



# **Ahsanullah University of Science and Technology**

## **Department of Electrical and Electronic Engineering**

### **LABORATORY MANUAL FOR ELECTRICAL AND ELECTRONIC SESSIONAL COURSE**

**Student Name :**

**Student ID :**

**EEE - 1102 ELECTRICAL CIRCUITS – I LAB**

**Department of EEE 1<sup>st</sup> Year, 1<sup>st</sup> Semester**

**EEE - 1132 BASIC ELECTRICAL TECHNOLOGY LAB.**

**Department of CE 1<sup>st</sup> Year, 1<sup>st</sup> Semester**

**EEE - 1242 BASIC ELECTRICAL ENGINEERING LAB.**

**Department of CSE 1<sup>st</sup> Year, 2<sup>nd</sup> Semester**

**EEE - 1288 BASIC ELECTRICAL ENGINEERING LAB.**

**Department of ME and MPE 1<sup>st</sup> Year, 2<sup>nd</sup> Semester**

**EEE - 2262 ELEMENTS of ELECTRICAL ENGINEERING and ELECTRONICS LAB**

**Department of TE 2<sup>nd</sup> Year, 2<sup>nd</sup> Semester**

Experiment Name :01

Name of the Experiment Familiarization of different equipment involved with Electrical Circuit Lab

### Objective:

The objective of the experiment is to learn about the commonly used equipments used in the lab and how to properly use it.

### Breadboard

Breadboard is a board used for electrical circuit prototyping. Before the circuit is permanently placed in a PCB (Printed Circuit Board) prototyping boards are used to verify the electrical circuit. Some other prototyping boards are: Perfboard, Stripboard, Veroboard etc.

Top two row (A and B) of the board are internally connected sideways and the holes in group B are connected vertically as show in the figure 1 and this sequence continue in the rest of the board.

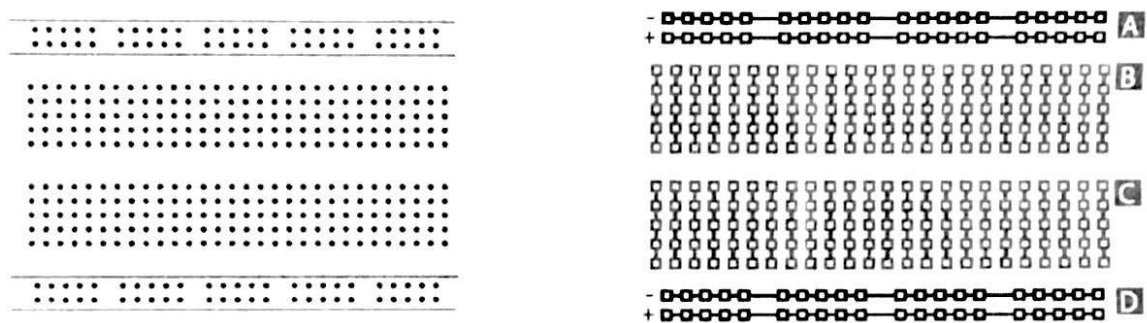


Figure 1.1: External and Internal construction of the breadboard

### From circuit to Breadboard:

Closely observe the circuit diagram (electronic schematic) and the equivalent connection on breadboard.

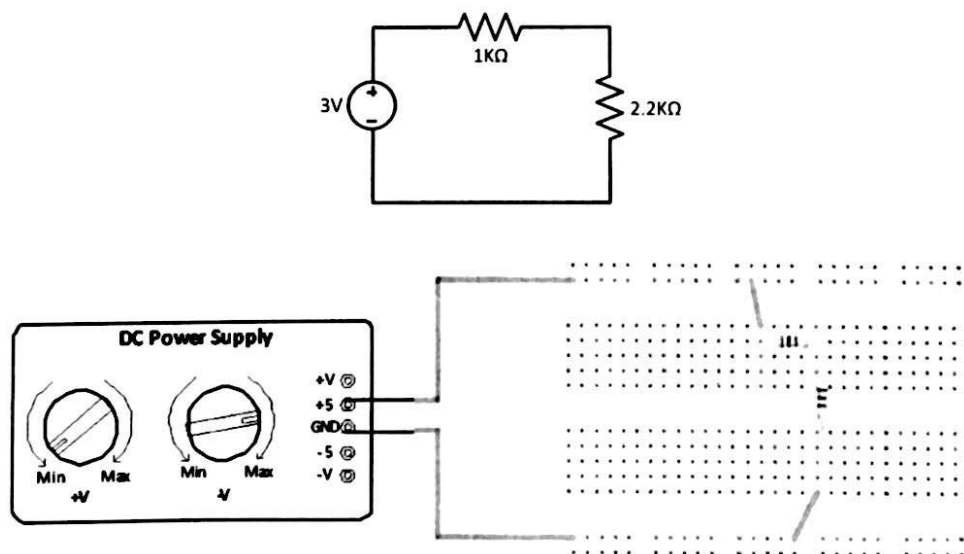
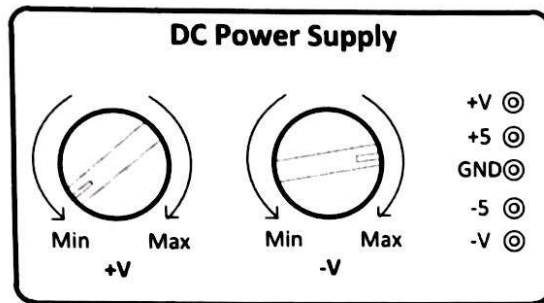


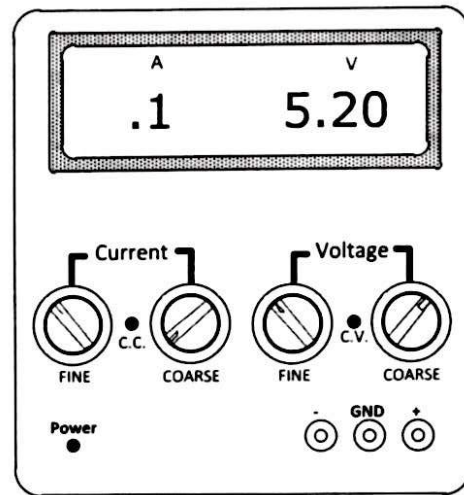
Figure 1.2: Circuit diagram and the equivalent breadboard connection

### DC Power Supply:

In the Lab we have two DC source in the workbench. One can be found in the trainer board Fig 1.3(a) and another is a individual DC power supply module Fig 1.3(b).



(a) Trainer board DC source



(b) DC power supply module

Figure 1.3: DC power sources

### **Trainer board DC source:**

Trainer board DC power supply can deliver two variable and two fixed DC voltage at the same time. The variable voltage can be adjusted using the two dial.

Voltage output at pin (reference to GND)	Value	Type
+V	1.2 V to 20 V	Variable
+5	5 V	Fixed
-5	-5 V	Fixed
-V	-1.2 V to -20V	Variable

### **DC power supply module:**

The DC power supply module can deliver voltage ranging from 0V to 30V.

1. To set a particular voltage turn on the power supply.
2. To change the voltage in big step use the coarse dial and to precisely vary the voltage use the fine dial in the voltage group.
3. Observe the output voltage change.

The coarse and fine dial in current group is used to set the maximum current limit at the output.

### Measuring Voltage:

1. To measure the voltage across the  $1\text{K}\Omega$  resistor circuit in Fig 1.4 (a), construct the circuit as shown in Fig 1.4 (b).
2. Rotate the multimeter dial in the V position.
3. Connect the red and black multimeter lead as shown in the Fig 1.4(a) (**parallel to the resistor**)
4. Multimeter should display the Voltage

**Warning:** while measuring voltage multimeter dial SHOULD NOT be in mA (current) position. It might destroy/damage the meter

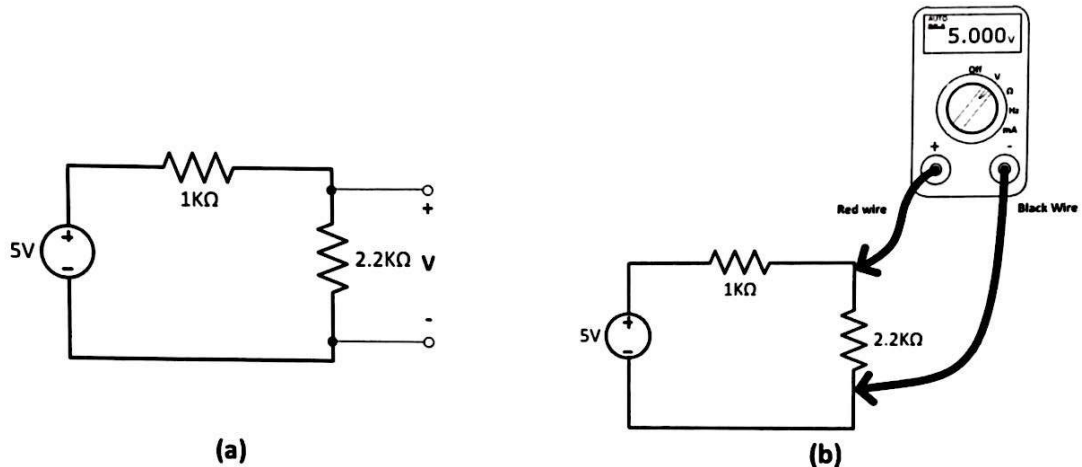


Figure 1.4: Circuit diagram and actual connection for measuring voltage

### Measuring Current:

1. To measure the current in the series circuit in Fig 1.5(a) construct the circuit and then **create a break** the circuit as shown in Fig 1.5 (b)
2. Rotate the multimeter dial in the mA position.
3. Connect the red and black multimeter lead as shown in the Fig 1.5(b) (**in series with the circuit**)
4. Multimeter should display the current

