Parul University

Faculty of Engineering & Technology

TABLE OF CONTENT

TABLE OF CONTENT

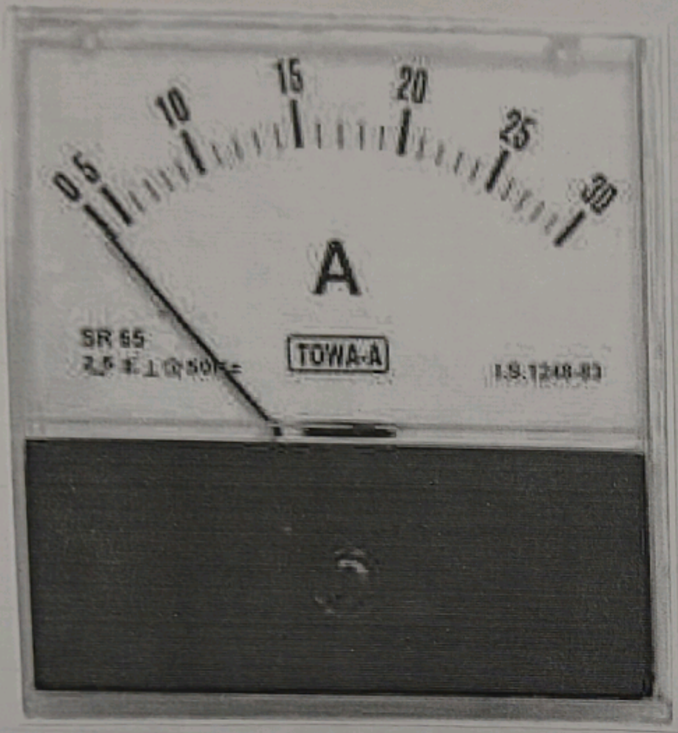


Fig 1.1 Ammeter

Fig 1.2 Capacitance meter

Experiment NO. 1

AIM : To study in Brief about Various Measuring Equipments Used in Electrical Laboratories.

Theory:

Ammeter:

An ammeter (from Ampere meter) is a measuring instrument used to measure the current in a circuit. Electric currents are measured in amperes (A), hence the name.
Instruments used to measure smaller currents, in the milliampere or microampere range, are designated as milli ammeters or micro ammeters. Early ammeters were laboratory instruments which relied on the Earth's magnetic field for operation. By the late 19th century, improved instruments were designed which could be mounted in any position and allowed accurate measurements in electric power systems.

Capacitance Meter:

A capacitance meter is a piece of electronic test equipment used to measure capacitance, mainly of discrete capacitors. Depending on the sophistication of the meter, it may display the capacitance only, or it may also measure a number of other parameters such as leakage, equivalent series resistance (ESR), and inductance. For most purpose and in most cases the capacitor must be disconnected from circuit; ESR can usually be measured in circuit.

Fig 1.3 Clamp meter

Fig 1.4 Electric meter

Current Clamp:

In electrical and electronic engineering, a current clamp or current probe is an electrical device having jaws which open to allow clamping around an electrical conductor. This allows measurement of the current in a conductor without the need to make physical contact with it, or to disconnect it for insertion through the probe. Current clamps are typically used to read the magnitude of alternating current (AC) and, with additional instrumentation, the phase and waveform can also be measured. Some clamp meters can measure currents of 1000A and more. Hall effect and vane type clamps can also measure direct current (DC).

Electricity Meter:

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device. Electric utilities use electric meters installed at ~~cus~~ customers' premises to measure electric energy delivered to their customers for billing purposes. They are typically calibrated in billing units, the most common one being the kilowatt hour [KWh]. They are usually read once each billing period.

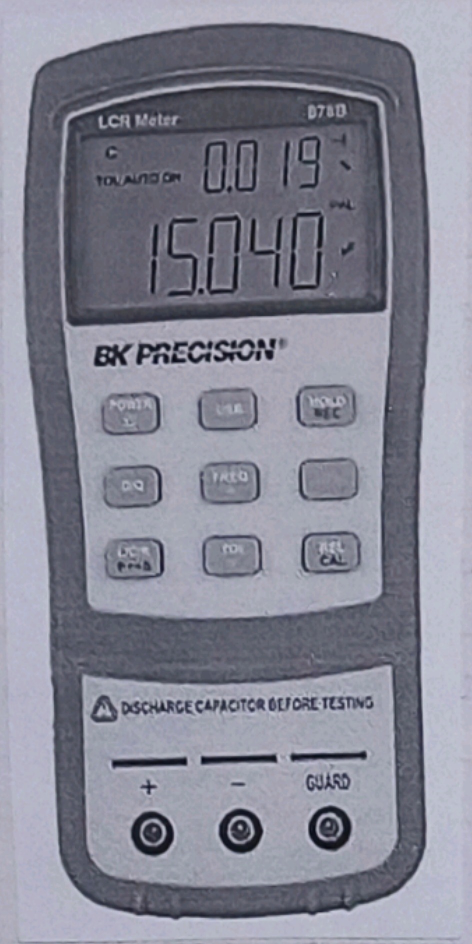


Fig 1.5 LCR meter

Fig 1.6 Multimeter

LCR meter :

An LCR meter is a type of electronic test equipment used to measure the inductance (L), capacitance (C), and resistance (R) of an electronic component. In the simpler versions of this instrument the impedance was measured internally and converted for display to the corresponding capacitance or inductance value. Readings should be reasonably accurate if the capacitor or inductor device under test does not have a significant resistive component of impedance. More advanced designs measure true inductance or capacitance, as well as the equivalent series resistance of capacitors and the Q factor of inductive components.

