Experiment No.1
Resistor Color Code

Object

1. To learn Resistor Color Code
2. To determine the stated value of a resistor by interpreting the color code indicated on the resistor.

Apparatus

1. Set of wires.
2. Carbon Resistors.
3. Digital A.V.O. meter.

Theory

There are two ways to find the resistance value of a resistor. The color bands on the body of the resistor tell how much resistance it has. As shown in the following diagrams figure (1), there are 5-band resistors and 4-band resistors. Form both 5- and 4-band resistors, the last band indicates tolerance in table (1). Consult with the “Resistor Tolerance” in table (2) chart for finding the tolerance value.

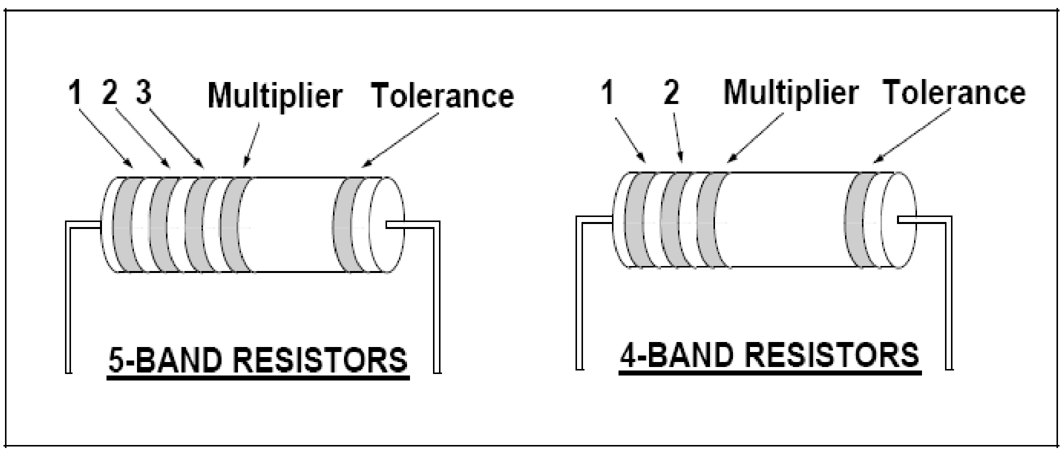


Fig.(1) 5- Band and 4- Band resistors

The first method for read resistor colors in Fig.(2)

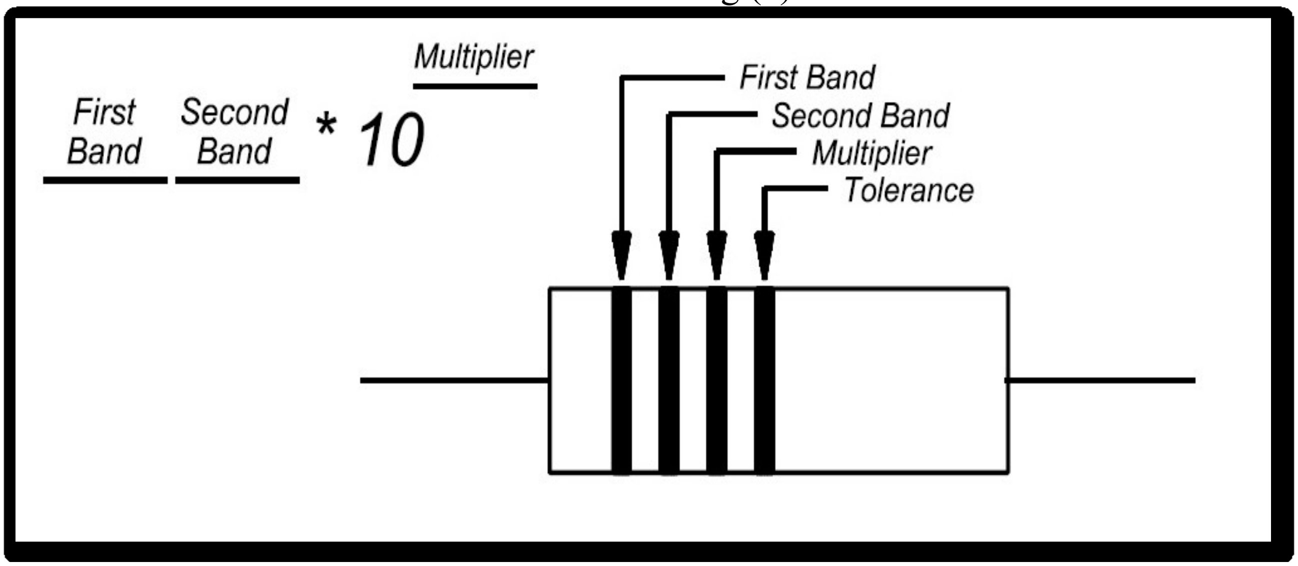


Fig.(2) First method read resistor

COLOR	FIRST BAND	SECOND BAND	MULTIPLIER	TOLERANCE
BLACK		0	$10^0 = 1$	
BROWN	1	1	$10^1 = 10$	
RED	2	2	$10^2 = 100$	
ORANGE	3	3	$10^3 = 1000$	
YELLOW	4	4	$10^4 = 10000$	
GREEN	5	5	$10^5 = 100000$	
BLUE	6	6	$10^6 = 1000000$	
VIOLET	7	7	$10^7 = 10000000$	
GREY	8	8	$10^8 = 100000000$	
WHITE	9	9	$10^9 = 1000000000$	
GOLD			$10^{-1} = 0.1$	5%
SILVER			$10^{-2} = 0.01$	10%
NO COLOR				20%

Table(1) Read resistor color

The first litter word to represent color resistor code in table (1)

Better **B**e **R**eady **O**r **Y**our **G**reat **B**ig **V**enture **G**oes **W**rong, **G**o **S**tudy **N**ow

Color	Tolerance
Silver	± 10%
Gold	± 5%
Red	± 2%
Brown	± 1%
Green	± 0.5%
Blue	± 0.25%
Violet	± 0.1%
Gray	± 0.05%

Table (2) Resistor Tolerance

View the resistors and based on the color bands determine its value. Below is an example:

Table 2-1		
Band	Color Code	Numeric Value
1^{st} Band	Brown	1
2^{nd} Band	Black	0
3^{rd} Band	Orange	10^3
4^{th} Band	Gold	±5%
The Resistor Value is 10K		**The tolerance is ±5%**

The first band is a one (1), the second band is a zero (0), and the multiplier band or third band is

one time text to the third power (10^3) or one thousand (1000). Multiply 10 times 1000.

Another way to tell the resistance value of a resistor is to actually measure it with the ohmmeter. The explanation of how to measure the resistance is given in the later tip.

Where:-

$R_{max} = R+(R \ * T)$

Procedure

1. Measure and record twenty resistors with value of 1 Kohm.
2. Find the R max. , R min. then calculate the percentage error.
3. Repeat the steps (1,2) with resistor value of 10K ohm.
4. Repeat the steps (1,2) with resistor value of 100K ohm.

Discussion

1. Comment for your results.
2. Determine the value and tolerance of the 10 resistors as shown in the following tables for chart fig. (3):

Table 2-2		
Band	Color Code	Numeric Value
1st Band	Orange	
2nd Band	Orange	
3rd Band	Orange	
4th Band	Silver	
The Resistor Value is____________		**The Tolerance is _____%**

Table 2-3		
Band	Color Code	Numeric Value
1st Band	Orange	
2nd Band	Orange	
3rd Band	Red	
4th Band	Silver	
The Resistor Value is____________		**The Tolerance is _____%**

Table 2-6		
Band	Color Code	Numeric Value
1st Band	Red	
2nd Band	Violet	
3rd Band	Brown	
4th Band	Gold	
The Resistor Value is____________		**The Tolerance is ______%**

Table 2-7		
Band	Color Code	Numeric Value
1st Band	Brown	
2nd Band	Brown	
3rd Band	Red	
4th Band	Gold	
The Resistor Value is____________		**The Tolerance is ______%**

Table 2-8		
Band	Color Code	Numeric Value
1st Band	Yellow	
2nd Band	Violet	
3rd Band	Red	
4th Band	Silver	
The Resistor Value is____________		**The Tolerance is ______%**

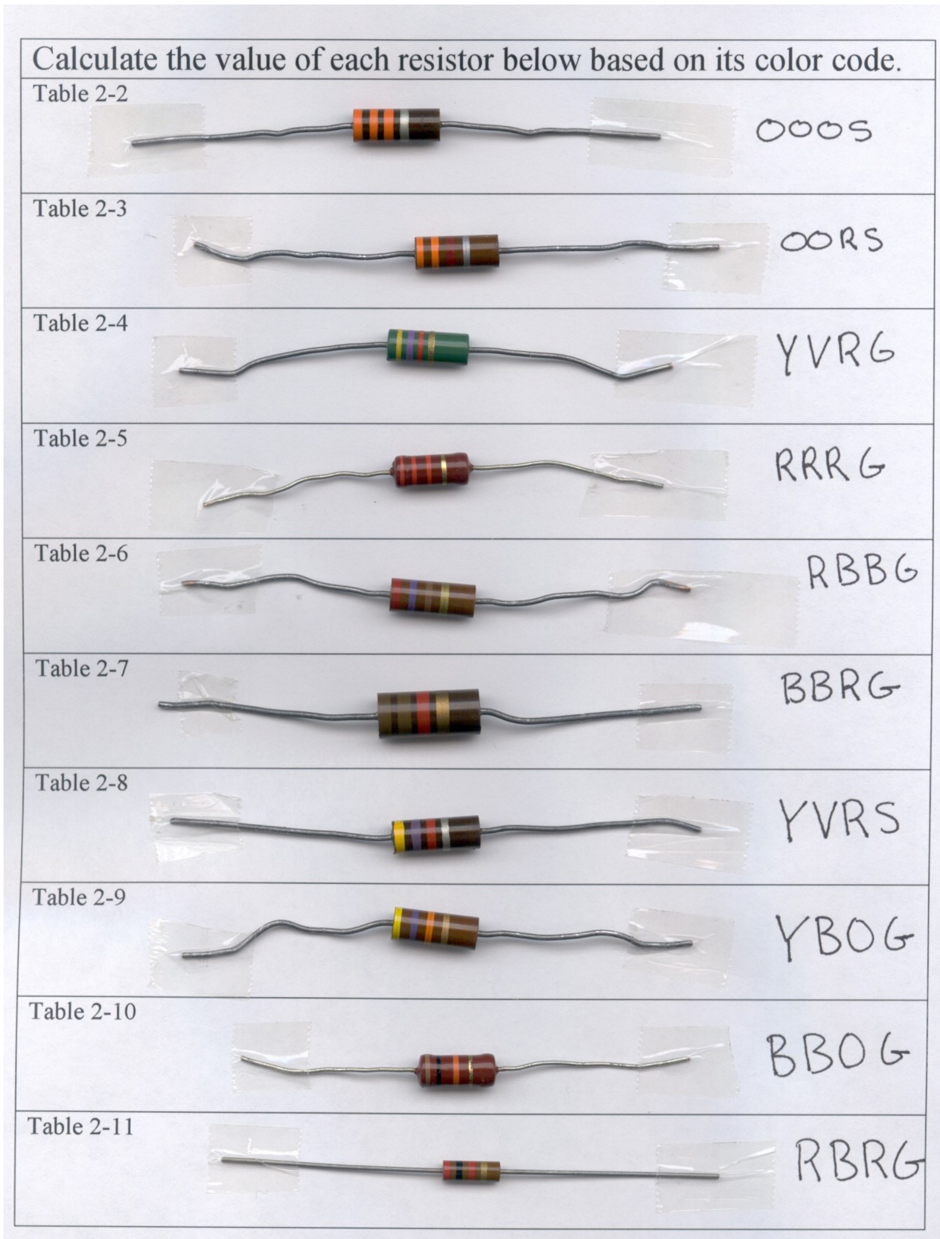


Fig.(3)

3. Record resistor colors gave to its value in below :

4.7 KΩ±5% , 910Ω ±10% , 12 Ω ±5%, 6.8KΩ ± 20%

4. Is there difference between percentage errors, of three resistors (1K, 10K,100K)ohms? Explain.

Experiment No.2
Ohm's Law

Aim of experiment: To investigate the Ohm's Law

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter.

Theory

In Fig.(1), the tungsten filament of the light bulb offers a considerable amount of opposition, or what is called **ELECTRICAL RESISTANCE,** to the passage of electric current through it. Because of the high resistance of the filament, the battery voltage **V** must be relatively high in order to produce the amount of current **I** required to heat the filament to incandescence.

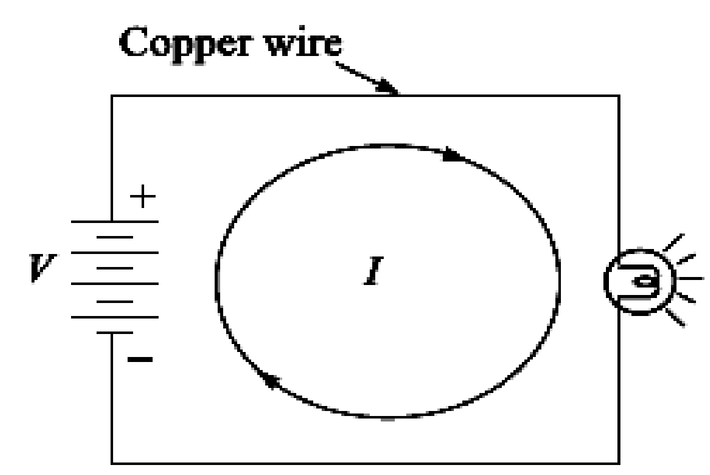


Fig.(1)

R denotes the amount of electrical resistance, and in electrical diagrams, the presence of resistance is representing by the symbol. Using this symbol, we have redrawn Fig.(1) as Fig.(2), in which **R** denotes the ‘‘electrical resistance’’ of the tungsten filament in the light bulb.

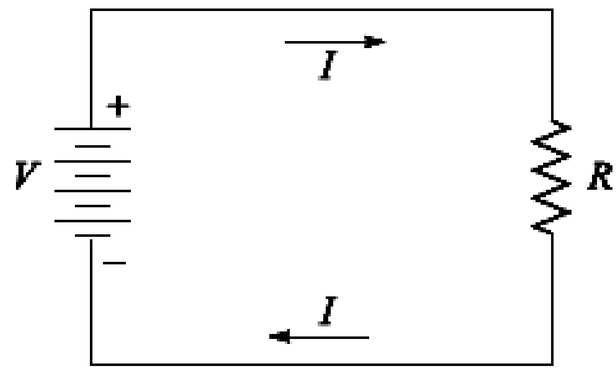


Fig.(2)

We have already learned that substances that offer little resistance to the passage of current are called ‘‘conductors,’’ while those that offer great resistance are called ‘‘insulators.’’

The first comprehensive investigation into the nature and measurement of electrical resistance was made by the ***German physicist Ohm*** (as in ‘‘home’’) around the year 1826. After a lengthy series of experiments, Ohm was able to report that,

> ***"The current in a conductor is directly proportional to the potential difference between the terminals of the conductor and inversely proportional to the resistance of the conductor"***

The above constitutes is called **OHM'S LAW**. If we let
V = potential difference (emf) applied to the conductor,
I = current in the conductor,
R = resistance of the conductor,

Therefore, if we express **V** in volts, **I** in amperes, and **R** in ohms, then the basic OHM'S LAW is:

$$\frac{V}{I} = R$$

The relationship between V & I can be represented in Fig.(3).

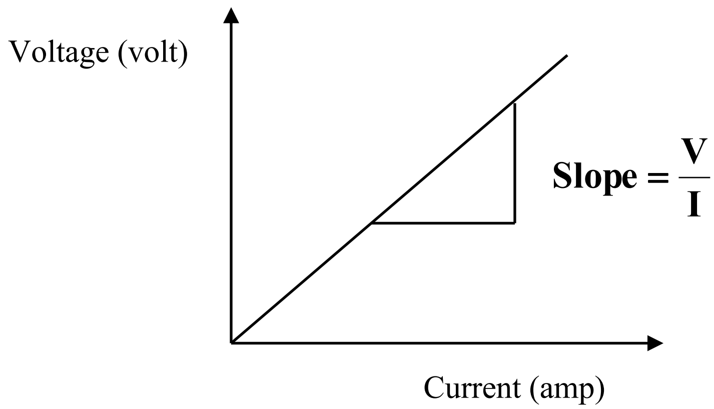


Fig.(3)

There are, of course, many grades of conductors (and insulators). Take, for example, two metals such as copper and tungsten. Both are classified as ''conductors,'' but a copper wire is a better conductor than a tungsten wire of the same length and diameter;

Conductor: A material, which gives up free electron early and offers little opposition to current flow and the unit of conductance, is (siemens).

The inverse of resistance called conductance (G) where

$$G = \frac{1}{R}$$

Procedure

1. Using the DC circuit trainer, connect the circuit shown in Fig. (4). Increase the voltage from 0-10v and measure current in each step, and then record it in table below.

V(volt)	0	1	2	3	4	5	6	7	8	9	10
I(mA)											

2. Repeat step (1) with exchange the R_1 by the light bulb
3. Connect the circuit shown in Fig.(5). Change the resistor value from 50-500Ω, measure current, and voltage in each step, and then record it in table below.

