Lab Work: Experiment-2: Verification of KVL & KCL

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Verification of KVL and KCL

2.1 Purpose/Objective:

The aim of this experiment is-

- To be familiar with the Kirchhoff's voltage and current laws.
- To verify the KVL and KCL with the help of simple series-parallel circuits and hence to determine the equivalent resistance of the circuits by experimental and analytical methods.

2.2 Theory:

In 1845, a German physicist, Gustav Kirchhoff developed a pair of laws which deal with the conservation of current and energy within electrical circuits. The rules are commonly known as: *Kirchoff's Circuit Laws:*

- One law dealing with current flow around a closed circuit, known as Kirchhoff's Current Law, (KCL)
- Other law deals with the voltage around a closed circuit, known as Kirchhoff's Voltage Law, (KVL).

2.2.1 Kirchhoff's First Law – KCL:

Kirchhoff's 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.e.,* $I_{(exiting)} + I_{(entering)} = 0$. This idea by Kirchhoff is known as the **Conservation of Charge**.

In the following figure, if KCL is applied then the equation is

$I_T = I_1+I_2+I_3$ ......(1)

$I_T = V/R_1+V/R_2+V/R_3$

$I_T = V(1/R_1+1/R_2+1/R_3)$

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$I_T/V = 1/R_{Equivalent} = 1/R_1 + 1/R_2 + 1/R_3$ ......(2)

Equation (2) gives the expression for the equivalent resistance R_{Eq} of a parallel combination.

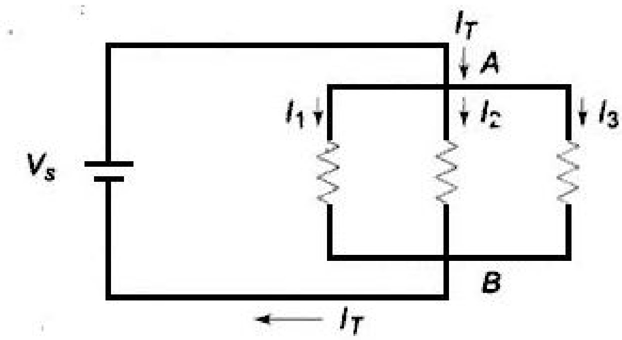

Figure-1: KCL

2.2.2 Kirchhoff's Second Law – KVL:

Kirchhoff's Voltage Law or KVL, states that-

"*in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop*" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero. This idea by Kirchhoff is known as the **Conservation of Energy**.

In the following figure, if KVL is applied then the equation is

$V_s = V_1 + V_2 + V_3$ ......(3)

$V_s = IR_1 + IR_2 + IR_3$

$V_s = I(R_1 + R_2 + R_3)$

$V_s/I = R_{Equivalent} = R_1 + R_2 + R_3$ ......(4)

Hence for series connections, we see from equation (4) that the equivalent resistance is the algebraic sum of all individual resistances.

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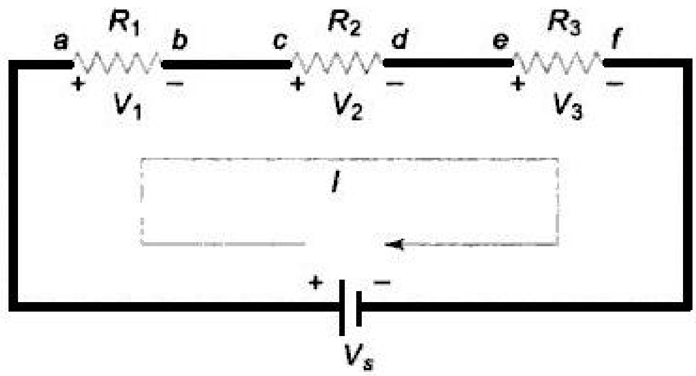

Figure-2: KVL

2.3 Equipment/ Apparatus:

a) One regulated variable Power Supply (0-30 V)

b) Two Digital Multimeter (One DC mili-ammeter, one DC voltmeter)

c) Circuit Experiment Board (Breadboard)

d) Three resistors (10KΩ, 15KΩ and 20KΩ)

e) Connecting wires

f) Cutting tools etc.

2.4 Cautions:

1. All connections should be tight and correct.
2. Switch off the supply when not in use.
3. Reading should be taken carefully.

