SASTRA

ENGINEERING · MANAGEMENT · LAW · SCIENCES · HUMANITIES · EDUCATION

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THINK MERIT | THINK TRANSPARENCY | THINK SASTRA

School of Electrical & Electronics Engineering

EEE105
PRINCIPLES OF ELECTRICAL ENGINEERING LAB
(For I Year/ I Semester B.Tech. CSBS)

Course Code: EEE105
Semester: I

PRINCIPLES OF ELECTRICAL ENGINEERING LAB

List of Experiments

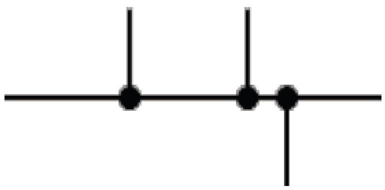
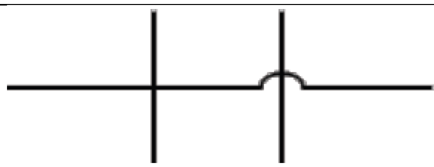
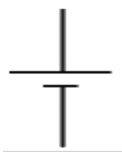
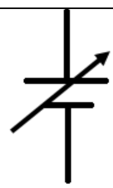
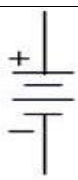
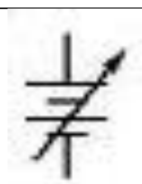
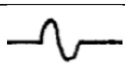
1. Familiarization of electrical Elements, sources, measuring devices and transducers related to electrical circuits
2. Verification of basic laws of electric circuits
3. Verification of voltage division and current division rules
4. Verification of Thevenin's and Norton's Theorem
5. Verification of Superposition and Maximum Power Transfer theorem
6. Simulation of R-L-C series circuits for X L > X C , X L < X C & X L = X C
7. Simulation of Time response of RC circuit
8. Verification of relation in between voltage and current in three phase balanced star and delta connected loads.
9. Demonstration of measurement of electrical quantities in DC and AC systems.
10. Voltage-current relationship in a R-L & R-C series circuits and to determine the power factor of the circuit
11. Domestic wiring
12. Demonstration of electric power supply system
13. Demonstration of statically induced EMF

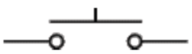
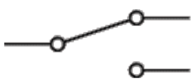
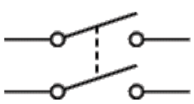
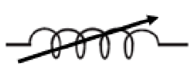
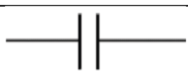
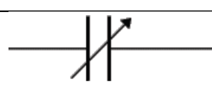
Laboratory Learning Outcomes

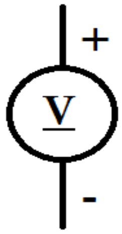
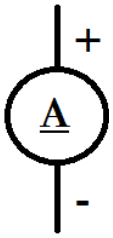
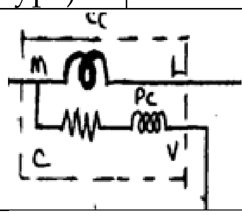
Upon successful completion of this course, the learner will be able to

- Analyze electric networks using basic laws and network theorems
- Interpret the simulation results of R-L-C series circuits
- Summarize the voltage-current relationship in three phase system
- Demonstrate domestic wiring and electric power supply system

BASIC SYMBOLS

Electrical Symbol	Components	Functions
	Wire	To pass current very easily from one part of a circuit to another.
	**Wires joined**	A 'blob' should be drawn where wires are connected (joined), but it is sometimes omitted. Wires connected at 'crossroads' should be staggered slightly to form two T-junctions, as shown on the right.
	**Wires not joined**	In complex diagrams it is often necessary to draw wires crossing even though they are not connected.
 Fixed Cell  Variable Cell	**Cell**	Supplies electrical energy. The larger terminal (on the top) is positive (+).
 Fixed Battery  Variable Battery	**Battery**	Supplies electrical energy. A battery is more than one cell. The larger terminal (on the top) is positive (+).
 AC Fuse  DC Fuse	**Fuse**	A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.
	**Earth**	A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.
	**Lamp (Lighting)**	A transducer which converts electrical energy to light. This symbol is used for a lamp providing

			illumination, for example a car headlamp or torch bulb.
		**Lamp (Indicating)**	A transducer which converts electrical energy to light. This symbol is used for a lamp which is an indicator, for example a warning light on a car dashboard.
		**Push Switch (push-to-make)**	A push switch allows current to flow only when the button is pressed. This is the switch used to operate a doorbell.
		**On-Off Switch (SPST)**	**SPST = Single Pole, Single Throw.** An on-off switch allows current to flow only when it is in the closed (on) position.
		**2-way Switch (SPDT)**	**SPDT = Single Pole, Double Throw.** A 2-way changeover switch directs the flow of current to one of two routes according to its position. Some SPDT switches have a central off position and are described as 'on-off-on'.
		**Dual On-Off Switch (DPST)**	**DPST = Double Pole, Single Throw.** A dual on-off switch which is often used to switch mains electricity because it can isolate both the live and neutral connections.
 Fixed inductor	 Variable Inductor	**Inductor (L)**	A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something.
 Fixed Capacitor	 Variable Capacitor	**Capacitor (C)**	A capacitor stores electric charge. A Capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.

 DC Voltmeters (MC type)	 AC Voltmeters (MI type)	**Voltmeters (V)**	A voltmeter is used to measure voltage. ➢ For AC circuit MI (Moving Iron) type is used. ➢ For DC circuit MC (Moving Coil) type is used.
 DC Ammeter (MC Type)	 AC Ammeter (MI Type)	**Ammeter (A)**	An ammeter is used to measure current. ➢ For AC circuit MI (Moving Iron) type is used. For DC circuit MC (Moving Coil) type is used.
		**Wattmeter**	The Wattmeter is used to find the power consumed at that instant time in watts.
 Transformer		**Transformer**	The Static Device which work on the principle of Mutual inductance (OR) Electromagnetic Induction and also used to convert the AC voltage. **Step up Transformer** - Low voltage to High voltage **Step down Transformer** – High voltage to Low voltage

Ex. No: 1 **FAMILIARIZATION OF ELECTRICAL ELEMENTS, SOURCES, MEASURING DEVICES AND TRANSDUCERS RELATED TO ELECTRICAL CIRCUITS**

Date :

AIM

1. To introduce the students to the basic electrical equipments in the lab.
2. To be able to deal with some of the frequently used instruments and equipment

THEORY

DC POWER SUPPLY

The DC power supply is used to generate either a constant voltage (CV) or a constant current (CC). That is, it may be used as either a DC voltage source or a DC current source. You will be using it primarily as a voltage source. Recall that DC is an acronym for direct current. The voltage produced by the power supply is controlled by the knob labeled voltage. The current is limited by adjusting the knob labeled current. As long as the circuit does not attempt to draw more current than the value set by the current knob, the voltage will remain constant. Current limiting allows the power supply to be set such that it will not generate more current than it is safe. This can be useful as a safety feature, preventing electrocution due to accidental contact with terminals. In addition, current limiting can prevent damage to equipment and parts which may be unable to handle excessive currents.

Task 1:

VOLTAGE MEASUREMENT.

1. Turn on the DC Power supply.
2. Make sure that the current knob is little bit above the minimum value.
3. Adjust the voltage knob at 6.5 V.
4. Measure the voltage value using the digital multimeter and write down the measured value.
5. Find the percentage of error for the measured values.
6. State the reasons of the error.

BREADBOARD

The breadboard consists of two terminal strips and two bus strips (often broken in the center). Each bus strip has two rows of contacts. Each of the two rows of contacts are a node. That is, each contact along a row on a bus strip is connected (inside the breadboard). Bus strips are used primarily for power supply connections but are also used for any node requiring a large number of connections. Each terminal strip has 60 rows and 5 columns of contacts on each side of the center gap. Each row of 5 contacts is a node.

You will build your circuits on the terminal strips by inserting the leads of circuit components into the contact receptacles and making connections with 22–26-gauge wire. There are wire cutter/strippers and a spool of wire in the lab. It is a good practice to wire +5V and 0V power supply connections to separate bus strips.

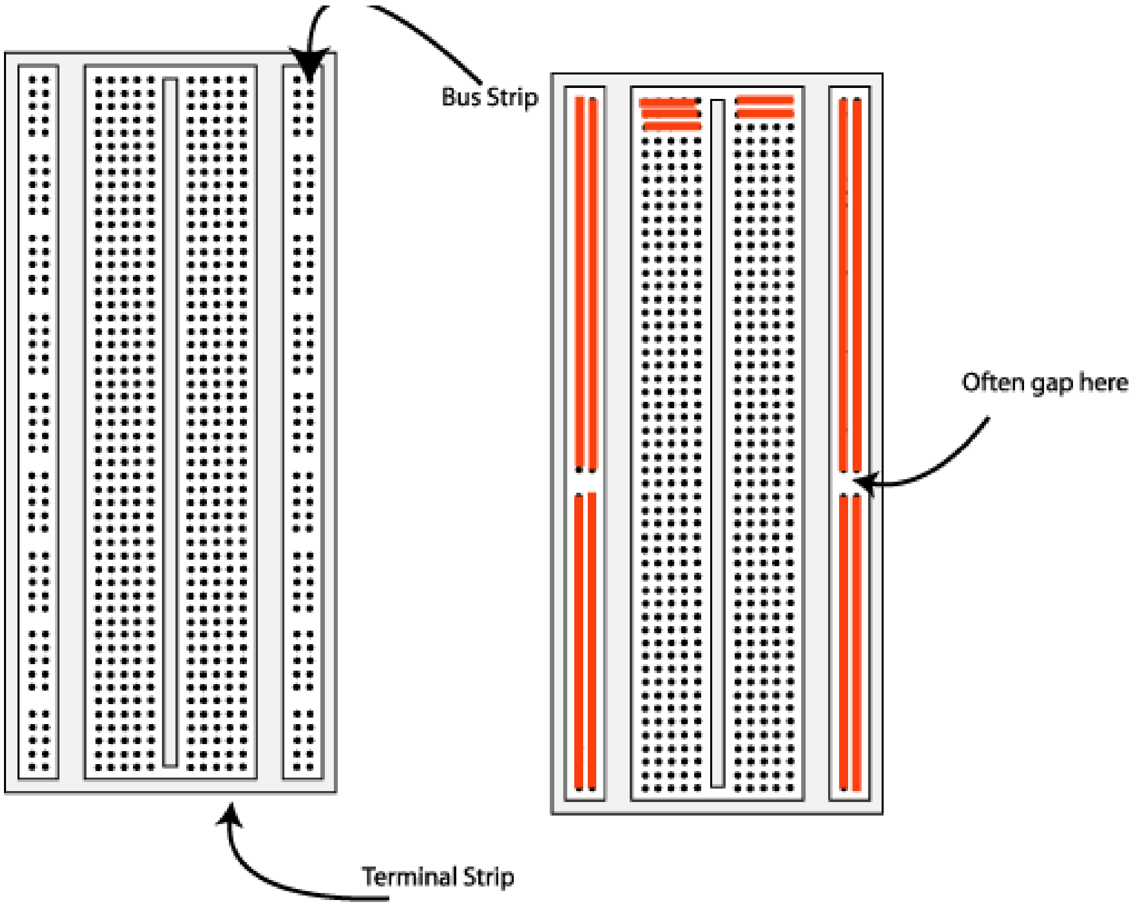


Figure 1.1 Breadboard with the lines indicating connected holes

RESISTOR

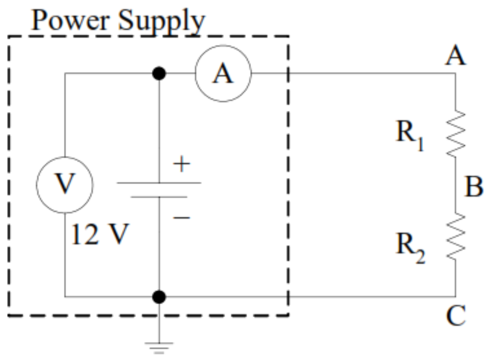
Resistors are used to resist the flow of current or to control the voltage in a circuit. The amount of resistance that a resistor offers is measured in Ohms. Most resistors have colored stripes on the outside and this code will tell you it's value of resistance. The tolerance band is typically either gold or silver. A gold tolerance band indicates that the measured value will be within 5% of the nominal value. A silver band indicates 10% tolerance.

Task 2:

1. Find the value of any resistance using the color coding.
2. State the usage of tolerance band.

DIGITAL MULTIMETER (DMM)

A multimeter is a device that's used to measure electric current (amps), voltage (volts) and resistance (ohms). It's a great for troubleshooting circuits and is capable of measuring both AC and DC voltage.



⊖ \ ⊕	A	B	C
A			
B			
C			

Figure 1.2 Voltage Measurement

Task 3:

1. Identify the mode that is used to check the continuity between two connected points.
2. Measure the value of any give resistance. Identify the error comparing with the value identified using color coding.
3. Holding one probe between the thumb and forefinger of each hand, measure the resistance of your body between your hands. Squeeze the probes tightly so that good contact is established. Record the value of your body's resistance.
4. Considering that a current of 100-200 mA through your heart will almost certainly kill you, how much voltage across your hands would be lethal?
5.

POTENTIAL DIFFERENCE

Exercise 4:

Use the DMM to measure the potential difference between various points as shown in Figure 1.2, according to the following table. Use any two resistors for R_1 andR_2.