R(Ω)	**50**	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**
I(mA)										
V(volt)										

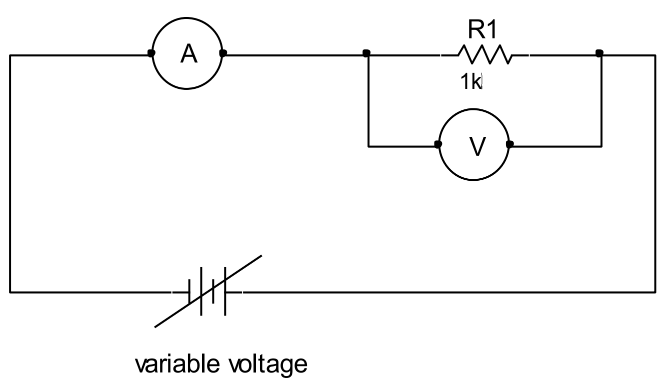


Fig.(4)

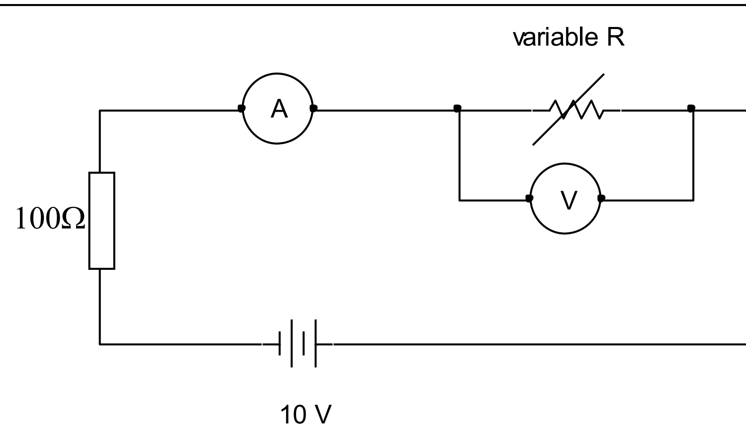


Fig.(5)

Discussion

1. Draw the relationship between V & I form table in step 1, and the relationship between R & I for table in step 2.
2. Is it necessary that the relationship between V & I start with the original point (0, 0) and why?
3. For the table in step 2, find G in each step.
4. What does the slopes represent in V & I relationship?
5. Why should the graphic be a straight line in step (1)?

Experiment NO.3
Series and parallel connection

Object
To study the properties of series and parallel connection.

Apparatus
1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory
1. The Series Circuit
A SERIES CIRCUIT or ''series-connected circuit'' is a circuit having **JUST ONE CURRENT PATH**. Thus, Fig.(1) is an example of a ''series circuit'' in which a battery of constant potential difference V volts, and three resistances, are all connected ''in series.''

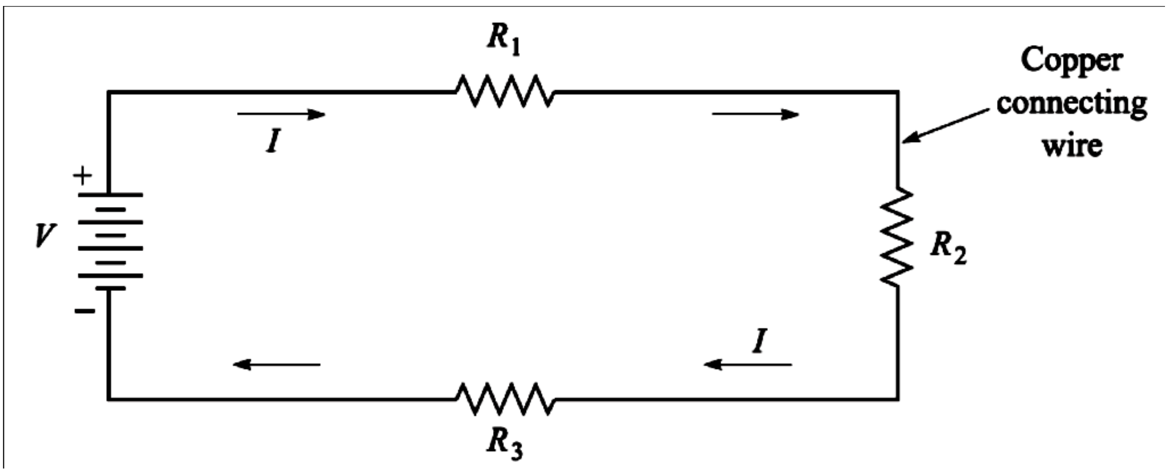


Fig.(1)

Since a series circuit has just one current path, it follows that all the components in a series circuit CARRY THE SAME CURRENT **I**, a fact evident from inspection of Fig.(1).

The current **I** is assumed to be a flow of positive charge, and thus flows out of the positive terminal of the battery and around through the external circuit, reentering the battery at the negative terminal. This is indicated by the arrows in Fig.(1).

In a series circuit, the **TOTAL** resistance, R_T, that the battery sees is equal to the **SUM** of the individual resistances. Thus, in the particular case of Fig.(1) the battery sees a total resistance, $\mathbf{R_T = R1 + R2 + R3}$, while in the general case of ''n'' resistances connected in series the battery sees a total resistance of :

$$\mathbf{R_T = R1 + R2 + R3 + \ldots.. Rn}$$

By Ohm's law, it follows that the current I in a series circuit is equal to

$$I = \frac{V}{R_T} = \frac{V}{R_1 + R_2 + \cdots + R_n}$$

Resistance, on the other hand, consumes electrical energy, removing it from the circuit in the form of heat. Since resistance does not produce or generate electrical energy, it is a non-active or PASSIVE type of circuit element.

The potential difference between the terminals of a resistor is called the VOLTAGE DROP across the resistor, and, ***is equal to the current I times the resistance R***; that is, the ''**voltage drop**'' across a resistance of **R** ohms carrying a current of *I* amperes is **I·R** volts.

$$V = IR_T$$
$$V = I(R_1 + R_2 + \cdots + R_n)$$
$$V = IR_1 + IR_2 + \cdots + IR_n$$

We have the important fact that:

In a series circuit, the applied voltage is equal to the sum of the voltage drops.

It should be pointed out that the voltage drop across a resistor is always from plus to minus in the direction of the current flow, a fact illustrated in Fig.(2).

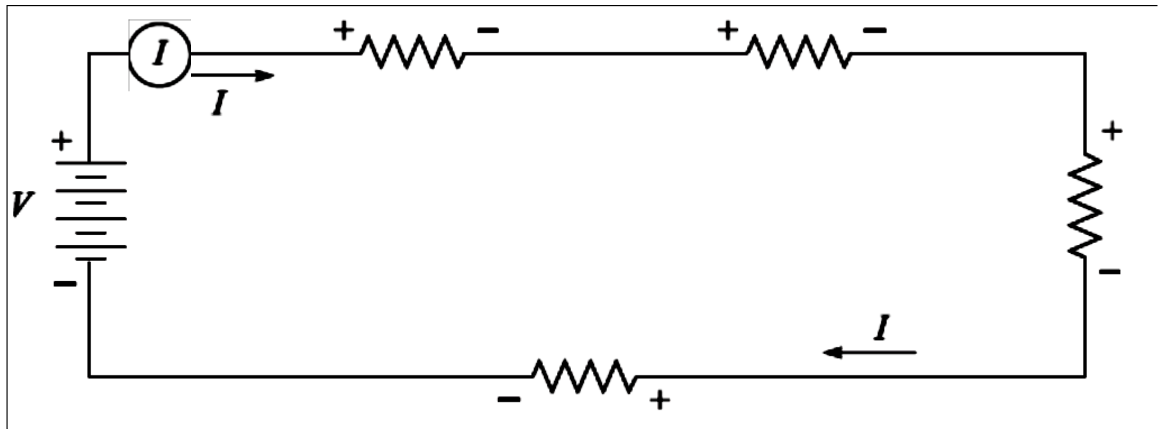


Fig.(2)

2. The Parallel Circuit

A PARALLEL circuit is one in which the battery current *divides* into a number of ''parallel paths.'' This is shown in Fig.(3), in which a battery, of constant **V** volts, delivers a current of **I** amperes to a load consisting of any number of **n** resistances connected ''in parallel.''

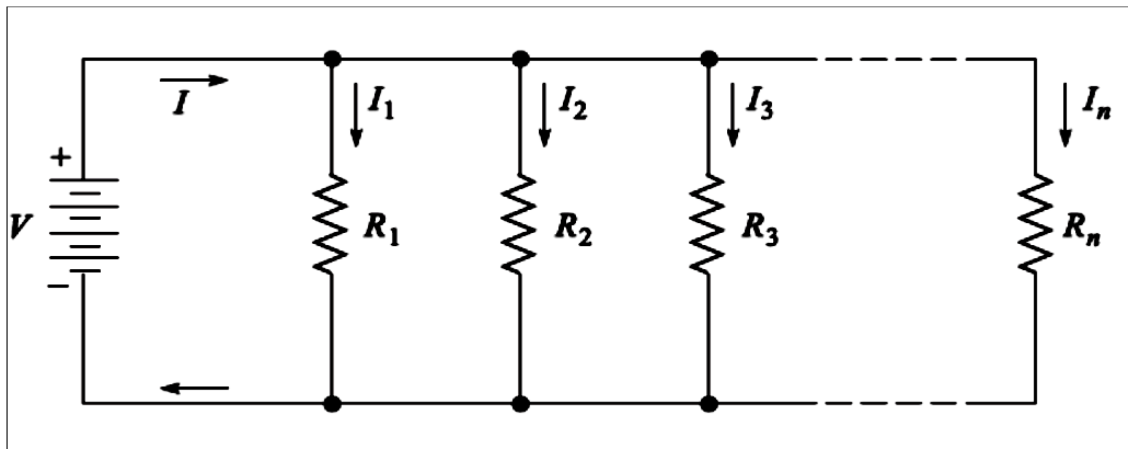


Fig.(3)

The currents in the individual resistances are called the ‘‘branch currents,’’ and the battery current **I** is often called the ‘‘line current.’’ From inspection of Fig.(3) we see that, in a parallel circuit, the battery current I is equal to the sum of the branch currents.

$$I = I_1 + I_2 + I_3 + \cdots + I_n$$

If the battery voltage V is applied equally to all n resistances; that is, the same voltage V is applied to all the parallel branches. Hence, by Ohm's law, the individual branch currents in Fig.(3) have the values:

$$I_1 = V/R_1, \qquad I_2 = V/R_2, \ldots, I_n = V/R_n$$

Then, we have:

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}\right)$$

Now let R_T be the total resistance as seen by the battery in Fig.(3). Then, by Ohm's law, it has to be true that:

$$I = \frac{V}{R_T}$$

Since the left-hand sides of the last two equations are equal, the two right-hand sides are also equal. Setting the two right-hand sides equal, then canceling the Vs, gives

$$\boxed{\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}}$$

Procedure

1. Using the DC circuit trainer, connect the circuit Shown in Fig. (4), take V_T =10V, and R_1=82Ω, R_2 = 100Ω and R_3 =150Ω.
2. Measured the voltage and current of "R_1 , R_2 & R_3", then record it in table below

	82Ω	100Ω	150Ω	
V(volt)				**V_T =**
I(mA)				**I_T =**

3. By using ohm's law, Calculate the R_T
4. Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

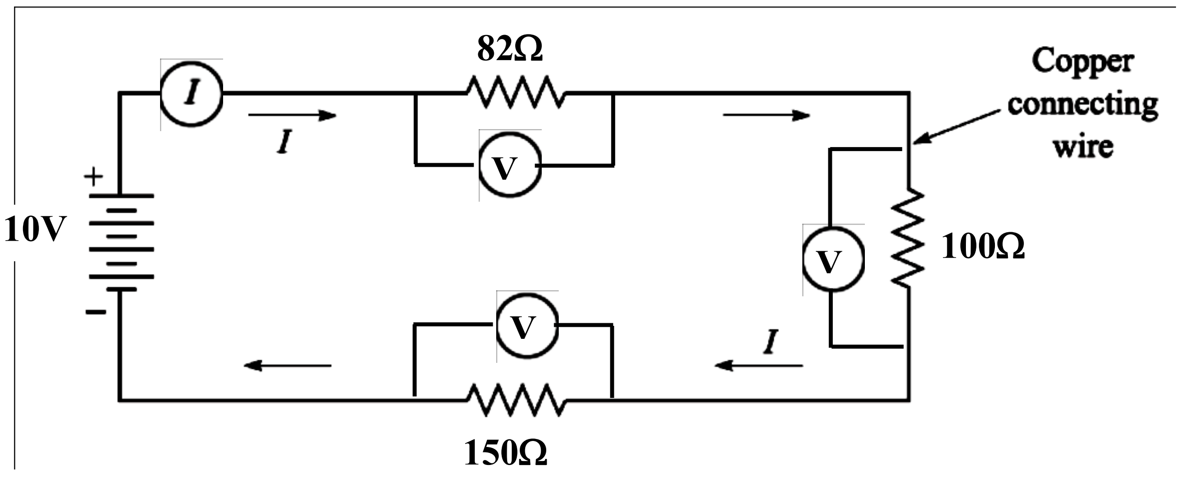


Fig.(4)

5. Using the DC circuit trainer, connect the circuit Shown in Fig.(5), and take V_T =10V, and R_1=82Ω, R_2 = 100Ω and R_3 =150Ω.
6. Measured the voltage and current of "R_1 , R_2 & R_3", then record it in table below

7. Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

	82Ω	100Ω	150Ω	
I (mA)				I_T=
V(volt)				V_T=

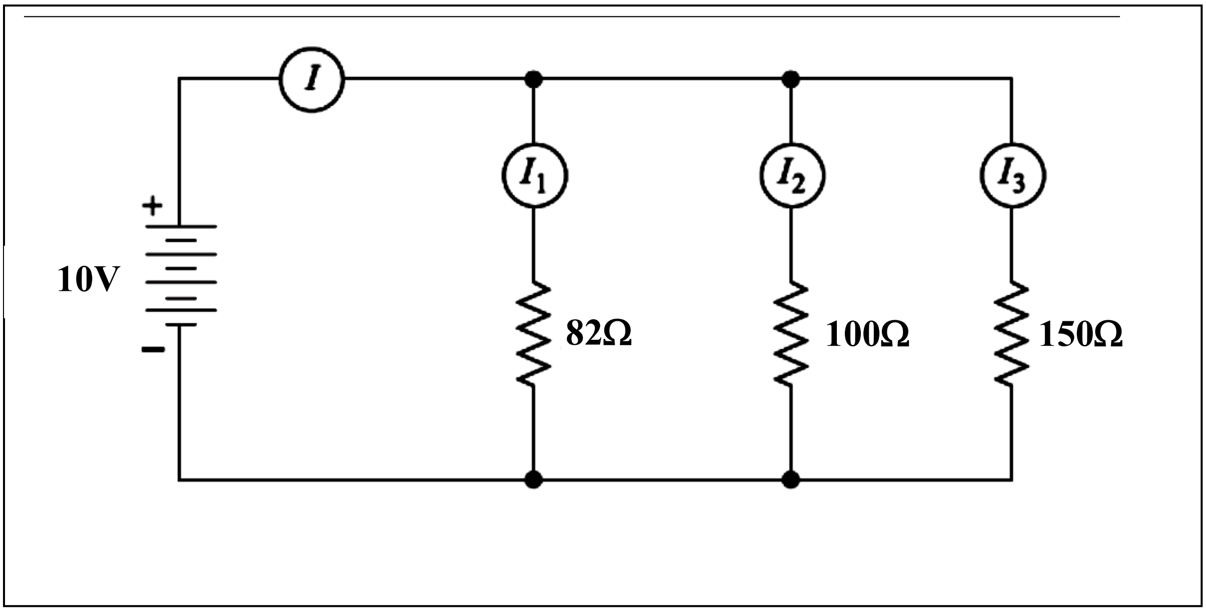


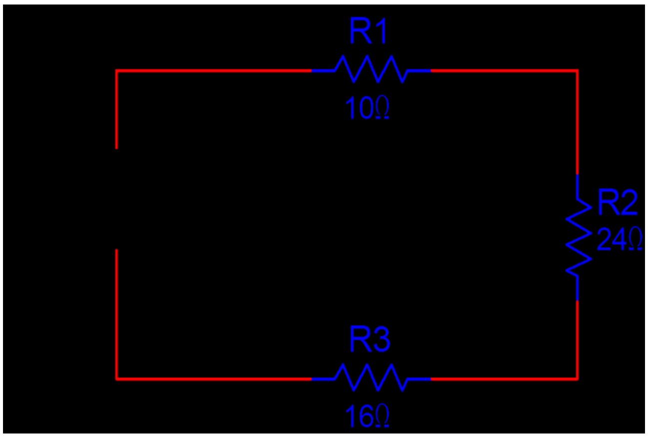
Fig.(5)

Discussion

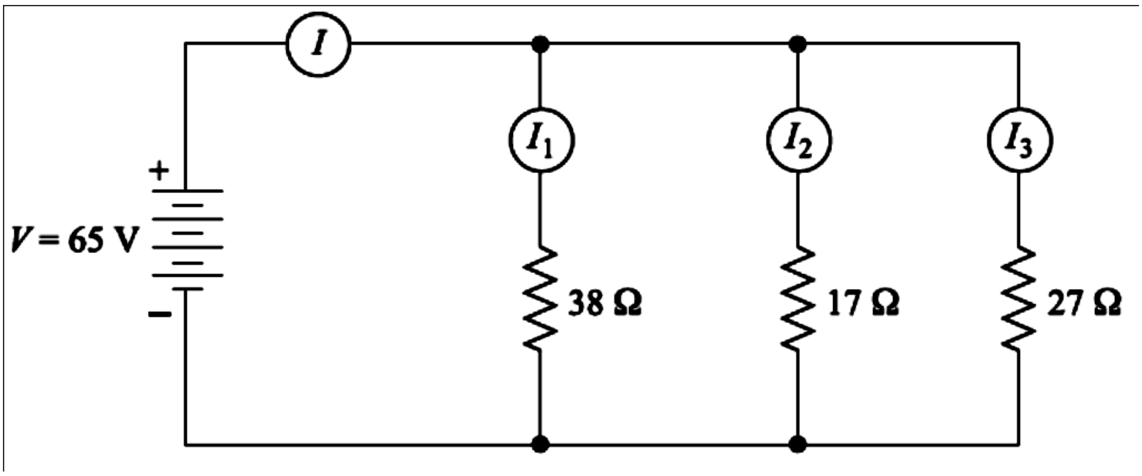
1. Tow resistors (R_1, R2) are connect in parallel, prove that

$$R_T = \frac{R_1\,R2}{R_1 + R_2}$$

2. For the circuit shown below, find R_T, V_2.



3. In Figure, the battery voltage is V = 65 volts, and the values of the resistances, in ohms, are 38, 17, and 27, as shown. Find:
   (a) Total resistance seen by the battery,
   (b) Current measured by the ammeters shown in the figure,
   (c) Power output of the battery,
   (d) Power input to each resistor.