Multimeter :

A multimeter or a multitester, also known as a VOM (Volt-Ohm-Millimeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. Analog multimeters use a micrometer with a moving pointer to display readings. Digital multimeters (DMM, DVOM) have a numeric display, and may also show a graphical bar representing the measured value. Digital multimeters are now far more common due to their cost and precision, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value.

Fig 1.7 Ohm meter

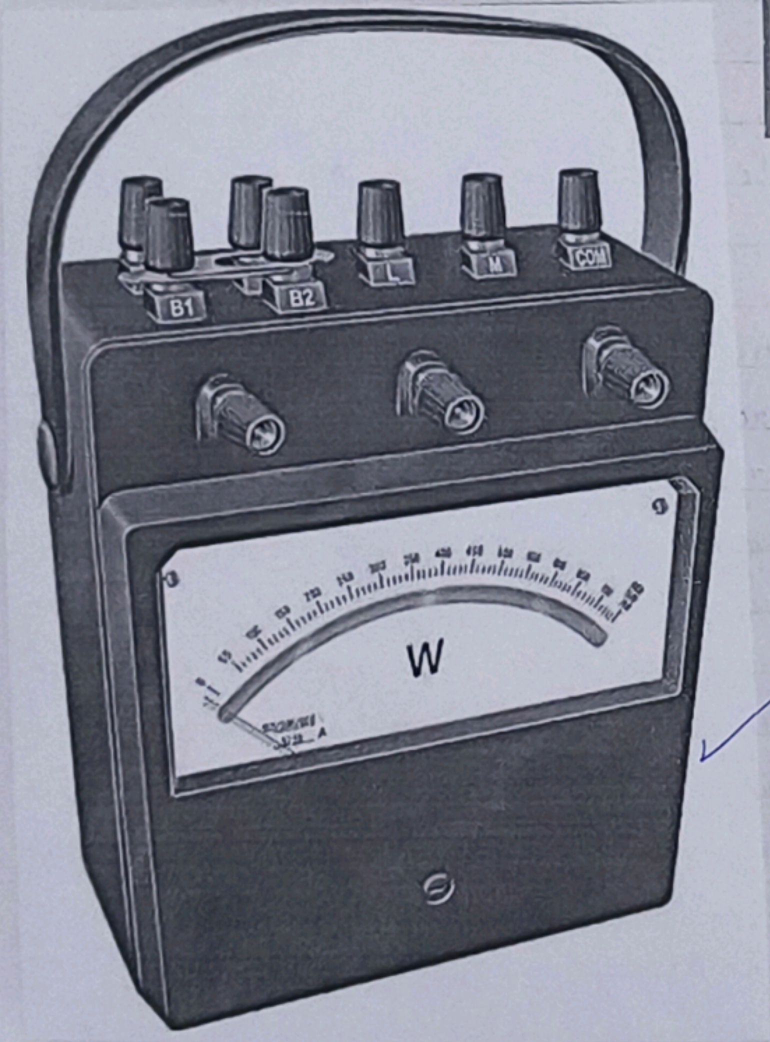


Fig 1.8 Wattmeter

Ohm meter:

An ohmmeter is an electrical instrument that measures electrical resistance, the opposition to an electric current. Micro-ohmmeters (microhmmeter or microohmmeter) make low resistance measurements. Megohmmeters (also a trademarked device Meggar) measure large values of resistance. The unit of measurement for resistance is ohms (Ω).

Wattmeter:

The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements.

The traditional analog wattmeter is an electrodynamic instrument. The device consists of a pair of fixed coils, known as current coils, and a movable coil known as the potential coil. The current coils are connected in series with the ~~device~~ circuit, while the potential coil is connected in parallel. Also, an analog wattmeters, the potential coil carries a needle that moves over a scale to indicate the measurement. A current flowing through the current coil generates an electromagnetic field around the coil. The strength of this field is proportional to the line current and in phase with it. The potential coil has, as a general rule, a high-value resistor connected in series with it to reduce the current that flows through it.

