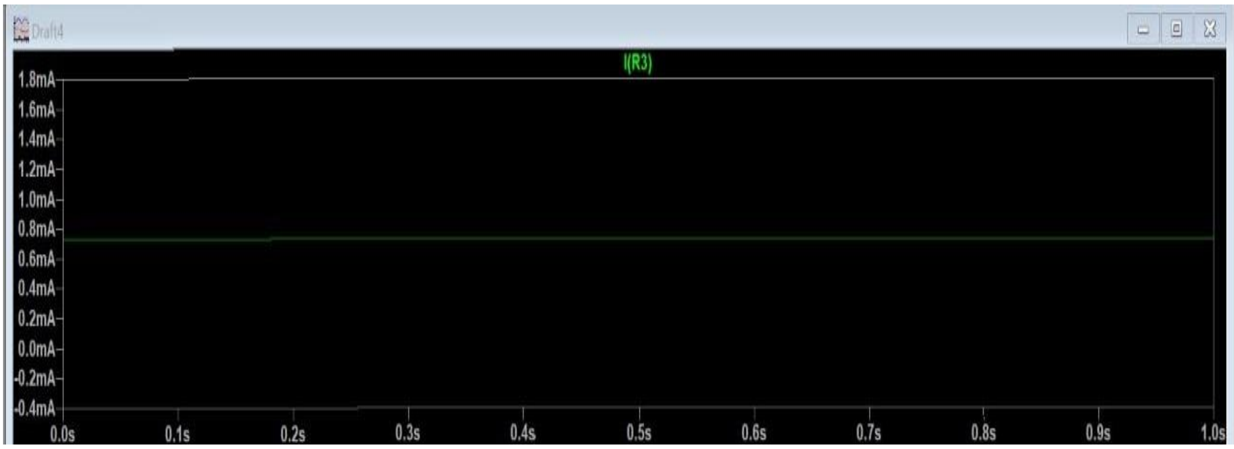
CALCULATIONS:

- current in R3 due to only 5v source - -520.83336 micro-A
- current in R3 due to only 7v source - 729.16667 micro-A
- current in R3 due to both the sources - -520.83336+729.16667
  = 208.33334 micro-A .

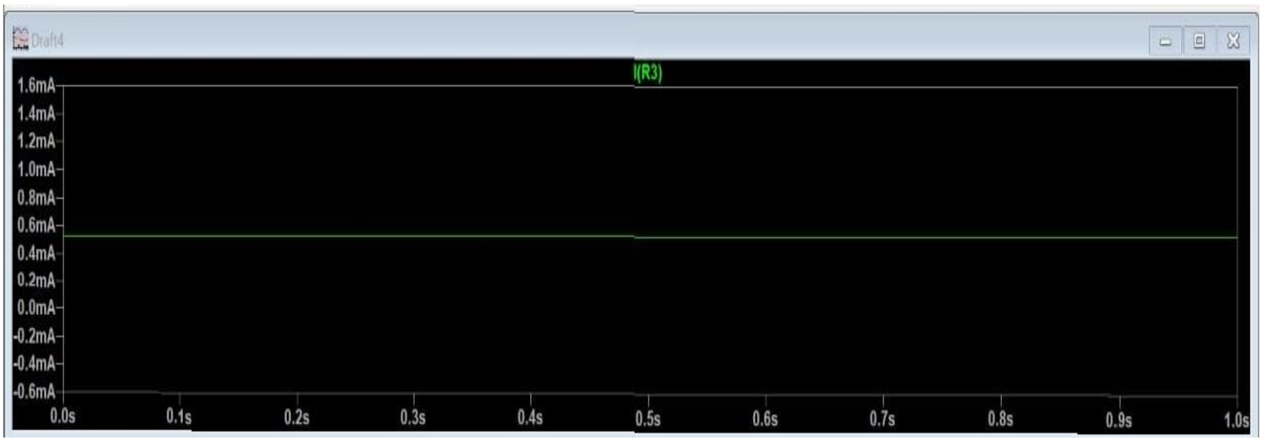
GRAPHS:

- Original Circuit:

- After short circuit of 5V source:



- After short circuit of 7V source:



Conclusion:

The Superposition Principle states that, for all linear systems, the net response caused by two or more stimuli is the sum of the responses that would have been caused by each stimulus individually. In the above experiment, the current across resistor R3 when both the voltage sources are connected is same as the sum of currents flowing through the resistor R3 when each voltage source is individually connected. Hence, the Superposition Principle is satisfied.

Part 4: Finding Current using Thevenin's Theorem

Aim:

To find current using Thevenin's theorem.