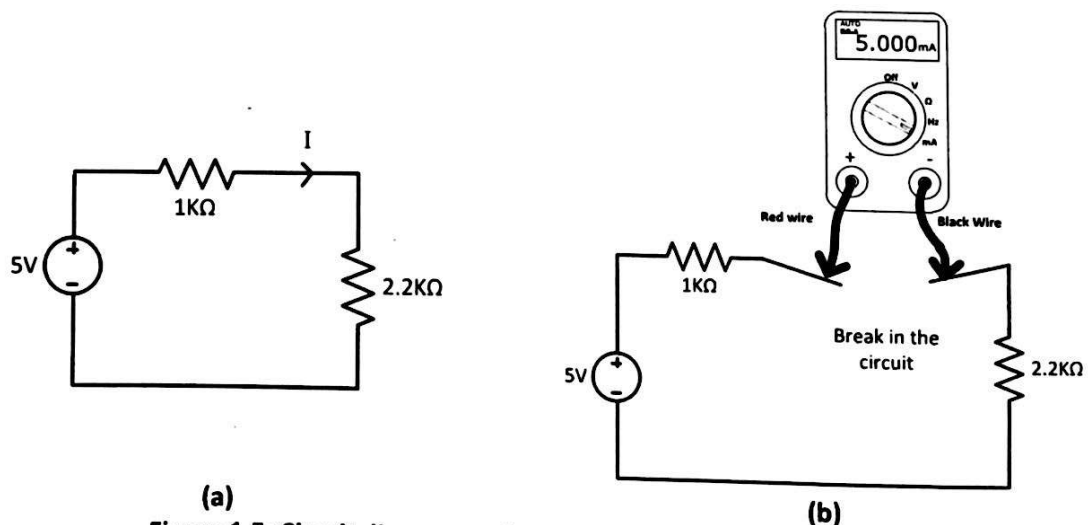


Figure 1.5: Circuit diagram and actual connection for measuring current



Experiment No. : 02

Name of the Experiment : Verification of Ohm's Law.

### OBJECTIVE:

To verify the following two equivalent forms of Ohm's Law:

- Express  $I$  as a function of  $V$  and  $R$ .
- Express  $V$  as a function of  $I$  and  $R$ .

### THEORY:

Ohm's law describes mathematically how voltage ' $V$ ', current ' $I$ ' and resistance ' $R$ ' in a circuit are related. According to this law:

"The current in a circuit is directly proportional to the applied voltage and inversely proportional to the circuit resistance".

#### Formula for voltage:

For a constant value of  $R$ ,  $V$  is directly proportional to  $I$   
i.e.  $V = IR$

#### Formula for current:

For a constant value of  $V$ ,  $I$  is inversely proportional to  $R$   
i.e.  $I = V/R$

### EQUIPMENTS:

- Variable DC power supply -1 piece
- Digital multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances: 1 K $\Omega$ , 2.2 K $\Omega$ , 3.3 K $\Omega$ , 4.7 K $\Omega$ , 5.6 K $\Omega$ , 10 K $\Omega$  -1 piece each.
- Trainer Board
- Connecting Wires.

### CIRCUIT DIAGRAM:

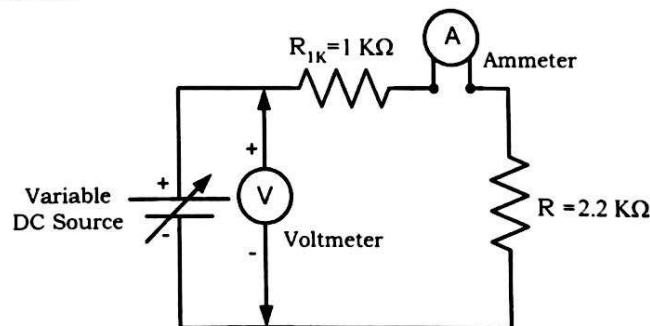
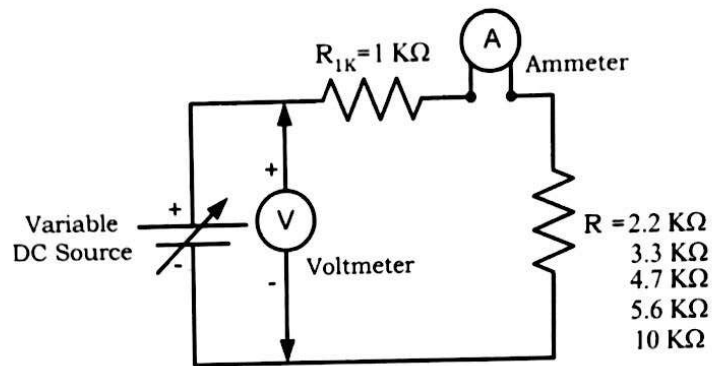


Figure 2.1: Verification of Ohm's Law



**Figure 2.2: Verification of Ohm's Law**

## **PROCEDURES:**

### **Current versus voltage:**

- Construct the circuit of Figure 2.1. Do not switch on the power supply.
- Turn on the power supply and adjust it to 5V by using Voltmeter. Measure the current  $I$  by ammeter and record it in the Table 2.2.
- Increase the values of voltage as shown in the Table 2.2. Measure the current  $I$  in turn and record the values in Table 2.2.
- Calculate the values of current  $I$  by using  $I = V/R_T$ . Use measured values of resistances.

### **Current versus resistance:**

- Construct the circuit of Figure 2.2. Do not switch on the power supply.
- Turn on the power supply and adjust it to 20V by using Voltmeter. Measure the current  $I$  by ammeter for  $R = 2.2 \text{ K}\Omega$  (Use measured values) and record it in the Table 2.3.
- Turn off the power supply and remove the resistance  $2.2 \text{ K}\Omega$ . Replace it by resistor  $3.3 \text{ K}\Omega$ .
- Now turn on the power supply. Measure and record the current  $I$  in turn, at each of the resistance settings shown in the Figure 2.2.
- Calculate the values of resistance  $R_T$  by using  $R_T = V/I$ . Use measured values of voltage and current.

# DATA SHEET:

Table 2.1: Measuring Resistances by using Ohmmeter

Nominal values of R (K $\Omega$ )	Measured values of R(K $\Omega$ ) by using Ohmmeter
1	
2.2	
3.3	
4.7	
5.6	
10	

Table 2.2: Current versus voltage

Supply Voltage (V)	Measured I by using Ammeter (A)	$R_T = R_{1K} + R_{2.2K}$ [Use measured values of R]	Calculate I (amp) $I = V/R_T$
5			
10			
15			
20			
25			

Table 2.3: Current versus resistance

Supply Voltage (V)	Measured I by using Ammeter (A)	$R_T$ (K $\Omega$ ) Use measured values of R	Calculate $R_T = V/I$ (K $\Omega$ )
20		$R_T = R_{1K} + R_{2.2K}$	
		$R_T =$	
20		$R_T = R_{1K} + R_{3.3K}$	
		$R_T =$	
20		$R_T = R_{1K} + R_{4.7K}$	
		$R_T =$	
20		$R_T = R_{1K} + R_{5.6K}$	
		$R_T =$	
20		$R_T = R_{1K} + R_{10K}$	
		$R_T =$	

Signature of the Teacher

### ASSIGNMENTS:

1. What can you say about the relationship between voltage and current, provided that the resistance is fixed?
2. Plot a graph of  $I$  versus  $V$  keeping the value of resistance constant. Use measured values of  $I$  and  $V$ . Comment on the graph briefly.
3. Plot a graph of  $I$  versus  $R_T$  keeping the value of supply voltage constant. Use measured values of  $I$  and  $R_T$ . Comment on the graph briefly.

Experiment No. : 03

Name of the Experiment: To investigate the characteristics of a series DC circuit and to verify Kirchoff's Voltage Law (KVL).

### OBJECTIVE:

The objective of this experiment is to investigate the characteristics of a series DC circuit and to verify Kirchoff's Voltage Law (KVL).

### THEORY:

In a series circuit (Figure 3.1) the current is same through all of the circuit elements.

The equivalent Resistance,  $R_T = R_1 + R_2 + R_3$ .

By Ohm's Law, the Current is

$$I = \frac{V_{Supply}}{R_T}$$

KVL states that the voltage rises must be equal to the voltage drops around a close circuit. Applying Kirchoff's Voltage Law around closed loop of Figure 3.1, we find,

$$V_{Supply} = V_1 + V_2 + V_3$$

Where,  $V_1 = IR_1$ ,  $V_2 = IR_2$ ,  $V_3 = IR_3$

Current I is same throughout the circuit for figure 3.1.