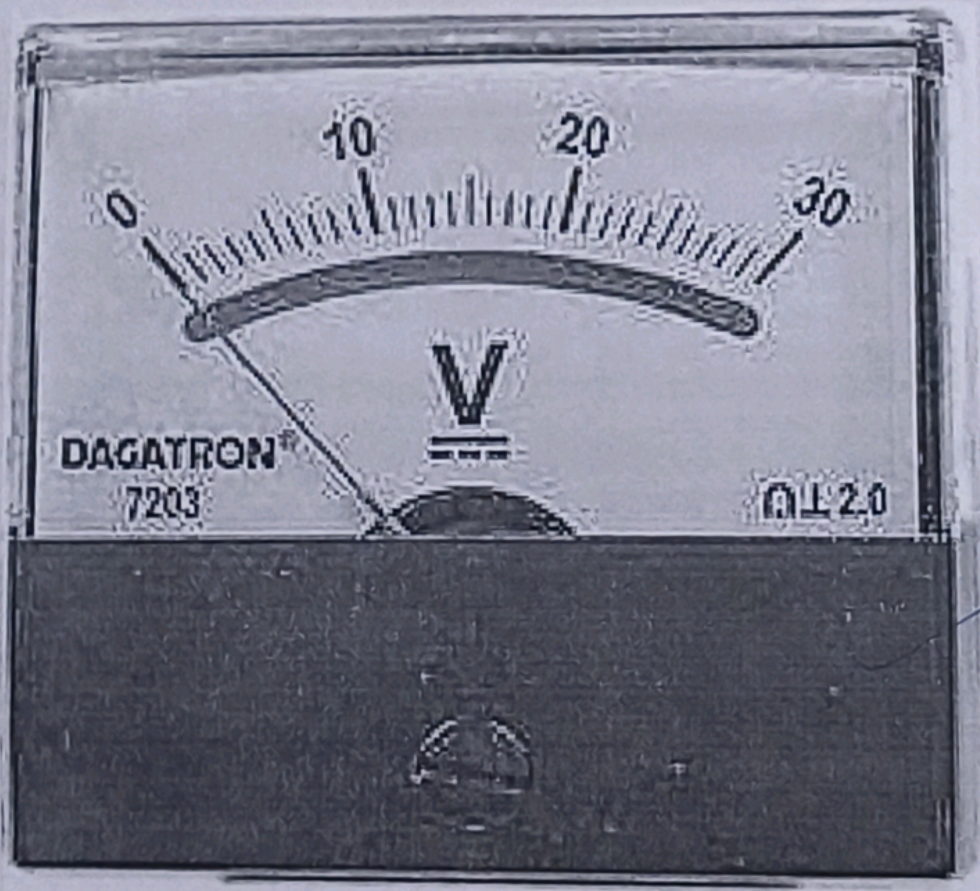


Fig 1.9 Voltmeter

The result of this arrangement is that on a dc circuit, the deflection of the needle is proportional to both the current (I) and the voltage (V), thus conforming to the equation $P = VI$.

For AC power, current and voltage may not be in phase, owing to the delaying effects of circuit inductance or capacitance. On an ac circuit the deflection is proportional to the average instantaneous product of voltage and current, thus measuring true power, $P = VI\cos\phi$. Here, $\cos\phi$ represents the power factor which shows that the power transmitted may be less than the apparent power obtained by multiplying the readings of a voltmeter and ammeter in the same circuit.

Voltmeter:

A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter. A voltmeter in a circuit diagram is represented by the letter V in a circle.

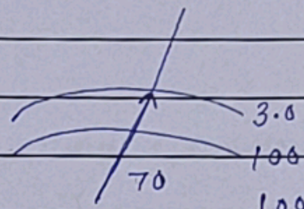
Conclusion: After this experiment, I know how to use these devices and what is the use of these devices.

Questions and Answers:

1. If an ammeter have 2 displaying scales of 30A and 100A and you are selecting the range of 30A, then what will be the value of current when the pointer is showing 70A in 100A scale?

→ 100A displays as 30A

1A Displays as $\frac{30}{100} = 0.3A$



100 → 70
30 → (?)

70A Displays as $= 70 \times 0.3 = 21A$

If an ammeter have 2 displaying scales of 30A and 100A and on selecting the range of 30A, the value of current when the pointer is showing 70A in 100A scale will be 21A.

2. Why Voltmeter is connected in parallel?

→ A voltmeter has very high resistance to ensure that it's connection do not alter flow of current in the circuit. Now if it is connected in series then no current will be there in the circuit due to it's high resistance. Hence it is connected in parallel to the load across which potential difference is to be measured.

3. Why does an Ammeter have a low resistance?

→ An ammeter is an instrument for measuring the electric current in amperes in a branch of an electric current. It must be placed in series with the measured branch & must have very low resistance to avoid significant alternation of the current it is to measure.

