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DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY
COURSE NO.: EEE 172

EXPT. NO. 1

NAME OF THE EXPT.: CONSTRUCTION & OPERATION OF SIMPLE ELECTRICAL CIRCUITS

OBJECTIVE:

The experiment is to acquaint the students with some simple circuits and to make them familiar with diagram reading, drawing and wiring with the help of different types of switches (SPST- Single pole single throw, SPDT- single pole double throw, DPST- Double pole single throw, DPDT- Double pole Double throw) that will be frequently encountered in different experiments.

INSTRUCTIONS:

Read the following procedure carefully and draw the circuit diagrams accordingly in the space allotted for each procedure and then implement it practically. Your report must contain neat diagrams of the circuits.

APPARATUS:

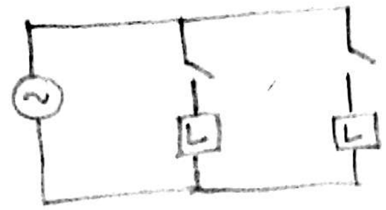
1) Two lamp boards (220v, 100w)
2) Two SPST, two SPDT and one DPDT switch.

PROCEDURE:

1. Connect an electric lamp so that it may be operated from a 220v ac supply using an SPST switch.

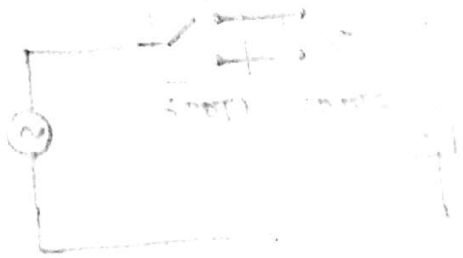
2. Connect a lamp so that it may be operated independently by either of two SPST switches.

3. Connect two lamps so that either may be operated from a common source by its own switch.

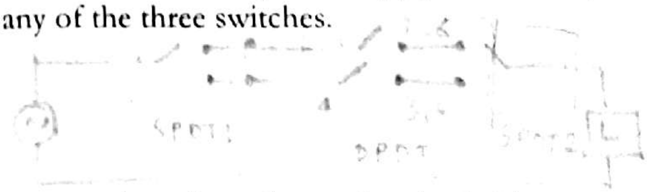


4. Connect two lamps so that both may be operated simultaneously from a common source by one SPST switch. Is it possible to do it in any other way? If possible, show both the diagrams and indicate the preferable one.

5. Connect a lamp so that it may be operated independently by either of two SPDT switches from a 220v source.



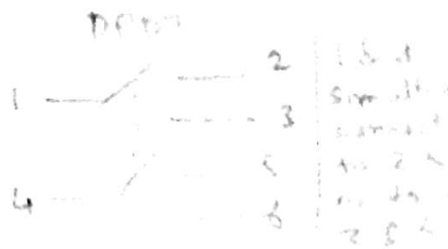
6. Connect a lamp using two SPDT and one DPDT switches to the power supply in such way so that the lamp may be turned ON/OFF by any of the three switches.



CAUTION:

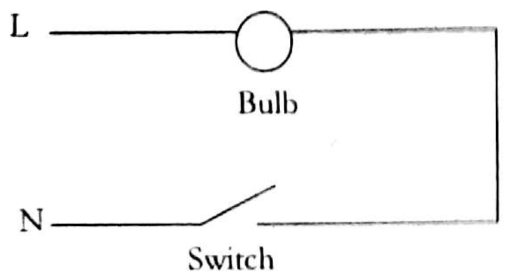
1. Don't switch on the supply until your teacher has checked the circuit.
2. Take care of the reading of the apparatus.
3. Take care of any bare circuit element in energized condition.
4. Put on shoes with good insulation.

QUESTIONS:



1. What is an electrical circuit?

2. What is a short circuit?
3. Which method in procedure 4 is preferable? Why?
4. What is the drawback of the following circuit in the connection of the switch?



6.

So the DPDT switch should be internally connected as

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EXPT. NO. 2

Verification of KVL & Voltage Divider Rule

OBJECTIVE :

This experiment is intended to verify Kirchhoff's voltage law (KVL) and voltage divider rule with the help of series circuits and derive equivalent resistance of the series circuit both experimentally and analytically.

THEORY:

KVL states that around any closed circuit the sum of the voltage rises equals the sum of the voltage drops.

$$\Sigma V_{RISES} = \Sigma V_{DROPS}$$

$$V_x = \frac{R_x}{R_s} \times V_s$$

The voltage divider rule is given by
The equivalent (total) resistance of a series circuit is given by

$$R_S = \Sigma R_X = R_1 + R_2 + R_3$$

Where X= 1, 2 & 3

*** While measuring resistance with multimeter, turn off the DC supply. Since, multimeter uses its own voltage to measure current through a resistance, and then calculate $R = \frac{V}{I}$, so external DC supply can cause overloading error.

APPARATUS:

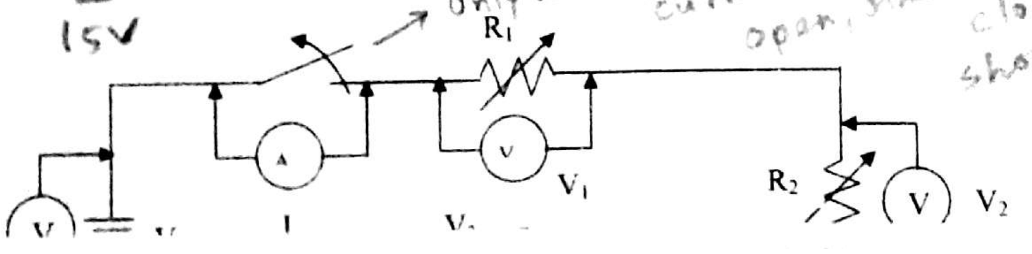
- One DC Voltmeter (0 - 300V)
- One DC Ammeter (0 - 5A)
- Three Rheostats
- One SPST switch → not needed
- One multimeter
- DC power supply

PROCEDURE:

1. Connect three rheostats R_1, R_2 and R_3 in series through a SPST switch to a DC power supply as shown in fig.
2. Apply 30 V DC from DC power supply.