The voltage divider rule states that the voltage across an element or across a series combination of elements in a series circuit is equal to the resistance of the element divided by total resistance of the series circuit and multiplied by the total impressed voltage. For the elements of Figure 3.1

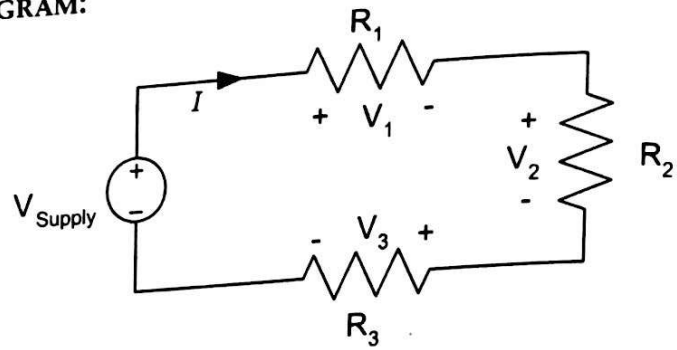
$$V_1 = \frac{R_1 E}{R_T}, \quad V_2 = \frac{R_2 E}{R_T}, \quad V_3 = \frac{R_3 E}{R_T}$$

### EQUIPMENTS:

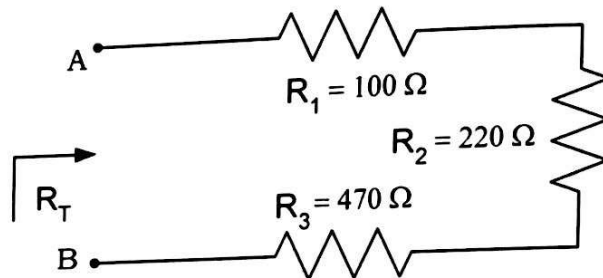
- Variable DC power supply -1 piece
- Digital Multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances: 100Ω, 220Ω, 470Ω -1 piece each.
- Trainer Board-1 piece
- Connecting Wires.



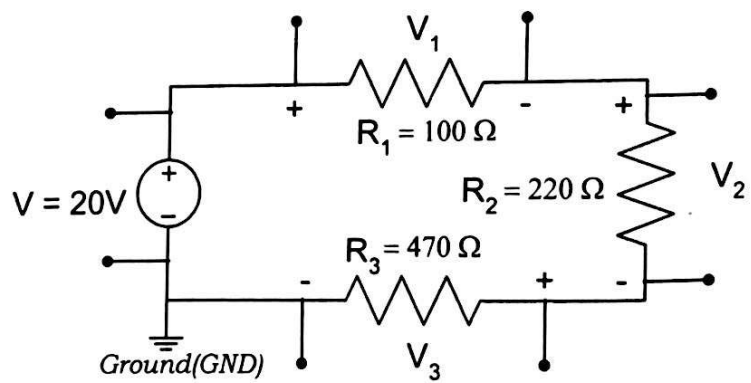
**CIRCUIT DIAGRAM:**



**Figure 3.1**



**Figure 3.2**



**Figure 3.3**

### PROCEDURE:

1. Measure the resistances having values  $100\Omega$ ,  $220\Omega$  &  $470\Omega$  by using Ohmmeter and record the values in Table 3.1.
2. Construct the circuit as shown in Fig 3.2.
3. Then measure input resistance  $R_T$  across points A-B using Ohmmeter and record that value in Table 3.1.
4. Now construct the circuit as shown in Fig 3.3. Turn on the DC power supply and set the DC supply to 20V by using Voltmeter.
5. Measure voltage across each resistor with Voltmeter and record in the Table 3.1
6. Calculate  $V_1$ ,  $V_2$  and  $V_3$  using Voltage Divider Rule (VDR). *[Use measured values of resistances for all calculations.]*

### ASSIGNMENTS:

1. What can you deduce about the characteristics of a series circuit from observation Table 3.1?
2. From the data found in Table 3.1, mathematically prove that the current in the series network of figure 3.3 is equal for each resistance.
3. Verify KVL from the data obtained in Table 3.1.

**DATA SHEET:**

**Table 3.1:**

Nominal values of Resistance ( $\Omega$ )	Measured values of Resistance by Ohmmeter ( $\Omega$ )	Equivalent Resistance, $R_T$		Measured voltage across each resistor (V)	Calculated Voltage using VDR (V)
		Measured $R_T$ by using Ohmmeter ( $\Omega$ )	Calculated $R_T = R_1 + R_2 + R_3$ ( $\Omega$ )		
$R_1=100$				$V_1=$	
$R_2=220$				$V_2=$	
$R_3=470$				$V_3=$	

**Calculation:**

Experiment No.	: 04
Name of the Experiment: To investigate the characteristics of a Parallel DC circuit and to verify Kirchoff's Current Law (KCL).	

### OBJECTIVE:

The objective of this experiment is to investigate the characteristics of a parallel DC circuit and to verify Kirchoff's Current Law (KCL).

### THEORY:

In a parallel circuit (Figure 4.1) the voltage across parallel elements is the same.

The total or equivalent resistance ( $R_T$ ) is given by,

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{-----} + \frac{1}{R_N}$$

If there are only two resistors in parallel, it is more convenient to use,

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

*In any case, the total resistance will always be less than the resistance of the smallest resistor of the parallel network.*

KCL states that the currents entering a node must be equal to the currents leaving that node. For the network of Figure 4.1 the currents are related by the following expression:

$$I_T = I_1 + I_2 + I_3 + \text{-----} + I_N$$

Applying current divider rule (CDR) for a circuit of only two resistors in parallel as shown in figure 4.2,

$$I_1 = \frac{R_2 I_T}{R_1 + R_2} \quad \text{and} \quad I_2 = \frac{R_1 I_T}{R_1 + R_2}$$

For equal parallel resistors, the current divides equally and the total resistance is the value of one divided by the 'N' number of equal parallel resistors, i.e.:

$$R_T = \frac{R}{N}$$

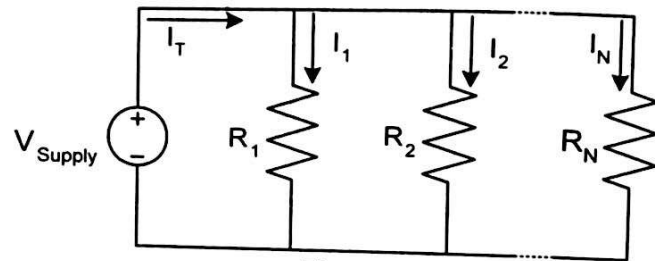
For a parallel combination of N resistors, the current  $I_1$  through  $R_1$  is:

$$I_1 = I_T \times \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N}}$$

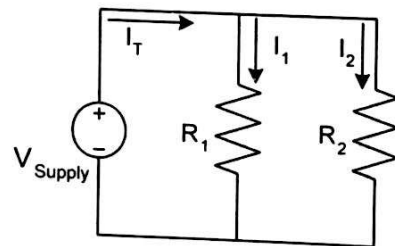
#### EQUIPMENTS:

- Variable DC power supply -1 piece
- Digital Multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances:  $1\text{K}\Omega$ ,  $2.2\text{K}\Omega$ ,  $4.7\text{K}\Omega$  -1 piece each.
- Trainer Board-1 piece
- Connecting Wires.

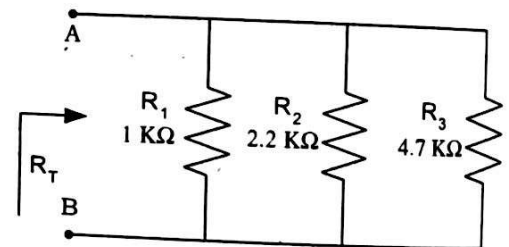
#### CIRCUIT DIAGRAM:



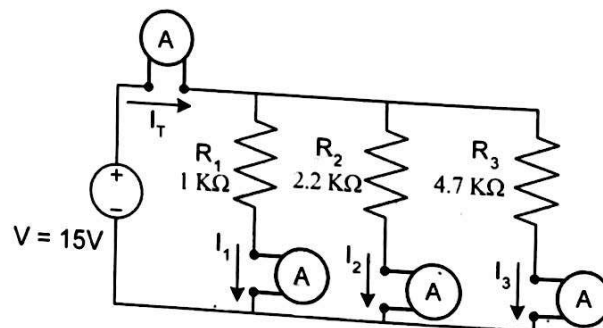
**Figure 4.1**



**Figure 4.2**



**Figure 4.3**



**Figure 4.4**



### PROCEDURE:

1. Measure the resistances having values  $1\text{ K}\Omega$ ,  $2.2\text{ K}\Omega$  &  $4.7\text{ K}\Omega$  by using Ohmmeter and record the values in Table 4.1.
2. Construct the circuit as shown in Fig 4.3.
3. Then measure input resistance  $R_T$  across points A-B using Ohmmeter and record that value in Table 4.1.
4. Now construct the circuit as shown in Fig 4.4. Turn on the DC power supply and set the DC supply to 15V by using Voltmeter.
5. Measure the currents  $I_T$ ,  $I_1$ ,  $I_2$  and  $I_3$  by using Ammeter and record in the Table 4.1.
6. Calculate  $I_1$ ,  $I_2$  and  $I_3$  using Current Divider Rule (CDR). [Use measured values of resistances for all calculations.]

### ASSIGNMENTS:

1. What can you deduce about the characteristics of a parallel circuit from observation Table 4.1?
2. From the data found in Table 4.1, Calculate  $I_1$ ,  $I_2$  and  $I_3$  using Ohm's Law.
3. Verify KCL from the data obtained in Table 4.1.