4. What is multiplying factor in watt meter?

→ $MF = \frac{(\text{Voltage range} \times \text{current range} \times \text{power factor})}{(\text{range of the wattmeter scale})}$

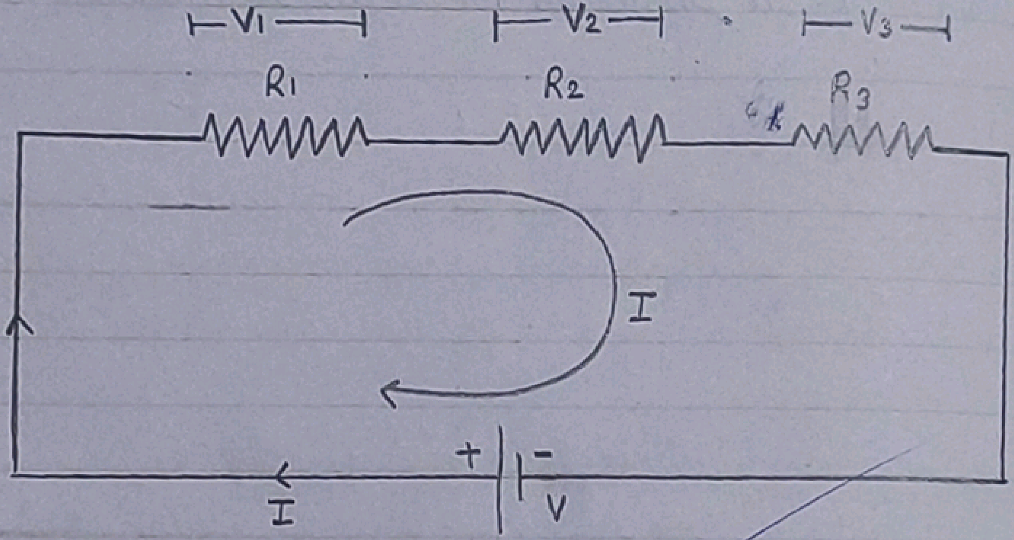
5. Is ammeter connected in series?

→ An ammeter is connected in series to measure current.

$$I_1 = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_2}{R_2}$$

$$I_3 = \frac{V_3}{R_3}$$



Series connection of Resistors

Experiment No. 2

Aim: To perform and solve electrical networks with series and parallel combinations of resistors using kirchhoff's laws.

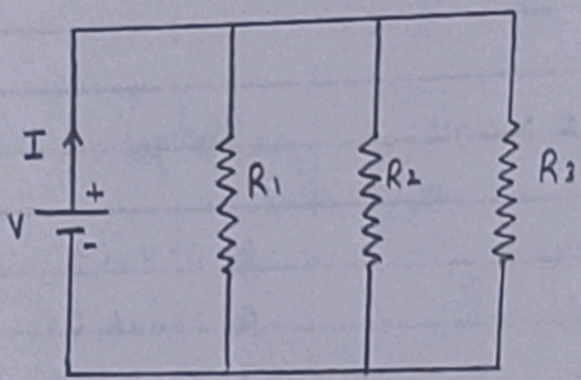
Apparatus:

Sr. No.	Equipment Name	Range	Quantity
(i)	Voltmeter	0 - 30V DC	1
(ii)	Ammeter	0 - 20mA DC	1
(iii)	Resistors	1KΩ, 2.2KΩ	1
(iv)	Experimental kit		
(v)	Multimeter		1
(vi)	Connecting wires		1

Theory:

Series connection

Ignore this space.



$V_1 = I_1 R_1$
$V_2 = I_2 R_2$
$V_3 = I_3 R_3$

Parallel connection of Resistors

A circuit in which two or more elements are connected end to end i.e. one after another and same current flows through all elements is known as series connection of resistance.
Figure shows three resistances connected in series obviously current flowing through each resistance will be same but voltage drop across each of them will vary as per value of individual resistance. Also the sum of all voltage drops ($V_1 + V_2 + V_3$) is equal to the applied voltage (V).

Using ohm's law : $V = IR$

$$V = V_1 + V_2 + V_3$$

$$IR = IR_1 + IR_2 + IR_3$$

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

$$R = R_1 + R_2 + R_3 + \dots + R_n$$

where R is the equivalent resistance of series combination.

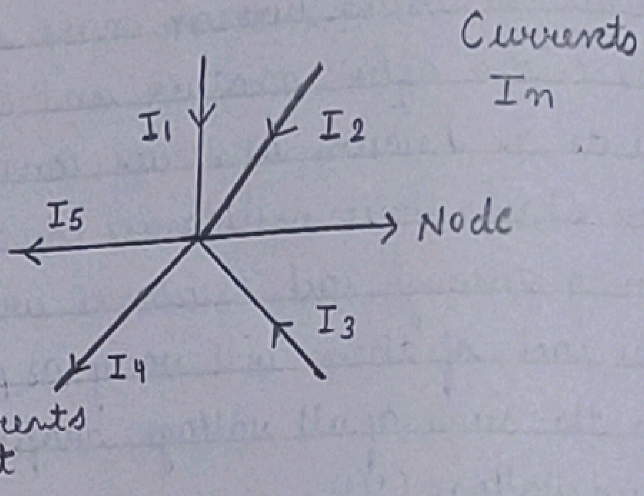
Parallel connection :