Experiment NO.4
Divider Rules

Aim of experiment

To verify the voltage divider rule (VDR) and the current divider rule (CDR).

Apparatus

1. DC circuit training system.
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter.

Theory

Voltage Divider Rule

The Voltage Divider Rule (VDR) 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 or series combination of elements divided by the total resistance of the series circuit and multiplied by the total impressed voltage in figure(1):

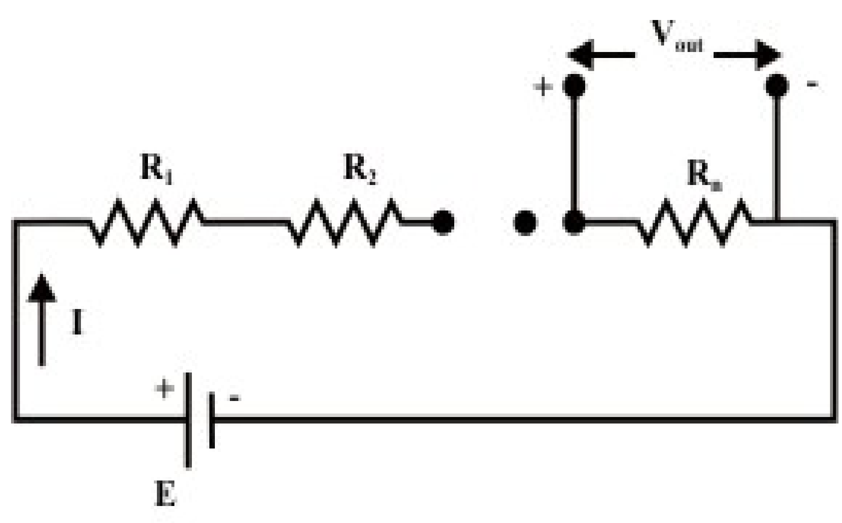


Fig. 1 Voltage Divider

$$Vout = IR_n = \frac{E}{R1+R2+R3+\cdots..+Rn} * Rn \quad ....(1)$$

Indicates that the voltage across any resistor Ri(Ri, i= 1,2,..... n) in a series circuit is equal to the applied voltage (E) across the circuit multiplied by a factor $\frac{\mathbf{Ri}}{\sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{Rj}}$

. It should be noted that this expression is only valid if the same current I flows through all the resistors.

Current Divider Rule

The Current Divider Rule (CDR) states that the current through one of two parallel branches is equal to the resistance of the other branch divided by the sum of the resistances of the two parallel branches and multiplied by the total current entering the two parallel branches in figure(2). That is,

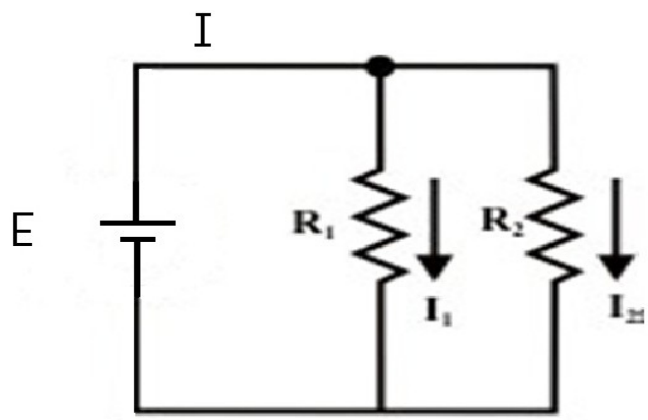


Fig. 2 Current Divider

$$\frac{I_1}{I_S} = \frac{V/_{R1}}{V(\frac{1}{R1} + \frac{1}{R2})} = \frac{R2}{R1 + R2}$$

Or $I_1 = \frac{R2}{R1+R2} * I_S$

Similarly, the current flowing through the R2 can be obtained as:

$$I_2 = \frac{R1}{R1 + R2} * I_S$$

It can be noted that the expression for I_2 has R_2 on its top line, that for I_1 has R_1 on its top line.

Procedure

Part 1: Voltage Divider Rule

1. Using the DC circuit trainer, connect the circuit shown in Fig. (1), take E =10V, R_1=82Ω, R_2 = 100Ω and R_3 =150Ω.
2. Measured the voltage and current of "R_1 , R_2 & R_3".
3. Exchange the value of resistors as following: R1= 10KΩ, R2= 1000 Ω, R3= 50 Ω.
4. Repeat step(2) , change the value of resistors as following: R1=30 Ω, R2= 500 Ω, R3= 100 Ω.

Part 2:Current Divider Rule

1. Using the DC circuit trainer, connect the circuit shown in Fig. (2). take E =10V, R_1=82Ω and R_2 = 100Ω .
2. Measured the voltage and current of "R_1 , R_2.
3. Exchange the value of resistors as following: R1= 10KΩ, R2= 1000 Ω.
4. Repeat step(2) , change the value of resistors as following: R1=30 Ω, R2= 500 Ω.

Discussion

1- Comment on your results.
2- Compare between the practical and theoretical results.
3- When is used VDR and CDR.
4- For the circuit shown in Figure(3) . Calculate V out, ignoring the internal resistance Rs of the source E. Use voltage division.

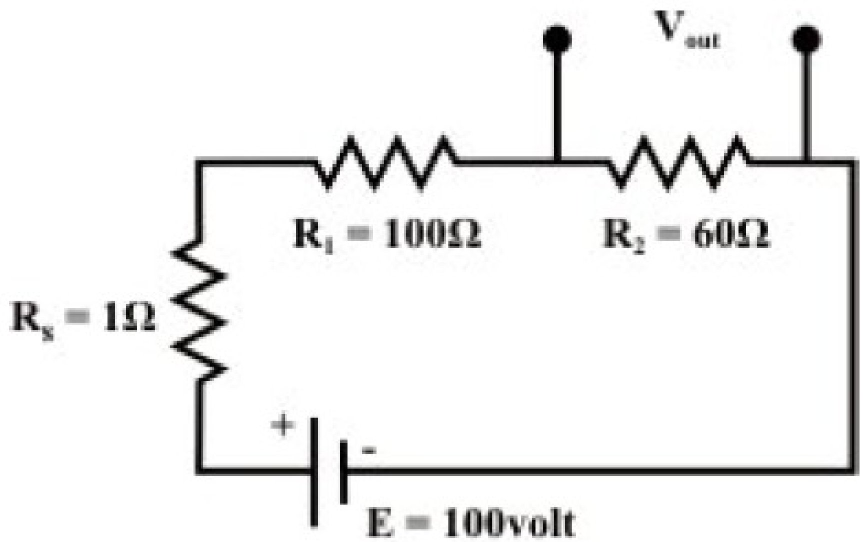
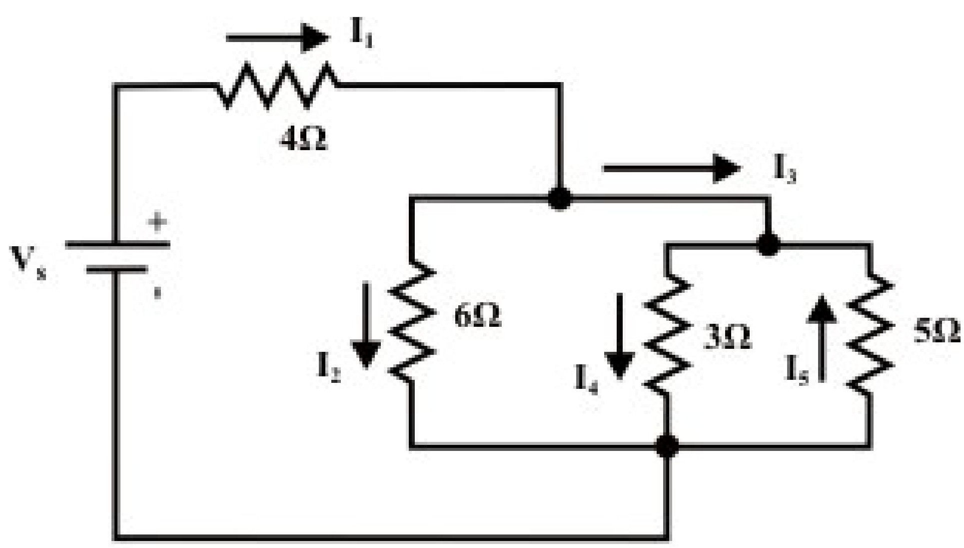


Fig. 3

4 . Determine I_1, I_2,I_3 and I_5 using only current divider formula when I_4 =4A.



Experiment No.5
Complex connection

Aim of experiment: To studies the properties of complex connection.

Apparatus

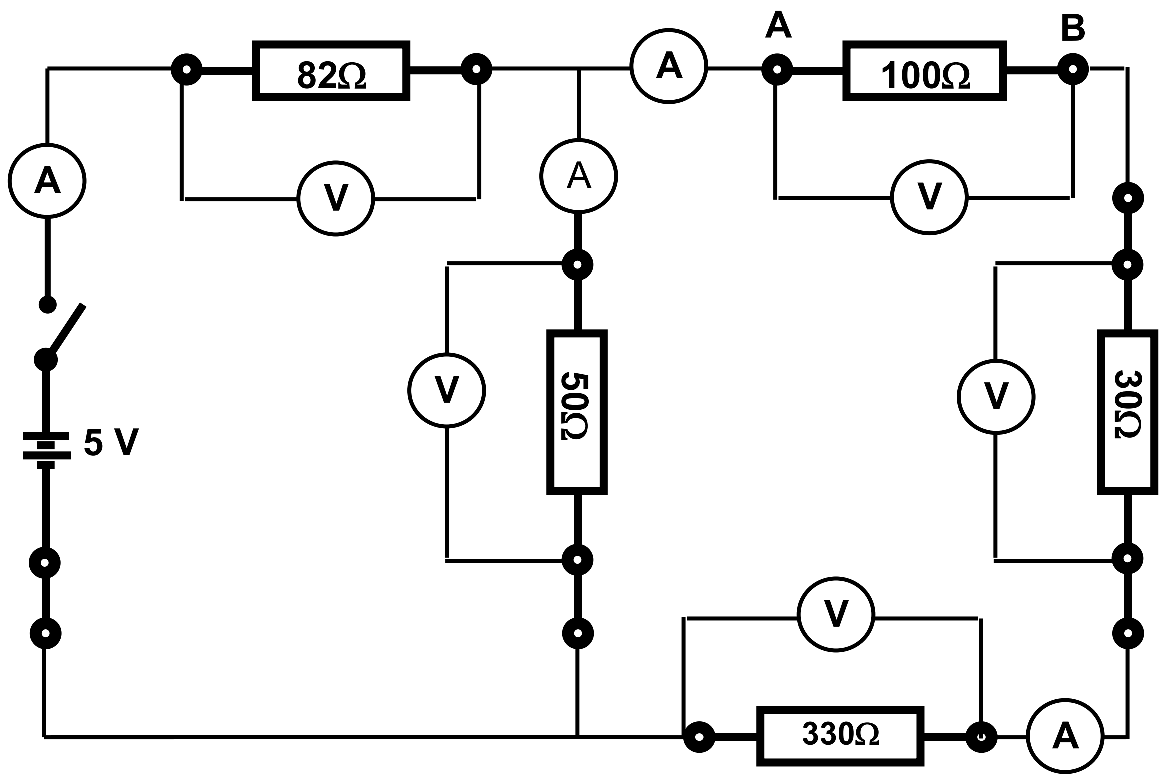
1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

The mesh current and node voltage methods are the principal techniques of dc resistive circuit analysis .However, the equivalent resistance of series and parallel branches, combined with the voltage and current division rules, provide another method of analyzing a network. This method is tedious and usually requires the drawing of several additional circuits. Even so, the process of reducing the network provides a very clear picture of the overall functioning of the network in terms of voltages, currents, and power. The reduction begins with a scan of the network to pick out series and parallel combinations of resistors.

Procedure

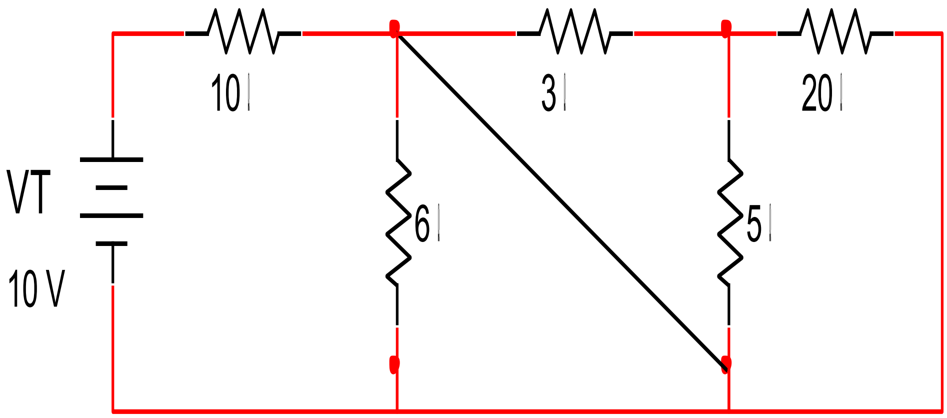
1. Using the DC circuit trainer, connect the circuit shown below.
2. Measured the values of voltage and current of each resistance in circuit and record it in table below:
3. By using ohm's law, calculate the total resistance.
4. Disconnect the DC power supply and measured the equivalent total resistance by using AVO meter.



Res.	R_1	R_2	R_3	R_4	R_T(A.V.O.)	R_T(ohms law)
V(volt)						
I(mA)						

Discussion

1. Compare between the theoretically and practical results.
2. Fined R_T for the circuit shown below

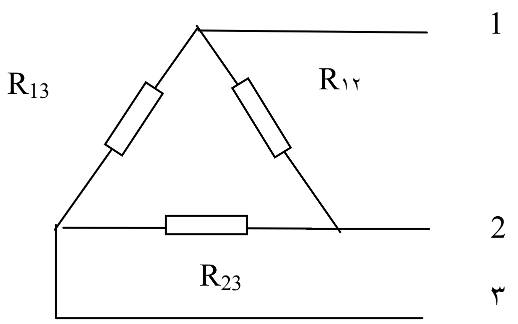

10
3
20
VT
10 V
6
5

Experiment No. 6
Delta – Star connection

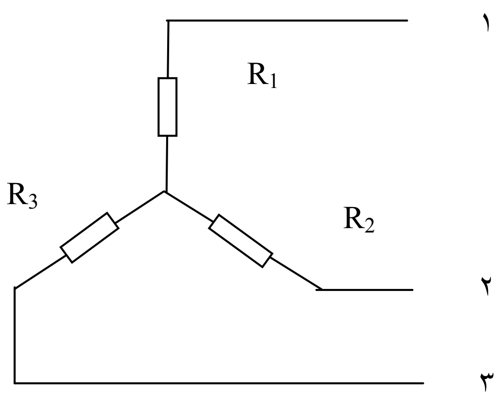
Aim of experiment: To study the properties of delta-star connection.

Apparatus
1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory
In solving networks (having considerable number of branches) by the application of Kirchhoff's Laws, one sometimes experiences great difficulty due to a large number of simultaneous equation that have to be solve. However, such complicated networks can simplify by successively replacing delta meshes by equivalent star systems and *vice versa*.



Delta-connection
(b)



Star-connection
(a)

Fig (1)

Suppose we are given three resistance R_{12},R_{23} and R_{13} connected in delta fashion between terminals 1,2 and 3 as in Fig.(1-a). So far as the respective terminals are concerned, these given three resistances can be replaced by the three resistances R_1, R_2 and R_3 connected in star as shown in Fig.(1-b). These two arrangements will be electrically equivalent if the resistance as measured between any pair of terminals is the same in both arrangements.