Materials Required:

- DC Power supply:5 V and 10 V
- Bread board
- Digital Multi Meter
- Connecting wires
- Resistors : 4.7KΩ (2 no.s), 1KΩ (3 no.s)

Theory:

Thevenin's Theorem states that "Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load". In other words, it is possible to simplify any electrical circuit, no matter how complex, to an equivalent two-terminal circuit with just a single constant voltage source in series with a resistance (or impedance) connected to a load as shown below.

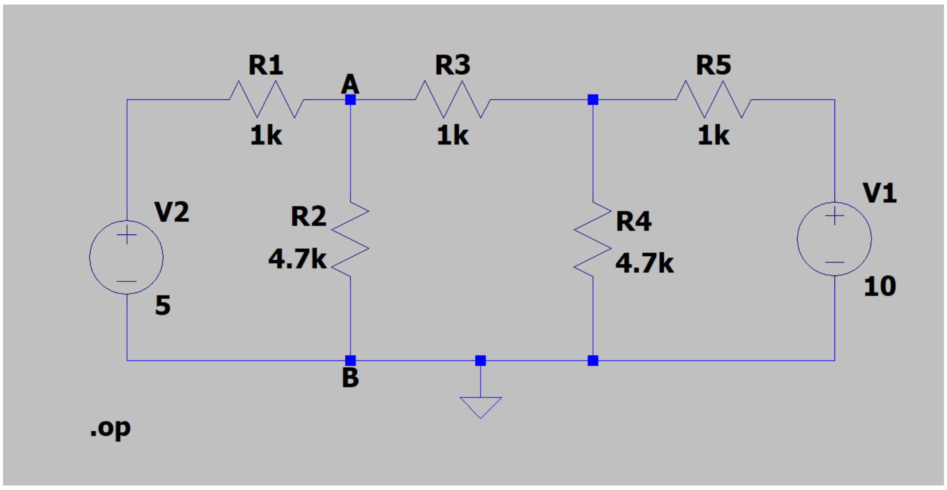
Thevenin's Theorem is especially useful in the circuit analysis of power or battery systems and other interconnected resistive circuits where it will have an effect on the adjoining part of the circuit.

Procedure:

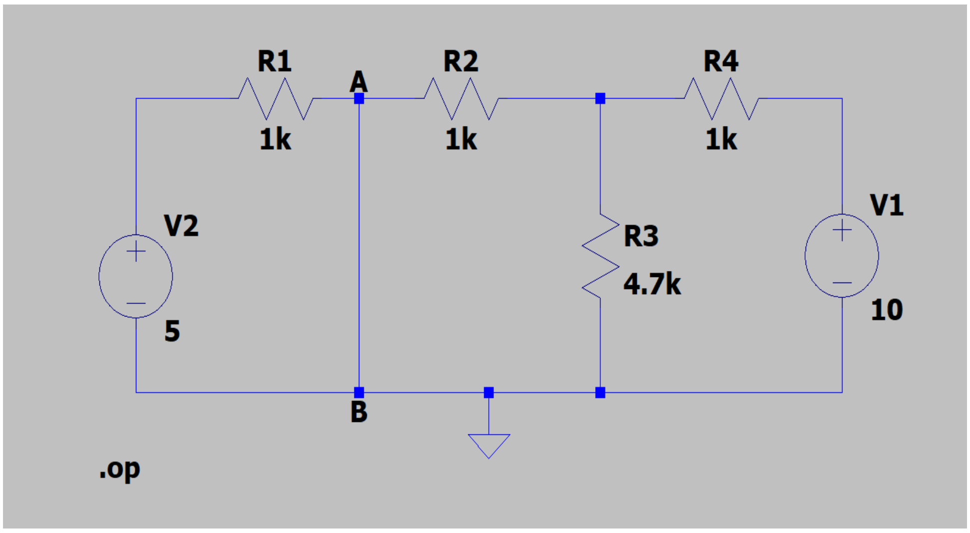
1. The given circuit was drawn using a stimulation software.
2. Values were assigned to resistors & voltage sources.
3. The current flowing through R_2 was noted as I_{ref}.
4. R_2 was disconnected and circuit was opened at points A & B.
5. The voltage between points A & B was noted which gave Thevenin's Voltage V_{AB}.
6. The two voltage sources, 5V & 10V were deactivated and the resistance between point A & B was measured keeping R_2 disconnected. This gave Thevenin's Resistance R_{AB}.
7. Thevenin's Equivalent circuit was made using single resistor R_{AB}, resistor R_2 and voltage source V_{AB}.
8. Current through R_2 was noted as I_{meas2}.