15V

Only when you measure current, keep SPST open, otherwise keep it closed to short ammeter resistance



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3. Set the rheostats at their maximum value and take readings of V_1, V_2, V_3, V_S using a voltmeter, I using an ammeter and R_1, R_2, R_3 using a multimeter. Vary the rheostats in such a way that ammeter reading does not exceed the current rating of any of the rheostats. Take at least 5 sets of reading and enter it in the table.

4. Verify KVL (i.e. $V_S=V_1+V_2+V_3$) for each set of data. Find total resistance of the series circuit using the formula $R_S = R_1+R_2+R_3$. Compare this with experimentally obtained value $R_S=V_S/I$. Verify voltage divider for each set of data.

TABLE:

No of Obs.	V_S Volts	I Amps	V_1 Volts	V_2 Volts	V_3 Volts	$R_S=R_1+R_2+R_3$ Ohms	$R_S = V_S / I$ Ohms	$V_1+V_2+V_3$

REPORT :

1. Show the results in tabular form.
2. Comment on the results obtained and discrepancies (if any).

CAUTIONS:

1. Don't switch on the supply until the circuit has been checked by your teacher.
2. Take care of the reading of the apparatus.
3. Take care of any bare circuit element in energized condition.

QUESTION:

1. State the rules of connecting voltmeter and ammeters in the circuit.
2. If a ammeter is connected in parallel across an element what could be the possible danger.
3. " KVL is a restatement of the law of the conservation of energy"— justify the statement.

4. Why rheostats have current ratings in addition to resistance ratings?
5. "KVL is applicable for open circuit too"—verify.

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EXPT. NO. 3

VERIFICATION OF KCL & CURRENT DIVIDER RULE.

OBJECTIVE :

This experiment is intended to verify Kirchhoff's current law (KCL) & current divider rule with the help of parallel circuit and derive equivalent resistance of the circuit both experimentally and analytically.

THEORY:

KCL states that the sum of the currents entering any node equals the sum of the currents leaving the node.

$$\Sigma\ i_{entering} = \Sigma\ i_{leaving}$$

$$I_X = \frac{R_P}{R_X} \times I_S$$

The current divider rule is given by
Where, x = 1, 2 & 3.
The equivalent (total) resistance of a parallel circuit is given by the formula

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

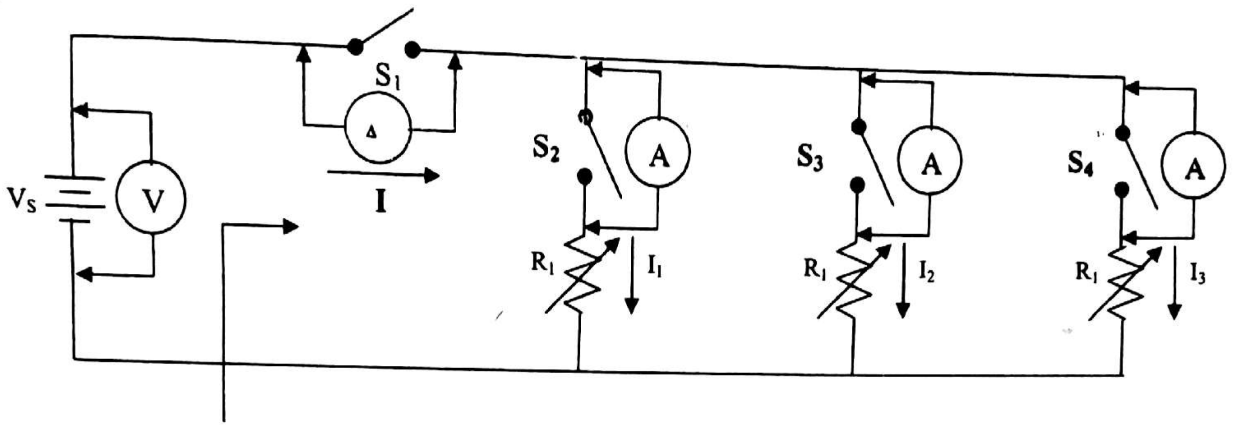
APPARATUS:

One DC Voltmeter (0 - 300V)
One DC Ammeter (0 - 5A)
Three Rheostat
Four SPST switches → not needed
One multimeter
DC power supply

PROCEDURE:

1. Connect three rheostats along with their own switches in parallel across the power supply as shown in figure.
2. Apply 60 V dc from dc power supply.

15 V



3. Set the rheostats R_1, R_2 & R_3 above 20Ω and measure V_S, I, I_1, I_2, I_3,R_1,R_2 &R_3.

4. Verify KCL (i.e. $I=I_1+I_2+I_3$) for each set of data.. Find total resistance of the parallel circuit using the formula. Compare this with experimentally obtained value $R_P=V_S/I$. Verify the current divider rule for each set of data.
5. Repeat steps 3 to 4 by changing R_1, R_2, R_3 and take five sets of readings

TABLE

Observation No.	V_S Volts	I Amps	I_1 Amps	I_2 Amps	I_3 Amps	$I_1+I_2+I_3$	R_P Ohms	$R_P = V_S / I$ Ohms

REPORT :

1. Comment on the obtained results and discrepancies (if any).
2. Show the results in tabular form.

CAUTIONS:

1. Don't switch on the supply until the circuit has been checked by your teacher.
2. Take care of the reading of the apparatus.
3. Take care of any bare circuit element in energized condition.