1. To convert from ***delta connection*** to ***star connection***

$$R_1 = \frac{R_{12} \times R_{13}}{R_{12} + R_{23} + R_{13}}$$

$$R_2 = \frac{R_{12} \times R_{23}}{R_{12} + R_{23} + R_{13}}$$

$$R_3 = \frac{R_{23} \times R_{13}}{R_{12} + R_{23} + R_{13}}$$

2. To convert from ***star connection*** to ***delta connection***

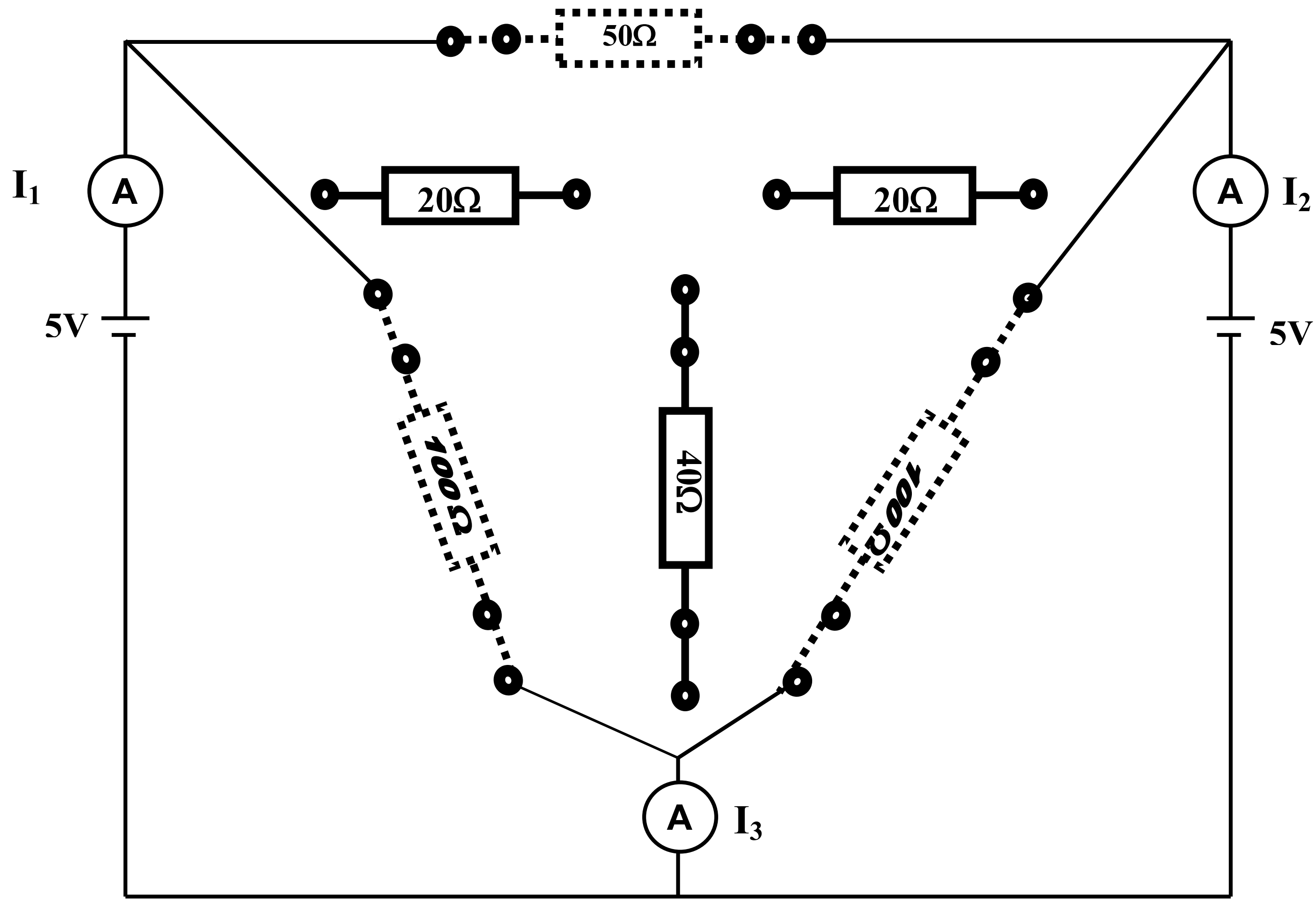
$$R_{12} = R_1 + R_2 + \frac{R_1 \times R_2}{R_3}$$

$$R_{23} = R_2 + R_3 + \frac{R_3 \times R_2}{R_1}$$

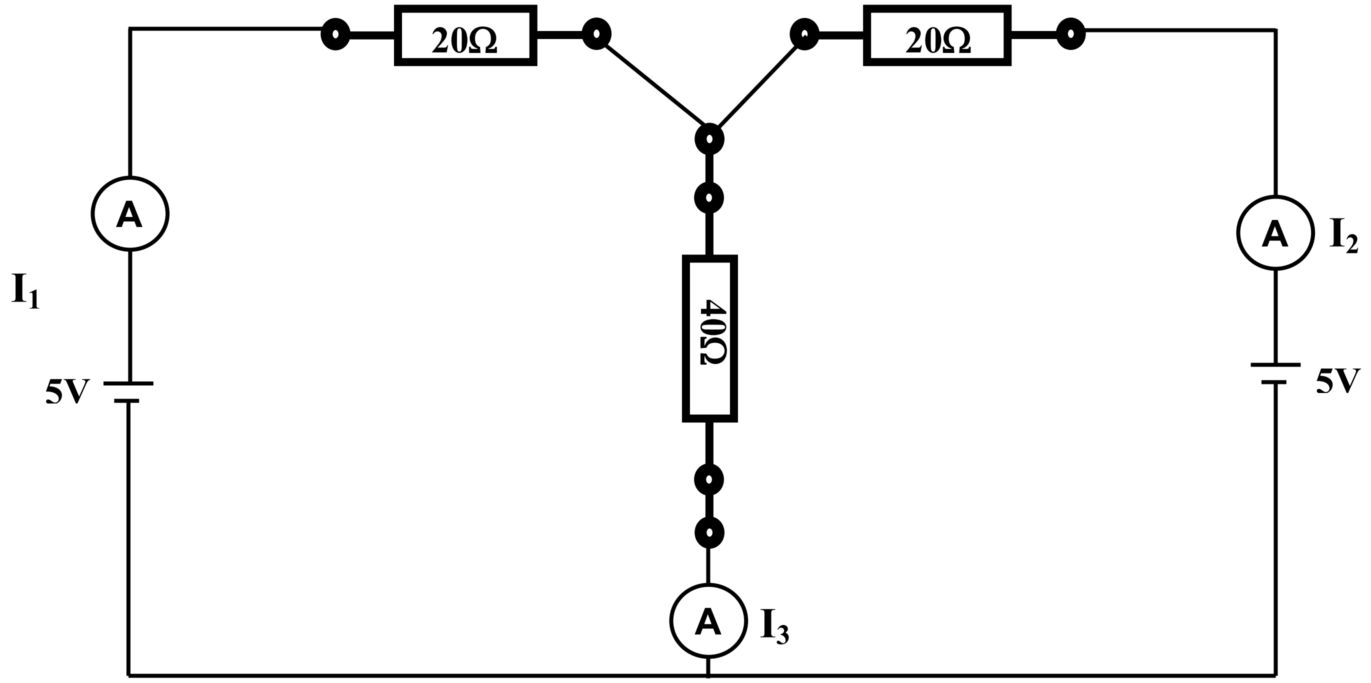
$$R_{13} = R_1 + R_3 + \frac{R_3 \times R_1}{R_2}$$

Procedure

1. Using the DC circuit trainer, connect the circuit shown below.
2. Measure "I_1, I_2, I_3" practically.
3. Record your results in the table below
4. By using delta-star conversion, find the star resistance R_1, R_2, R_3 theoretically.



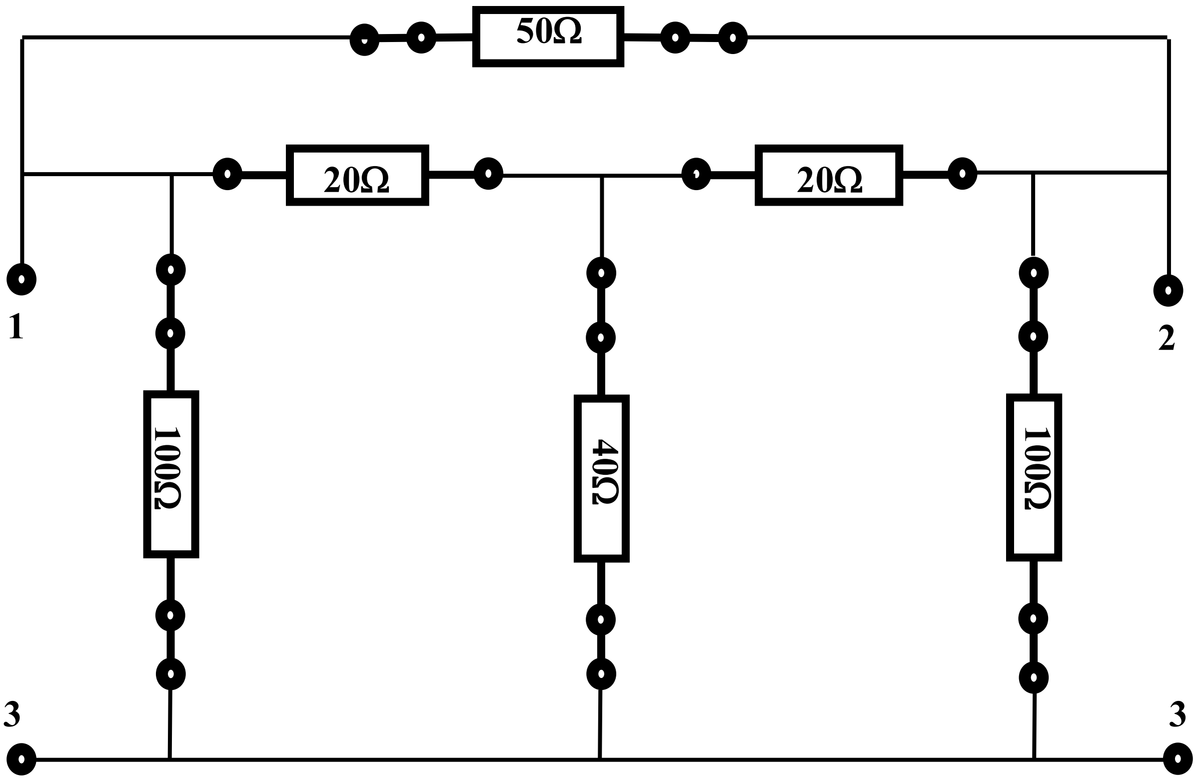
5. Using the DC circuit trainer, connect the circuit shown below:



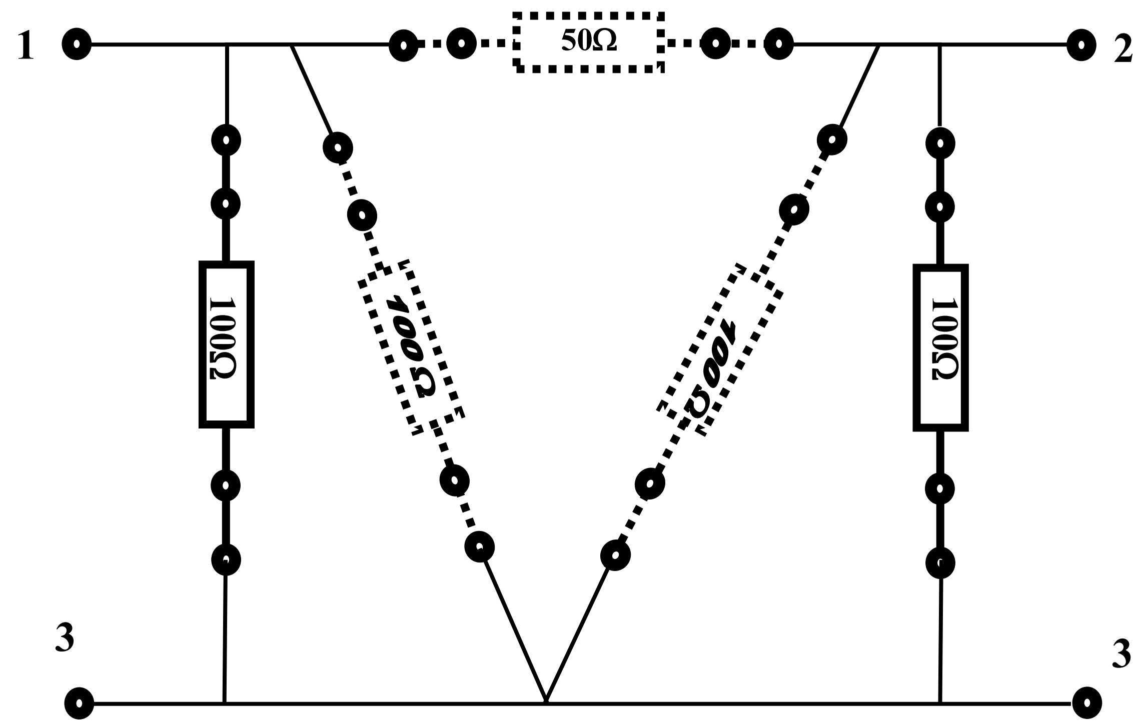
6. Measure "**I_1, I_2, I_3**" practically.
7. Record your results in the table below

	I_1	**I_2**	**I_3**
Delta connection			
Star connection			

8. Connect circuit the circuit shown in Figure below and measured the equivalent resistance between any two terminals "1-2, 2-3, 1-3" by using AVO meter.

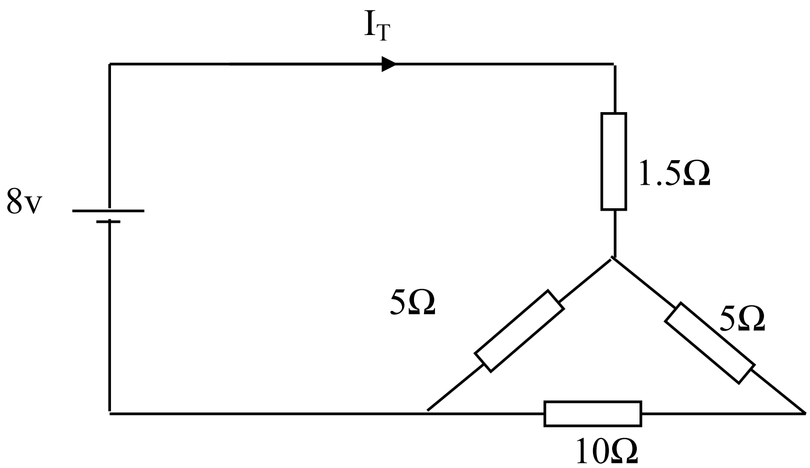


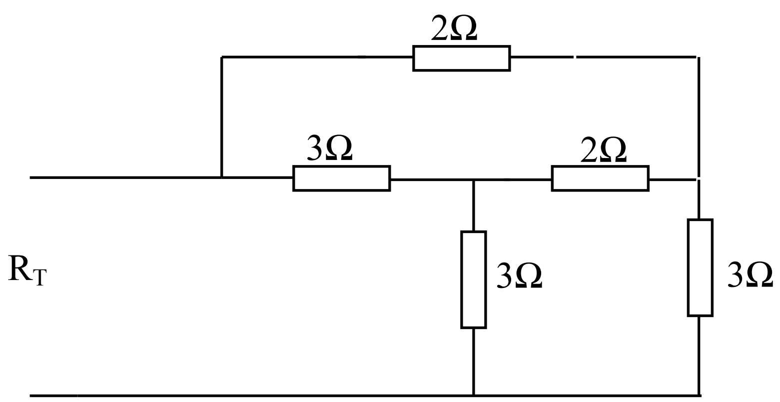
9. Using the DC circuit trainer, Connect circuit the circuit shown in Figure below and measured the equivalent resistance between any two terminals "1-2, 2-3, 1-3" by using AVO meter.



Discussion

1. Comment on your results.
2. Compare between the practical and theoretical results.
3. Comment on step 8 and step 9
4. Find I_T and R_T for the circuit below





Experiment No.7
Kirchhoff's Laws

Aim of experiment: To investigate Kirchhoff 's laws practically.

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

Kirchhoff 's laws relate to the conservation of energy, which states that energy cannot be created or destroyed, only changed into different forms. This can be expanded to laws of conservation of voltage and current. In any circuit, the voltage across each series component (carrying the same current) can be added to find the total voltage. Similarly, the total current entering a junction in a circuit must equal the sum of current leaving the junction.

1. Kirchhoff's Current Law "KCL"

Kirchhoff's ''current law'' is based upon the fact that at any connecting point in a network the sum of the currents flowing toward the point is equal to the sum of the currents flowing away from the point. The law is illustrated in the examples in Fig.(1), where the arrows show the directions in which it is given that the currents are flowing. (The number alongside each arrow is the amount of current associated with that arrow.)

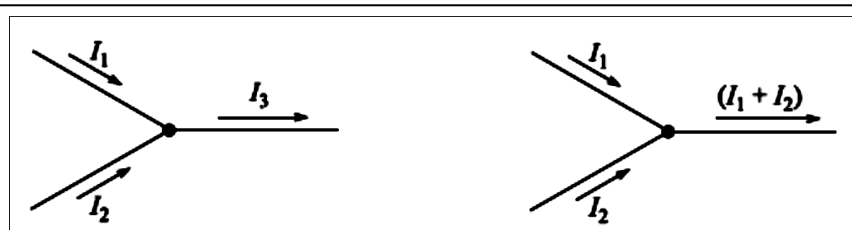


Fig.(1)

The sum of the currents flowing **TO** a node point equals the sum of the currents flowing **FROM** that point.

However, by Kirchhoff's current law, $\mathbf{I_3 = I_1 + I_2}$, and thus, as shown in Fig. (1), we need to use only two current designations. In other words, if we know any two of the three currents, we can then find the third current. In the same way, if there are, say, four branch currents entering and leaving a node point, and if we know any three of the currents, we can then find the fourth current, and so on.

$$I_1 + I_2 = I_3$$

$$I_1 + I_2 - I_3 = 0$$

The Kirchhoff's current law can be state in the form:

The algebraic sum of the currents at a node (junction point) is equal to zero

2. Kirchhoff's Voltage Law "KVL"

It states as follows:

The algebraic sum of the products of currents and resistance in each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the e.m.fs. in that path is zero.