AMMETER

Ammeter is employed for measuring of current in a circuit and connected in series in the circuit. As ammeter is connected in series, the voltage drop across ammeter terminals is very low. This requires that the resistance of the ammeter should be as low as possible. The current coil of ammeter has low current carrying capacity whereas the current to be measured may be quite high. So for protecting the equipment a low resistance is connected in parallel to the current coil and it is known as shunt resistance.

VOLTMETER

Voltmeter is employed to measure the potential difference across any two points of a circuit. It is connected in the parallel across any element in the circuit. The resistance of voltmeter is kept very high by connecting a high resistance in series of the voltmeter with the current coil of the instrument. The actual voltage drop across the current coil of the voltmeter is only a fraction of the total voltage applied across the voltmeter which is to be measured.

Task 5:

1. If you double the resistance in a circuit while keeping the current unchanged, what happens to the voltage? What if, instead, you keep the voltage unchanged?
2. Sketch the relationship between voltage and current implied by Ohm's Law.
3. You are told that a certain voltage will be between 3 V and 5 V to be measured and are given a non-auto ranging voltmeter. If the range selectors are labeled 200 mV, 2 V, and 20 V, which range do you select and why?

RESULT:

(Write in your own words)

Ex. No: 2 VERIFICATION OF BASIC LAWS
Date :

Aim:

To verify Kirchhoff's current and Kirchhoff's voltage laws.

Apparatus Required:

Sl. No	Name of Apparatus	Range	Type	Quantity
1.	Resistor	500 Ω, 1 k Ω, 2.2 k Ω	CARBON 1 W	2 each
2.	Multimeter	-	Digital	1 No.
3.	Ammeter	(0-25) mA	MC	3 Nos.
4.	Connecting Wires	-	-	As required
5.	Breadboard	-	-	1

Theory:

Kirchhoff's current law: The algebraic sum of the currents at a junction in the network is zero.

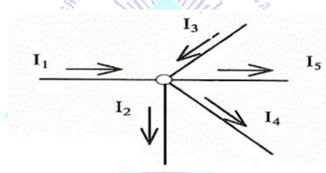


Figure 2.1 : Illustration for Kirchhoff's current law

From figure 1.1 above, equation shown below describe the relationship between I_1, I_2, I_3, I_4 and I_5.

$$I_1 + I_3 = I_2 + I_4 + I_5 \qquad (1)$$

Kirchhoff's voltage law: Kirchhoff's voltage law states that the algebraic sum of all voltage rises and drops in a closed path equals zero.

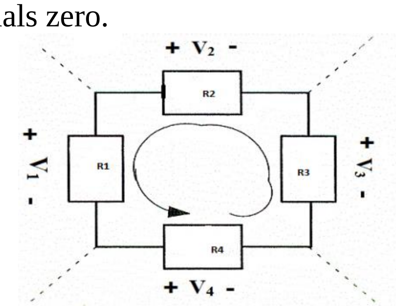


Figure 2. 2: Illustration for Kirchhoff's voltage law

From figure 2.2, using Kirchhoff's voltage law in a counter clockwise direction the equation is written as follow:

$$V_1 + V_4 = V_3 + V_2 \qquad (2)$$

Circuit Diagram:

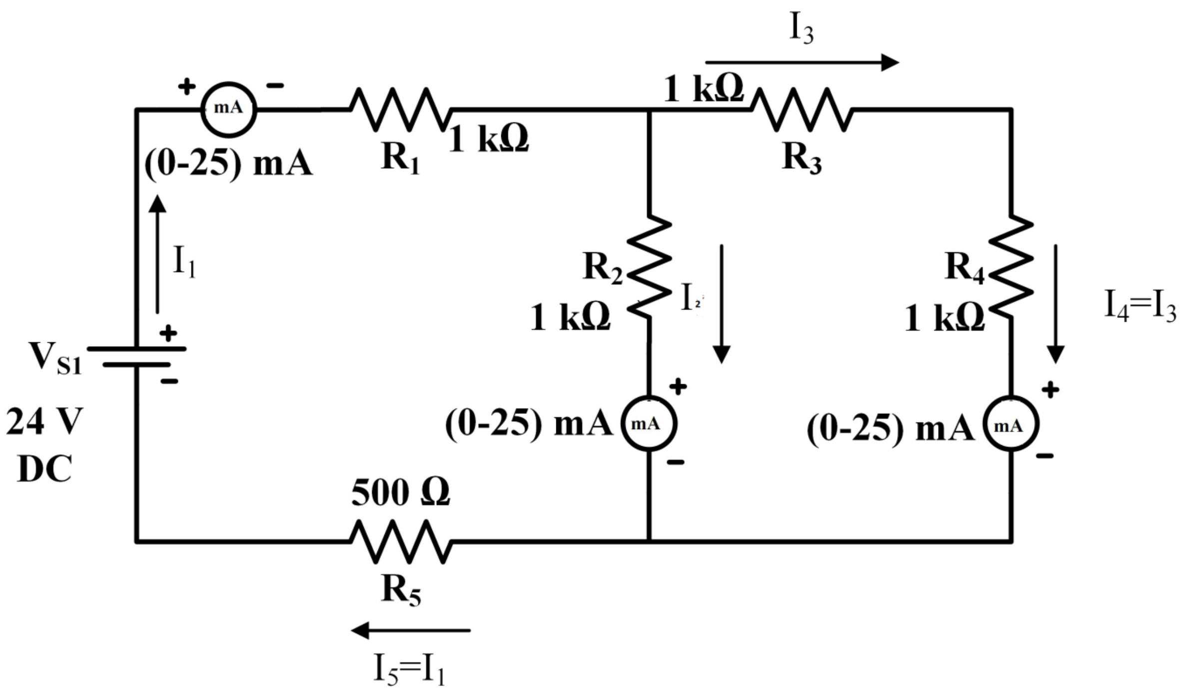


Figure 2. 3 Circuit Diagram

Procedure:

Kirchhoff's current law

1) Consider the circuit in figure 2.3. Calculate theoretically current $\mathbf{I_1}$ when $\boldsymbol{V}$ = 24 V. Record the value and verify theoretically Kirchhoff's current law at nodes **b** and **d**.
2) Connect the circuit shown in figure 2. 3 on breadboard.
3) Turn on DC power supply at 24 V. By using multimeter measure the voltage across each resistor and record the same.
4) Take the readings of all milli-ammeters in the circuit and record it.
5) Verify Kirchhoff's current law at nodes b and d in Fig. 2.3.
6) Repeat by replacing R_1 = 2 k.

Kirchhoff's voltage law

1) Refer to the circuit in figure 2.3, Calculate theoretically voltage across every resistors when $\boldsymbol{V}$ = 24 V. Record the calculations and verify theoretically Kirchhoff's voltage law for all closed loops shown below:

    (i) **V**, $\mathbf{R_4}$, $\mathbf{R_3}$, $\mathbf{R_5}$, $\mathbf{R_1}$

(ii) **V**, **R_1**, **R_2**, **R_5**

(ii) **R_2**, **R_4**, **R_3**

2) Turn on DC power supply at 24 V. By using multimeter, measure voltage drop across every resistor. Record all measurement. *(Make sure the polarity of multimeter is correct in order to prevent damage to that equipment)*.

3) Verify Kirchhoff's voltage law in 3 loops.

4) Repeat by replacing R_1 = 2 k.

Model Calculations:

Tabulation:

V_{DC} = 24 V

Kirchhoff's current law

when R_1 = 1 k

Current	**Calculated**	**Measured**
I_1 (mA)		
I_2 (mA)		
I_3 (mA)		
I_4 (mA)		
I_5 (mA)		

Kirchhoff's voltage law

when R_1 = 1 k

Voltage	**Calculated**	**Measured**
V_{R1} (V)		
V_{R2} (V)		
V_{R3} (V)		
V_{R4} (V)		
V_{R5} (V)		

Kirchhoff's current law

when R_1 = 2 k

Current	Calculated	Measured
I_1 (mA)		
I_2 (mA)		
I_3 (mA)		
I_4 (mA)		
I_5 (mA)		

Kirchhoff's voltage law

when R_1 = 2 k

Voltage	Calculated	Measured
V_{R1} (V)		
V_{R2} (V)		
V_{R3} (V)		
V_{R4} (V)		
V_{R5} (V)		

Result:

(Write in your own words)

Ex. No: 3 **VERIFICATION OF VOLTAGE DIVISION AND CURRENT DIVISION RULES**
Date :

Aim:
To verify the voltage and current division rules.

Apparatus Required:

Sl. No	Name of Apparatus	Range	Type	Quantity
1.	Resistor	500 Ω, 1 k, 2k	CARBON 1 W	2 each
2.	Multi meter	-	Digital	1 No.
3.	Ammeter	(0-2.5) mA	MC	3 Nos.
4.	Breadboard	-	-	1
5.	Connecting Wires	-	-	As required

Theory:

Voltage and Current division rules allow to simplify the task of analyzing a circuit.

Voltage Division allows to calculate what fraction of the total voltage across a series string of resistors is dropped across any one resistor.
For the circuit of figure 3. 1, Voltage Division formulae are:

$$V_1 = \frac{R_1}{R_1 + R_2} V_S \tag{1}$$

$$V_2 = \frac{R_2}{R_1 + R_2} V_S \tag{2}$$

Current Division allows to calculate what fraction of the total current into a parallel string of resistors flows through any one of the resistors.
For the circuit of figure 3.2, Current Division formulae are:

$$i_1 = \frac{R_2}{R_1 + R_2} I_S \tag{3}$$

$$i_2 = \frac{R_1}{R_1 + R_2} I_S \tag{4}$$

Circuit Diagram:

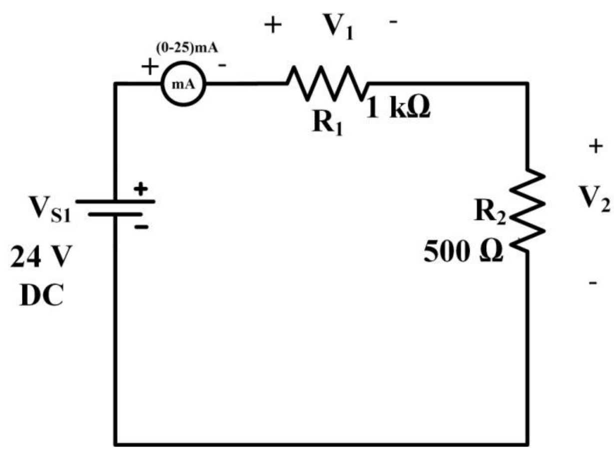


Figure 3.1 Voltage Division Rule

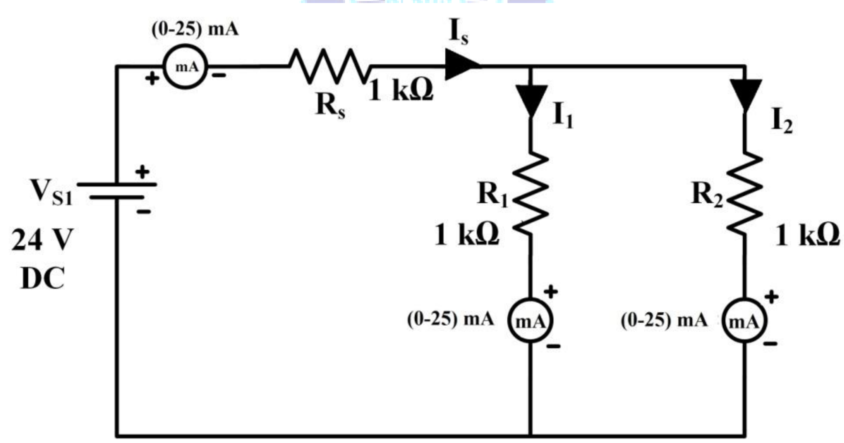


Figure 3.2 Current Division Rule

Procedure:
Voltage Division

1. Construct the circuit as shown in Figure 3.1.
2. Measure the voltages V_1 and V_2 by using multimeter .
3. Calculate the voltages V_1 and V_2 by using the formulae.
4. Compare the calculated and measured values.

Current Division

1. Construct the circuit as shown in Figure 3.2.
2. Measure the currents I_1 and I_2 by using milli-ammeter
3. Calculate the currents I_1 and I_2 by using the formulae.
4. Compare the calculated and measured values.