# DATA SHEET:

Table 4.1:

Nominal values of Resistance (KΩ)	Measured values of Resistance by Ohmmeter (KΩ)	Equivalent Resistance, R <sub>T</sub>		Measured current through each resistor (A)	Calculated Current using CDR (A)
		Measured R <sub>T</sub> by using Ohmmeter (KΩ)	Calculated $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (KΩ)		
R <sub>1</sub> =1				I <sub>1</sub> =	
R <sub>2</sub> =2.2				I <sub>2</sub> =	
R <sub>3</sub> =4.7				I <sub>3</sub> =	

Calculation:

Experiment No.	: 05
Name of the Experiment	: Use of Galvanometer as Ammeter and Voltmeter.

### OBJECTIVE:

The objective of this experiment is to show how a galvanometer can be used as an ammeter and a voltmeter.

### THEORY:

An ammeter is an instrument, while connected in series with a branch, measure the current of that branch. Ideally it should be of zero resistance, so that there is no voltage drop across it and hence it has no effect on the circuit where it is connected.

A voltmeter is an instrument, while connected in parallel with a branch, measure the voltage of that branch. Ideally it should be of infinite resistance, so that it draws no current and hence it has no effect on the circuit where it is connected.

A galvanometer is an instrument that can detect current. This meter can be used either as an ammeter or as a voltmeter. To use this meter as an ammeter, a very small resistance is connected in parallel with it so that a small voltage drop will occur across it. When the galvanometer is used as a voltmeter, a very high resistance is connected in series with it so that it will draw a little current.

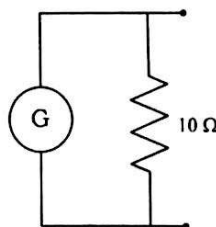
### EQUIPMENTS:

- Trainer Board - 1 piece.
- Digital Multi-meter - 1 piece.
- Galvanometer - 1 piece.
- Potentiometer - (10K $\Omega$ ) 1 piece.
- Resistances: 10  $\Omega$ , 100  $\Omega$ , 1 K $\Omega$ , 10K $\Omega$  -1 piece each.

### PROCEDURES:

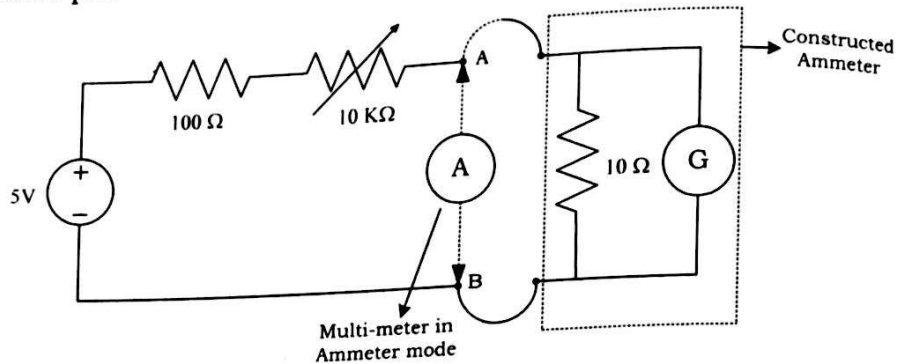
#### PART A:

1. Construct an ammeter using a galvanometer as shown in Figure 5.1



**Figure 5.1:** Constructed Ammeter circuit

2. Now place the constructed ammeter in the circuit shown below in Figure 5.2.



**Figure 5.2:** Use of galvanometer as an ammeter.

3. Connect the constructed ammeter and vary the pot until full-scale deflection is obtained. Then disconnect the constructed ammeter and place actual ammeter. Measure the current from multi-meter in ammeter mode.

The value of each division of the galvanometer scale

$$= \frac{\text{Measured current}}{\text{No. of divisions deflected in full scale.}} =$$

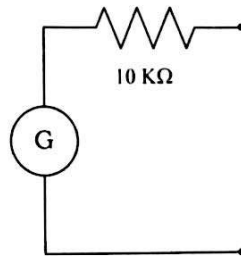
4. Connect the constructed ammeter and vary the pot. Note the number of divisions deflected by the galvanometer. Then disconnect the constructed ammeter and place the actual ammeter. Measure the current from multi-meter in ammeter mode. Record these readings in Table 5.1.
5. Increase the pot several times. Repeat step 4 for each increment of pot and record the readings in Table 5.1.

**Table 5.1:** Data for Ammeter.

No. of divisions deflected by the galvanometer	Current = No. of divisions deflected X Value of each division. (mA)	Measured Current (Reading from multi-meter in ammeter mode) (mA)

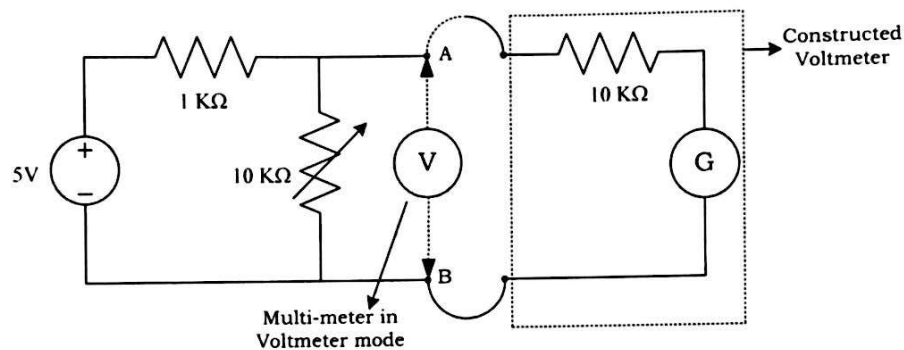
## **PART B:**

1. Construct a voltmeter using a galvanometer as shown in Figure 5.3.



**Figure 5.3:** Constructed Voltmeter circuit

2. Now place the constructed voltmeter in the circuit shown below in Figure 5.4.



**Figure 5.4:** Use of galvanometer as voltmeter.

3. Connect the constructed voltmeter and vary the pot until full-scale deflection is obtained. Then place the actual voltmeter. Measure the voltage from multi-meter in voltmeter mode.

The value of each division of the galvanometer scale

$$= \frac{\text{Measured Voltage}}{\text{No. of divisions deflected in full scale.}} =$$

4. Connect the constructed voltmeter and vary the pot. Note the number of divisions deflected by the galvanometer. Then place the actual voltmeter. Measure the voltage from multi-meter in voltmeter mode. Record these readings in Table 5.2.
5. Increase the pot several times. Repeat step 4 for each increment of pot and record the readings in Table 5.2.



**Table 5.2: Data for Voltmeter.**

<b>No. of divisions deflected by the galvanometer</b>	<b>Voltage = No. of divisions deflected X Value of each division. (v)</b>	<b>Measured Voltage (Reading from multi-meter in voltmeter mode) (v)</b>

**ASSIGNMENTS:**

1. Comment on the results found in Part A and Part B.
2. Suppose we want to measure a current greater than the full-scale deflection of the constructed ammeter (Figure 5.1). In this case, should the resistance in parallel with the galvanometer be increased or decreased? Explain in brief.

Experiment No. : 06

Name of the Experiment : Verification of Superposition Theorem.

### OBJECTIVE:

Superposition theorem states that current through and element for multiple sources is equal to the summation of currents due to individual sources. In this experiment we measure the current (or voltage) due to combination of sources of the original circuit and then measure the current for each individual source. Then verify the theorem by comparing the algebraic sum to of the currents due to individual sources with the current due to original setup.

### EQUIPMENTS:

- Variable DC Power Supply (20 V)-1 piece.
- Trainer Board-1 piece.
- Digital Multimeter-1 piece.
- Resistances: 100  $\Omega$ , 220  $\Omega$ , 330  $\Omega$ , 470  $\Omega$  and 560  $\Omega$  -1 piece each.
- Connecting Wires.

### CIRCUIT DIAGRAM:

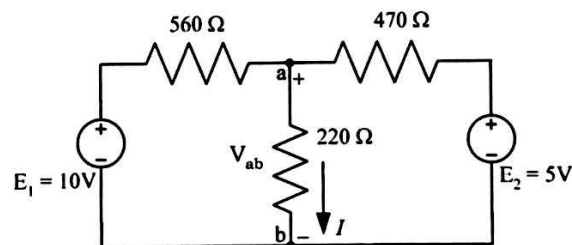


Figure 6.1: Circuit 01 ( $E_1$  and  $E_2$  activated)