2.5 Circuit Diagram:

The circuit diagram to verify KVL is shown below:

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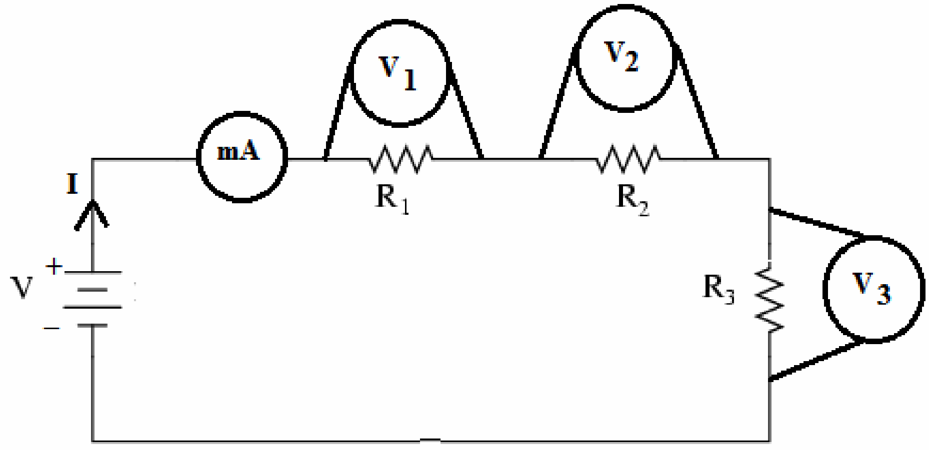

Figure-3: Circuit diagram for KVL verification

The circuit diagram to verify KCL is shown below:

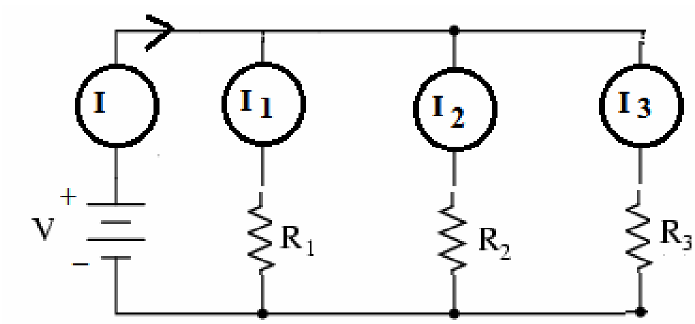

Figure-4: Circuit diagram for KCL verification

2.6 Procedure for KVL Verification:

1. Construct the circuit on the breadboard, as shown in figure-3.
2. Start the experiment from the zero voltage of the power supply. For zero supply voltage, the current flow is zero. Now increase the supply voltage from 0 to 20 V in at least five steps. For each step, take the ammeter and voltmeter readings and check for $V=V_1+V_2+V_3$.
3. Find the value of R_1, R_2 and R_3 from color coding and from direct ohmmeter readings. Algebraically add these three resistances.
4. From the experimental readings of step 2, find the equivalent resistance using equation (4) and compare it with the result of step 3.

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2.7 Procedure for KCL Verification:

1. Construct the circuit on the breadboard, as shown in figure-4.
2. Start the experiment from the zero voltage of the power supply. For zero supply voltage, the current flow is zero. Now increase the supply voltage from 0 to 20 V in at least five steps. For each step, take the ammeter and voltmeter readings and check for $I=I_1+I_2+I_3$.
3. Find the value of R_1, R_2 and R_3 from color coding and from direct ohmmeter readings. Find the equivalence resistance of parallel combination of these three resistors.
4. From the experimental readings of step 2, find the equivalent resistance using equation (2) and compare it with the result of step 3.

2.8 Data Table for KCL Verification:

For each reading, fill up the following table:

Reading No.	Applied Voltage (**Volt**)	I_1 **(mA)**	I_2 **(mA)**	I_3 **(mA)**	I **(mA)**	$I_{in}= I_1+ I_2+I_3$	R_{Eq}=V/I **(KΩ)**
1.							
2.							
3.							
4.							
5.							

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2.9 Data Table for KVL Verification:

For each reading, fill up the following table:

Reading No.	Applied Voltage (**Volt**)	V_1 **(mA)**	V_2 **(mA)**	V_3 **(mA)**	I **(mA)**	$V_{in}= V_1+V_2+V_3$	R_{Eq}=V/I **(KΩ)**
1.							
2.							
3.							
4.							
5.							

2.10 Result:

1. The incoming current is found to be equal to the outgoing current.

2. The total input voltage is equal to the total voltage drop in the circuit.