QUESTION:

1. Show analytically that for a parallel circuit

$$\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

2. "KCL is a restatement of the law of conservation of charge"---Justify the statement.

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3. "KCL is applicable for a closed surface too"---Explain. ?

KCL is applicable for capacitors too.

For A, what will be I outgoing ?

Due to accumulation of +ve charges on A, -ve charges [illegible] be induced in nearby atoms [illegible] gives rise to I outgoing.

* But what happens if there is vacuum btw^n 2 capacitor plates?

→ There will still be electric field around plates, but there won't be any atoms

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EXPT. NO. 4

NAME OF THE EXPT.: VERIFICATION OF SUPERPOSITION THEOREM.

OBJECTIVE:

To verify experimentally the Superposition theorem which is an analytical technique of determining currents in a circuit with more than one emf source.

THEOREM:

In a circuit (network) made up of linear elements (e.g. resistors) and containing two or more sources of emf, the current in any particular branch when all the emf sources are acting simultaneously may be found by considering the sources of emf to act one at a time, then finding the current in the specified branch due to each source and then superimposing, or adding algebraically, these component currents.

Note regarding Superposition theorem:
While the current due to a particular source of emf is being found the other emf sources are rendered inactive and if any branch element is in series with those sources that remains intact.

APPARATUS:

Two DC power supplies of suitable voltage and current ratings.
Three potentiometers each of 10KΩ rating. Rheostats were used due to their high current capacity
X Three DC voltmeters (0-5 V).
One multimeter.
X Trainer board
One DC Ammeter

PROCEDURES:

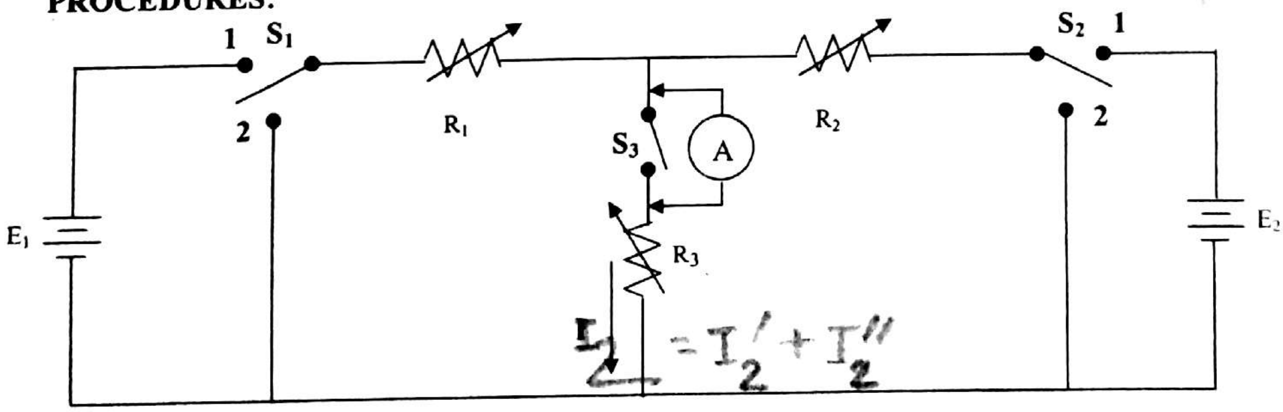

Fig. 1

1. Set up the network (circuit) as in Fig. 1.
2. Keep both sources active in the circuit by keeping the poles of SPDT s in proper position.

3. Apply 5 volts from E_1 and 10 volts from E_2.

4. Set the rheostats R_1, R_2, R_3 at such value so that none of the ammeter readings I_1, I_2, I_3 exceed the power supplies (E_1 and E_2 current ratings and the rheostat current) ratings.

5. Measure the current I_2 and record it in the given table.

6. Render E_2 inactive.

7. Measure the current I_2' in the branch R_2 and record it in the Table.

8. Render E_1 inactive.

9. Measure the current I_2'' in the branch R_2 and record it in the Table.

10. Verify if $I_2 = I_2' + I_2''$ which would validate the superposition theorem for this particular circuit.

11. Repeat steps 4 to 10 by changing R_1, R_2, and R3 and take a few more sets of readings.

TABLE:

Values of R_1, R_2, R_3 (ohms)	I_2 with both E_1 and E_2 active (amps)	I_2' with only E_1 active (amps)	I_2'' with only E_2 active (amps)

REPORT:

(1) Show the table
(2) Comment on the obtained results and discrepancies (if any).
(3) Find theoretically the current I_2 with reference to Fig. 1 applying the superposition theorem
Considering $E_1 = 15$ volts, $E_2 = 20$ volts and R_1, R_2, R_3 at their values recorded in no. 1 observation of the Table shown.

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EXPT. NO. 5

VERIFICATION OF THEVENIN'S THEOREM

OBJECTIVE:

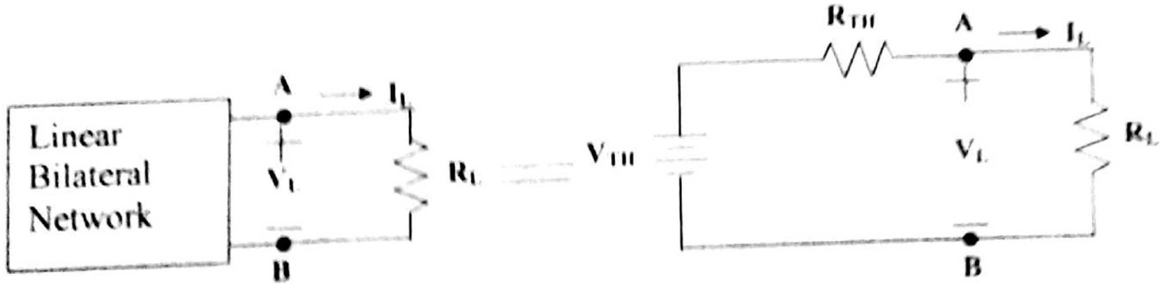
To verify Thevenin's theorem with reference to a given circuit theoretically as well as experimentally.