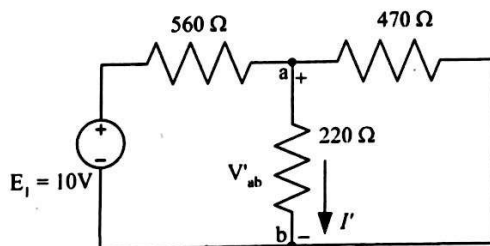


Figure 6.2: Only  $E_1$  activated

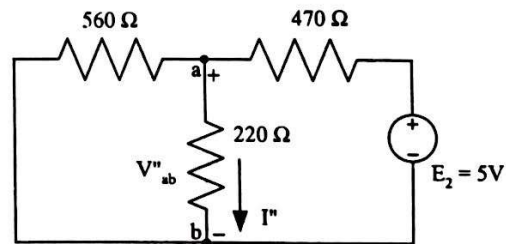
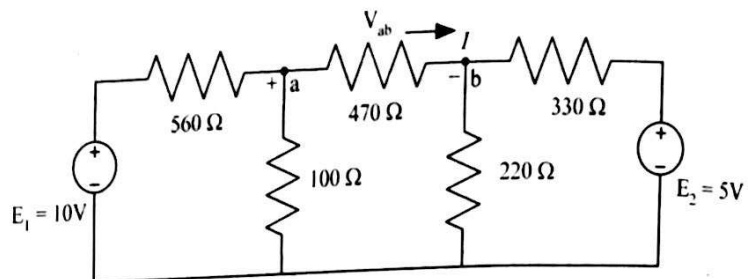
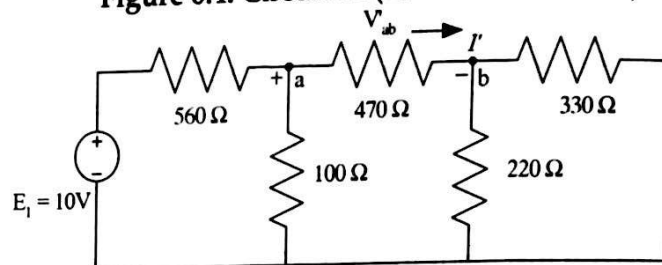


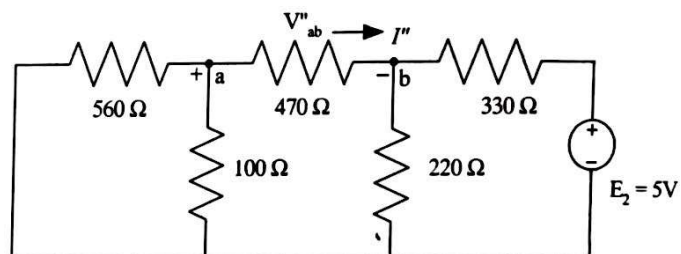
Figure 6.3: Only  $E_2$  activated



**Figure 6.4:** Circuit 02 ( $E_1$  and  $E_2$  activated)



**Figure 6.5:** Only  $E_1$  activated



**Figure 6.6:** Only  $E_2$  activated

#### PROCEDURES:

1. Measure the values of the resistances. Make the necessary circuit connection of circuit 01 shown in Figure 6.1.
2. Measure the voltage  $V_{ab}$ .
3. Make voltage source  $E_2$  deactivate (Remove the source and short the terminals). Measure the voltage  $V'_{ab}$  and record the value in Table 6.2.
4. Make voltage source  $E_1$  deactivate (Remove the source and short the terminals). Measure the voltage  $V''_{ab}$  and record the value in Table 6.2.
5. Make necessary circuit connection of circuit 02 shown in Figure 6.4.
6. Repeat procedure 2 to 4 for this circuit and record the values in Table 6.2.
7. Calculate currents and record the values in Table 6.3.

# DATA SHEET:

**Table 6.1: Measuring Resistances by using Ohmmeter**

Nominal values of R ( $\Omega$ )	Measured values of R( $\Omega$ ) by using Ohmmeter
100	
220	
330	
470	
560	

**Table 6.2: Data for verification of Superposition theorem**

Circuit	[E <sub>1</sub> & E <sub>2</sub> active] V <sub>ab</sub> (volt)	[only E <sub>1</sub> active] V' <sub>ab</sub> (volt)	[only E <sub>2</sub> active] V'' <sub>ab</sub> (volt)
CKT - 01			
CKT - 02			

**Table 6.3:**

***\*\*[Use measured values of resistances for all calculations.]***

Circuit	[E <sub>1</sub> & E <sub>2</sub> active] (A)	[only E <sub>1</sub> active] (A)	[only E <sub>2</sub> active] (A)
01	$I = \frac{V_{ab}}{220 \Omega} =$	$I' = \frac{V'_{ab}}{220 \Omega} =$	$I'' = \frac{V''_{ab}}{220 \Omega} =$
02	$I = \frac{V_{ab}}{470 \Omega} =$	$I' = \frac{V'_{ab}}{470 \Omega} =$	$I'' = \frac{V''_{ab}}{470 \Omega} =$

*Signature of the Teacher*

### ASSIGNMENTS:

1. Verify Superposition theorem for the circuit shown in Figure 6.1 both experimentally and theoretically. [Use measured value of resistance for calculations.]
2. Verify Superposition theorem for the circuit shown in Figure 6.4 both experimentally and theoretically. [Use measured value of resistance for calculations.]



Experiment No.	: 07
Name of the Experiment	: Methods of Measuring Resistance Looking Through any Two Terminals of a Network.

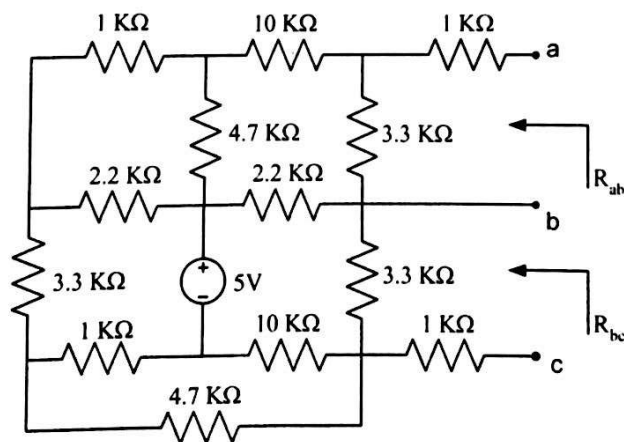
### OBJECTIVE:

In this experiment we will learn the different methods used to measure the resistance looking through any two terminals of a circuit. In practical cases, it is not always possible to measure the resistance using an ohmmeter or by using circuit-reduction techniques. In many cases, especially in circuits containing electronic devices or dependent sources, indirect approaches are usually used to measure the resistance. We will be familiar with several such methods of measuring resistance. Besides, some more Spice syntax and commands will be introduced in this experiment.

### EQUIPMENTS:

- Trainer board-1 piece.
- Digital multimeter (DMM)-1 piece.
- Potentiometer: 10 K $\Omega$ -1 piece.
- Resistances:
  - 1 K $\Omega$ -4 pieces,
  - 2.2 K $\Omega$  -2 pieces,
  - 3.3 K $\Omega$ -3 pieces,
  - 4.7 K $\Omega$  -2 pieces
  - 10 K $\Omega$ -1 piece

### CIRCUIT DIAGRAM:



**Figure 7.1: Resistance measurement**

## PROCEDURES:

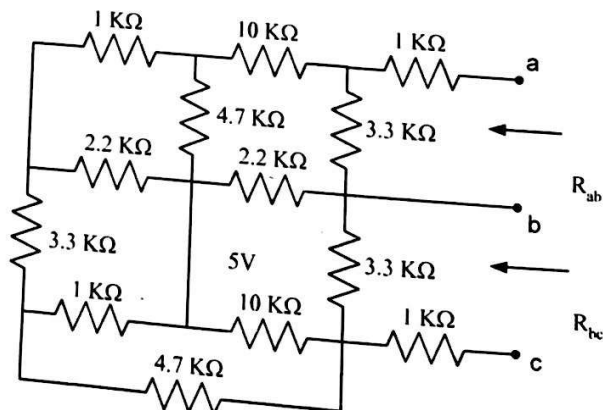
Connect the circuit given in Figure 7.1. Then measure the equivalent resistance looking through terminals a-b ( $R_{ab}$ ) and also the equivalent resistance looking through terminals b-c ( $R_{bc}$ ). For this purpose, different methods will be used as described below:

**Table 7.1:** Measured resistances using different methods:

Resistance to be measured	Using Ohmmeter ( $K\Omega$ )	Using $V_s/I_s$ ( $K\Omega$ )	Using $V_{oc}/I_{sc}$ ( $K\Omega$ )	Using Potentiometer ( $K\Omega$ )
$R_{ab}$				
$R_{bc}$				

### (A) USING OHMMETER:

1. As the ohmmeter itself employs a battery to measure the resistance in a circuit, we have to de-energize the circuit or deactivate all the independent sources (i.e., we have to switch all the power supplies off) before measuring any resistance. This method is not applicable if the circuit contains any dependent source.
2. Next we have to replace all the independent sources by their internal resistance. The resistance of an ideal voltage source is zero and the resistance of an ideal current source is infinite. So, the 5V voltage source in the circuit of Figure 7.1 should be removed completely and replaced by a short circuit (zero ohms). This will result in the circuit of Figure 7.2.

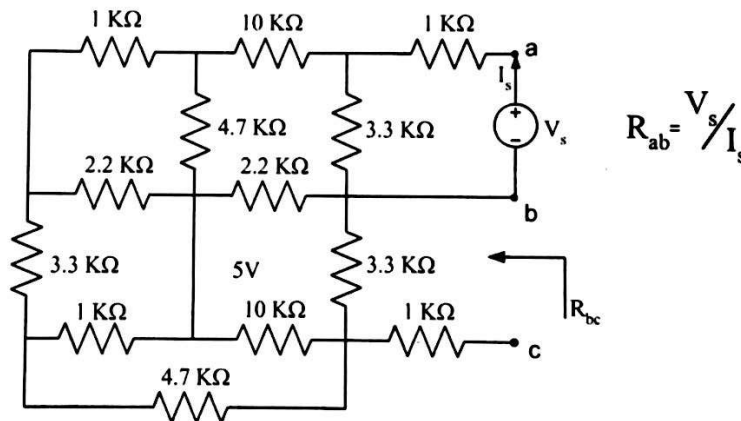


**Figure 7.2:** Resistance measurement using ohmmeter method

- Now to measure the resistance  $R_{ab}$  (equivalent resistance looking through terminals a-b), hold the ohmmeter terminals at terminals a and b and record the reading in Table 7.1.
- Similarly measure the resistance  $R_{bc}$  by holding the ohmmeter at terminals b and c and record the reading in Table 7.1.