Tabulation:

Current Division

Current	**Calculated**	**Measured**
$\mathbf{I_s}$ (mA)		
$\mathbf{I_1}$ (mA)		
$\mathbf{I_2}$ (mA)		

Voltage Division

Voltage	**Calculated**	**Measured**
$\mathbf{V_{s1}}$ (V)		
$\mathbf{V_{R1}}$ (V)		
$\mathbf{V_{R2}}$ (V)		

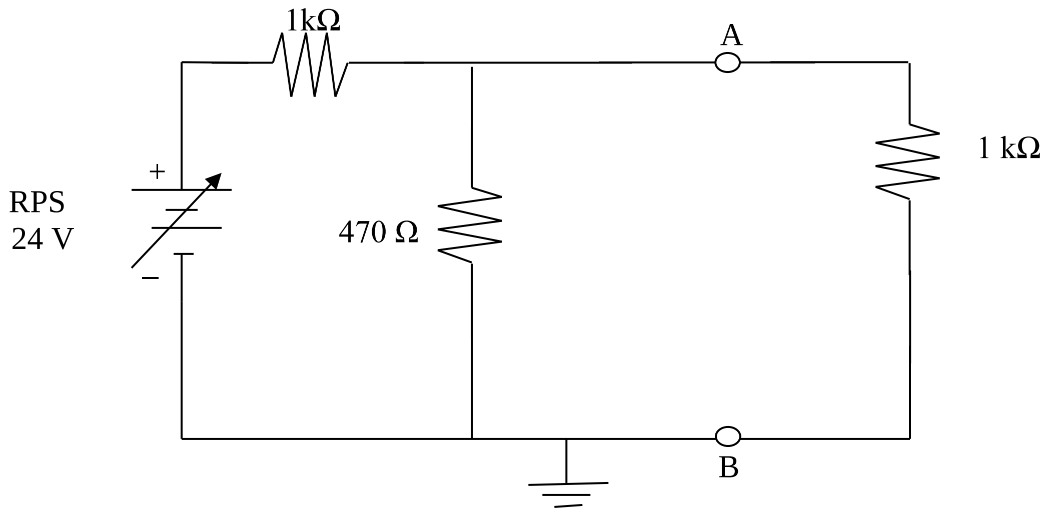
Model Calculations:

Result :

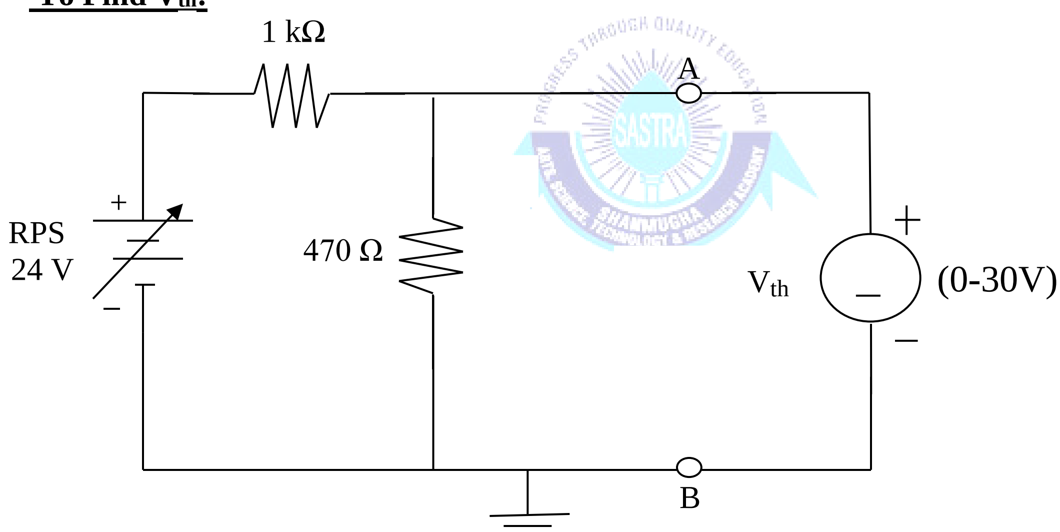
(Write in your own words)

CIRCUIT DIAGRAM - THEVENIN'S THEOREM:

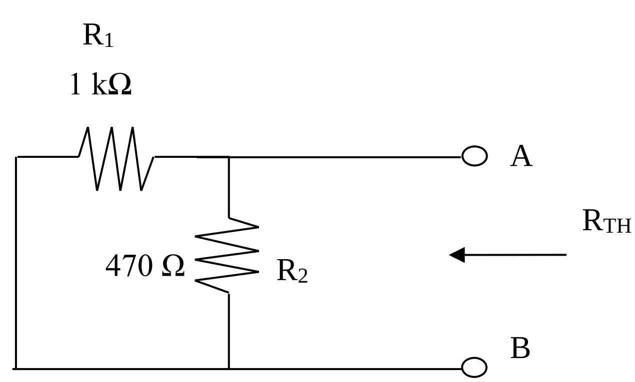
CIRCUIT DIAGRAM



To Find V_{th}:



To find R_{th}:



Ex. No: 4 (a) **VERIFICATION OF THEVENIN'S THEOREM**

Date :

AIM

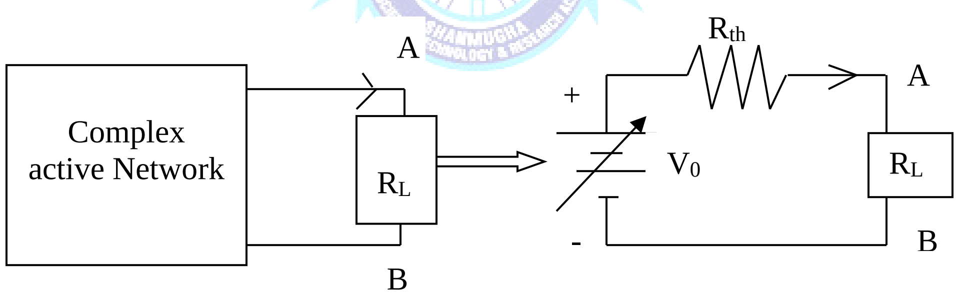
To verify the Thevenin's Theorem for the given circuit.

APPARATUS REQUIRED

S.No	Name of the Apparatus	Range	Quantity
1.	RPS	(0-30) V	1
2.	Resistors	1 kΩ, 470 Ω	2,1
3.	Voltmeter	(0-30) V	1
4.	Ammeter	(0-25)mA	1
5.	Connecting wires	-	As Required
6.	Bread board	-	1

THEORY

A complex network consisting of linear, bilateral active and passive elements with two accessible terminals A & B can be reduced to a simple circuit as shown below consisting of a voltage source V_{th} and a series resistance R_{th}



V_0 = Open circuit voltage at terminals AB, removing R_L

R_{th} = Looking back resistance or Thevinin's resistance across AB

FORMULA:

$$I_L = \frac{V_{TH}}{R_{TH} + R_L}$$

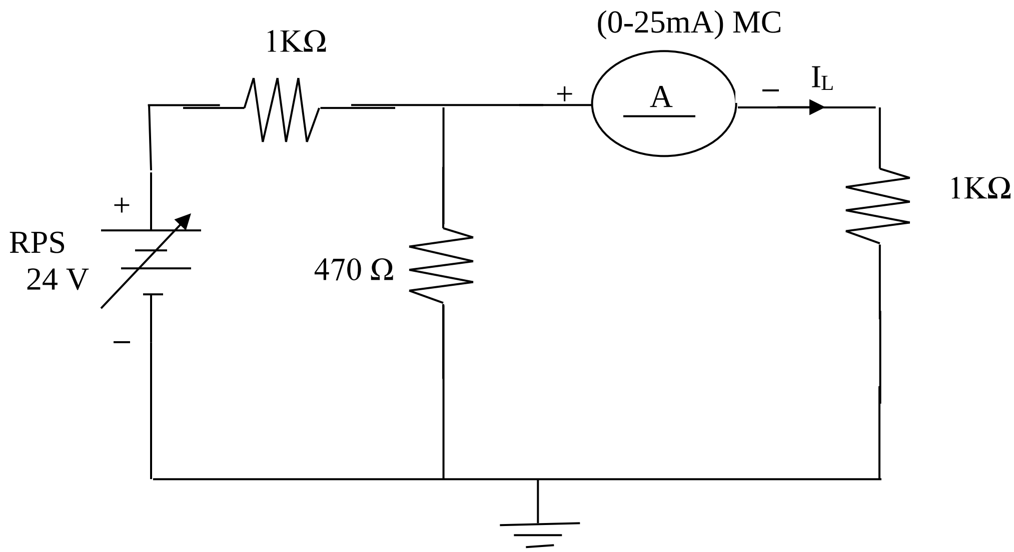
I_L = Load current in amperes.

V_{TH} = Thevenin's voltage or open circuit Voltage in Volts across AB

R_{TH} = Thevenin's resistance in ohms across AB

R_L = Load resistance in ohms.

To find I_L:



TABULATION

S. No	SUPPLY VOLTAGE (Volts)	V_{TH} Open Circuit Voltage (volts)		Rth Thevinin's Resistance (Ohms)		Load Current I_L(mA)	
		Theoretical Value	Measured Value	Theoretical Value	Measured Value	Theoretical Value	Measured Value

PROCEDURE:

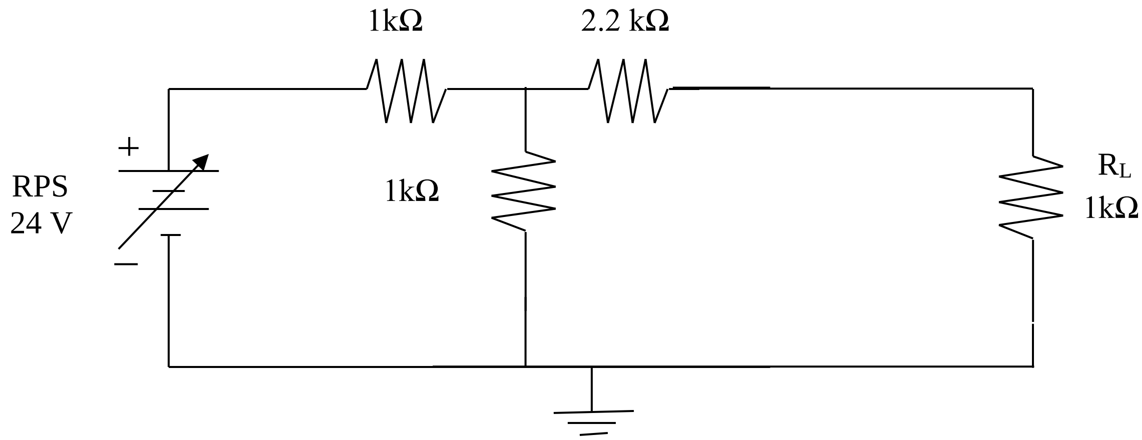
1. The connections are made as per the circuit diagram.
2. The load resistance across the terminals AB is removed and measure open circuit voltage across it. This voltage is called Thevenin's voltage ($V_{th.}$)
3. The voltmeter across the terminals, AB is removed.
4. The voltage source is removed and terminals are shorted. Using a multimeter the looking back resistance or Thevenin's resistance is measured.
5. The current flowing through the removed load resistance R_L is calculated by using the formula.

MODEL CALCULATION:

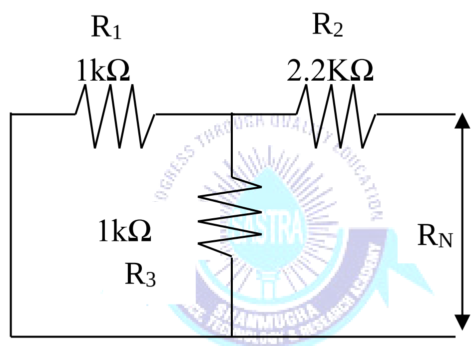
RESULT:

(Write in your own words)

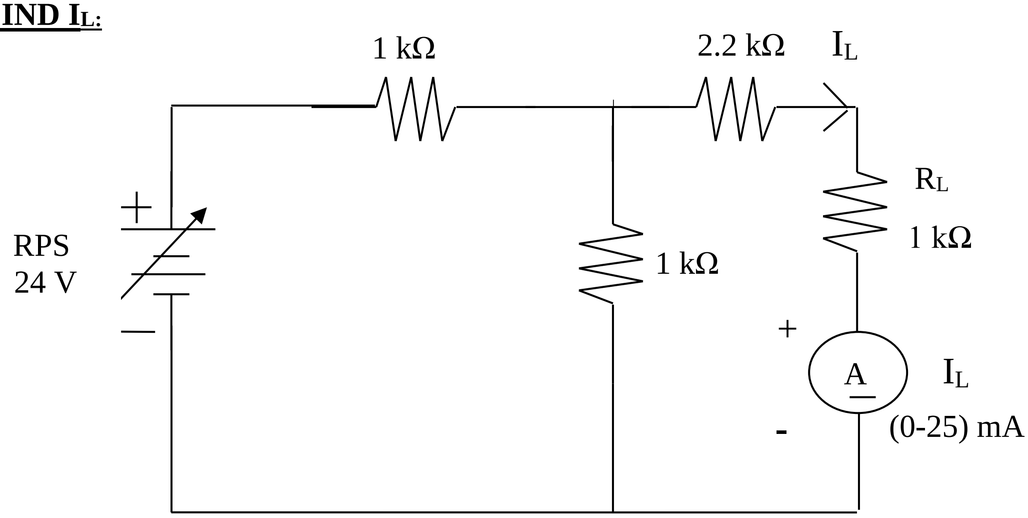
CIRCUIT DIAGRAM - NORTON'S THEOREM:



TO FIND R_N:



TO FIND I_L:



Ex. No: 4 (b) **VERIFICATION OF NORTON'S THEOREM**
Date :

AIM:

To Verify Norton's theorem for the given circuit.