INTRODUCTION:

It is often desirable in circuit analysis to study the effect of changing a particular branch element while all other branches and all the sources in the circuit remain unchanged. Thevenin's theorem is a technique to this end and it reduces greatly the amount of computations which we have to do each time a change is made. Using Thevenin's theorem the given circuit excepting the particular branch to be studied is reduced to the simplest equivalent circuit possible and then the branch to be changed is connected across the equivalent circuit.

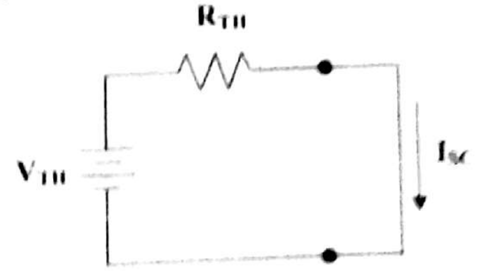
The Thevenin's theorem states that any two terminal linear bilateral network containing sources and passive elements can be replaced by an equivalent circuit consist of a voltage source V_{th} in series a resistor R_{th} where

V_{th} = The open circuit voltage (V_{OC}) at the two terminals A & B.
R_{th} = The resistance looking into the terminals A and B of the network with all sources removed.



There are several methods for determining Thevenin resistance R_{TH}. An attractive method for determining R_{TH} is : (1) determine the open circuit voltage, and (2) determine the short circuit current I_{SC} as shown in the figure; then

$$R_{TH} = \frac{V_{OC}}{I_{SC}}$$



APPARATUS :

Four Rheostats.
Ammeter (0-5 A).
Voltmeter (0-300 V).
DC Power Supply.
Three SPST Switches.

PROCEDURE :

For Original Circuit:

1. Arrange the original circuit as shown in figure 1. Keep the rheostats R_1, R_2 & R_3 at maximum position. (or at least above 20Ω each). Apply 30 V dc from dc power supply.
2. Measure V_L, I_L for three values of R_L & record the data in the table.

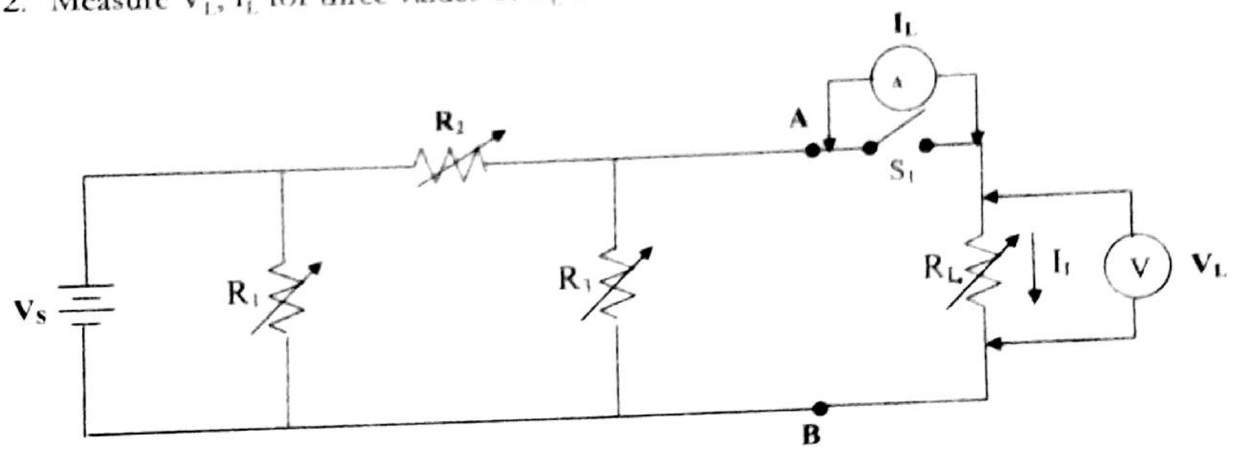


FIG.1: Original Circuit

FINDING V_{Th} & R_{TH} :

3. Remove the load resistance R_L and find the open circuit voltage between terminals A & B. This voltage is Thevenin voltage i.e. $V_{TH}=V_{OC}$.

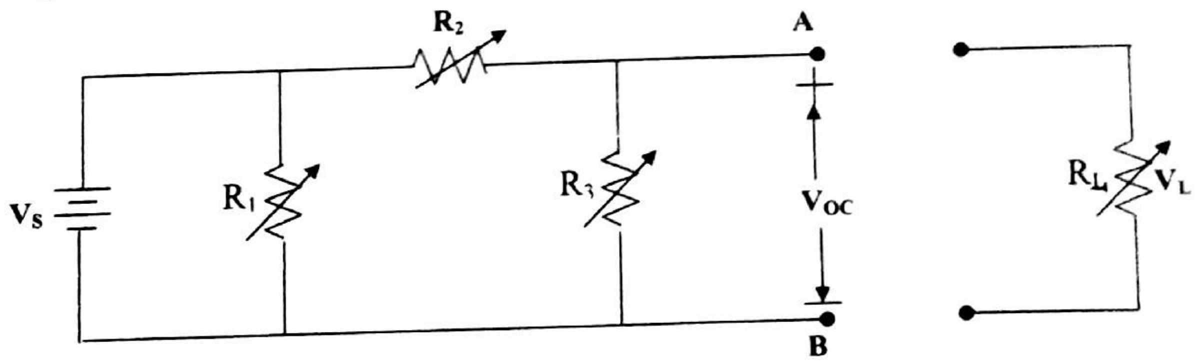


FIG.2: Circuit for finding V_{OC}.