**(B) USING  $V_s/I_s$ :**

- This method is an indirect approach of the above method. For this purpose, deactivate the 5V supply of Figure 7.1 as before and replace it with a short circuit.
- Now to measure the resistance  $R_{ab}$ , insert a voltage source  $V_s$  (take  $V_s = 5V$ ) between terminals a and b as shown in Figure 7.3.
- Measure  $V_s$  and  $I_s$  (the current supplied by  $V_s$ ) and calculate  $R_{ab}$  from  $R_{ab} = \frac{V_s}{I_s}$ .
- To measure  $R_{bc}$  repeat step 2 (in this case, insert  $V_s$  between terminals b and c) and step 3. Record the readings in Table 7.1.



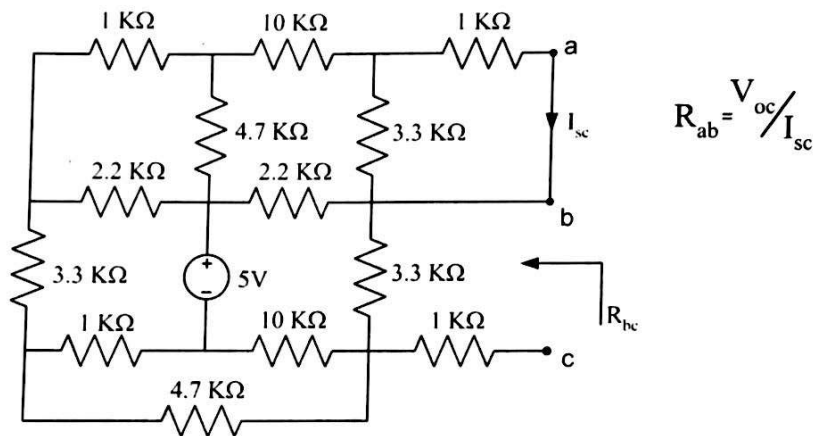
**Figure 7.3: Resistance measurement using  $V_s/I_s$  method**

**(C) USING  $V_{oc}/I_{sc}$ :**

- This method uses Thevenin's theorem. Here the source need not be removed or deactivated as in previous two methods. This method is very useful in cases where the resistance is needed to be measured without

deactivating the sources as in circuits containing dependent sources or electronic devices. Reconnect the circuit of Figure 7.1.

2. Measure the voltage  $V_{ab}$  in between terminals a and b. this voltage is called the open-circuit voltage  $V_{OC}$ .
3. Short-circuit the terminals a and b as shown in Figure 7.4 and measure the current flowing through these terminals. This is the short-circuit current  $I_{SC}$ .
4. Calculate  $R_{ab} = \frac{V_{OC}}{I_{SC}}$  and record this reading in Table 7.1.
5. Repeat steps 2 to 4 to measure  $R_{bc}$  in between terminals b and c.

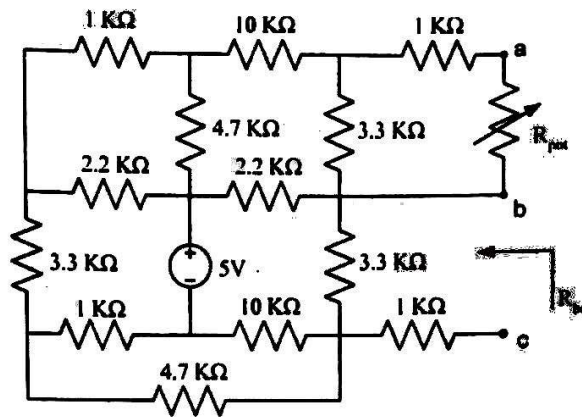


**Figure 7.4:** Resistance measurement using  $V_{oc}/I_{sc}$  method

#### (D) USING POTENTIOMETER:

1. This method also uses the principle of Thevenin's theorem and can be applied without removing any source from the original circuit. For this purpose, first measure the open-circuit voltage  $V_{OC}$  across terminals a and b of Figure 7.1.
2. Now connect a potentiometer in between terminals a and b as shown in Figure 7.5. Vary the pot until the voltage  $V_{ab} = \frac{V_{OC}}{2}$ .
3. Carefully remove the pot from the circuit and measure its resistance. The resistance of the potentiometer gives the equivalent resistance  $R_{ab}$ .

4. To measure the resistance  $R_{bc}$ , repeat steps 1 to 3 (in this case, terminals b and c should be used). Record these readings in Table 7.1.



**Figure 7.5: Resistance measurement using potentiometer method**



Experiment No. : 08  
Name of the Experiment : Verification of Thevenin's Theorem and  
Maximum Power Transfer Theorem.

### OBJECTIVE:

To verify and interpret two most important theorems:

- (1) Thevenin's Theorem
- (2) Maximum Power Transfer Theorem.

### THEORY:

Thevenin's Theorem states that the voltage across or current through element of a network can be calculated by constructing a Thevenin's equivalent circuit. This circuit is represented by a voltage source, called Thevenin's voltage, a resistance, called Thevenin's resistance and the element itself - all connected in series. After removing the element Thevenin's voltage and Thevenin's resistance are calculated, where the open circuit voltage ( $V_{oc}$ ) measures Thevenin's voltage ( $V_{th}$ ) and the resistance looking through the open circuited terminals represents Thevenin's resistance ( $R_{th}$ ).

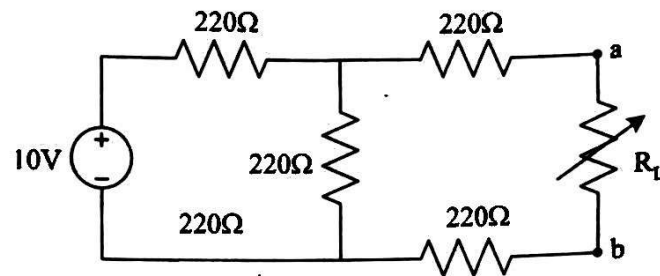
The maximum power transfer theorem states that maximum power can be transferred to the load when the load resistance is equal to equivalent resistance looking through the terminals where the load is connected.

### EQUIPMENTS:

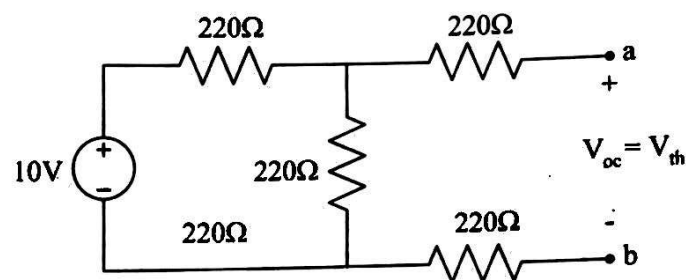
- Variable DC Power Supply (20 V)-1 piece.
- Trainer Board-1 piece.
- Digital Multimeter-1 piece.
- Resistances:  $220\ \Omega$  -4 piece.
- Rheostat (1k) - 2 piece.
- Connecting Wires.



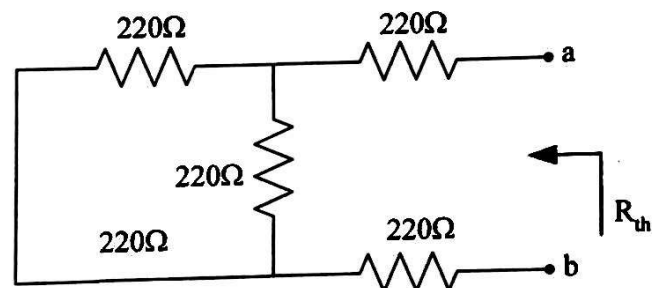
**CIRCUIT DIAGRAM:**



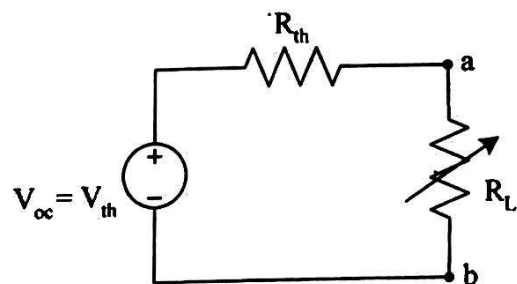
**Figure 8.1: Circuit 01**



**Figure 8.2: Circuit setup for finding  $V_{oc}$  or  $V_{th}$**



**Figure 8.3: Circuit setup for finding  $R_{th}$**



**Figure 8.4: Thevenin's equivalent circuit**

### PROCEDURES:

1. Connect the circuit as shown in figure-8.1. Remove the load resistance (rheostat) as shown in figure-8.2. Measure the open circuited voltage, ( $V_{oc}$ ). This represents Thevenin's voltage ( $V_{th}$ ).
2. Now construct the circuit as shown in figure-8.3. Make voltage source deactivate (Remove the source and short the terminals). To measure the resistance  $R_{th}$  (Thevenin's equivalent resistance looking through terminals a-b), hold the ohmmeter at terminals a and b.
3. Finally construct the Thevenin's equivalent circuit as shown in figure-8.4.
4. Connect the circuit as shown in figure-8.1. Vary the load resistance (rheostat) from  $100\ \Omega$  to  $1K\ \Omega$  with a  $100\ \Omega$  stepping. For each step measure voltage across the load resistance (rheostat) and calculate the current ( $I_L$ ) through the load. Fill the table-8.1 using these values.
5. Now connect the same load resistance (rheostat) at the Thevenin's equivalent circuit as shown in figure-8.4 and vary the load resistance (rheostat) from  $100\ \Omega$  to  $1K\ \Omega$  with a  $100\ \Omega$  stepping. For each step measure voltage across the load resistance (rheostat) and calculate the current  $I_L$ . Fill the table-8.2 using these values.