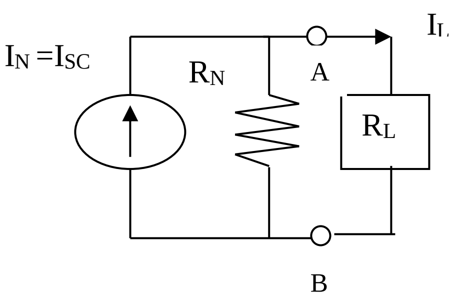
APPARATUS REQUIRED:

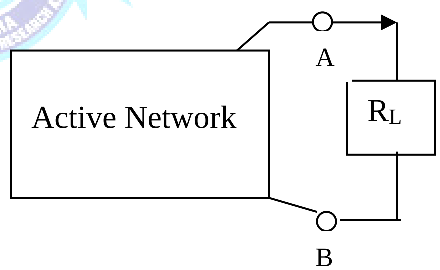
S.No	Name of the Apparatus	Range	Quantity
1.	RPS	(0-30) V	1
2.	Resistors	1 kΩ, 2.2 kΩ	3, 1
3.	Ammeter	(0-25) mA	1
4.	Breadboard	-	1
5.	Connecting wires	-	As Required

THEORY:

STATEMENT:

A Linear active bilateral, resistive network containing one or more Voltage (or) Current source across any two of its terminals AB, can be replaced by a single current source and a parallel resistance as shown below.





FORMULA:

$$I_L = \frac{I_{SC}}{R_N + R_L} \times R_N$$

Where,

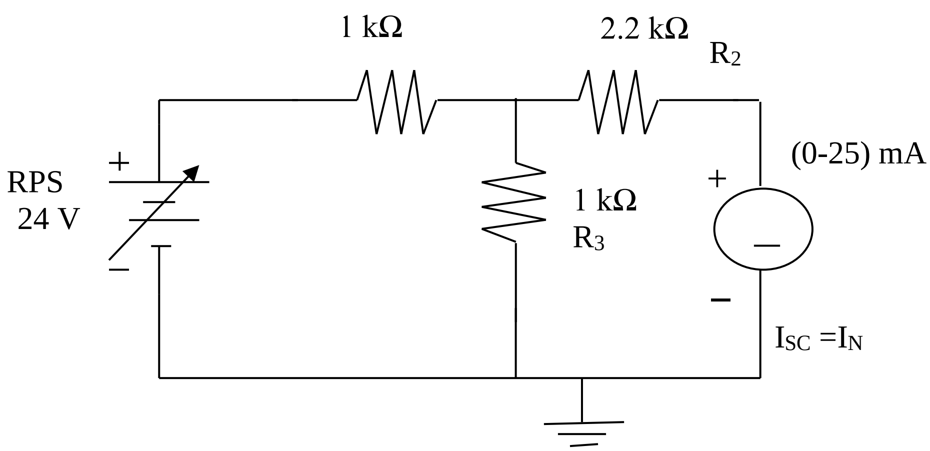
I_L = Load current in Amps. I_n – Norton's Current source

I_{SC} = Short circuit current in Amps.

R_N = Norton's Resistance in ohms.

R_L = Load resistance in ohms.

To FIND I_{SC}:



TABULATION:

S. No.	Supply Voltage V in volts	I_{SC} Short Circuit Current (Amps)		R_N Norton's Resistance (Ohms)		I_L load current (Amps)	
		Theoretical Value	Measured Value	Theoretical Value	Measured Value	Theoretical Value	Measured Value

PROCEDURE:

1. The connections are made as per the circuit diagram.
2. The load resistance is removed and the output terminals are shorted.
3. The current flowing through the short circuited path is measured using an ammeter, for a particular value of the supply voltage. Let this short circuit current be I_{sc} or I_n.
4. To find the Thevenin's equivalent resistance, the load resistance is removed and all the sources are replaced by their internal resistances. The equivalent resistance between the open output terminals is measured by using a multimeter.
5. The load current is calculated by using the formula,

$$I_L = \frac{I_{SC}}{R_N + R_L} \times R_N$$

6. The same procedure is repeated for various values of supply voltage and the readings are tabulated.

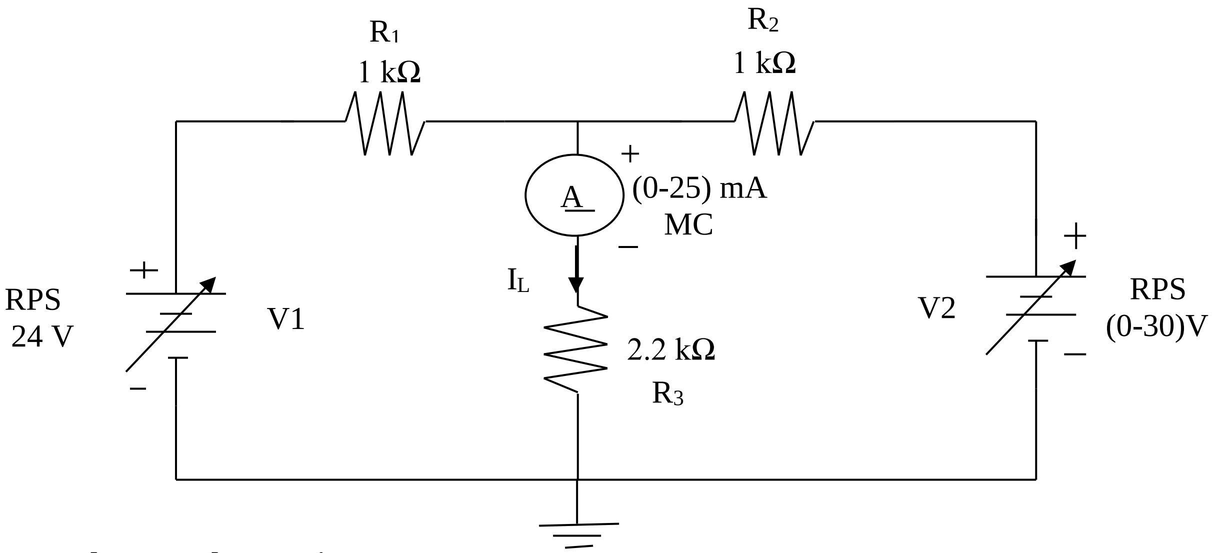
MODEL CALCULATION:

RESULT:

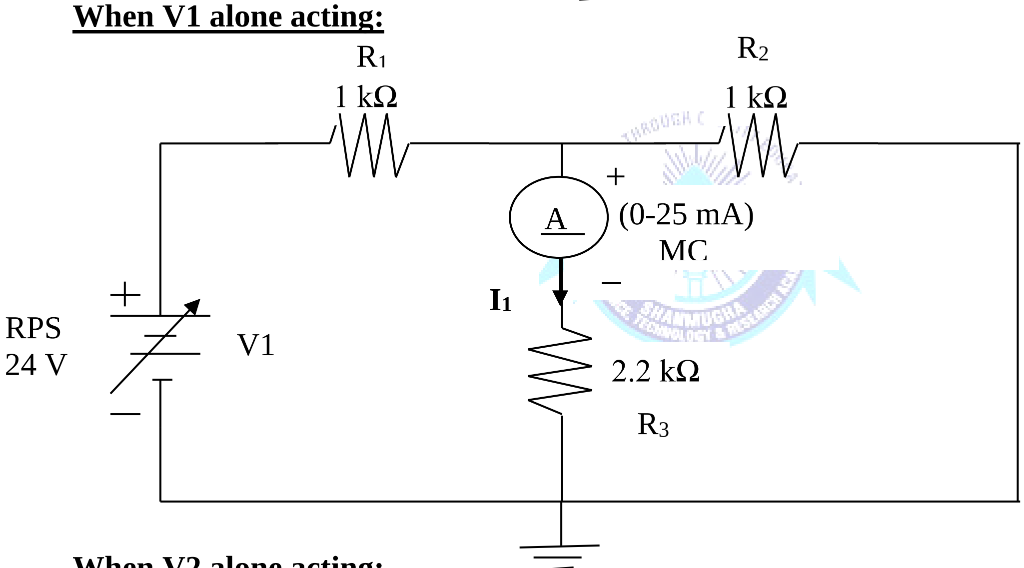
(Write in your own words)

CIRCUIT DIAGRAM - SUPERPOSITION THEOREM

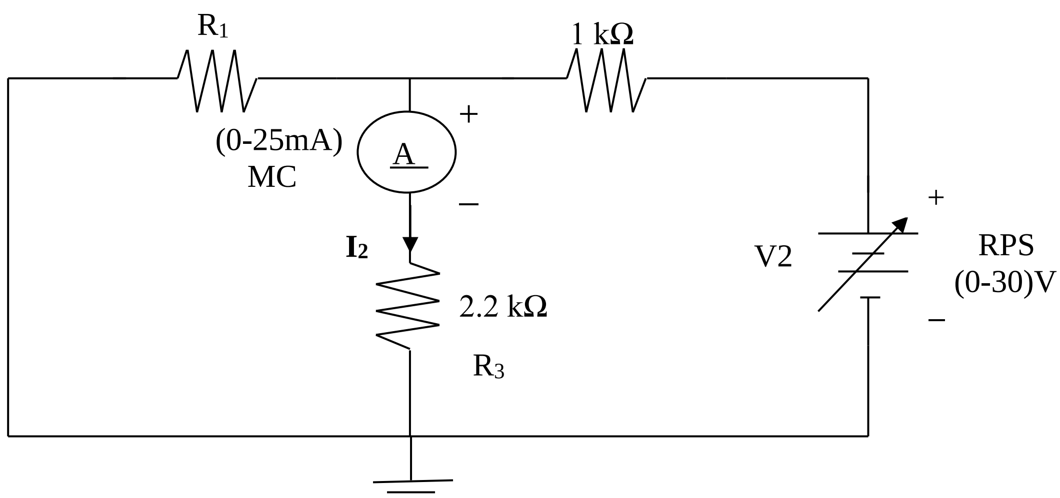
CIRCUIT DIAGRAM:



When V1 alone acting:



When V2 alone acting:



Ex. No: 5 (a) **VERIFICATION OF SUPERPOSITION THEOREM**
Date :

AIM:

To verify the Superposition theorem for the given circuit.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	Dual RPS	(0-30) V	1
2.	Resistors	1 kΩ, 2.2 kΩ	2,1
3.	Ammeter	(0-25)mA	1
4.	Breadboard	-	1
5.	Connecting wires	-	As Required

THEORY:

STATEMENT:

"In a linear, lumped, bilateral electric circuit energized by two or more sources the current in any resistor is equal to the algebraic sum of the separate currents in that resistor when each source acts separately. While one source is applied, the other sources are replaced by their respective internal resistances."

To replace the other sources by their respective internal resistances, the voltage sources are short circuited and the current sources are open circuited.

PROCEDURE:

STEP 1: [WHEN BOTH THE SOURCES V_1 AND V_2 ARE ACTING]

1. The connections are given as per the circuit diagram.
2. V_1 Volts and V_2 Volts are given to the circuit from the two regulated power supplies.
3. The current flowing through R3 resistor is measured by using an ammeter

STEP 2: [WHEN SUPPLY VOLTAGE V_1 ALONE IS ACTING]

1. Connections are made as per the circuit diagram.
2. The supply voltage V2 volts is removed and replaced by its internal resistance.

3. V_1 Volts supply is given to the circuit and the current flowing through R_3resistor is noted down using the ammeter.

STEP 3: [WHEN SUPPLY VOLTAGE V_2 ALONE IS ACTING]

1. Connections are made as per the circuit diagram.
2. The supply voltage V_1 volt is measured and replaced it by its internal resistance.
3. V_2 Volts supply is given to the circuit and the current flowing through R_3 resistor is noted down using the ammeter.

TABULATION:

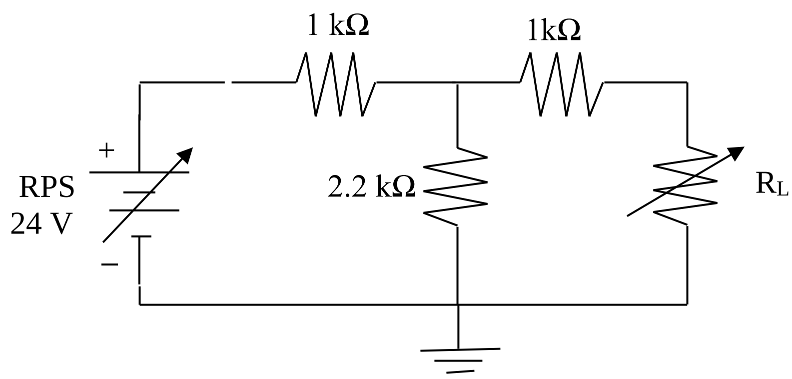
S.No	Supply voltage V in (volts)		Ammeter readings I in (mA)				I(mA)	
	V_1	V_2	Theoretical Value		Measured Value		Theoretical Value	Measured Value
			I_1	I_2	I_1	I_2		

MODEL CALCULATION:

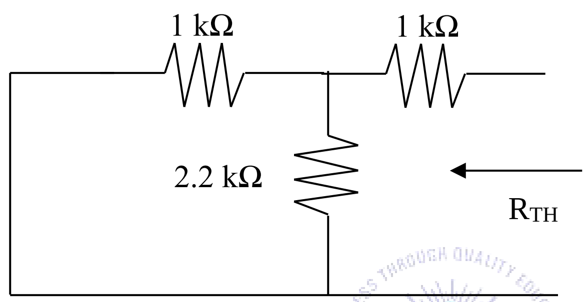
RESULT:

(Write in your own words)