... a short circuit between terminals A & B and find the short circuit current I_{SC}. Divide The open circuit voltage by the short circuit current to find the Thevenin resistance R_{TH} i.e.

$$R_{TH} = \frac{V_{OC}}{I_{SC}}$$

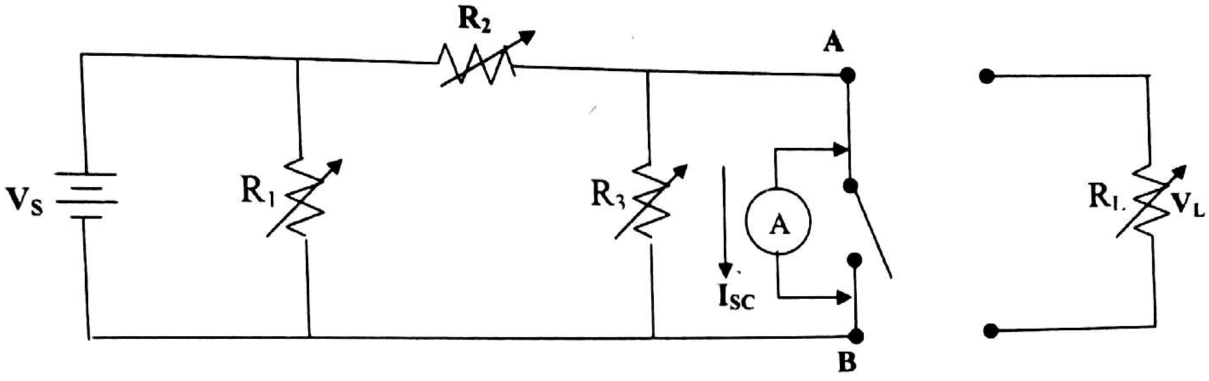


FIG.3: Circuit for finding I_{SC}

For Thevenin Equivalent Circuit:

5. Construct the Thevenin's equivalent circuit as shown in figure 4 setting the power supply at V_{TH} volts and the rheostat at R_{TH} ohms. Now measure the load current I_L and the load voltage V_L for the values of R_L determined in step 2. Compare these values with previous values.

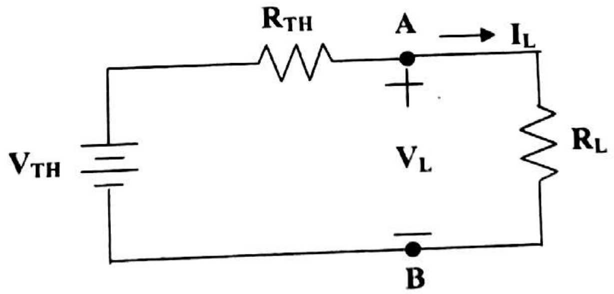


FIG.3: Thevenin Equivalent Circuit of Circuit1.

EXPERIMENTAL DATA:

Table1: Data for Original circuit R_1= , R_2= , R_3= , V_S=

No. of Obs.	Values of R_L	Load Voltage V_L	Load current I_L
1.			
2.			
3.			

V_{TH} = , R_{TH} =

Table2: Data for Thevenin equivalent circuit

No. of Obs	Values of R_L	Load Voltage V_L	Load current I_L
1.			
2.			
3.			

REPORT:

1. Find theoretically the Thevenin equivalent circuit for the values of R_0, R_2, R_3 & V_S recorded in table. Also find I_L, V_L.
2. Show the results in tabular form.
3. Comment on the results obtained and discrepancies (if any).

QUESTION:

1. Define unilateral, bilateral & equivalent circuit.
2. Describe other methods for determining Thevenin resistance.
3. Mention the advantages of using Thevenin Theorem.

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EXPT. NO.: 6

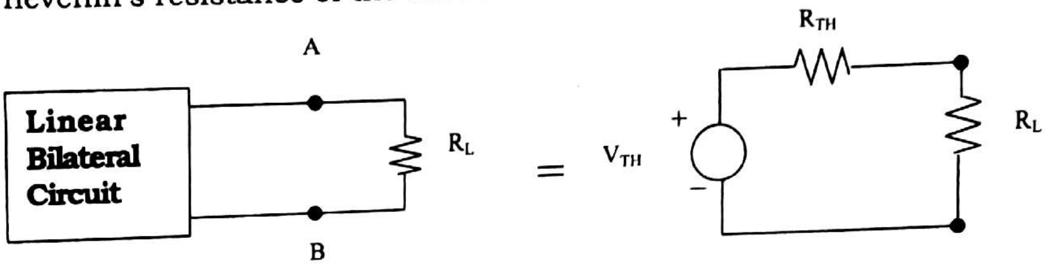
NAME OF THE EXPT.: VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM

OBJECTIVE:

The objective of this experiment is to verify maximum power transfer theorem.

THEORY:

The maximum power transfer theorem states that a resistive load will receive maximum power when its total resistive value is exactly equal to the Thevenin's resistance of the network as "seen" by the load.