### ASSIGNMENTS:

1. Plot  $V_L$  vs.  $R_L$  curves for both original and equivalent circuits on the same graph.
2. Plot  $I_L$  vs.  $R_L$  curves for both original and equivalent circuits on the same graph.
3. Plot  $P_L$  vs.  $R_L$  curves for both original and equivalent circuits on the same graph.
4. Comparing the graphs verify Thevenin's Theorem.
5. From  $P_L$  vs.  $R_L$  graphs verify maximum power transfer theorem.

**DATA SHEET:****\*\*[Use measured values of resistances for all calculations.]****Table 8.1: For original circuit**

$R_L$ ( $\Omega$ )	$V_L$ (Volt)	$I_L = \frac{V_L}{R_L}$	$P_L = \frac{(V_L)^2}{R_L}$	$P_L = (I_L)^2 \times R_L$
100				
200				
300				
400				
500				
$R_{th} = R_L =$				
600				
700				
800				
900				
1000				

**SAMPLE CALCULATION:**

---

***Signature of the Teacher***

**DATA SHEET:**

***\*\*[Use measured values of resistances for all calculations.]***

**Table 8.1: For Thevenin's equivalent circuit:**

$R_L$ ( $\Omega$ )	$V_L$ (Volt)	$I_L = \frac{V_L}{R_L}$	$P_L = \frac{(V_L)^2}{R_L}$	$P_L = (I_L)^2 \times R_L$
100				
200				
300				
400				
500				
$R_{th} = R_L =$				
600				
700				
800				
900				
1000				

**SAMPLE CALCULATION:**

\_\_\_\_\_  
Signature of the Teacher

Experiment No. : 09

Name of the Experiment : Uses of Different Types of Switches.

### OBJECTIVE:

Different types of switches are used in electrical circuits. Each type of switch has a particular feature and its uses obviously depend on its inherent property. Although various types of switches may be involved in a particular application, we, however, concentrate our interest into the following types of switches:

- a. Single pole single throw (SPST)
- b. Single pole double throw (SPDT)
- c. Double pole single throw (DPST)
- d. Double pole double throw (DPDT)

### SCHEMATIC DIAGRAM:

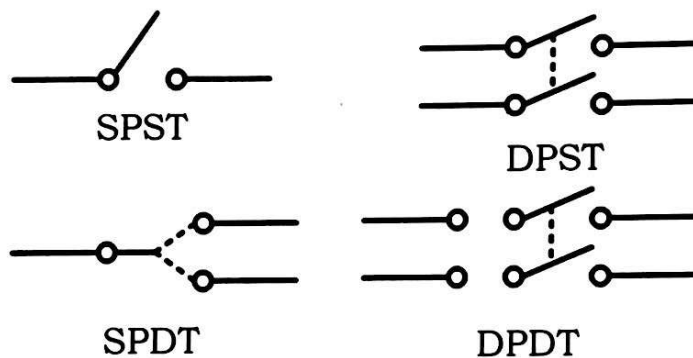


Figure 1.1: Different types of switches

### EQUIPMENTS:

- Power cord-1 piece
- SPST switch-2 pieces
- SPDT switch-2 pieces
- Lamps: 60W-1piece  
100W-1piece

### PROCEDURES:

1. Connect a bulb so that it can be operated from the source by an SPST switch.
2. Connect a bulb so that it may be operated by either of two SPST switches.
3. Connect two bulbs (one 60W and one 100W) so that either may be operated from a common source by its own switch.
4. Connect two bulbs (one 60W and one 100W) so that both may be operated simultaneously from a common source by one SPST switch.
5. Connect a bulb so that it may be operated independently by either of two SPDT switches from a source.

### ASSIGNMENTS:

1. For each of the cases given below, mention whether the switches of procedure 2 are dependent on each other to turn the lamp ON:
  - a. When the switches are connected in series.
  - b. When the switches are connected in parallel.
2. Which method of procedure 4 is preferable and why?
3. Explain the variations of the brightness level of the two lamps in procedure 4.
4. What are the applications of the arrangement of procedure 5?
5. What is the drawback of the switch connection of the circuit in Figure 1.2?

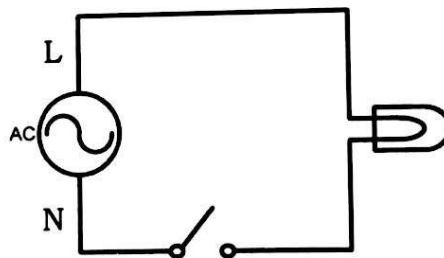


Figure 1.2: Circuit diagram for assignment 5



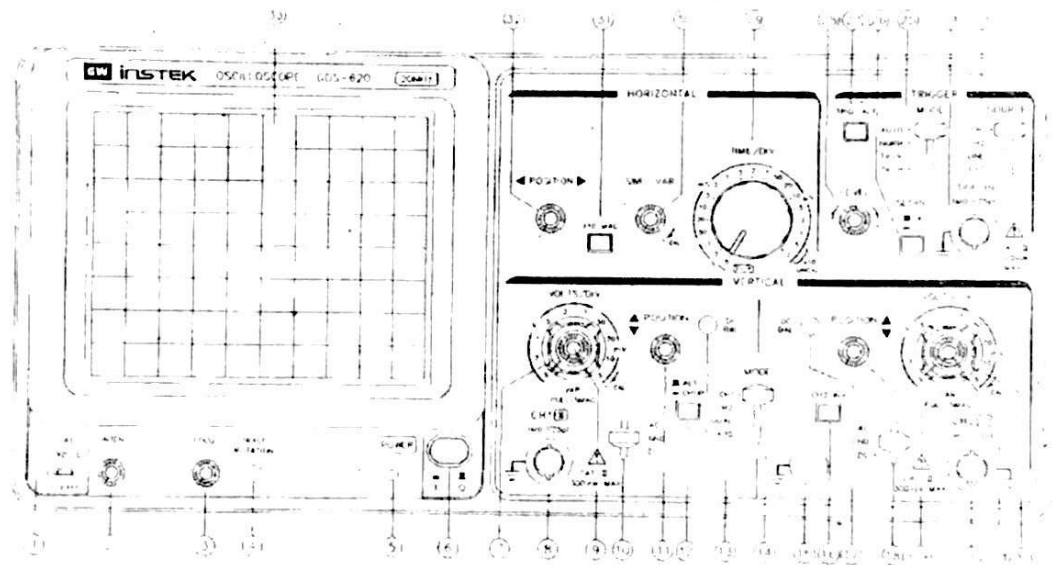
Experiment No. : 10

Name of the Experiment : **Introduction to Oscilloscope Operation.**

### OBJECTIVE:

This experiment is designed for the under-graduate students to introduce themselves and to be familiar with the oscilloscope and its operation. This experiment will help the students to have basic ideas about key functions of different knobs of oscilloscope and also to know how to measure voltage/current of a circuit-using oscilloscope as a measuring instrument.

### FRONT VIEW OF THE LABORATORY OSCILLOSCOPE:



### Introduction to front Panel:

The front panel consists of the following parts:

- CRT
- Vertical axis
- Triggering
- Time
- Others

## BRIEF DESCRIPTION:

### 1. CRT:

- a) Power (6)  
The main power switch.
- b) Inten (2)  
Controls the brightness of the spot.
- c) Focus (3)  
For focusing the spot for sharp image.
- d) Trace rotation (4)  
For aligning the horizontal trace in parallel with graticule lines.
- e) Filter (33)

### 2. Vertical axis:

- a) CH1 (X) input (8)  
Vertical input of CH1. When in X-Y mode this acts as an X-axis input
- b) CH2 (Y) input (20)  
Vertical input of CH2. When in X-Y mode this acts as a Y-axis input
- c) AC-GND-DC (10,18)  
Switch for selecting connection mode between input signal and vertical amplifier.
- d) Volt/Div (7,22)  
Selection of vertical axis sensitivity, from 5mV/Div to 5V/Div in 10 ranges.
- e) Variable (9,21)
- f) CH1 & CH2 DC BAL (13,17)
- g) Position (11,19)  
Control the position of the vertical trace or spot.
- h) Vert mode (14)  
There are four positions to switch the operation of CH1 and CH2. When position in either CH1 or CH2; then oscilloscope operates as single channel instrument with CH1 or CH2 respectively. When position in DUAL then the oscilloscope operates as dual-channel of both CH1 and CH2. When position in ADD, then oscilloscope displays the algebraic sum (CH1+CH2) or difference (CH1-CH2). During difference operation, CH2 INV must be pushed.
- i) ALT/CHOP (12)  
When this switch is released then CH1 and CH2 are alternately displayed. When this switch is engaged then CH1 and CH2 are chopped and displayed simultaneously.
- j) CH2 INV (16)  
This inverts the CH2 input signal when this knob is pushed in.