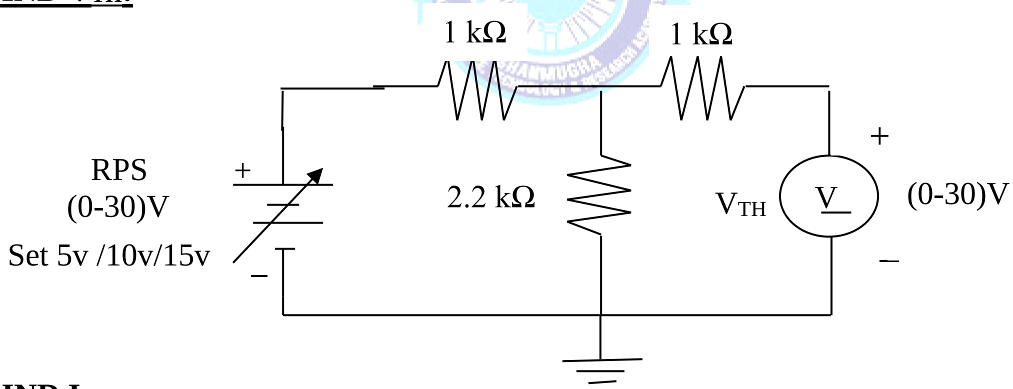
CIRCUIT DIAGRAM - MAXIMUM POWER TRANSFER THEOREM:



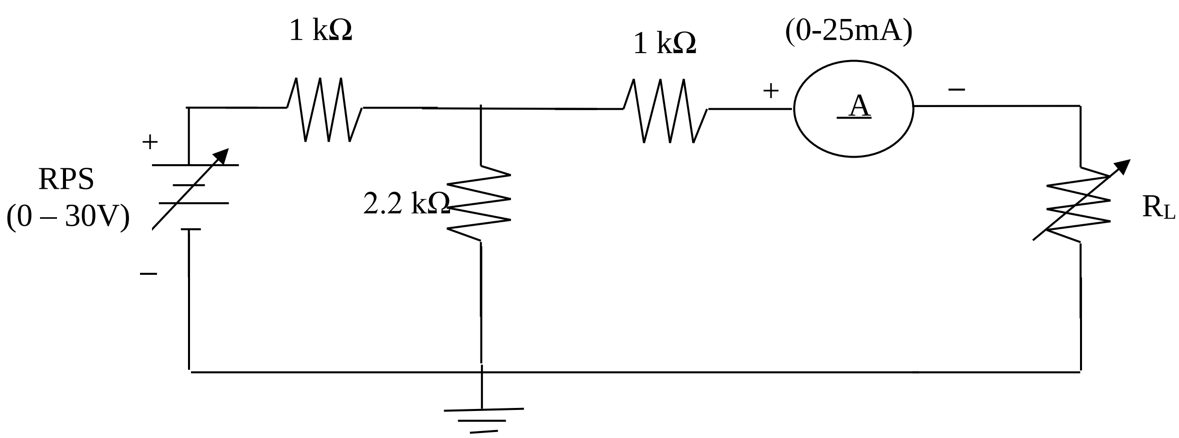
TO FIND R_{TH}:



TO FIND V_{TH}:



TO FIND I_L:



Ex. No: 5 (b) **VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM**
Date :

AIM:

To verify the maximum power transfer theorem for the given circuit.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Quantity
1.	RPS	(0-30) V	1
2.	Resistors	1 kΩ, 2.2 kΩ	2, 1
4.	Voltmeter	(0-30)V	1
5.	Ammeter	(0-25)mA	1
6.	Breadboard	-	1
7.	Connecting wires	-	As Required

THEORY:

STATEMENT:

"In a linear, lumped, bilateral electric circuit, maximum power is transferred to the load resistor, when it has a value equal to the Thevnin resistance of the network looking back at it from the load terminals."

PROCEDURE:

1. The connections are made as per the circuit diagram.
2. Load resistance R_L across the terminals AB is removed and measure open circuit voltage across AB is measured by using the voltmeter.
3. The voltage source is removed and the terminals AB are short circuited and by using the Multimeter the looking back resistance R_{th} is measured.
4. The current flowing through the load resistance is calculated, as follows

$$R_{th} = R_L$$

To calculate the power through R_L.

$$R_L = R_{th}$$

$$P = I^2_L R_L$$

TABULATION:

$R_{TH} =$

S.NO	R_L (Ω)	Load Current I_L (mA)		Power (mW)	
		Theoretical Value	Measured Value	Theoretical Value	Measured Value

MODEL CALCULATION:

RESULT:

(Write in your own words)

Ex. No: 6 **SIMULATION OF R-L-C SERIES CIRCUIT**
Date :

AIM

To simulate a series RLC circuit under the following conditions

(i) $X_L > X_C$

(ii) $X_L < X_C$

(iii) $X_L = X_C$

THEORY

Each element has a unique phase response: for resistors, the voltage is always in phase with the current, for capacitors the voltage always lags the current by 90 degrees, and for inductors the voltage always leads the current by 90 degrees. Consequently, a series combination of R, L, and C components will yield a complex impedance with a phase angle between +90 and -90 degrees. Due to the phase response, Kirchhoff's Voltage Law must be computed using vector (phasor) sums rather than simply relying on the magnitudes. Indeed, all computations of this nature, such as a voltage divider, must be computed using vectors.

FORMULAE

Inductive reactance, $X_L = 2 * \pi * f * L$

Capacitive reactance, $X_C = \frac{1}{2*\pi*f*C}$

Resonant Frequency, $F_0 = \frac{1}{2\pi\sqrt{LC}}$

PROCEDURE:

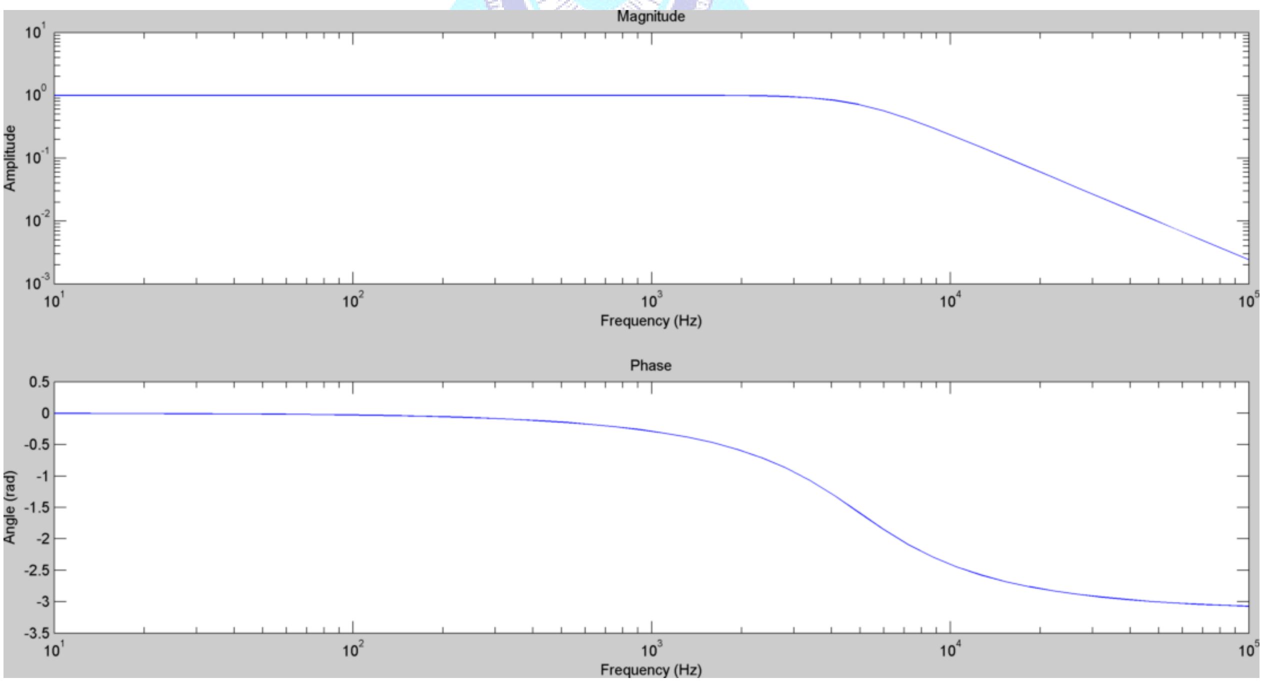
1. Fix the values for R,L,C
2. Run the MATLAB code and obtain the results.
3. Modify values and try with different values of R,L,C

MATLAB CODE

```
%Simulation of RLC series circuit
clear all;close all;clc
%% Circuit Parameters
R= 30; % Resistance (30 Ohm)
L= 0.7e-3; % Inductance (0.7 mH)
C= 1.5e-6; % Capacitance (1.5 microfarad)
```

```
% Please see "help logspace" in order to understand how does it work?
f= logspace(1,5); % Frequency range between 10 Hz and 100 kHz
omega= 2*pi.*f; % Angular Frequency
ZC= 1./(1i.*omega.*C); % Capacitive Reactance
ZL= 1i.*omega.*L; % Inductive Reactance
Hf=ZC./(ZC+ZL+R); % Transfer Function (V0/V1)
%% Plot the phase and the magnitude response of a transfer function
%Magnitude Plot
subplot(211)
%loglog(...) is the same as PLOT(...), except logarithmic scales are used for
both the X- and Y- axes.
loglog(f,abs(Hf))
title('Magnitude')
xlabel('Frequency (Hz)')
ylabel('Amplitude')
% Please see "help axis" in order to understand how does axis work.
axis([10 1e5 1e-3 10]) % Manual axis adjustment
 %Phase Plot
subplot(212)
%semilogx(...) is the same as PLOT(...), except a logarithmic (base 10) scale
is used for the X-axis.
semilogx(f,angle(Hf))
title('Phase')
xlabel('Frequency (Hz)')
ylabel('Angle (rad)')
axis([10 1e5 -3.5 0.5]) % Manual axis adjustment
```

Model Plot



EXERCISE

For a fixed frequency of 50 Hz, compute the values of C,

Condition	R	L	C
(i) $X_L > X_C$	30	0.7 mH	
(ii) $X_L < X_C$	30	0.7 mH	1.5 µF
(iii) $X_L = X_C$	30	0.7 mH	

RESULT:

(Write in your own words)

Ex. No: 7 **SIMULATION OF TIME RESPONSE OF RC CIRCUIT**
Date :

AIM:

To study the transient response of RC circuit and to determine the time constant of the circuit.

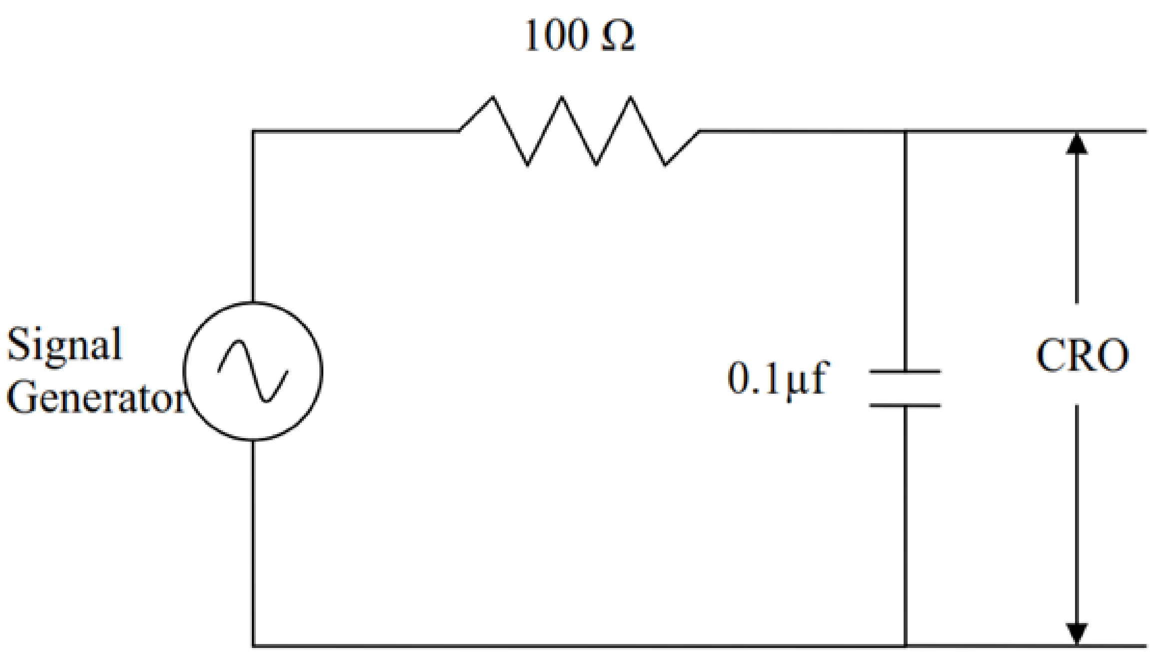
THEORY:

When a RC circuit is suddenly energized or de-energized a transient phenomenon which dies out as the circuit approaches its steady state. This is because of the way in which capacitor store energy and resistor dissipate it. The exact nature of the transient depends on R and C as well as how they are connected in the circuit. The time constant τ represent the time for the system to make significant change in charge (V) or current (I) whenever a capacitor is charging or discharging.