In other words, $\sum \boldsymbol{IR} + \sum \boldsymbol{e.m.f.} = \boldsymbol{0}$ round a mesh

Let us now write the equation for Fig. (2) in accordance with Kirchhoff's voltage law. To do this, we start at any point, such as A, and move completely around the circuit (we will assume in the CW sense here), listing the ''voltage drops'' and the ''voltage rises'' as we go. (In doing this, remember that we have defined that going from ''minus to plus'' constitutes a **RISE** in voltage and going from ''plus to minus'' constitutes a **DROP** in voltage.) Thus, if we agree to list all ''voltage drops'' on the left-hand sides of our equations and all the ''voltage rises'' on the right-hand sides, the Kirchhoff voltage equation for Fig. (2) is:

$$\boldsymbol{R_1 I + V_2 + R_2 I = V_1}$$

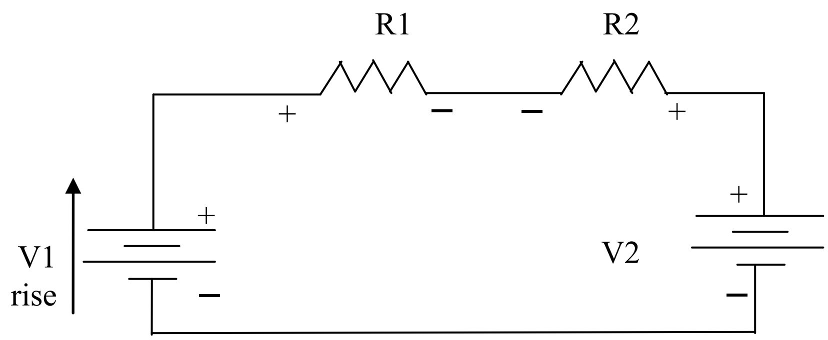


Fig. (2)

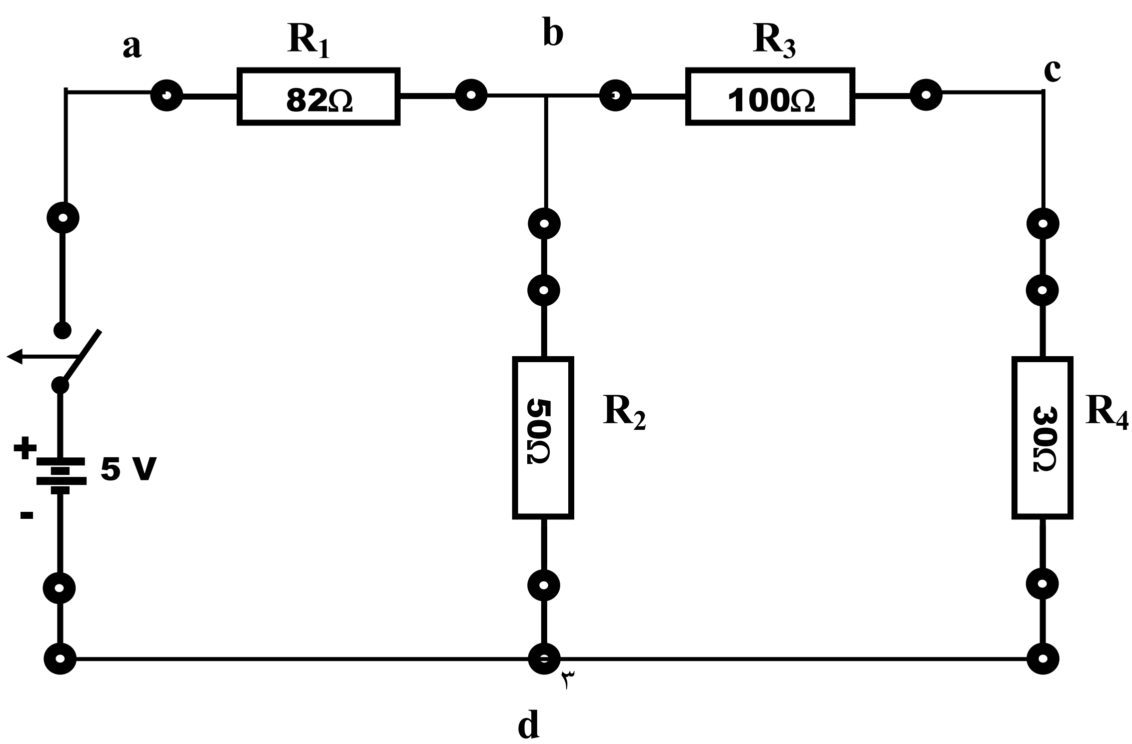
Note that V_2 appears as a voltage drop, because we go through that battery from plus to minus (+ to -). Alternatively, putting all the battery voltages on the right-hand side, the above equation becomes

$$R_1 I + R_2 I = V_1 - V_2$$

$$\text{hence} \quad I = \frac{V_1 - V_2}{R_1 + R_2}$$

Procedure

1. Using the DC circuit trainer, Connect the circuit shown below:



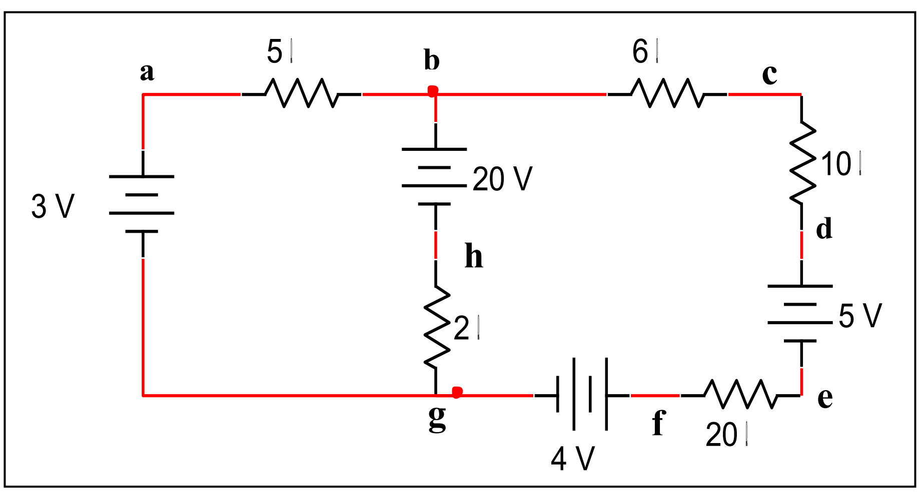
2. Measure the values of voltage and current of each resistor in circuit and record it in the table below.

	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	$R_4(\Omega)$
V(volt)				
I(mA)				

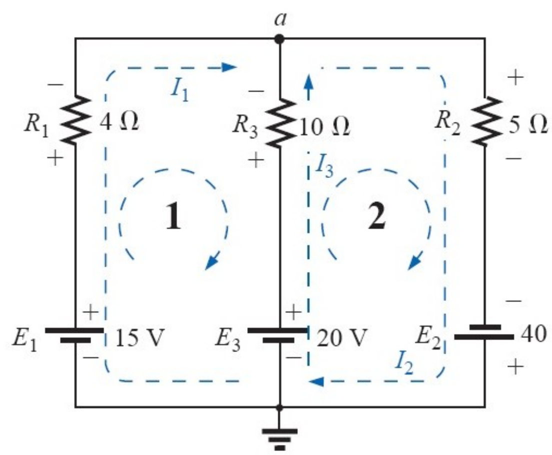
3. Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

Discussion

1. Verify (KCL and (KVL) .
2. Comment on results .
3. Find I_1 , I_2 , I_3 .



4. Find the branch current analysis at the circuit shwon in figure below.



Experiment No.(8)
Mesh Method

Aim of experiment: Solve a circuit using mesh analysis

Apparatus:-

1. DC circuit training system.
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter.

Theory:-

The method of analysis to be described is called mesh analysis. The term mesh is derived from the similarities in appearance between the closed loops of a network and a wire mesh fence. To solve an N mesh circuit, a set of N simultaneous equations are needed. There are several ways to derive a solution (i.e. Matrix algebra).

Essentially, the mesh-analysis approach simply eliminates the need to substitute the results of Kirchhoff's current law into the equations derived from Kirchhoff's voltage law. It is now accomplished in the initial writing of the equations. The systematic approach outlined below should be followed when applying this method:-

1. Assign a distinct current in the clockwise direction to each independent, closed loop of the network. It is not absolutely necessary **to choose the clockwise direction for each loop current. In fact, any** direction can be chosen for each loop current with no loss in accuracy, as long as the remaining steps are followed properly. However, by choosing the clockwise direction as a standard, we can develop a short and method for writing the required equations that will save time and possibly prevent some common errors.

2. Indicate the polarities within each loop for each resistor as determined by the assumed direction of loop current for that loop. Note the requirement that the polarities be placed within each loop. This requires, as shown in fig (1), (R_1,R_2), two sets of polarities across it.

3. Apply Kirchhoff's voltage law around each closed loop in the clockwise direction. Again, the clockwise direction was chosen to

establish uniformity and prepare us for the method to be introduced in the next section.

a. If a resistor has two or more assumed currents through it, the total current through the resistor is the assumed current of the loop in which Kirchhoff's voltage law is being applied, plus the assumed currents of the other loops passing through in the same direction, minus the assumed currents through in the opposite direction.

b. The polarity of a voltage source is unaffected by the direction of the assigned loop currents.

4. Solve the resulting simultaneous linear equations for the assumed loop currents.

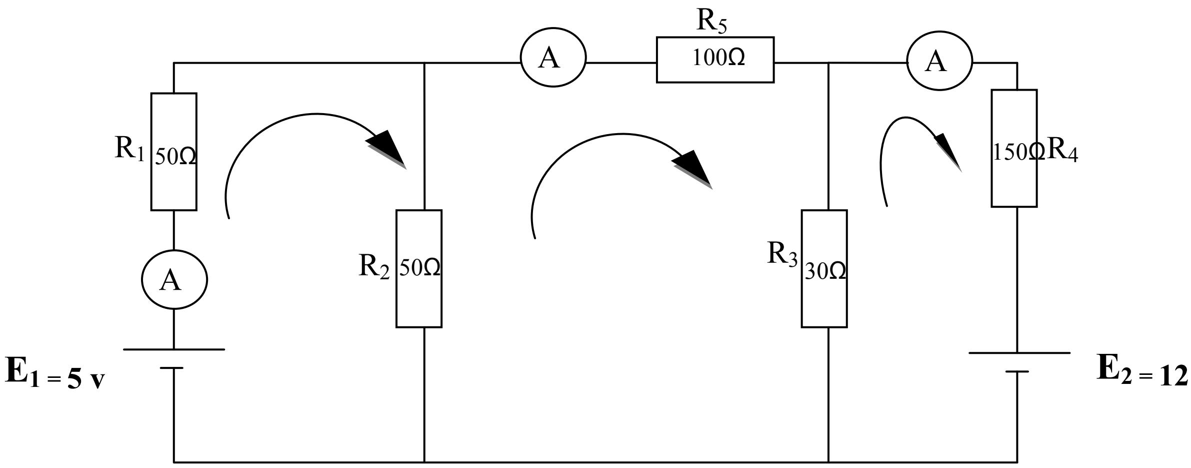


Fig. (1) Mesh Circuit

Procedure:-

1. Connect the circuit of Figure (1)
2. measure each of the mesh currents by inserting an ammeter into the top edge of each of the mesh windows in the circuit of Figure (1). Write down the results in the table.

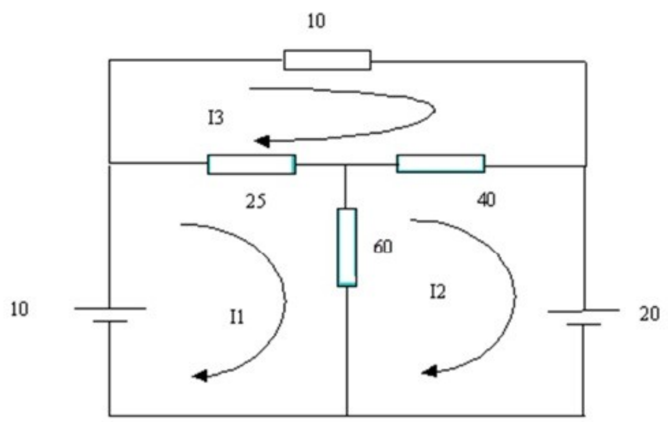
	I1	I2	I3
Assumed Current Direction			

3- measure the current and voltage through each resistor and write down the results in the table.

	R_1=50Ω	R_2=50Ω	R_3=30Ω	R_4=150Ω	R_5=100Ω
I (mA)					
V (volt)					

<u>Discussion and calculation :-</u>

1- Compare between the practical and theoretical results and Comment on your results.
2- Find the current through each branch of the network shown below .



Experiment No.9

Nodal Theorem

Object:-

To verify the Nodal Theorem

Apparatus

1. DC circuit training system.
2. Set of wires.
3. DC Power supply.
4. Digital A.V.O. meter.

Theory

A node is defined as a junction of two or more branches. If we now define one node of any network as a reference (that is, a point of zero potential or ground), the remaining nodes of the network will all have a fixed potential relative to this reference. For a network of N nodes, therefore, there will exist (N-1) nodes with a fixed potential relative to the assigned reference node. Equations relating these nodal voltages can be written by applying Kirchhoff's current law at each of the (N-1) nodes. To obtain the complete solution of a network, these nodal voltages are then evaluated in the same manner in which loop currents were found in loop analysis.

The nodal analysis method is applied as follows:

1. Determine the number of nodes within the network.

2. Pick a reference node, and label each remaining node with a subscripted value of voltage: V1, V2, and so on.

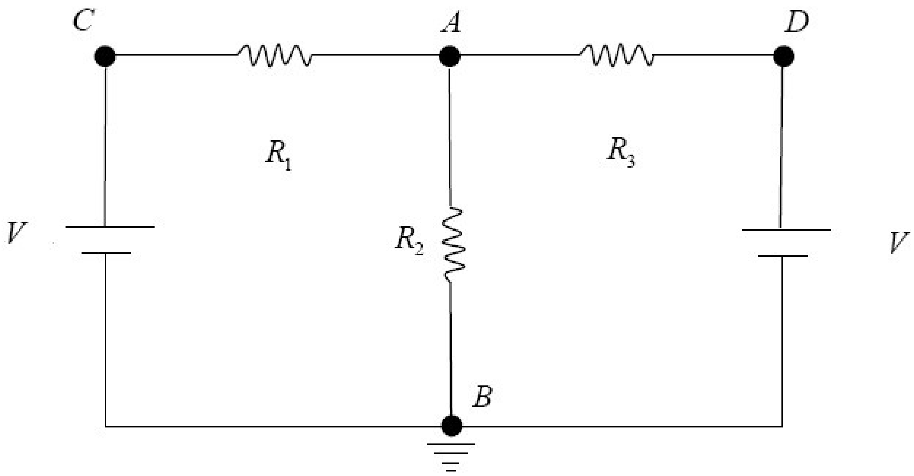
3. Apply Kirchhoff's current law at each node except the reference. Assume that all unknown currents leave the node for each application of Kirchhoff's current law. In other words, for each node, don't be influenced by the direction that an unknown current for another node may have had. Each node is to be treated as a separate entity, independent of the application of Kirchhoff's current law to the other nodes.

4. Solve the resulting equations for the nodal voltages. A few examples will clarify the procedure defined by step 3. It will initially take some practice writing the equations for Kirchhoff's current law correctly, but in time the advantage of assuming that all the currents leave a node rather than identifying a specific direction for each branch will become obvious

Procedure

1 . Using the DC circuit trainer, connect the circuit Shown in Fig. (1)

Take V1= 5 volt , V2= 9 volt. R1= 82**Ω** , R2= 50**Ω** , R3= 150**Ω**.



`

Fig (1)

2. Measured the current of "R_1 , R_2 & R_3", then record it in table below:

	82Ω	50Ω	150Ω
I (mA)			

3. Measured the voltage to each node in the cct.

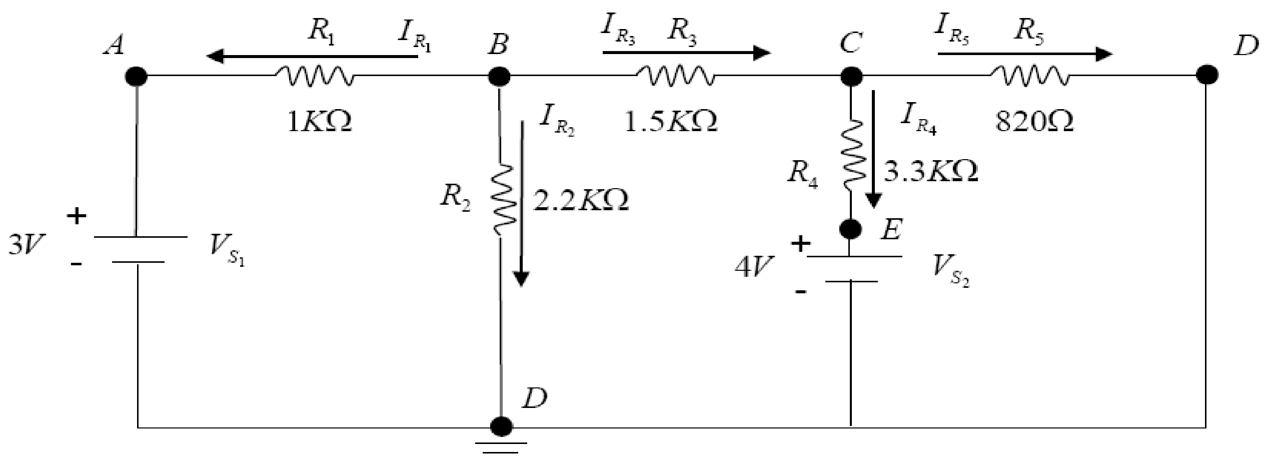
	Vab	Vac	Vad
V (volt)			

Discussion

1. Comment on your results.

2. Compare between the practical and theoretical results.

3. Find V_B, V_C on the figure below:



Experiment No.10
Thevenin's Theorem

Aim of experiment: To investigate Thevenin's theorem practically.