When one lead of ~~resistance~~ is joined together and similarly another ~~leads~~ are also joined together the connection is parallel connection. Voltage V is applied across three two terminals each resistor gets voltage V. Total current I taken from the supply as ~~on~~ the sum of branch currents $I_1, I_2, \dots$

Let the equivalent resistance be R ohm,

$$I = I_1 + I_2 + I_3$$

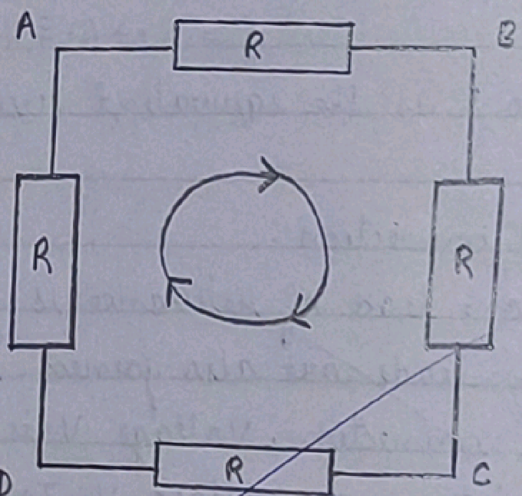
Currents entering the node equals currents leaving the node



Kirchhoff's current law (KCL)

The sum of all the voltage drops around the loop is equal to zero.

$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$



Kirchhoff's Voltage law (KVL)

$$\therefore \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\therefore \frac{V}{R} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

$$\therefore \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Kirchhoff's current law (KCL):

In a network algebraic sum of electric currents at any node is zero. Currents flowing towards node are considered positive where as currents flowing away from node is considered negative.

$$I_1 + I_2 - I_3 - I_4 - I_5 - I_6 = 0$$

$$I_1 + I_2 = I_3 + I_4 + I_5 + I_6$$

Kirchhoff's Voltage law (KVL):

The algebraic sum of product of current and resistance algebraic sum of voltage in a closed loop is zero. From the figure consider a closed path ABCDA.

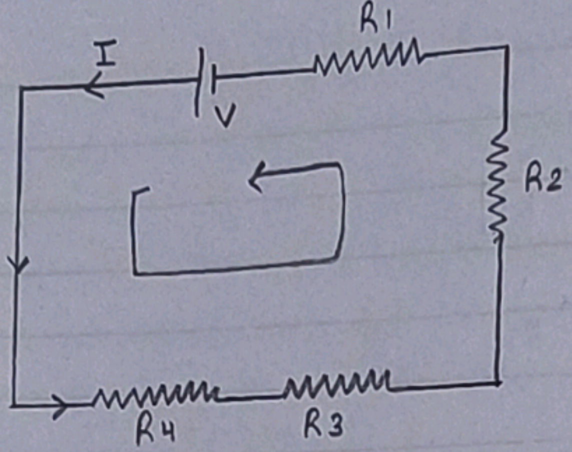
$$(-I_1R_1) + (+E_2) + (+I_3R_3) + (-E_1) + (-I_4R_4) = 0$$

$$E_2 - E_1 = I_1R_1 - I_3R_3 + I_4R_4$$

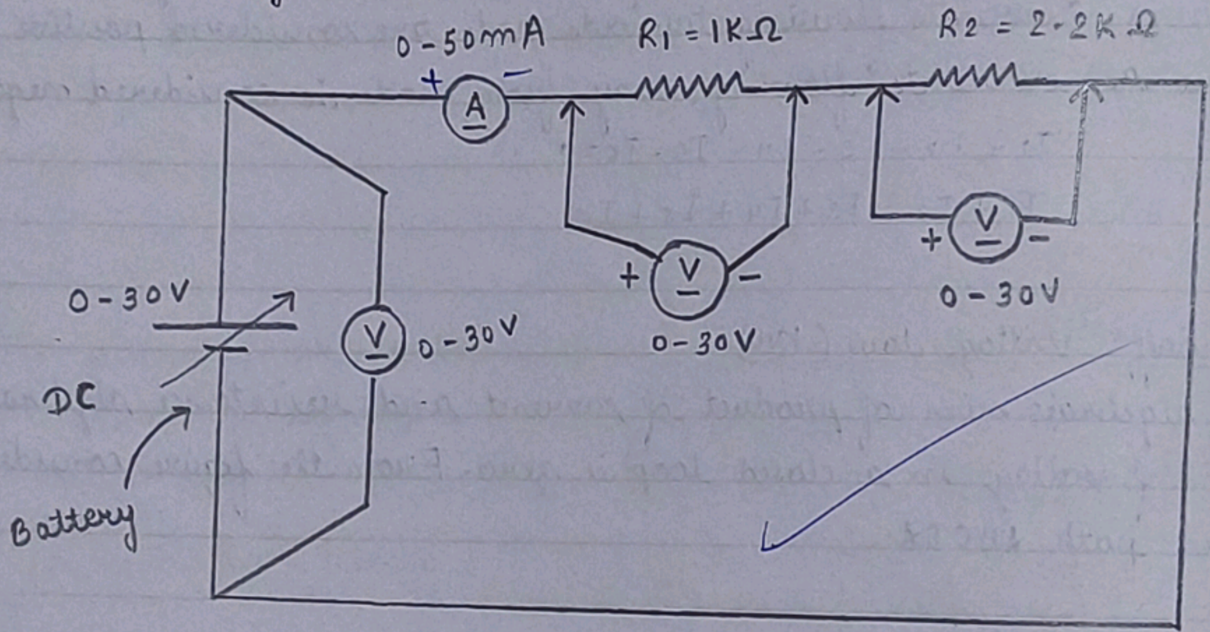
* Procedure:

1. First complete the series circuit :

Battery (+) → Ammeter (+) → Ammeter (−) → R_1 (+) → R_1 (−) → R_2 (+) → R_2 (−) → Battery (−).



* Circuit diagram:



2. Now take 2 separate wires insert in voltmeter and insert these 2 across whatever (battery, R_1, R_2) device voltage you want to measure →
there is a hole in each socket → the other slots of seperate wires from the voltmeter will go 1'r to sockets in devices.

1 small division of voltmeter = 0.2 V.

Questions & Answers:

1. For a closed loop network KVL is applicable. (KVL/KCL/Both).

2. Can we apply KVL to parallel circuit and KCL to series circuit?
→ No, because in parallel circuit there are nodes but no/fewer closed loops and in series circuit there are proper closed loops but no nodes!

3. The Resistance of two wires is 4 Ω and 6 Ω joined in parallel; Find the total resistance.

$$\rightarrow R_{eq} \Rightarrow \frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{6} \Rightarrow \frac{3+2}{12} = \frac{5}{12}$$

$$R_{eq} = \frac{12}{5} = 2.4\,\Omega$$

4. The resistance of two wires is 10 Ω and 30 Ω joined in series. Find the total resistance.

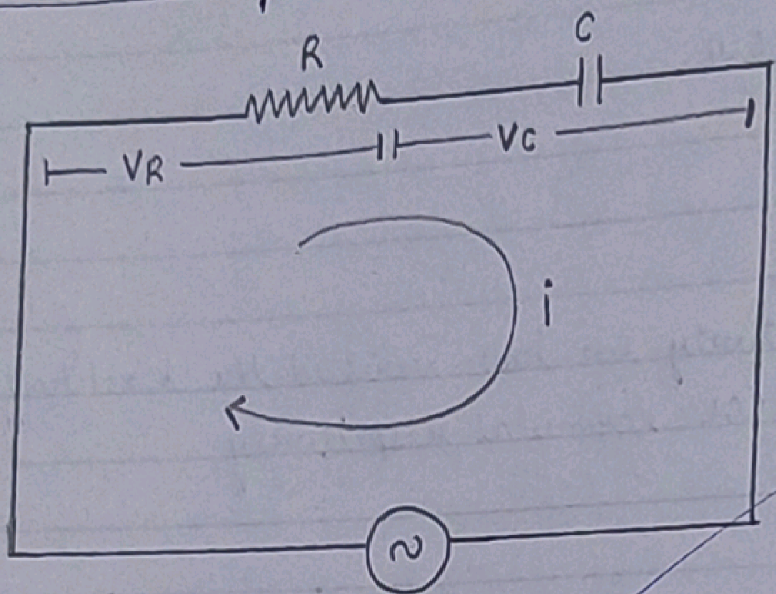
$$\rightarrow \frac{1}{Req} = \frac{1}{10} + \frac{1}{30} \Rightarrow \frac{3+1}{30} \Rightarrow \frac{4}{30} \rightarrow \frac{2}{15}$$

$$Req = \frac{15}{2} \Rightarrow 7.5\,\Omega$$

Conclusion:

Hence, through the activity we have verified the kirchhoff's laws using KVL and KCL formulas respectively.

Diagram in theory:



single phase AC supply.
series R-C circuit

Experiment No. 3

Aim: To obtain capacitance, power factor, power of the series R-C circuit with AC supply using phasor diagram.

When resistance is connected in an AC circuit; is the AC circuit current and voltage both are in phase with each other.