PROCEDURE:

1. Fix the values for R and C
2. Run the MATLAB code and obtain the results.
3. Modify values and try with different values of R and C

CIRCUIT DIAGRAM:

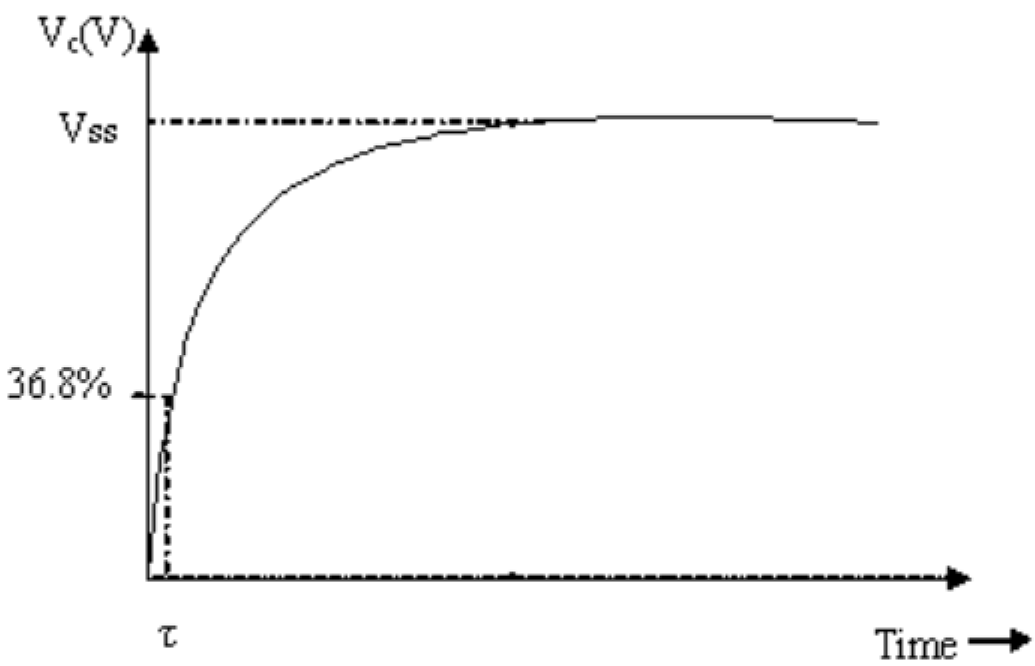


MATLAB CODE

```
% Define the voltage source
Vs = 10;
% Define the capacitor in the circuit
C = 0.1e-6;
% Define the time lapse that we're going to explore
t = 0 : 0.0005 : 0.001;
% Define the resistors in each time constant and
% calculate the voltage across the capacitor
R1 = 100;
tau1 = R1*C;
V1 = Vs * ( 1 - exp(-t/tau1) );
plot(t,V1)
grid on
title('Transient Analysis - RC circuit')
xlabel('Time (s)')
ylabel('Voltage across capacitor (V)')
```

OBSERVATION:

From the output waveform, for the 36.8% of maximum voltage find the time period t



where, Vss = Steady State Voltage

CALCULATION

Time constant	Theoretical value	Simulated value
$\tau = RC$		

RESULT

(Write in your own words)

Ex. No: 8
Date :

VERIFICATION OF RELATION IN BETWEEN VOLTAGE AND CURRENT IN THREE PHASE BALANCED STAR AND DELTA CONNECTED LOADS

AIM

To study the relationship between voltage and current in three-phase circuits and examine wye and delta connections.

THEORY

In practice three-phase circuits in proper working order tend to be symmetrical, consisting of three identical branches, each with the same impedance, voltage and current. Each of the branches can be treated as a single-phase circuit, and thus the analysis of a three-phase circuit is not necessarily any more difficult than the corresponding single-phase network. Unbalanced three-phase networks usually represent a problematic condition, such as a fault, and can be much more difficult to analyze. Unbalanced conditions are beyond the scope of this laboratory exercise.

Three-phase systems are normally configured in either a WYE or DELTA. The names result from the physical similarity of the wye connection to the letter Y and the delta connection to the Greek letter of the same name (a triangular symbol). Each of these configurations has unique electrical characteristics.

FORMULAE

For star connection,

$$Line\ voltage = \sqrt{3}\ \times Phase\ voltage$$
$$Line\ current = \ Phase\ current$$

For delta connection,

$$Line\ voltage = \ Phase\ voltage$$
$$Line\ current = \sqrt{3}\ \times Phase\ current$$

PROCEDURE

1. Connect the given rheostats in delta configuration (Figure & Figure 8.28.2) and measure the phase and line values of voltage and current.
2. Connect the given rheostats in star configuration as shown in Figure 8.3 and measure the phase and line values of voltage and current

CIRCUIT DIAGRAM

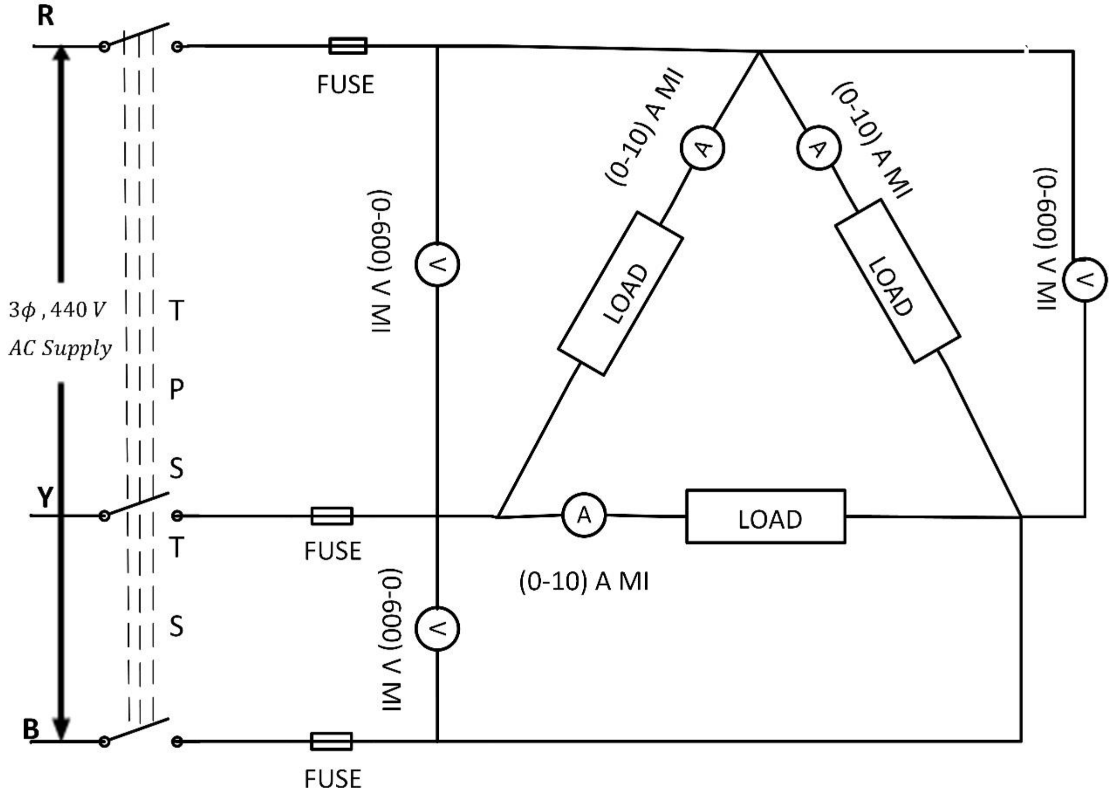


Figure 8.1 Delta circuit

TABULATION 1: DELTA CIRCUIT

Parameter	Measured value
$\boldsymbol{V_1}$	
$\boldsymbol{V_2}$	
$\boldsymbol{V_3}$	
$\boldsymbol{I_1}$	
$\boldsymbol{I_2}$	
$\boldsymbol{I_3}$	

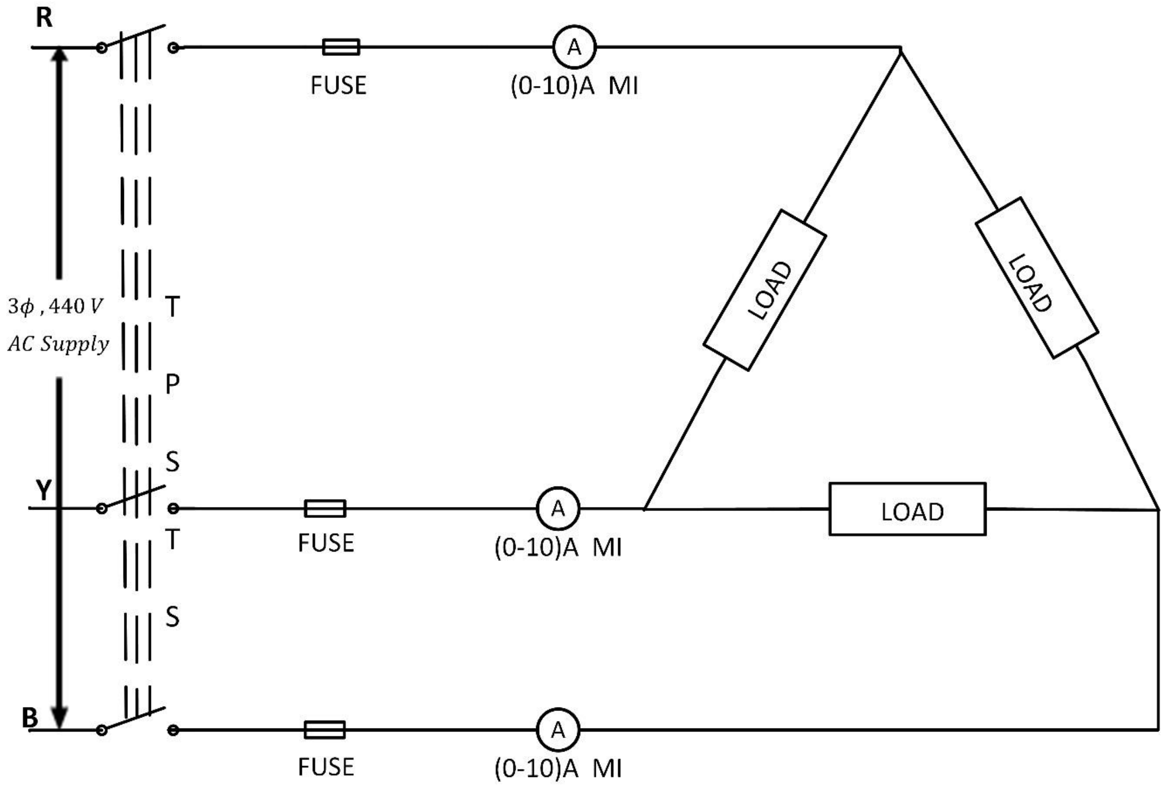


Figure 8.2 Delta circuit for line current measurement

TABULATION 2: DELTA CIRCUIT LINE CURRENT MEASUREMENT

Parameter	Measured value
I_4	
I_5	
I_6	

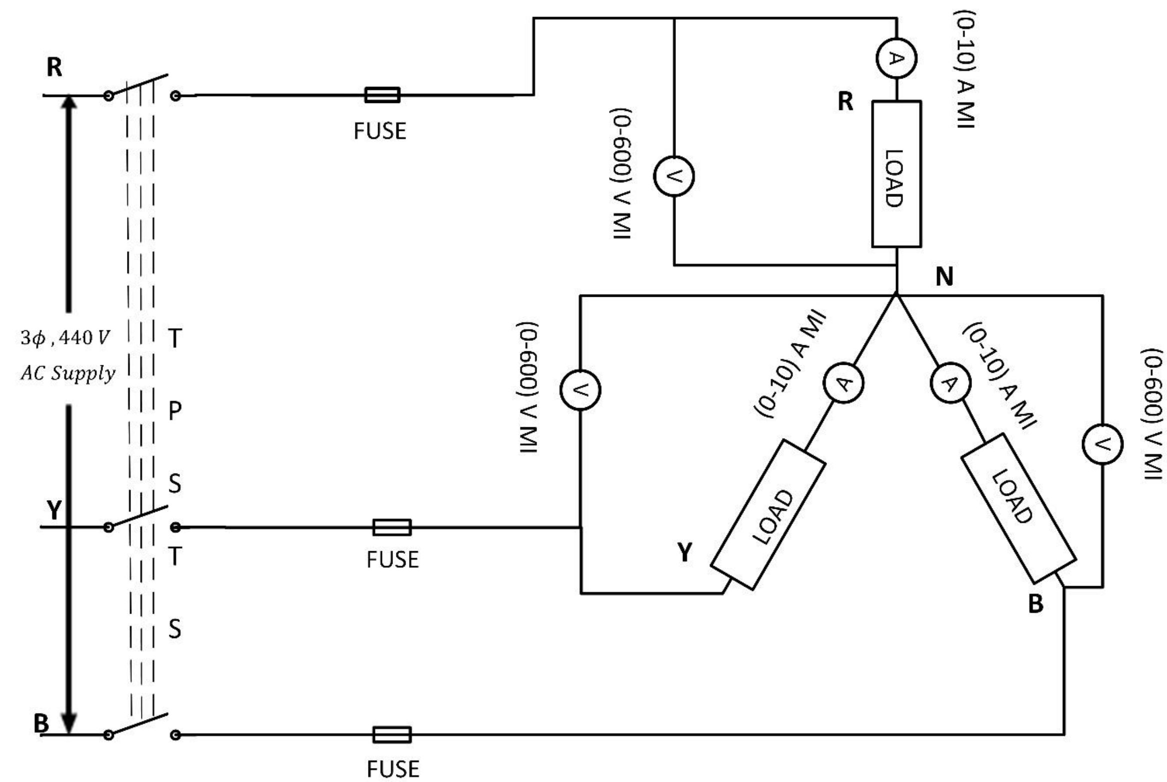


Figure 8.3 Star circuit

TABULATION 3: STAR CIRCUIT

Parameter	Measured value
V_1	
V_2	
V_3	
I_1	
I_2	
I_3	

RESULT

(Write in your own words)

Ex. No: 9 **DEMONSTRATION OF MEASUREMENT OF ELECTRICAL QUANTITIES IN DC AND AC SYSTEMS**
Date :

AIM:

To measure the electrical quantities like voltage, current and energy in an electrical circuit.