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

let ‘‘ab’’ be two terminals coming out of any network composed of generators and resistances, as indicated by the box in Fig.(1). THEVENIN’S THEOREM says that, as far as the voltage and current in any external load resistance, $\mathbf{R_L}$, is concerned:

The entire network, inside the box, can be replaced by a single generator whose generated voltage is equal to the open-circuit voltage appearing between a and b, and whose internal resistance is equal to the resistance seen looking back into the open-circuited terminals, with all generators removed and replaced with resistances equal to their internal resistances.

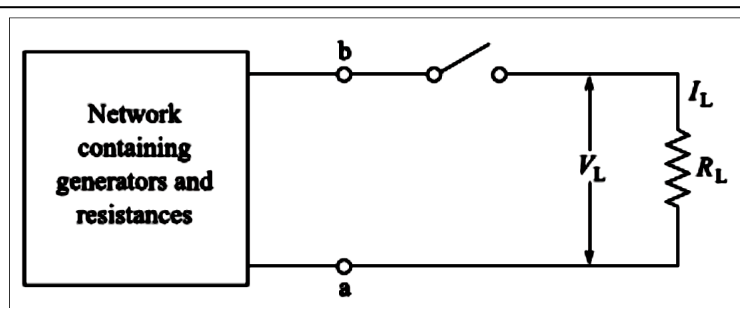
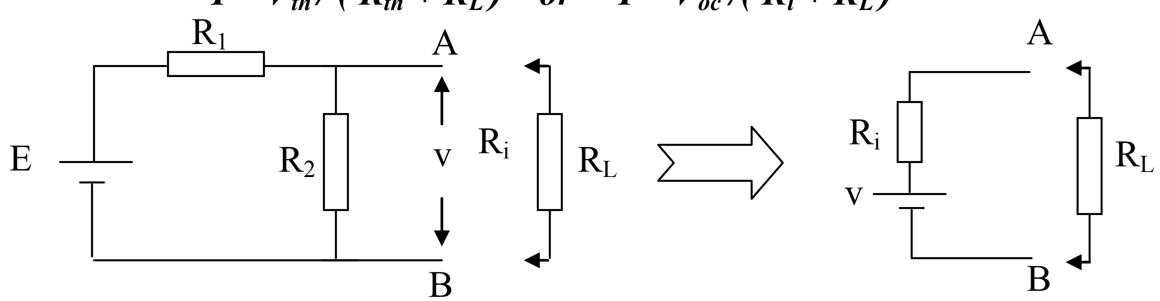


Fig.(1)

Procedural Steps for finding Thevenin's Equivalent Circuit

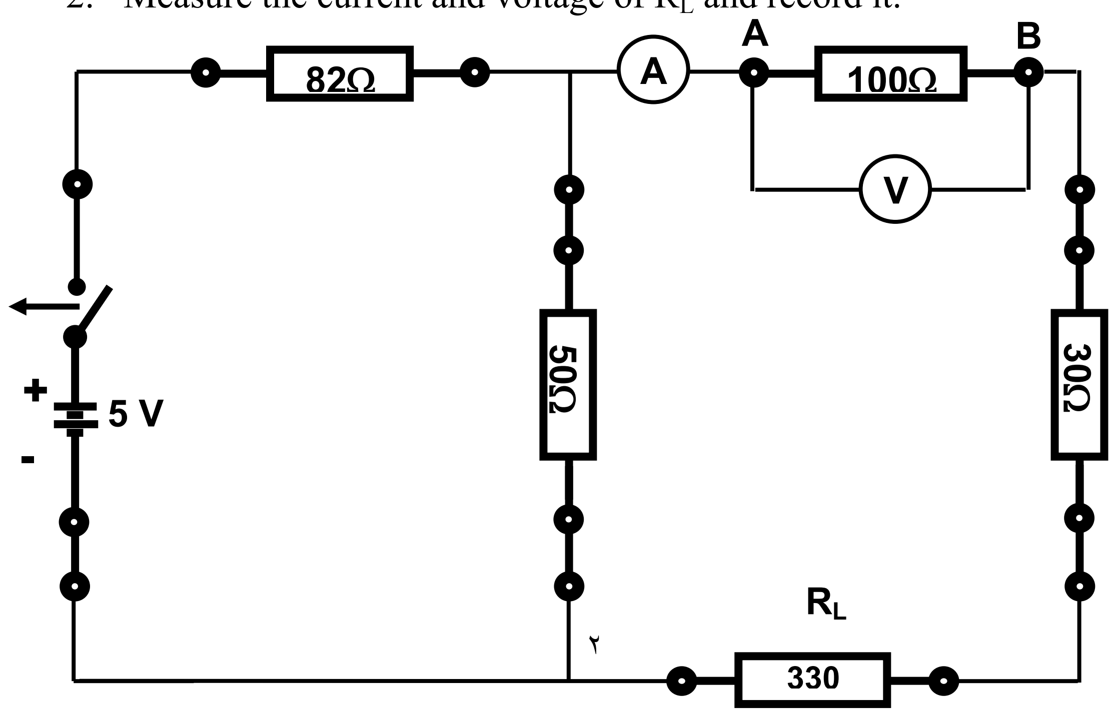
- Remove the resistance (called load resistance R_L) whose current is required.
- Find the open-circuit voltage V_{oc} that appears across the two terminals from where resistance has removed. It also called ***Thevenin voltage*** V_{th}.
- Compute the resistance of the whole network as looked into from these two terminals after all sources of e.m.f. have removed. It also called Thevenin resistance R_{th}.
- Replace the entire network by single Thevenin source whose voltage is V_{th} or V_{oc} and whose internal resistance is R_i or R_{th}.
- Connect R_L back to its terminals where it previously removed.
- Finally, calculate the current flowing through R_L by using the equation,

$$I = V_{th} / (R_{th} + R_L) \quad or \quad I = V_{oc} / (R_i + R_L)$$

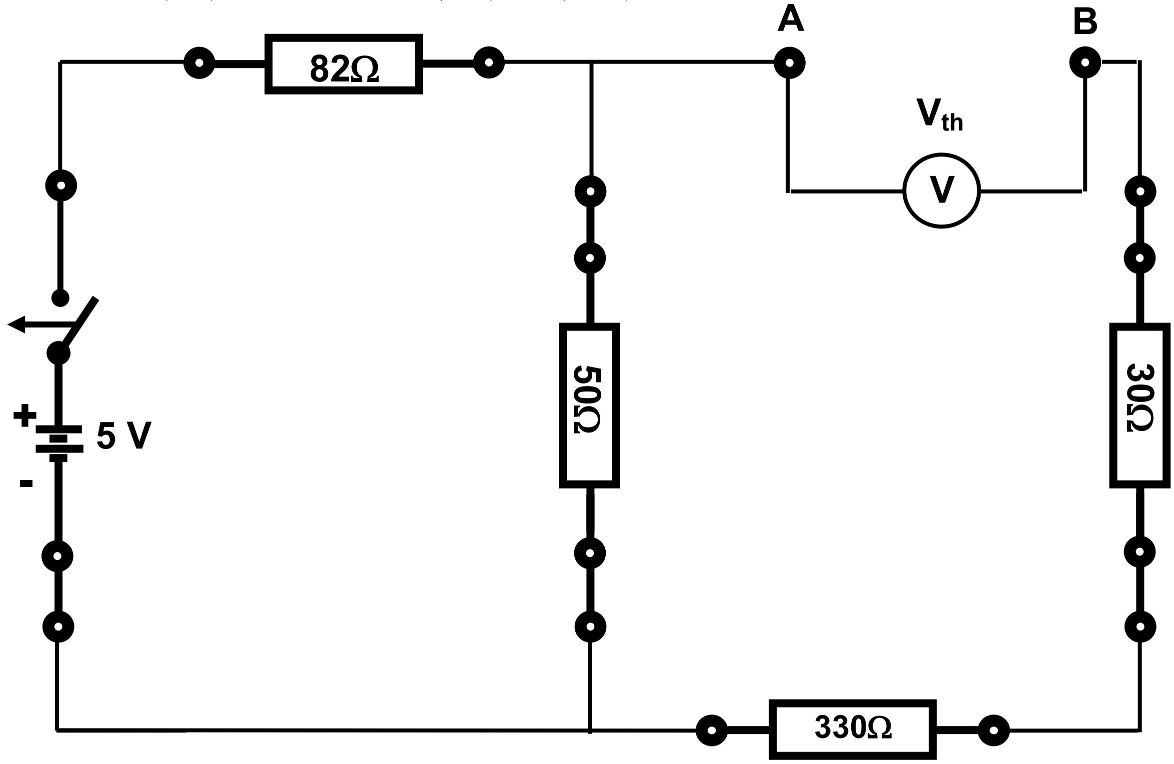


Procedure

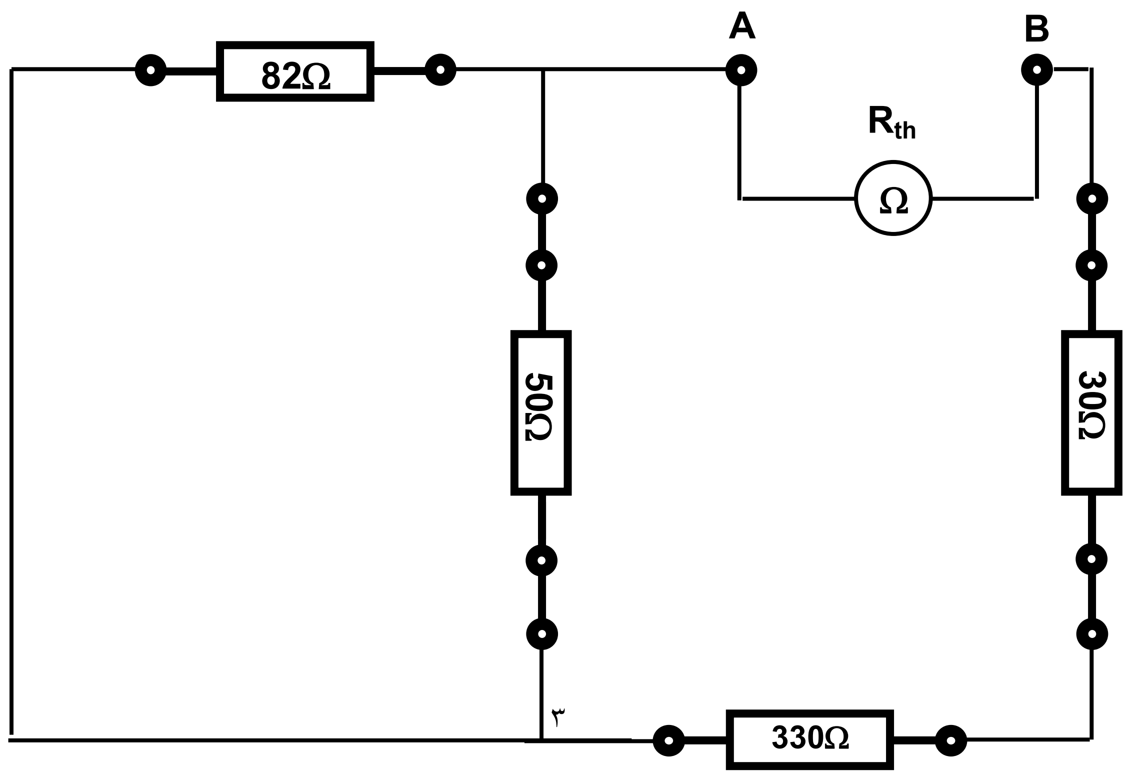
1. Using the DC circuit trainer, connect the circuit shown below.
2. Measure the current and voltage of R_L and record it.



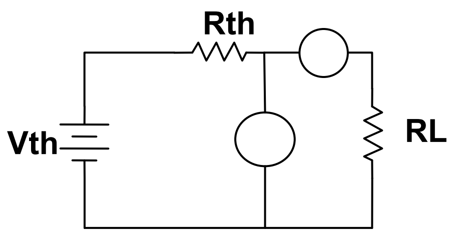
3. Remove **(R_L)** and measure **(V_{th})** or **(V_{AB})** as shown below



4. Replace voltage source by short cct , then measure **(R_{th})** or **(R_{AB})**



5. Using the DC circuit trainer, connect the circuit shown in figure below **(Thevenin's equivalent circuit)** according to the results from step (3) & (4) and then measure **(I_L &V_L).**

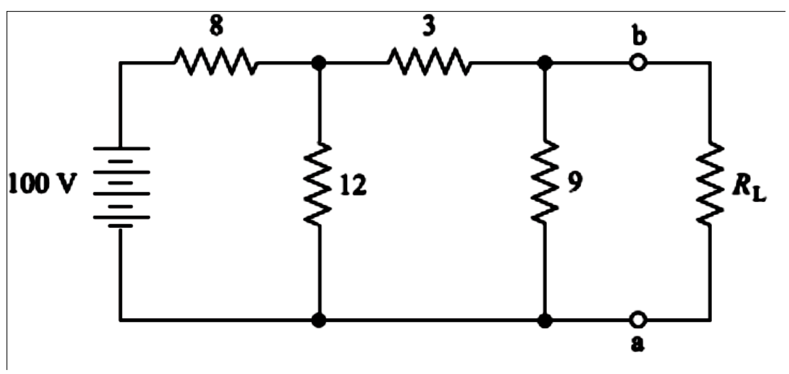


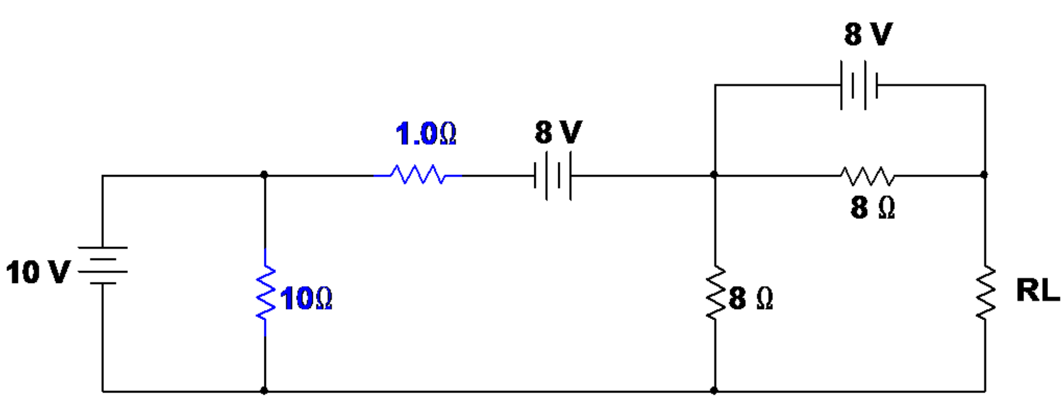
Thevenin s equivalent cct

6. Repeat the steps (2 to 5) by using RL = (30,330,50,82)

Discussion and calculation

1. Compare between the practical and Theoretical results.
2. Comment on the results
3. Find Thevenin's equivalent circuit for the circuit shown below





Experiment No.11
Norton's Theorem

Aim of experiment: To investigate *Norton's* theorem practically.

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

Another widely used network theorem, called **NORTON'S THEOREM**, makes use of a theoretical, but very useful, device called a **CONSTANT-CURRENT GENERATOR**. As the name says, a ''constant-current generator'' is a theoretical generator that delivers the *same constant current to all finite load resistances* it is connected to.

Norton's theorem is expressed in terms of the short-circuit current delivered by the network, and in terms of conductances instead of resistances. This makes Norton's theorem especially useful in the study of parallel circuits. The statement of Norton's theorem is as follows,

The current in any load conductance GL, when connected to two terminals of a network, is the same as if GL connected to a constant-current generator whose constant current is equal to the current that flows between the two terminals when they short-circuited together. This constant-current generator then being put in parallel with a conductance equal to the conductance seen looking back into the open-circuited terminals of the network. (In this last step, all generators removed and replaced with conductances equal to their internal conductances.)

Norton's theorem is summarized graphically in Fig.(1), where $\mathbf{I_{sc}}$ is the short-circuit current that flows from the network when terminals a, b are ''shorted'' together. $\mathbf{G}_g$ is the conductance seen looking back into the network with the terminals open-circuited, that is, with the switch open.