Circuit Diagram:

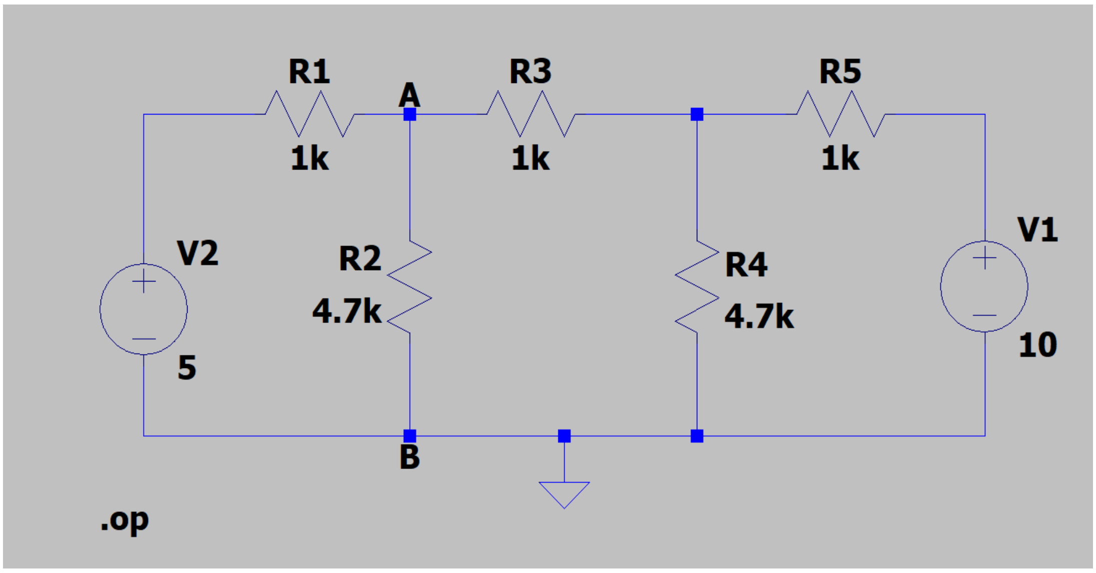
1. Original circuit:



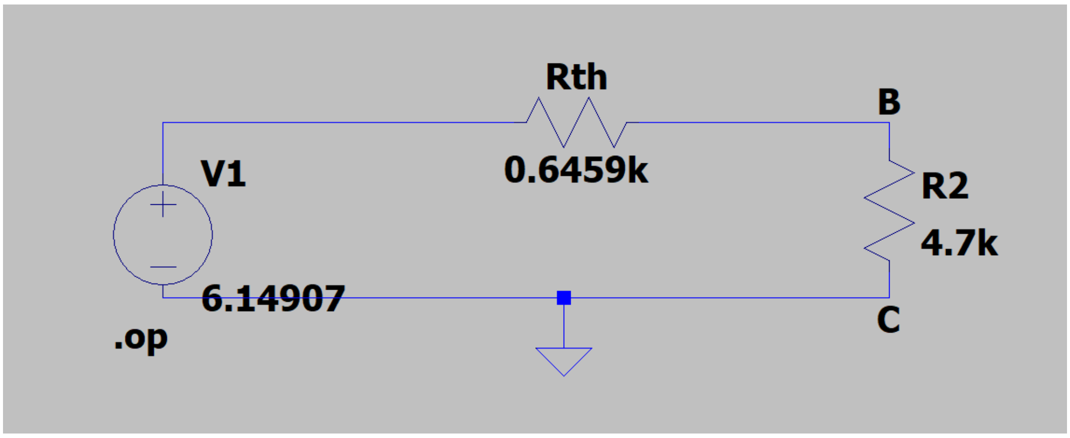
2. Removing R_2:



3. Short circuiting voltage sources:



4. Thevenin's Equivalent Circuit:



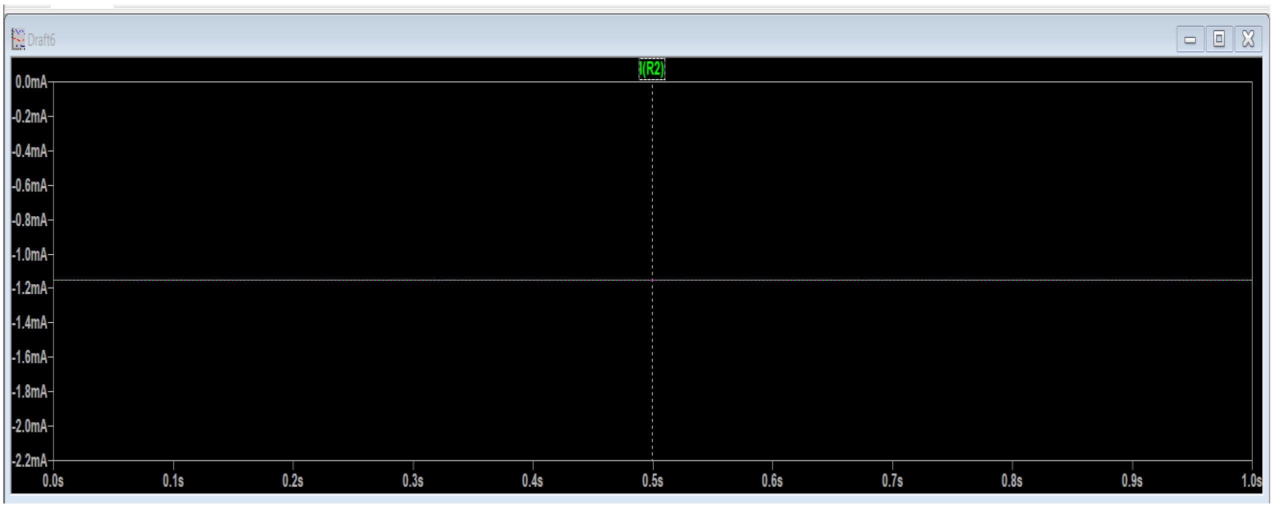
Observations:

Quantity	**Value**
I_{ref}	1.15mA
V_{th}	6.149V
R_{th}	645.952Ω
I_{meas1}	$V_{th}/(R_{th}+R_2)=$

	1.15mA
I_{meas2}	1.15mA
I_{calc}	1.15mA

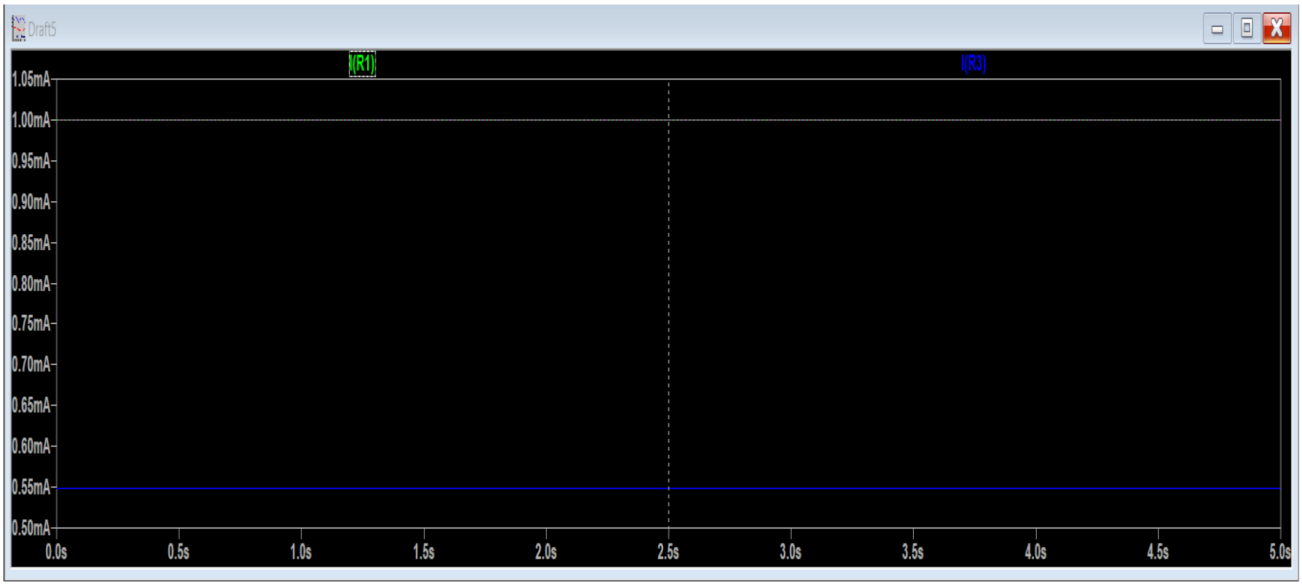
GRAPHS:

1) Original Circuit:-



2)Removing R2:-

3) Short Circuiting Voltage Sources:-



4) <u>Thevenin's Equivalent Circuit:</u>

<u>Conclusion:</u>

Thevenin's theorem states that any linear electrically complex circuit is reduced into a simple electric circuit with one voltage and resistance connected in series. In the above experiment, we have reduced the circuit into Thevenin equivalent and measured the current through resistor R2 in both the cases which are same. Thus, Thevenin's theorem is verified.

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