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0- 10) A	MI	1
2.	Voltmeter	(0- 300) V	MI	1
3.	Energy meter	150 V /300 V/ 10 A	Induction	1
4.	Load	--	Resistive	1
5.	Stop Watch	-	-	1
6.	Connecting Wires	-	-	As required

FORMULAE USED:

Energy meter Constant = 600 revolutions / kWh.

$1\text{Rev} = \frac{(1\text{x}1000\text{x}3600)}{600} = 6000$ (Watt-sec)

For 'N' number of revolutions,

Indicated energy (E_i) = N x 6000 (Watt-sec)

Calculated energy $E_a = (V_L \text{ x } I_L) \text{ x } T$ (Watt-sec)

where, V_L –Load voltage I_L-Load current

$\% \text{ Error} = \frac{(Ei - Ea)}{Ei} \text{x}100$

PROCEDURE:

1. Connect the energy meter just after the supply terminals.
2. Connections are made as per the circuit diagram.
3. Switch on the supply and note down the ammeter, voltmeter readings and time taken by the discs for 'N' number of revolution using stop watch.

CIRCUIT DIAGRAM:

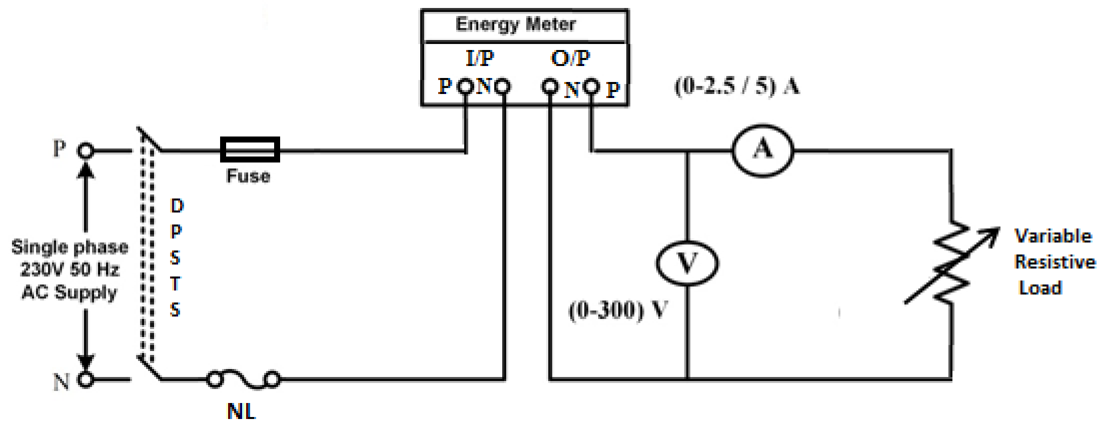


Figure : 9.1 Circuit Diagram

A – Ammeter
V – Voltmeter

TABULATION:

S.No.	Voltmeter reading (volts)	Ammeter reading (amps)	Time taken for 5 revolutions (secs)	Calculated Energy (E_a)	Indicated Energy (E_i)	% Error

MODEL CALCULATION:

1. Calculate the indicated energy obtained from rotation (count value)
2. Calculate the theoretical energy using $E_a = (V_L \times I_L) \times T$ (Watt-sec)
3. % Error =

RESULT:

(Write in your own words)

Ex. No: 10
Date :

VOLTAGE–CURRENT RELATIONSHIP IN A R-L & R-C SERIES CIRCUITS AND DETERMINATION OF POWER FACTOR OF THE CIRCUIT

AIM:

To calculate the power factor of R-L and R-C series circuits

APPARATUS REQUIRED:

S.No	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0-1)A	MI	1
2.	Voltmeter	(0-300)V	MI	2
3.	Wattmeter	150 V/300 V / 2.5 A	UPF	1
4.	Resistor	220Ω / 1.8A	Rheostat	1
5.	Inductor	0.25 H	Iron Core	1
6.	Capacitor	2 µF / 300 V	Fan Capacitor	1
7.	Multi meter	-	Digital	1
8.	Connecting Wires	-	-	As required

THEORY:

Resistor–capacitor (RC) and resistor–inductor (RL) circuits are the two types of first-order circuits: circuits with either one capacitor or one inductor.

(a) RL circuit:

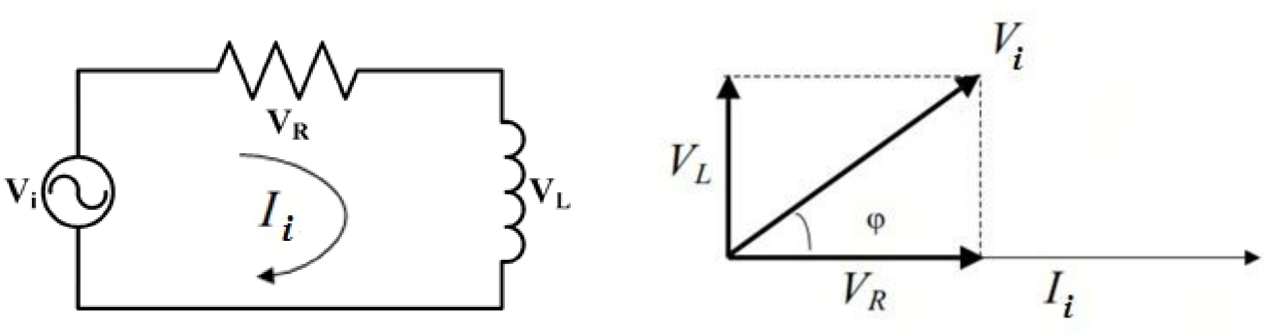


Figure 10.1: Circuit and Phasor Relationship of R-L Series Circuit

Consider a simple RL circuit in which resistor, R and inductor, L are connected in series with a supply voltage of V_i volts. The current flowing in the circuit is I_i (amp). In inductor, the voltage and the current are not in phase. The voltage leads that of current by 90^o in a pure inductance or in other words, voltage attains its maximum and zero value 90^o before the current attains these respective values which is shown in the phasor relationship. Similarly, from the phasor diagram shown in Figure 10.1, it is clear that the current in the circuit lags the applied voltage by an angle ϕ and this angle is called the phase angle.

(b) RC circuit:

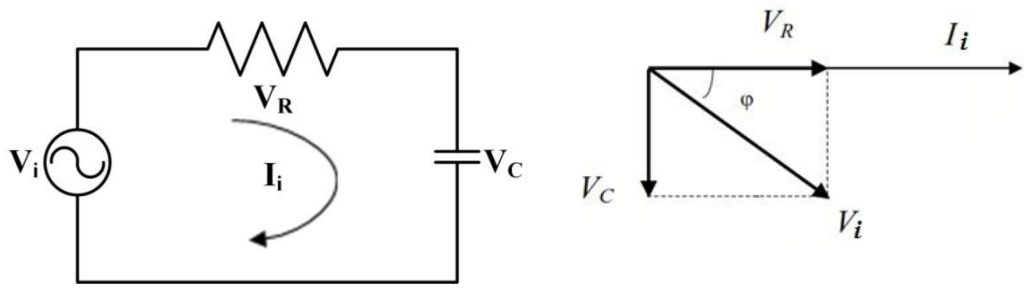


Figure 10.2: Circuit and Phasor Relationship of R-C Series Circuit

Here the current through the capacitor C leads the voltage V_c across it and the phasor diagram is shown in figure 10.2.

CIRCUIT DIAGRAM:

The detailed analysis of a RL and RC circuits is done using the medium power circuit shown in figure 10.3. The experiment is done in 2 parts as follows.

01. Keep only the elements R and L by removing C and record the readings of all meters in Table 10.1.
02. Keep only the elements R and C by removing L and record the readings of all meters in Table 10.2.

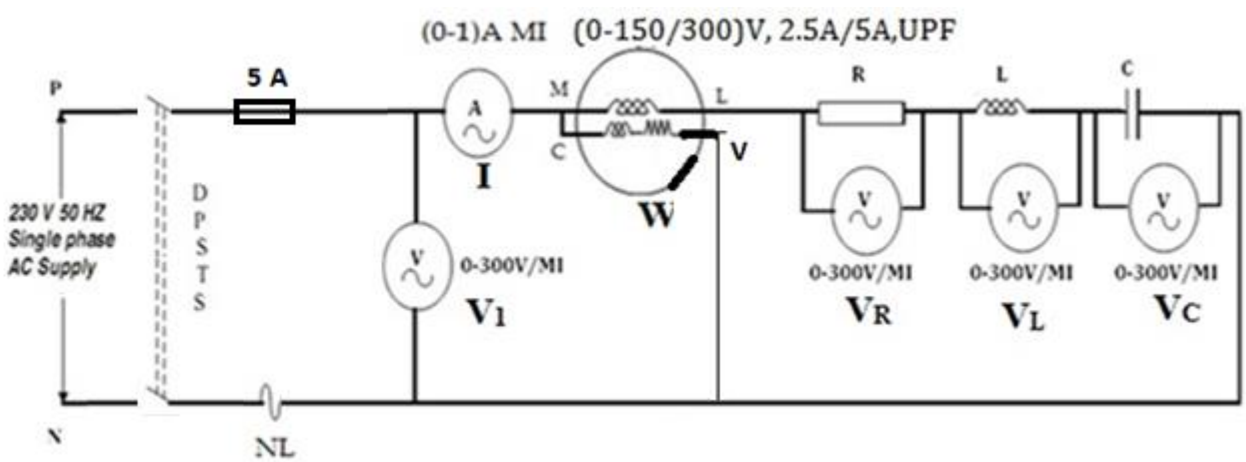


Figure 10.3 : Laboratory Set - Up

PROCEDURE:

01. Fig. 10.3 shows a RLC circuit which is used for R-L / R-C , one at a time.
02. Set the auto transformer to have zero output voltage.
03. Switch on the supply.
04. Gradually increase the output voltage. For various values of voltage, note down the corresponding current (I), voltage across Resistor (V_R), voltage across Inductor (V_L) or voltage across capacitor (V_C) and Power (W).
05. Calculate the Power Factor by using the formula

$$\text{Power Factor} = \cos \Phi = \frac{W}{V \times I}$$

06. After the measurements are over, switch OFF the supply and discharge the capacitor.

TABULATION:

Table 10.1: R-L Series Circuit

S.No.	Voltmeter Readings in Volts (V)	Ammeter Readings in Amps (I)	Wattmeter Readings in Watts (W)	V_R in Volts	V_L in Volts	Apparent Power = VxI (VA)	Power Factor $\cos \Phi = \frac{W}{V \times I}$

Table 10.2: R-C Series Circuit

S.No.	Voltmeter Readings in Volts (V)	Ammeter Readings in Amps (I)	Wattmeter Readings in Watts (W)	V_R in Volts	V_C in Volts	Apparent Power = VxI (VA)	Power Factor $\cos \Phi = \frac{W}{V \times I}$

MODEL CALCULATION:

Take the typical set of readings of V, I and W in each table and calculate the power factor and draw the phasor diagram showing voltages across the elements

RESULT:

(Write in your own words)

Ex. No: 11 **DOMESTIC WIRING**

Date :

AIM:

To wire for a stair case arrangement using two-way switches.

APPARATUS REQUIRED:

S.No	Name of the Component/Tool	Quantity
1.	Screw Driver	1
2.	Tester	1
3.	Nose Plier	1
4.	Wire Stripper	1
5.	Two-way switch	2
6.	Bulb holders	1
7.	Incandescent Lamp	1
8.	Connecting Wires	As required

THEORY:

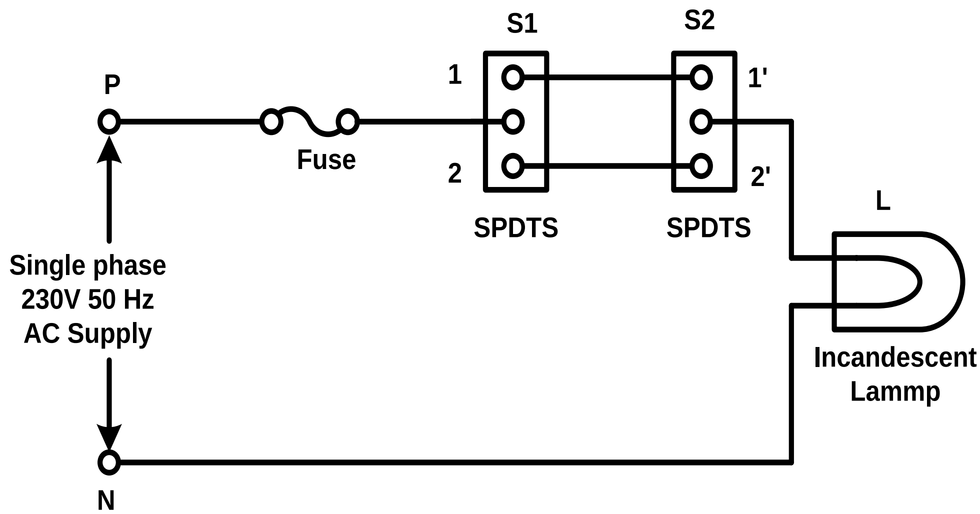
A staircase wiring makes the feasibility for the user to turn ON and OFF a lamp load from two switches placed apart from each other. Here, one lamp is controlled by two switches from two different positions. This wiring is used to operate the load from separate positions such as above or below the staircase, from inside or outside of a room, or as a two-way bed switch, etc.