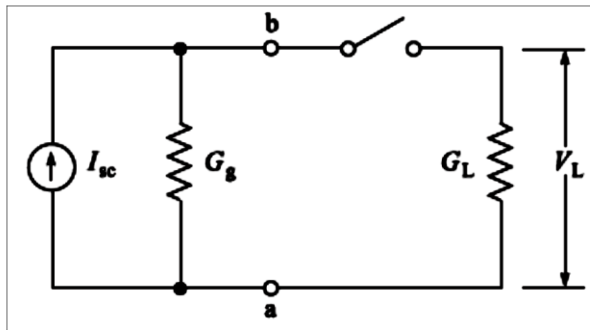


Fig.(1)

Practical procedure for finding Norton's equivalent circuit:-

- Remove the resistance (if any) across the two given terminals and put a short circuit across them.
- Compute short-circuit current I_{sc}.
- Remove all voltage sources but retain their internal resistances, if any.
- Next find the resistance $\mathbf{R_i}$ of the network as looked into from the given terminals.
- The current source (I_{sc}) joined in parallel across $\mathbf{R_i}$ between the two terminals gives Norton 's equivalent circuit.

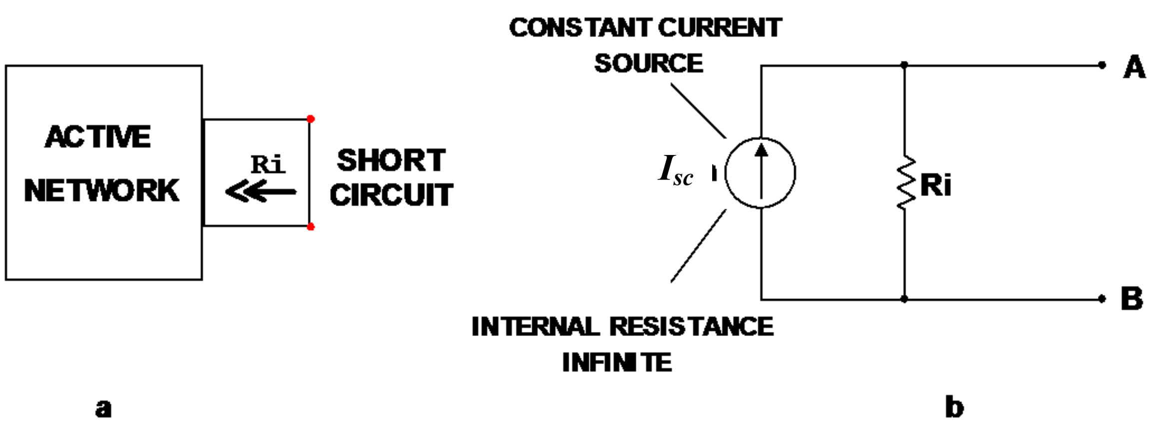
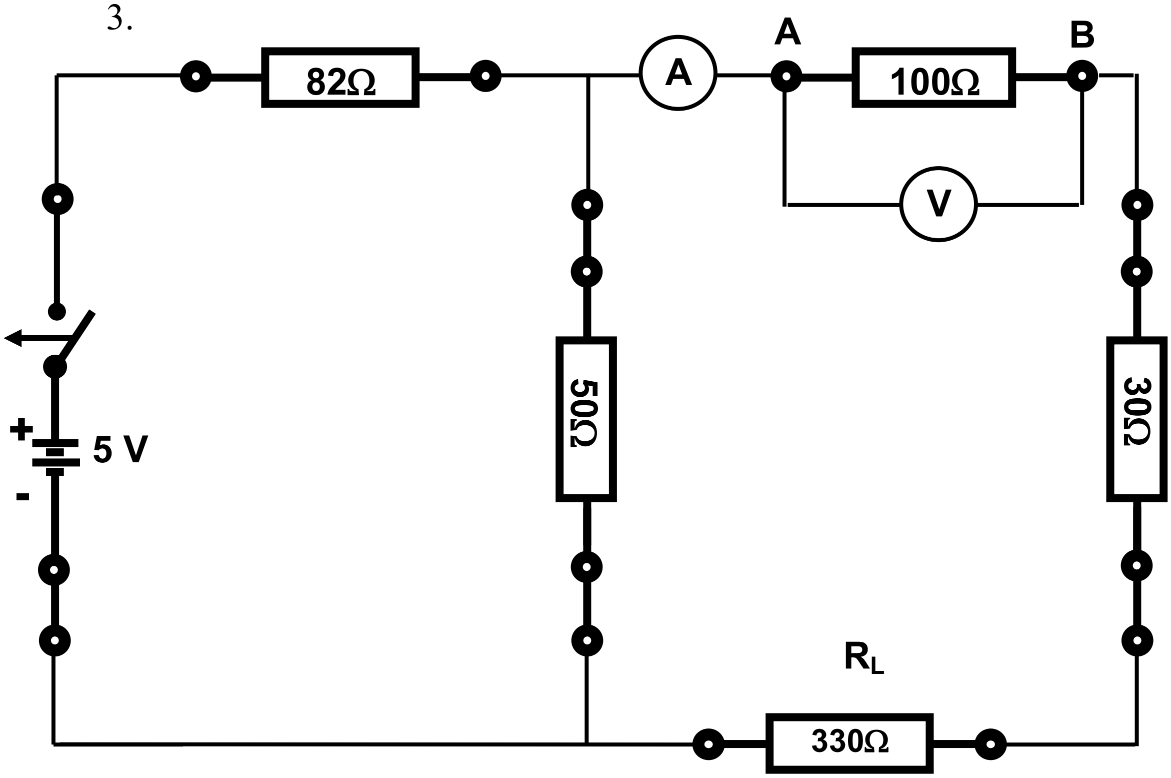


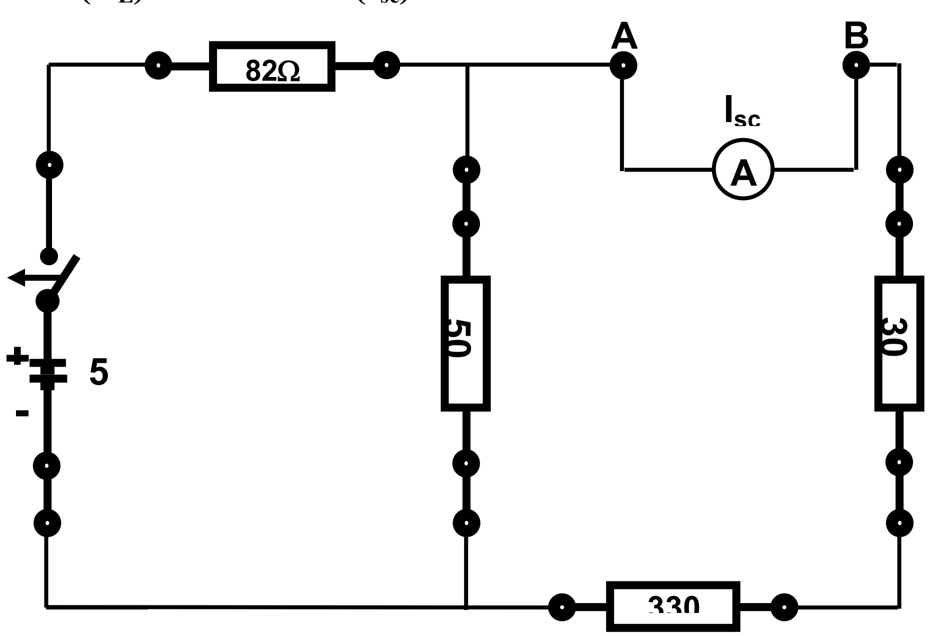
Fig.(2)

Procedure

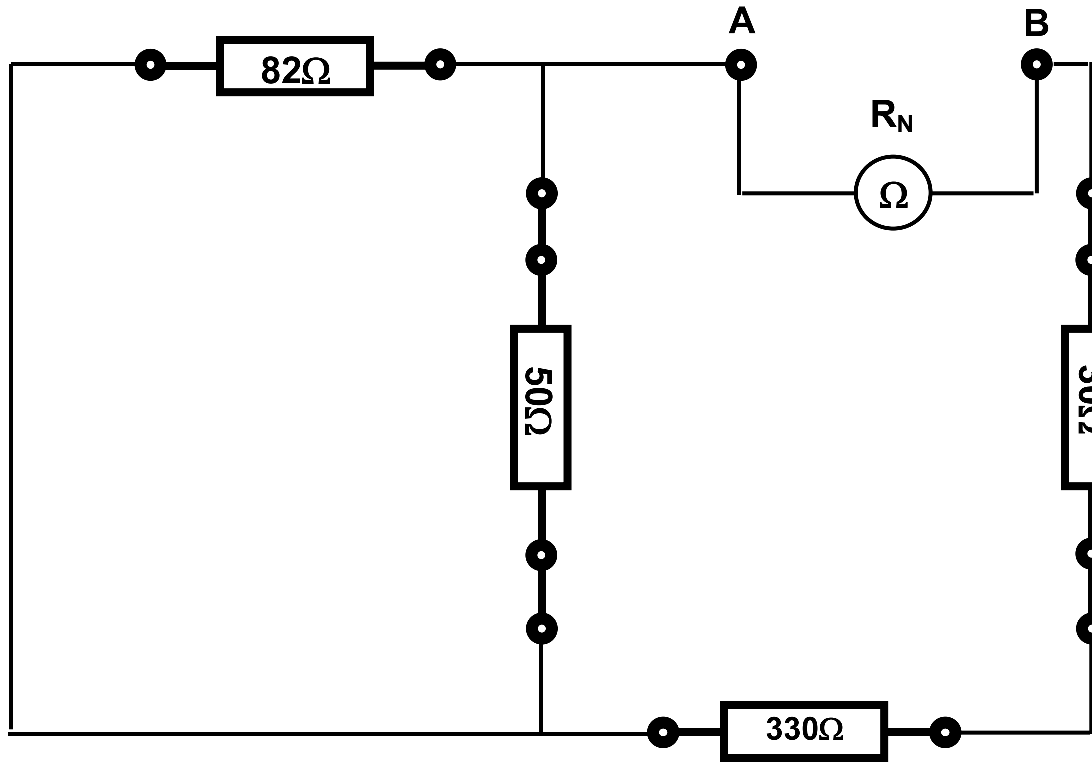
1. Using the DC circuit trainer, connect the circuit shown below.
2. Measure the current and voltage of R_L and record it.
3.



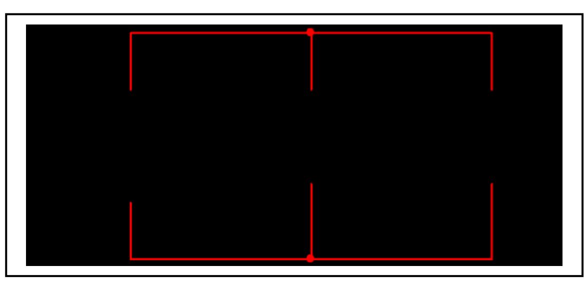
3. Remove **(R_L)** and measure **(I_{sc})** as shown below



4. Replace voltage source by short cct , then measure **(R_N)** or **(R_{AB})**

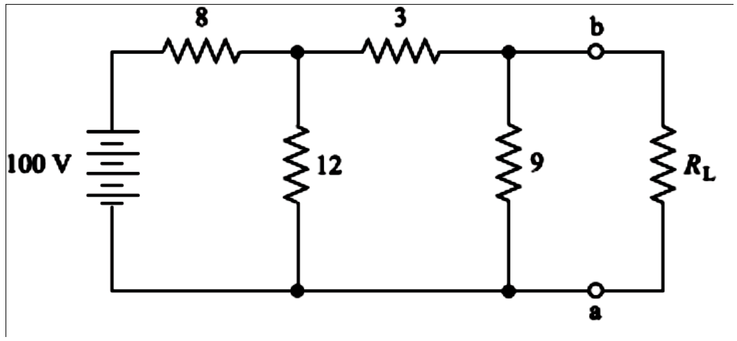


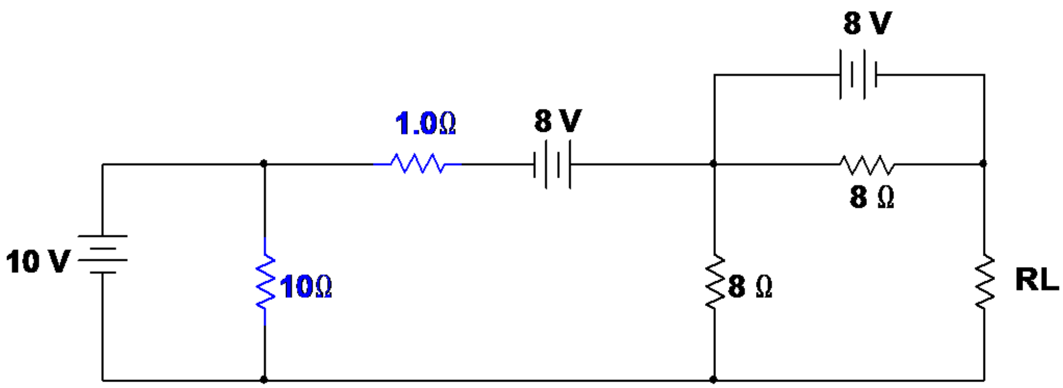
5. Connect the circuit shown in figure below **(Norton □s equivalent circuit)** according to the results from step (3) & (4) and then measure **(I_L &V_L).**



<u>Discussion</u>

1. Compare between the practical and Theoretical results.
2. Comment on the results
3. Find Norton □s equivalent circuit for the circuit shown below


8
3
b
100 V
12
9
R_L
a


8 V
1.0Ω
8 V
8 Ω
10 V
10Ω
8 Ω
RL

Experiment No.12

Superposition Theorem

Aim of experiment: To study Superposition theorem practically.

Apparatus

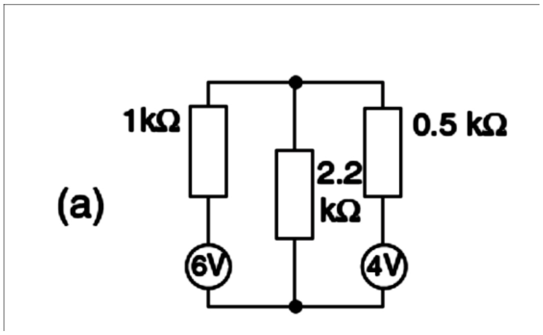
1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

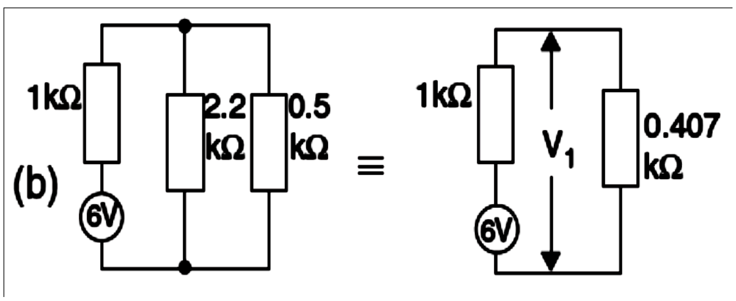
The superposition theorem is very useful for finding the voltages and currents in a circuit with two or more sources of supply, and is usually easier to use than Kirchoff 's law equations. One supply is selected and the circuit is redrawn to show the other supply (or supplies) short-circuited (leaving only the internal resistance of each supply). The voltage and current caused by the first supply can then be calculated, using **V = RI** methods together with the rules for combining series and parallel resistors. Each supply is treated in turn in the same way, and finally the voltages and currents caused by each supply are added.
Hence, this theorem may be state as follows:

In a network of linear resistances containing more than one generator (or source of e.m.f.), the current which flows at any point is the sum of all the currents which would flow at that point if each generator were considered separately and all the other generators replaced for the time being by resistances equal to their internal resistances.

Example: In the network shown, find the voltage across the 2.2 kΩ resistor.



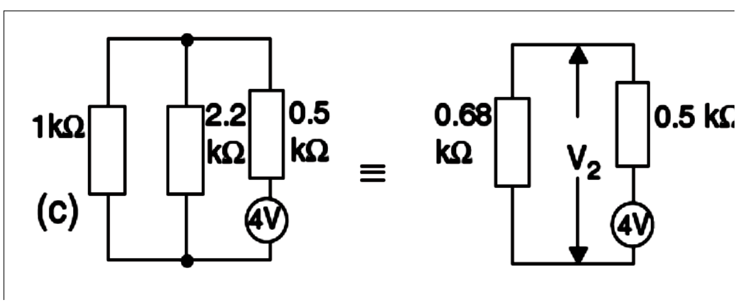
In this network, there are two generators and three resistors. The generators might be batteries, oscillators, or other signal sources.



To find the voltage caused by the 6V generator, replace the 4V generator by its internal resistance of 0.5kΩ. Using Ohm's law, and the potential divider equation: V = 1.736V.

To find the voltage caused by the 4 V generator, the 6 V generator is replaced by its 1kΩ internal resistance. In this case: V = 2.315 V.