### 3. Triggering:

- a) EXT TRIG IN input terminal (24)
- b) SOURCE (23)
  - 1) **CH1**: When Vert mode switch is at DUAL/ADD position select CH1 for internal triggering.
  - 2) **CH2**: When Vert mode switch is at DUAL/ADD position select CH2 for internal triggering.
  - 3) **TRIG.ALT**: It will alternately select CH1 and CH2 for internal triggering.
  - 4) **Line**
  - 5) **EXT**
- c) SLOPE (26)
  - 1) **'+'**: Triggering occurs when triggering signal crosses triggering level in +ve going direction.
  - 2) **'-'**: Triggering occurs when triggering signal crosses triggering level in -ve going direction.
- d) LEVEL (28)

To display synchronized stationary waveform and set a start point of it.
- e) TRIGGER MODE (25)

### 4. Time Base:

- a) TIME/DIV (29)

Ranges are available from 0.2  $\mu$ sec/div to 0.5 sec/div in 20 steps.

**X-Y mode**: This position is used when oscilloscope functions as an X-Y oscilloscope.
- b) SWP.VAR (30)
- c) Position (32)

Control the position of the horizontal trace or spot.
- d)  $\times 10$  MAG (31)

When this button is pushed, magnification of 10 occurs.

### 5. Others:

- a) CAL (1)

This terminal gives the calibration voltage of 2 Vp-p, 1 kHz, and positive square wave.
- b) GND (15)

The ground terminal of the oscilloscope mainframe.

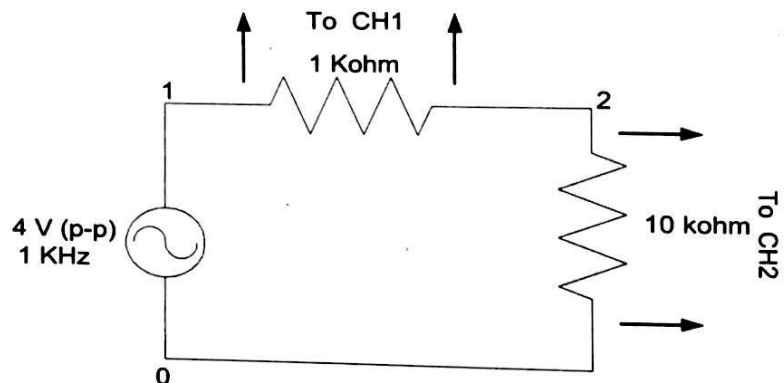
## BASIC OPERATION WITH OSCILLOSCOPE:

1. Single channel operation.
2. Dual-channel operation.
3. ADD operation.
4. Frequency measurement
5. Sweep Magnification
6. X-Y Operation.
7. To display two input signals still on oscilloscope

## EQUIPMENTS:

1. Oscilloscope - 1 unit
2. Oscilloscope probe (10 x) - 2 pieces
3. Signal Generator - 1 unit
4. Signal Generator probe - 1 piece
5. Resistor 1k $\Omega$ , 10k $\Omega$
6. Bread Board - 1 piece.
7. Multi-meter

## CIRCUIT DIAGRAM:



## PROCEDURES:

1. Connect the circuit according to the above circuit diagram.
2. Set the AC-GND-DC of CH1 in the GND position and align the trace with horizontal central line and then set to AC position.
3. Now apply sine wave of 1 kHz from signal generator to CH1 and adjust its magnitude to 4V (p-p) by varying the attenuator knob of the signal generator.
4. If the signal is not still just slowly vary the 'level' knob to make it still.
5. Now disconnect the signal from CH1 and apply to terminals between 1 and 0.

6. Don't change the attenuator knob throughout the experiment.
7. Now connect the oscilloscope probes across 1 k $\Omega$  resistor to CH1 and across 10 k $\Omega$  resistors to CH2 according to circuit diagram.
8. Push CH2 INV button.

### 1. Single channel operation:

- a) Set the AC-GND-DC of both channels in the GND position and align the trace with horizontal central line and then set to AC position.
- b) Adjust the FOCUS control so that the trace image appears sharply.
- c) Set the VOLTS/DIV switch at 1 V and TIME/DIV switch at 0.5 ms position so that signal waveform is displayed clearly.
- d) Adjust vertical POSITION and horizontal POSITION controls in appropriate position so that the displayed waveform is aligned with the graticule and voltage (p-p) and period (T) can be read conveniently.
- e) Set the Vert mode to CH1 and measure the p-p voltage across 1 k $\Omega$  resistor. Find the rms value of the signal from the following diagram:  

$$V_{rms} = V_{measured} (p-p) / (2\sqrt{2}) \text{ volt.}$$
- f) Measure the voltage across 1 k $\Omega$  resistor by multimeter and compare with the measured value.
- g) Set the Vert mode to CH2 and repeat procedure (e).
- h) Change the signal frequency to 100Hz, 10 kHz and observe the waveform.

### 2. Dual-channel operation:

- a) Set the Vert mode switch to DUAL state so that both channels are displayed simultaneously. To display each channel separately change the vertical POSITION control of both channel to convenient position.
- b) When ALT/CHOP switch is released (ALT mode) signals respectively to CH1 and CH2 appear on screen alternately.
- c) When ALT/CHOP switch is pushed (CHOP mode) signals respectively to CH1 and CH2 are switched at 250 kHz.

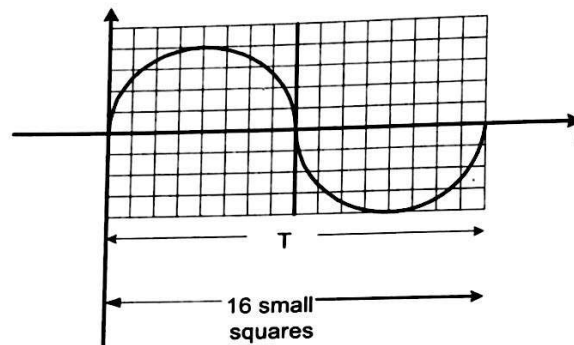
### 3. ADD operation:

- a) When Vert mode switch is at ADD position then the displayed signal is the algebraic sum of CH1 and CH2. If the CH2 INV switch is pushed then displayed signal is the difference of CH1 and CH2.
- b) Observe the waveform for both cases and draw.



#### 4. Frequency measurement:

- a) The frequency of any waveform can be measured by adjusting the TIME/DIV control knob of oscilloscope. Adjust the TIME/DIV control knob to position 0.5 ms to observe the waveform.
- b) Now measure the frequency of the wave using the following formula:  
1 large square or 5 small squares =  $t$  sec, here  $t = 0.5$  ms  
# of small squares required to represent a full cycle of wave =  $n$  sec  
Where,  $n$  may have fraction value.  
Time period,  $T = (n/5) \times t$  s  
Frequency,  $f = 1/T$  Hz



Now compare this value with the main signal frequency.

- c) Now vary the TIME/DIV control knob to different position and repeat (b).

#### 5. Sweep Magnification:

- a) Set the TIME/DIV switch at 0.5 ms and VOLTS/DIV at 1 V. Set AC-GND-DC position at GND position and align the trace with horizontal central line.
- b) Set the Vert mode at CH1 and AC-GND-DC at AC and then push  $\times 10$  MAG button.
- c) The displayed waveform will be expanded 10 times to the right and left with the centre of the screen as the centre of expansion.

#### 6. X-Y operation:

- a) Set the TIME/DIV switch at X-Y position. Now CH1 acts as X-axis input and CH2 as Y-axis input.
- b) X-Y positions are adjusted by horizontal position and CH2 vertical position control respectively.
- c) Adjusted the amount of vertical Y-axis with CH2 VOLTS/DIV controls.



- d) Adjust the amount of horizontal X-axis with CH1 VOLTS/DIV controls.
- e) Observe the waveforms and draw.

**7. To display two input signals still on oscilloscope:**

- a) Apply 2v (p-p), 1 kHz ac signal (sine wave) from signal generator-1 to CH1 of oscilloscope.
- b) Set VOLT/DIV of CH1 to 1 V and TIME/DIV to convenient position to observe the wave shape clearly.
- c) Repeat (1) from signal generator-2 to CH2 of oscilloscope.
- d) Set VOLT/DIV of CH2 to 0.5 v.
- e) Now set the Vert mode to DUAL position and observe the wave shapes.
- f) Note two waves that were displayed individually still are not still now.
- g) Set the SOURCE to CH1 and then CH2 position and observe what happens.
- h) Push the TRIG. ALT button and observe the wave shapes.

**Note:**

- 1) Don't put any sort of electrical equipments (such as signal generator, dc supply etc.) on the top of the oscilloscope.
- 2) Place the oscilloscope away from any magnetic field (as far as possible)
- 3) If the GND horizontal line deviates significant amount then adjust it by rotating the position of oscilloscope.
- 4) Always check the 10x switch of probe according to your measurement.
- 5) Always avoid common grounding resulting from improper connection of knobs in the circuit.

**COMMON MISTAKES USING OSCILLOSCOPE:**

- 1) Changing the calibration knob during experiment.
- 2) Changing the SWP.VAR knob during experiment.
- 3) Improper 10x max for probe.
- 4) Improper 10x max for frequency.
- 5) Ground level adjustment during measurement.