The first pole and second pole of the SPDT switch S1 has connected to the corresponding first and second pole of the SPDT switch S2. The phase of the supply line is connected to the common pole of a switch and the phase line to the load is taken from the common pole of the next switch. It makes an arrangement that, to close the circuit both the switches should be in the same position in order to make the two common poles in contact to achieve a closed circuit. Changing ON & OFF condition of a single switch can determine whether the circuit is closed or open.

PROCEDURE:

1. Fix the two-way switches and bulb holder.
2. Connections are made as per the circuit diagram.
3. Test the working of the bulbs by giving electric supply to the circuit.

CIRCUIT DIAGRAM:



S_1, **S_2** – Two-way switches
L – Incandescent Lamp

Tabulation:

Position of Switch (S_1)	Position of Switch (S_2)	Condition of Lamp (L)
1	1′	
1	2′	
2	1′	
2	2′	

RESULT:

(Write in your own words)

Ex. No: 12 **ELECTRIC POWER SUPPLY SYSTEM**
Date :

AIM:
To study and wire a typical power distribution model.

APPARATUS REQUIRED:

1. Power distribution system model
2. Connecting wires

THEORY:
A typical 11 kV power distribution system consists of the following

1. TNEB double pole structure
2. Consumer double pole structure
3. 11 kV/440 V distribution transformer
4. MV panel board
5. Distribution panel boards

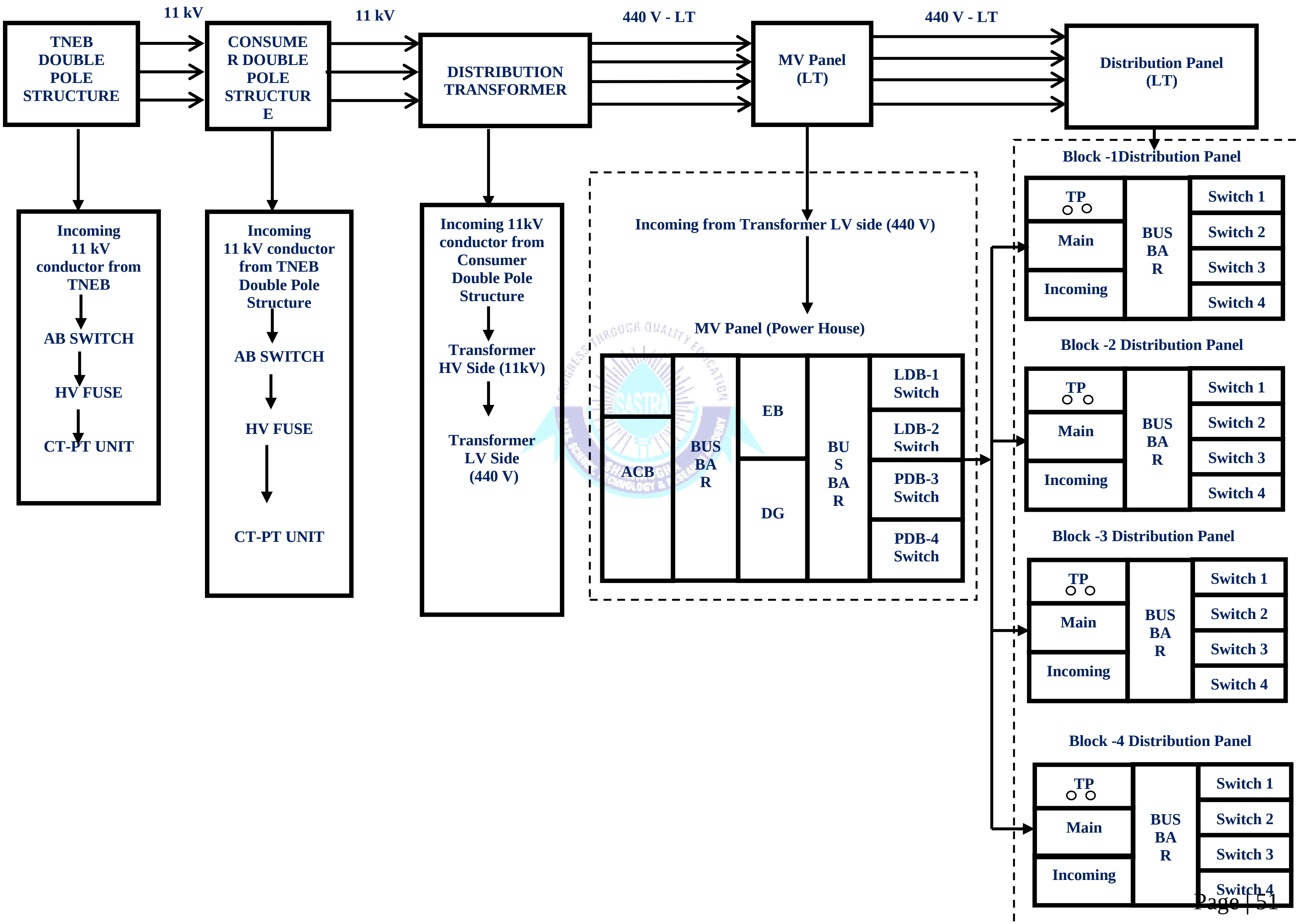
The TNEB double pole structure consists of air brake switch, horn gap fuse, current transformer & potential transformer set. The consumer structure is a similar structure. It is mandatory because the TNEB structure is sealed and replacement of fuses another maintenance are to be done by TNEB personnel. The distribution transformer is the vital part of the power system. The 11 kV voltage is stepped down to 440 V three phase voltage. This 440V power is fed to the main panel board (MV Panel) in the substation. The incoming power enters through an Air Circuit Breaker (ACB). In case of power failures power can be fed from backup diesel generator sets. From the main panel, power is distributed to various distribution panels.

PROCEDURE:

1. The various components in the model are studied and their significances are learnt.
2. The main component blocks such as TNEB structure, Consumer structure Transformer, MV panel and distribution panels are connected through connecting wires as per the layout.
3. The main power supply to the kit is switched ON
4. Power flow through various components is studied

RESULT:

(Write in your own words)


11 kV
11 kV
440 V - LT
440 V - LT
TNEB DOUBLE POLE STRUCTURE
CONSUMER DOUBLE POLE STRUCTURE
DISTRIBUTION TRANSFORMER
MV Panel (LT)
Distribution Panel (LT)
Incoming 11 kV conductor from TNEB
AB SWITCH
HV FUSE
CT-PT UNIT
Incoming 11 kV conductor from TNEB Double Pole Structure
AB SWITCH
HV FUSE
CT-PT UNIT
Incoming 11kV conductor from Consumer Double Pole Structure
Transformer HV Side (11kV)
Transformer LV Side (440 V)
Incoming from Transformer LV side (440 V)
MV Panel (Power House)
ACB
BUS BAR
EB
DG
BUS BAR
LDB-1 Switch
LDB-2 Switch
PDB-3 Switch
PDB-4 Switch
Block -1Distribution Panel
TP
Main
Incoming
BUS BAR
Switch 1
Switch 2
Switch 3
Switch 4
Block -2 Distribution Panel
TP
Main
Incoming
BUS BAR
Switch 1
Switch 2
Switch 3
Switch 4
Block -3 Distribution Panel
TP
Main
Incoming
BUS BAR
Switch 1
Switch 2
Switch 3
Switch 4
Block -4 Distribution Panel
TP
Main
Incoming
BUS BAR
Switch 1
Switch 2
Switch 3
Switch 4

Ex. No: 13 **STUDY OF STATICALLY AND DYNAMICALLY INDUCED EMF**
Date :

(a) Study of statically induced EMF

AIM : To study the principle behind the statically induced emf.

THEORY:

1. Statically Induced E.M.F.

Key Point: Statically induced e.m.f., it's an e.m.f. induced in a coil without physical moving the coil or the magnet.

Explanation: To have an induced e.m.f. there must be change in flux associated with a coil. Such a change in flux can be achieved without any physical movement by increasing and decreasing the current (alternating current) producing the flux with time. Such alternating current means it changes its magnitude and direction periodically with time. This produces the flux which is also alternating i.e. changing with time. Thus, there exists $\frac{d\Phi}{dt}$ associated with the coil placed in the vicinity of an electromagnet. This is responsible for producing an e.m.f. in the coil. This is called statically induced e.m.f.

The statically induced e.m.f. is further classified as,

1) Self induced e.m.f. and 2) Mutually induced e.m.f.

Self Induced E.M.F.

According to Faraday's law, due to rate of change of flux linkages there will be induced **e.m.f.** in the coil. So without physically moving coil or magnet, there appears an induced e.m.f. in the coil. The phenomenon is called self induction. The e.m.f. induced in a coil due to the change of its own flux linked with itself is called self-induced **e.m.f**.

Mutually Induced E.M.F.

If the flux produced by one coil is getting linked with another coil and due to change in this flux produced by first coil, there is induced e.m.f. in the second coil, then such an e.m.f. is called mutually induced e.m.f.

Such an induced e.m.f. can be observed in a multi winding transformer and the connection diagram is shown in Fig. 13.1

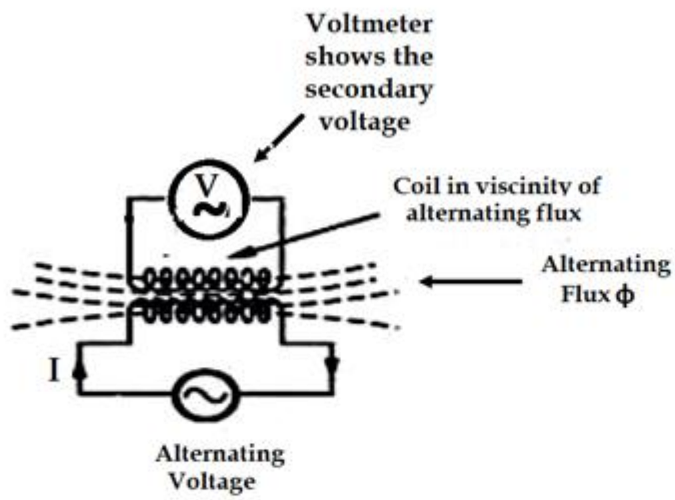


Figure 13.1. Concept of statically induced e.m.f.

The primary winding of the transformer is connected with Alternating supply voltage. Due to the production of mutual induced emf, the voltage is observed in the multi meter connected at the secondary of the transformer.

Result:

The statically induced emf is measured at the secondary winding of the transformer using a multimeter.

THEORY:

1. Dynamically Induced EMF:

Key Point: Dynamically induced e.m.f., it's an e.m.f. induced in a coil with either physical moving the coil or the magnet.

The Fig.13.2 shows the set up for verifying dynamically induced emf due to relative motion of a permanent magnet (PM) with respect to a multi turn fixed coil.

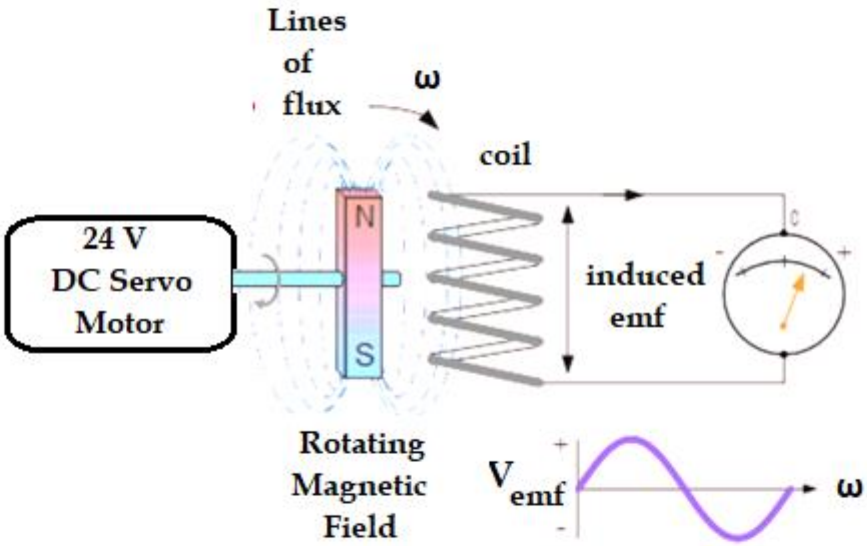


Figure 13.2 Concept of dynamically induced e.m.f

Here, during rotation the magnetic flux at the alternate north (N) and south (S) poles of the bar magnet intersect the conductors of the multi turn coil, which is fixed. As the prime mover is energized from 24 V dc supply, the servo motor and a PM bar magnet fixed to the shaft rotate at about 80 rpm. The alternate magnetic fields at the poles cause dynamically induced emf at the 60-turn coil, thereby producing an AC voltage which can be observed by connecting a multimeter.

RESULT:

(Write in your own words)