Apparatus:

Sr. No.	Equipment Name	Range	Quantity
1.	AC source	0 - 300V	1
2.	Voltmeter	0-150V	1
3.	Multimeter		1
4.	Resistance		2 - 3
5.	Capacitor		1
6.	Ammeter	0 - 3A	1
7.	Connecting wires		-

Theory:

The current I leads the applied voltage by ϕ instantaneous values are given by,

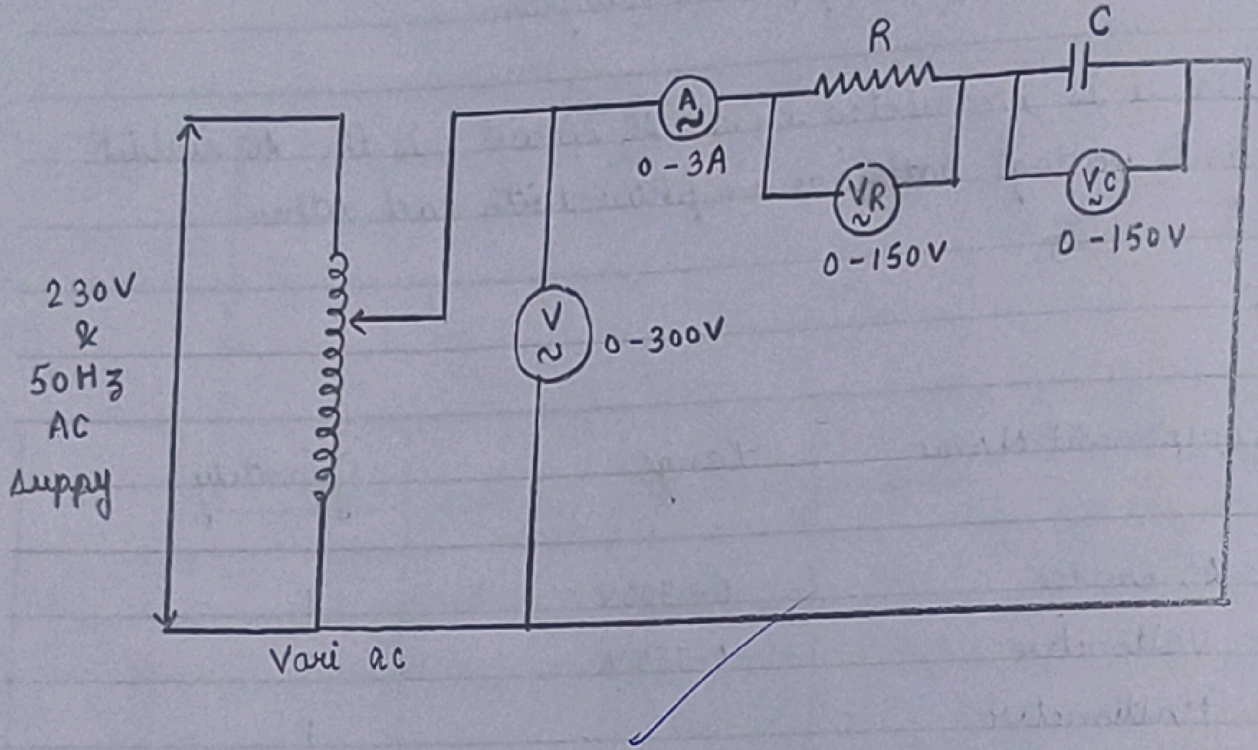
$$V = V_m \sin(\omega t)$$

$$I = I_m \sin(\omega t + \phi).$$

Instantaneous power in R-C circuit:

$$P = VI$$

Circuit diagram :



$P = V_m \sin \omega t \times I_m \sin(\omega t + \phi)$.

$P = V_m I_m \sin(\omega t) \sin(\omega t + \phi)$.

$= \frac{V_m I_m}{2} [2 \sin \omega t \sin(\omega t + \phi)]$

$= \frac{V_m I_m}{2} \cos\phi - \frac{V_m I_m}{2} \cos[2\omega t + \phi]$

Average Power in R-C circuit:

By putting values of ωt, we find that the average values of the variable power component over a complete cycle is zero.

Thus, the average power over one complete cycle $= \frac{V_m I_m}{2} \cos\phi$.

$\Rightarrow \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi = VI \cos\phi$

$P = VI \cos\phi$.

Procedure:

1. Connecting the circuit.

AC source (+) → Ammeter (+) → Ammeter (−) →

Resistance (+) → Voltmeter (+).

Resistance (−) → Capacitors (+).

Capacitor (−) → AC source / voltmeter (−)

2. Then connect VR & VC across resistance and capacitor in parallel connection.

Observation Table :

Sr. No.	Supply Voltage (Vs)	I (Amp)	V_R (V)	Vc (V)
1.	80V	0.7A	54 V	60V
2.	100V	0.8 A	74 V	70V
3.	125V	0.92 A	95V	84V

Sr. No.	$R = V_R / I$ (Ω)	$X_C = V_C / I$ (Ω)	$Z = \sqrt{R^2 + X_C^2}$ (Ω)	$\cos\phi = R/Z$	Phase angle ϕ (deg)
1.	0.675 Ω	0.75 Ω	1 Ω	0.675	47.5
2.	0.74 Ω	0.70 Ω	1.01 Ω	0.73	43.1
3.	0.76 Ω	0.67 Ω	1.01 Ω	0.75	41.4