We know that any circuit A terminated with a load R_L can be reduced to its Thevenin's equivalent. Now according to this theorem the load R_L will receive maximum power when

$$R_L = R_{TH}$$

The efficiency of power transfer is defined as the ratio of the power delivered to the load P_{OUT}, to the power supplied by the source P_{IN}.

$$\%\eta = \frac{P_{OUT}}{P_{IN}} \times 100 = \frac{V_L}{V_{TH}} \times 100 = \frac{R_L}{R_L + R_{TH}} \times 100$$

The voltage regulation is defined as

$$\%VR = \frac{\text{Load voltage at no load} - \text{Load voltage at full load}}{\text{Load voltage at full load}} \times 100$$

$$= \frac{V_{TH} - V_{TH} \times \frac{R_L}{R_L + R_{TH}}}{V_{TH} \times \frac{R_L}{R_L + R_{TH}}}$$

$$= \frac{R_{TH}}{R_L} \times 100$$

At maximum power transfer condition, η= 50 % & VR= 100 %.
A relatively low efficiency of 50 % can be tolerated in situations where power levels are relatively low such as in electronic & communications

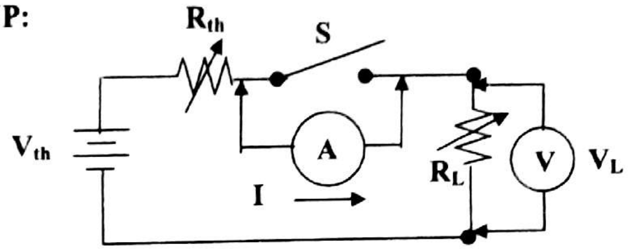
circuits for transmission & reception of signal where the Engineer's goal is to receive or transmit maximum amount of power.

However, when large power levels are involved, such as at generating stations, efficiencies of 50 % would not be acceptable. The goal here is high efficiency and not maximum power. Power utility systems are designed to transmit the power to the load with the greatest efficiency by reducing the losses on the power lines. Thus the effort is concentrated on reducing R_{TH}, which would represent the resistance of the source plus the line resistance.

APPARATUS:

1. One DC voltmeter
2. One DC Ammeter
3. DC power supply
4. Rheostats (R_{TH}= 22Ω, R_L= 44Ω)
5. One SPST switch
6. Wires & Chords

EXPERIMENTAL SETUP:



PROCEDURE:

1. Set up the circuit as shown in figure.
2. Apply 30V dc from dc power supply.
3. Keep the Thevenin rheostat, R_{th} (22Ω) at maximum position.
4. Vary the load rheostat (44Ω) from minimum to maximum value in step & measure the voltages V_L , & I. Take at least 15 sets of reading.
5. Keep the Thevenin rheostat at another position & repeat step4.

EXPERIMENTAL DATA:

No. of Obs.	V_{TH}	V_L	I	$P_{IN}=V_{TH}I$	$P_{OUT}=V_LI$	LOSS= $P_{IN}-P_{OUT}$	%η	%VR	$R_L=V_L/I$
1.									
2.									
3.									
4.									
5.									

REPORT:

1. Show the results in tabular form.
2. Plot the following curves on the graph paper

i) % η vs R_L

ii) % VR vs R_L

iii) loss vs R_L

iv) P_{OUT} vs R_L

v) I_L vs R_L

vi) V_L vs R_L

QUESTIONS:

1. Why high voltage transmission is used in case of transmitting electric power?
2. Where maximum power transfer is used?
3. Why instead of transmitting maximum power, power utility transmits power at maximum efficiency?
4. Deduce the condition for maximum power transfer.

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EEE 172
EXP NO.- 7

FAMILIARIZATION WITH ALTERNATING CURRENT (AC) WAVES

OBJECTIVE:

To study ac (sinusoidal) wave forms and correlate them with practically measurable effective values. An understanding on a simple ac circuit is also expected to be developed in the experiment.

INTRODUCTION:

Any periodic variation of current or voltage where the current (or voltage), when measured along any particular direction, goes positive as well as negative, is defined to be an AC quantity. Sinusoidal AC wave shapes are the ones where the variation (current or voltage) is a sine function of time.

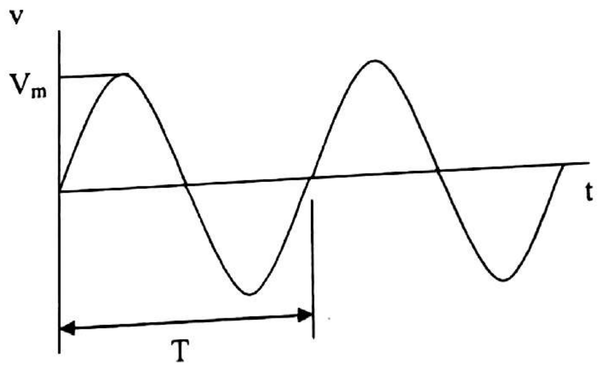

Fig 1. An ac (sinusoidal) voltage waveform

For the wave form in Fig.1,

Time period = T
Frequency f = 1/T
$v = V \sin 2\pi ft = V \sin(2\pi / T)t$

EFFECTIVE VALUE:

Effective (rms) values of sinusoidal waveforms are given as:

$$V = \sqrt{\frac{1}{T}\int_0^T v^2 dt} = \frac{V_m}{\sqrt{2}} \quad \text{(For sinusoidal wave)}$$

$$I = \sqrt{\frac{1}{T}\int_0^T i^2 dt} = \frac{I_m}{\sqrt{2}} \quad \text{(For sinusoidal wave)}$$

These values are directly measured in ac voltmeter / ammeters and can be used in power calculation as:

$P = I^2 R = V^2 / R$

PHASE DIFFERENCE:

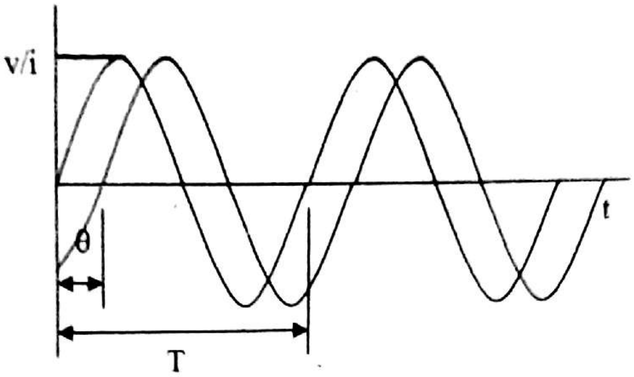

Fig 2. Two sinusoidal waves with phase difference

Phase difference between two ac sinusoidal waveforms is the difference in electrical angle between two identical points of the two waves. In fig. 2, the voltage and current equations are given as:

$$v = V_m Sin(2\pi / T)t$$
$$i = I_m Sin(2\pi / Tt - \theta)$$

IMPEDANCE:

Relation between the voltage across and the current through any component of an ac circuit is given by impedance. For the voltage and current waveforms in Fig. 2, the corresponding impedance Z is given as:

$$Z = V_m / I_m \angle\theta) = V_{rms} / I_{rms} \angle\theta$$

EQUIPMENT LIST:

- Oscilloscope
- Function generation
- Decade resistor
- Capacitor bank
- AC voltmeter
- AC ammeter
- SPST
- Breadboard

CIRCUIT DIAGRAM:

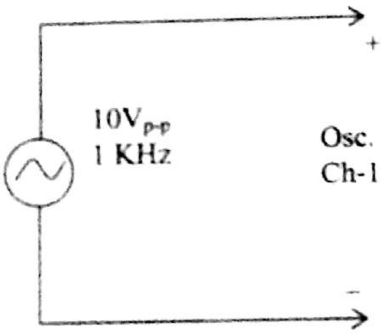

Fig 1

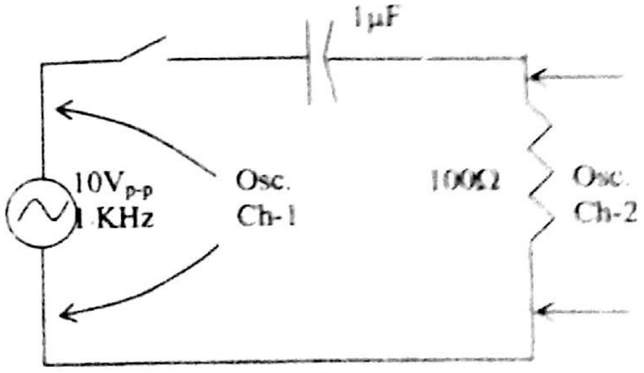

Fig 2

PROCEDURE:

1. Connect the output of the function generator directly to channel 1 of the oscilloscope as shown in fig 1. Set the amplitude of the wave at 10V and the frequency at 1 kHz. Select sinusoidal wave shape.
2. Sketch the wave shape observed on the oscilloscope. Determine the time period of the wave and calculate the frequency.
3. Measure the voltage with an ac voltmeter.
4. Change the frequency to 500Hz and note what happens to the display of the wave. Repeat when the frequency is increased to 2 KHz.
5. Construct the circuit as shown in Fig. 2. Measure the input voltage with an ac voltmeter and the input current with an ac ammeter. The ration between the voltage and the current gives the magnitude of the impedance, Z.
6. Observe the wave shapes of oscilloscope channels 1 and 2 simultaneously. Find the frequency of both the waves and amplitude from the display. Determine the phase difference between the two waves. The phase difference is give by 360ft, where 't' is the time delay between the two waves. Also observe which of the two waves lead. Note that the voltage in channel 2 is the voltage across a resistance and hence this is in phase with the current flowing in the circuit.

REPORT:

1. Compare the frequency of the wave determined from the oscilloscope with the mentioned value on the function generator in step 2 of the procedure.
2. Calculate the rms value of the voltage observed in step 2 of the procedure and compare with that measured in step 3.
3. How does the time period vary when the frequency of the wave is changed in step 4?
4. Calculate the magnitude of the impedance from the readings taken in step 5.
5. Find the magnitude and the phase angle of the impedance from the readings taken in step 5 and 6.

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EXPT. NO:- 8

VERIFICATION OF KVL AND KCL USING REACTIVE ELEMENTS

OBJECTIVE:

The objective of this experiment is to study RLC series and series-parallel circuits when energized by an AC source and to construct their phasor diagram. KVL and KCL in phasor form will also be verified.

EQUIPMENT:

- Function Generator
- AC Voltmeter
- AC Ammeter
- Decade Resistor box
- Decade Inductor box
- Decade Capacitor box
- 120 ohm Resistor
- 1μF Capacitor
- SPST Switches
- Bread Board

CIRCUIT DIAGRAM:

P = S cos θ = VI

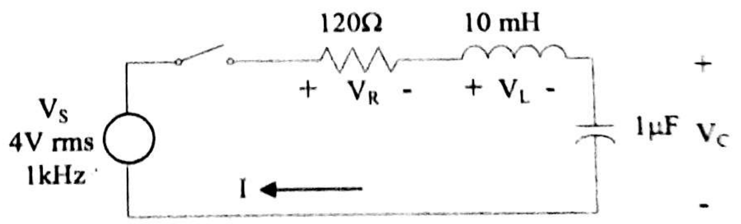

Fig. 1

VI + P1 + P2

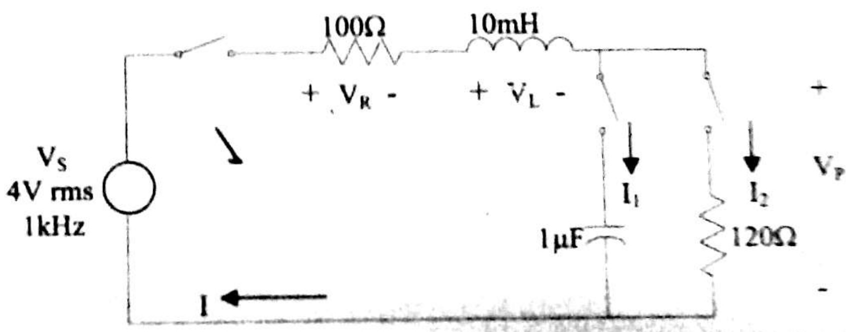

Fig. 2

PROCEDURE:

1. Construct the circuit as shown in Fig. 1. Set the function generator to supply a voltage of 4V rms at a frequency of 1kHz. Note that the voltage magnitude should be set after the source is connected to the circuit.
2. Measure the voltages V_R, V_L and V_C and the current I with the help of AC meters.
3. Construct the circuit of Fig. 2. The 100Ω resistance is obtained using the decade resistor box. Again set V_S=4V rms, f=1kHz. Now the function generator is connected to the circuit.
4. Measure the voltages V_R, V_L and V_P and the currents I, I_1 and I_2.

REPORT:

1. Theoretically calculate all the voltages and the currents in the circuits shown in Fig.1 and Fig. 2. Comment on the relative magnitudes I, I_1 and I_2 in the circuit of Fig. 2.
2. Assuming the circuit elements to be ideal, draw the phasor diagrams for both the circuits using the experimental data. The diagrams should be drawn to scale on graph paper.
3. From the phasor diagrams, express the voltages and the currents as phasors and compare those with the values calculated in step 1.
4. Show that the voltage and the current phasors obtained in step 3 satisfies KVL and KCL.

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EXPT. No.- 9

AC POWER MEASUREMENT USING WATTMETER

OBJECTIVE

The objective of this experiment is to use wattmeter in measuring power in ac circuits.

EQUIPMENT

Lamp board – 2
Capacitor Bank – 1
AC voltmeter – 1
AC ammeter – 1
Wattmeter – 1
SPST switches – 3

CIRCUIT DIAGRAM

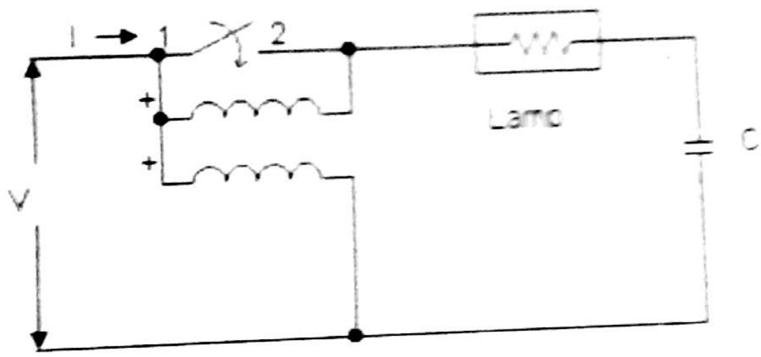

Figure 1

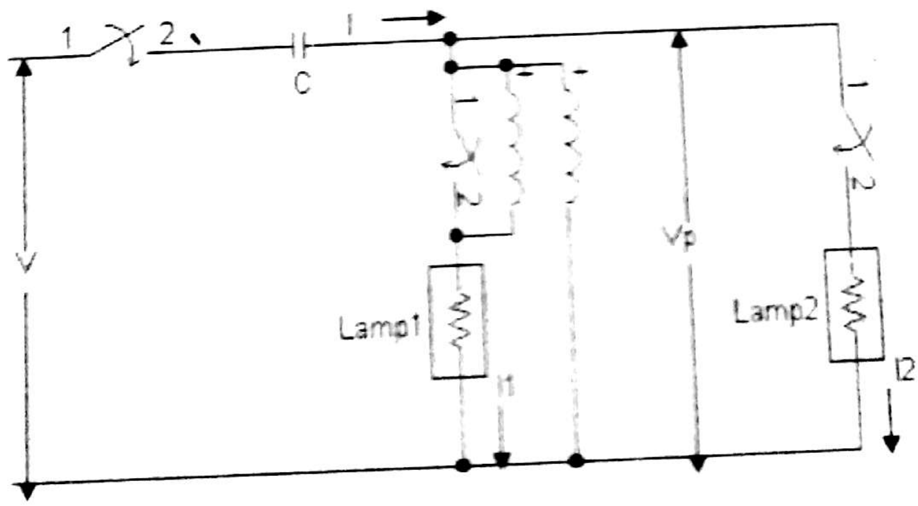

Figure 2

1. Connect the circuit in Fig. 1 without wattmeter. Measure V and I.

2. Connect the wattmeter as shown and measure the power W.

3. Put the potential coil of the wattmeter only across the lamp board. Measure the power W′.

4. Repeat steps 2, 3 for a different combinations of lamp and capacitance.

5. Connect the circuit in Fig 2 without wattmeter. Measure V, V_P, I, I_1 and I_2.

6. Connect the wattmeter to measure the total power W into the circuit.

7. Connect the wattmeter to measure power consumption (W_1 and W_2 respectively) in the two parallel branches.

REPORT

1. Compare/relate the wattmeter readings (W and W′ or W, W_1 and W_2) for both circuits. Give your comments.

2. Use your results to find out the values of individual circuit components and also the power factors of each circuit.