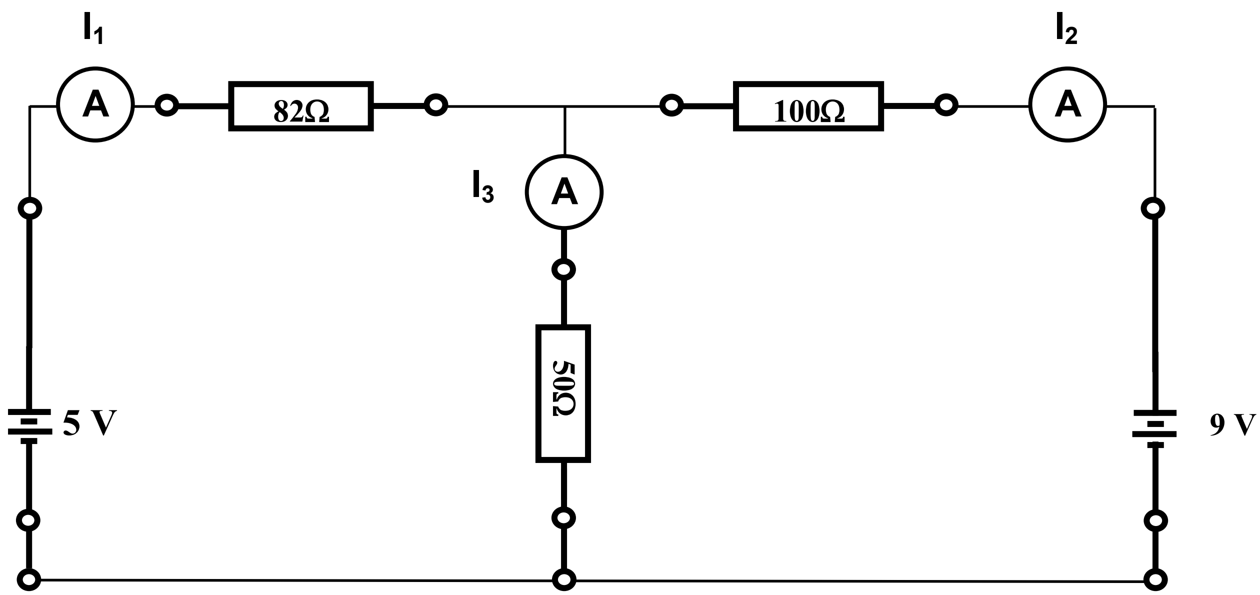
Now the total voltage in the original circuit across the 2.2kΩ resistor is simply the sum of these: 4.051 V



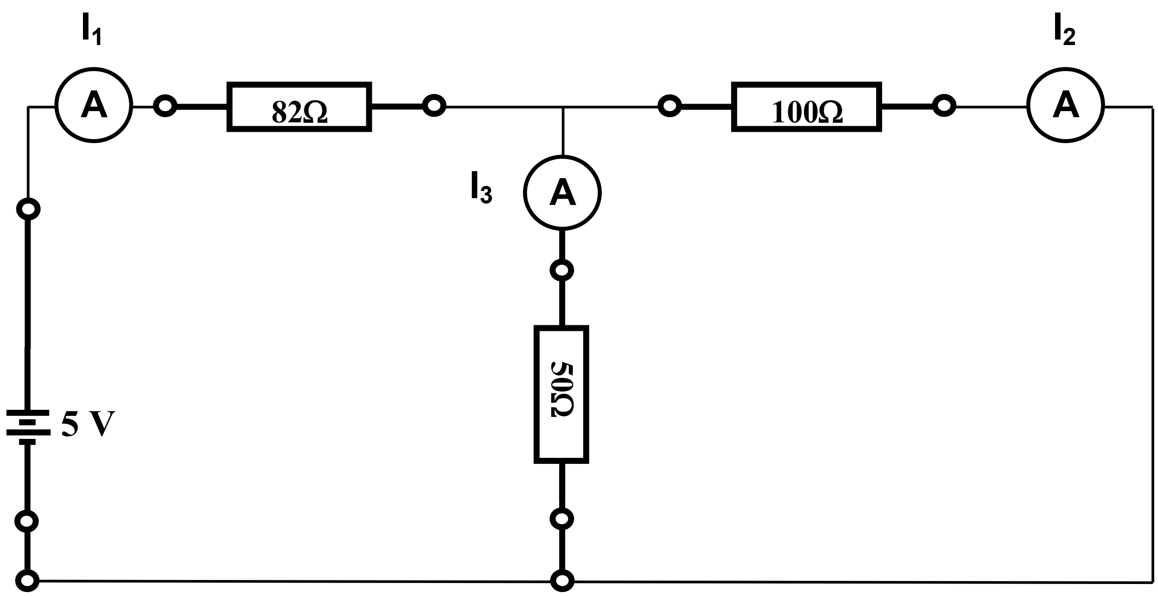
Procedure

1. Connect the circuit shown below.
2. Measure values of **(I_1 , I_2 , I_3)** and record it in the table

I_1 (mA)	I_2 (mA)	I_3 (mA)



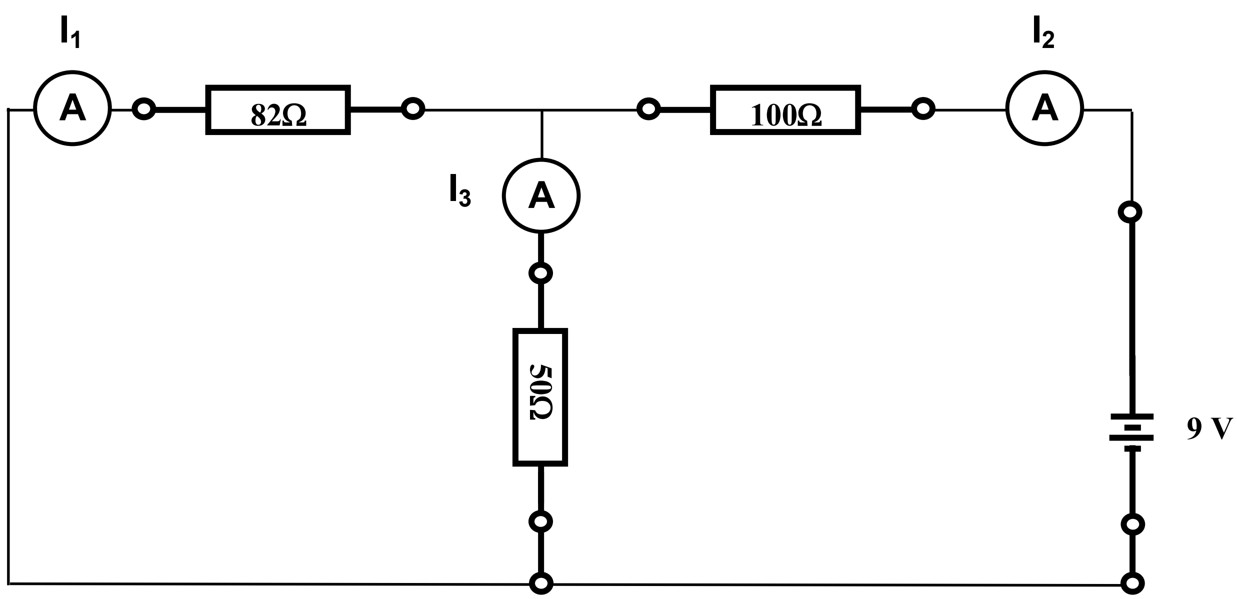
3. Connect the circuit below, when V_1 = on and V_2 = short



4. Measure values of **(I_1 , I_2 , I_3)** and record it in the table

I_1 (mA)	I_2 (mA)	I_3 (mA)

5. Connect the circuit below, when V_1 =short and V_2 = on



5. Measure values of **(I_1 , I_2 , I_3)** and record it in the table

I_1 (mA)	I_2 (mA)	I_3 (mA)

6. From results, calculate the current pass through each resistor and voltage across each resistor.

Discussion

1. Compare between the theoretical and practical results.
2. Comment on your results.
3. Find (I_a) by using superposition theorem for the circuit below.

Experiment No.(13)
Maximum Power Transfer Theorem

Aim of experiment: To prove Maximum Power Transfer theorem practically.

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory

The power transferred from a supply source to a load is at its maximum when the resistance of the load is equal to the internal resistance of the source. On the other words" A resistive load will be consumptive maximum power from the supply when the load resister is equal to the equivalent (Thevenin) network resister"

$R_L = R_{th}$ ……. **For maximum power transfer.**

$$I_L = V_{th} / (R_{th} + R_L)$$
$$= V_{th} / (R_{th} + R_{th})$$
$$= V_{th} / 2 R_{th}$$

Where,

$$P_{max} = I_L^2 R_L$$
$$= V_{th}^2 / 4R_{th}$$

A graph of R_L against P is shown in Fig.(1), the maximum value of power which occurs when $R_L = R_{th}$.

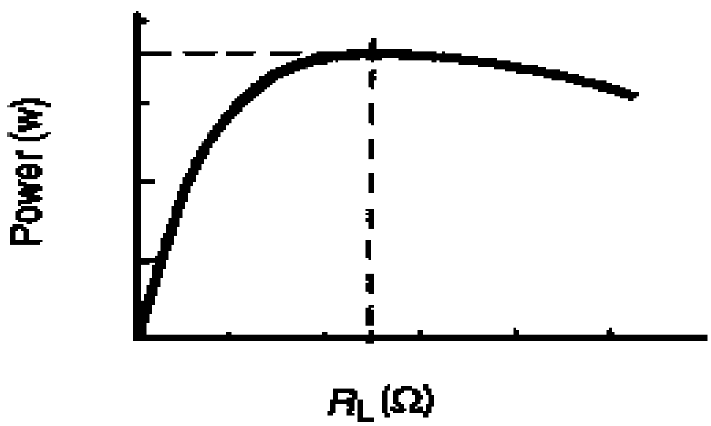
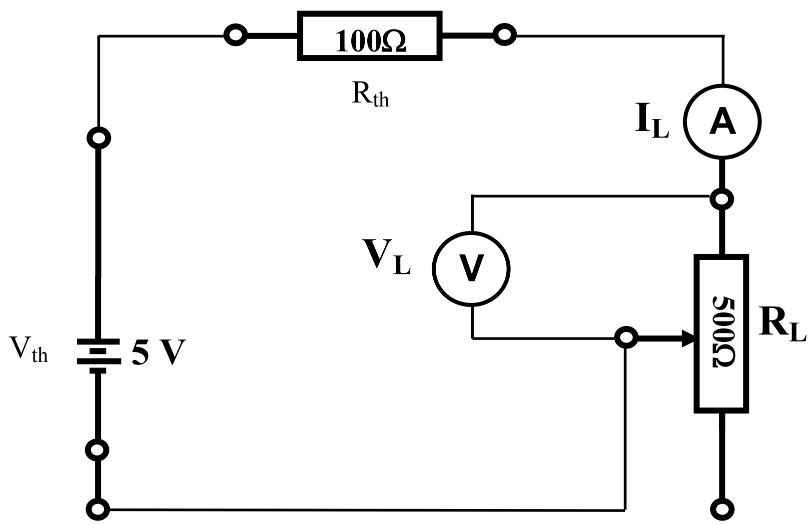


Fig.(1)

Procedure

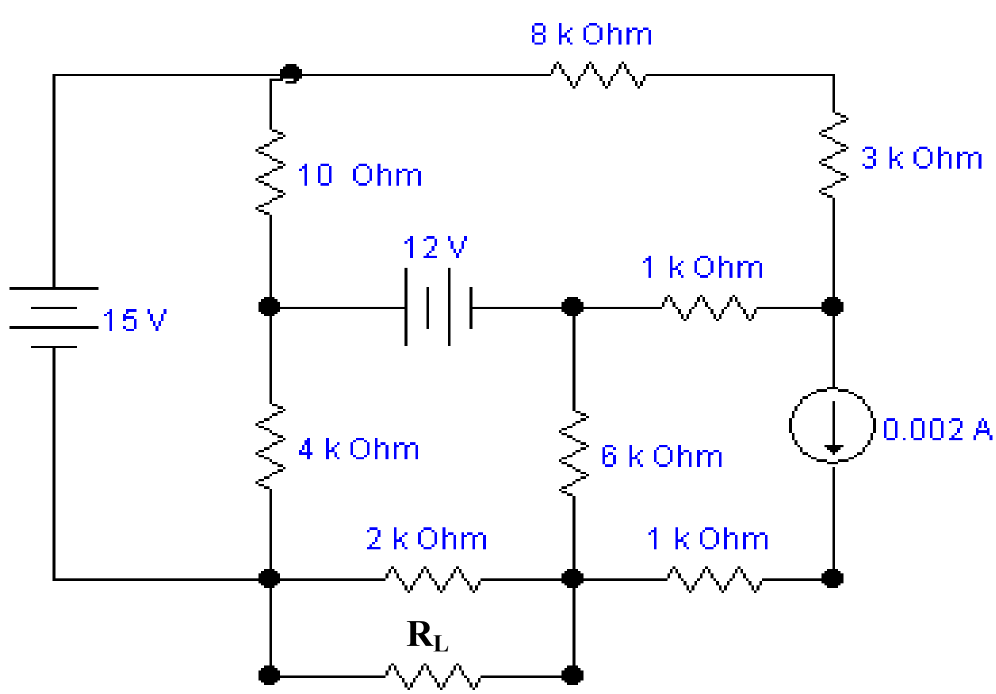
1. Connect the circuit shown in figure below. From the circuit, we can note that **R_{th}=100Ω** and **V_{th}=5V**.
2. Change the value of **R_L** in steps as shown in table.
3. Measure the voltage **"V_L"** and current **"I_L"** and record it in the table.
4. Repeat steps (2-3) by using R_{th} = 150**Ω**

R(Ω)	**20**	**40**	**60**	**80**	**100**	**120**	**150**	**180**	**220**	**300**
$I_{L(mA)}$										
V_L(volt)										
Power										



Discussion and calculation:

1. Plot the curve of the power against the load resistance and determine the maximum power.
2. Compare between the theoretical and practical results.
3. Comment on your results.
4. Find $\mathbf{R_L}$ for the maximum power transfer in the circuit shown.



Experiment No.(14)

Reciprocity theorem

Object

Verification of Reciprocity theorem

Apparatus

1. DC circuit training system
2. Set of wires.
3. DC Power supply
4. Digital A.V.O. meter

Theory:-

In any bilateral linear network containing one or more generators the ratio of a voltage introduced in on mesh to the current (I) in any second mesh is the same as the ratio obtained if the position of voltage and current are interchanged other emf being removed .Let us consider a general network.

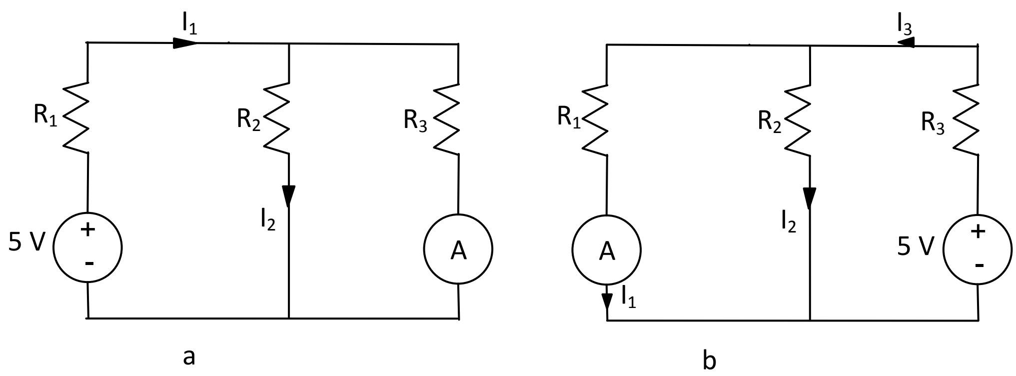


Fig (1)

Procedure:-

1- Using the DC circuit trainer, connect the circuit Shown in Fig. (1-a) , take V =5V, and R_1=10kΩ, R_2 = 100Ω and R_3 =1kΩ.

2- Measure the voltage and current of "R_1 , R_2 & R_3", then record it in table below

	10kΩ	**100Ω**	**1kΩ**	**$R_{T=}$**
V(volt)				**V_T =**
I(mA)				**I_T =**

3- Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

4- Change the voltage supply position shown in fig (1-b) .

5- Measure the voltage and current of "R_1 , R_2 & R_3", then record it in table below

	82Ω	**50Ω**	**150Ω**	**$R_{T=}$**
V(volt)				**v_T =**
I(mA)				**I_T =**

6- Disconnect the DC power supply, and then measure the equivalent resistance by using the AVO meter only.

Discussion and Calculation:-

1. Compare between the theoretically and practical results.

2. in the network of Fig. (2), find (a) ammeter current when battery is at A

and ammeter at B and (b) when battery is at B and ammeter at point A. Values of various resistances

are as shown in fig(2).

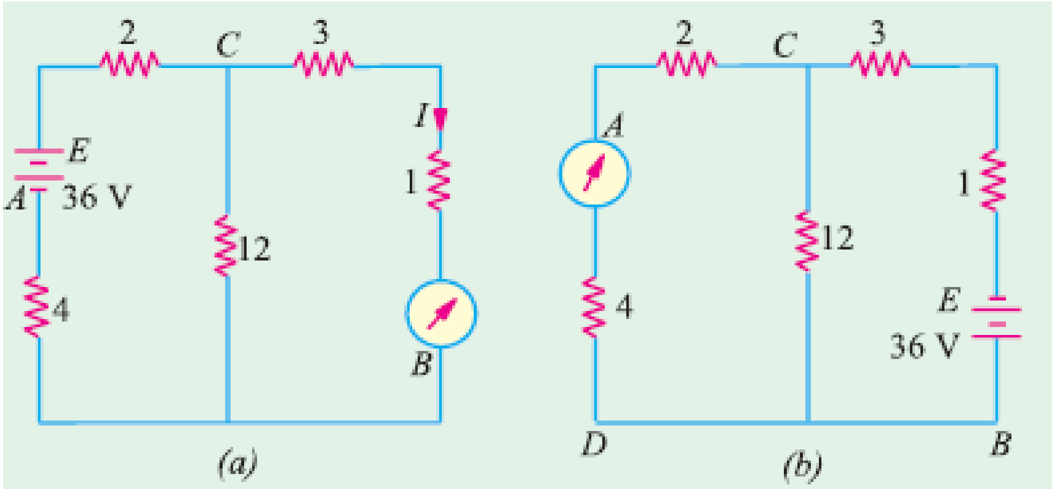


Fig (2)