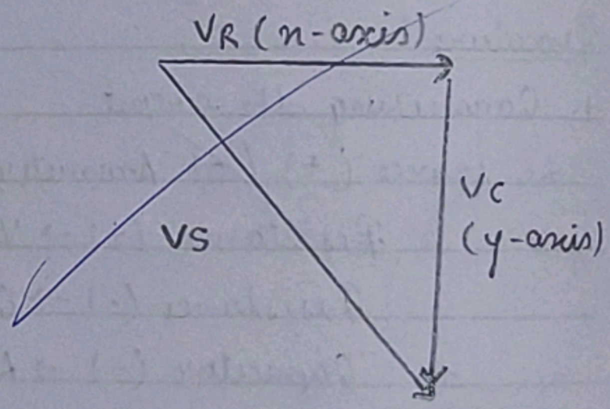
* **Calculation :**

$$V_S = \sqrt{V_R^2 + V_C^2}$$

① $= \sqrt{(54)^2 + (60)^2} = 80.72 \approx 80V$

② $= \sqrt{(74)^2 + (70)^2} = 101.84 \approx 100V$

③ $= \sqrt{(95)^2 + (84)^2} = 126.8 \approx 125V$



3. Turn the switch on and take the readings of ammeters, V_R and V_C.

4. Now vary ac source and take readings to get various readings.

Questions and Answers:

1. What is power factor for a series RL circuit if $R = 10\ \Omega$.
& $C = 5F$

2. What is inductive reactance, capacitive reactance and impedance.

→ Inductive : $X_L = \omega L$;

Capacitive : $X_C = \frac{1}{\omega C}$;

∴ Impedance : $\sqrt{X_C^2 - X_L^2}$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

3. If for an RC series circuit Active power = 60 & reactive power is 80 then what is the value of power factor?

→ power factor = $\frac{\text{total active power}}{\text{total apparent power}}$

apparent power = $\sqrt{P^2 + Q^2}$

P → active power consumed

Q → reactive power consumed

$$\therefore \cos\phi = \frac{60}{\sqrt{60^2 + 80^2}} = 0.6 \text{ lag.}$$

4. If frequency increases what will happen to X_C ?

→ since $X_C = \frac{1}{\omega C}$ and $\frac{1}{2\pi f C}$ if frequency increases,

Capacitive reactance X_C will decreases.

Conclusion:

Through the performed experiment we have successfully obtained the inductance, power factor, power of the series R-C circuit, (AC supply) using phasor diagram.

Experiment No. 4

Aim: To perform and verify Thevenin's Theorem.

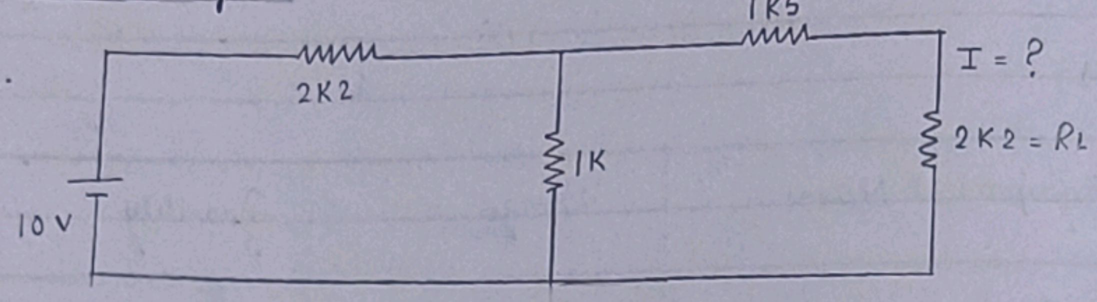
Apparatus:

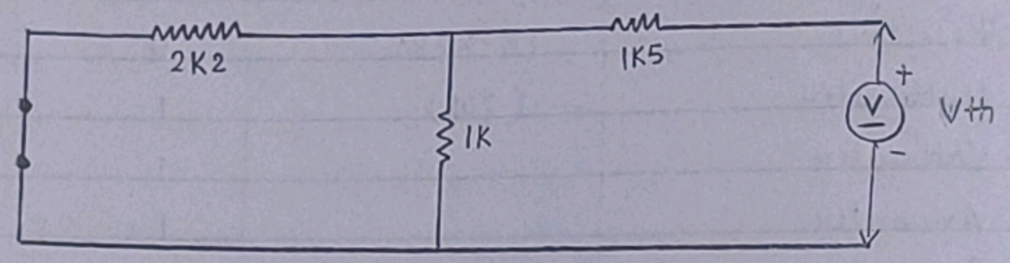
Sr. No.	Equipment Name	Range	Quantity
1.	Battery	10V	1
2.	Resistors	1K → 2K2	4
3.	Multimeter	(20K)	1
4.	Voltmeter		1
5.	Ammeter		1
6.	Connecting wires	-	-

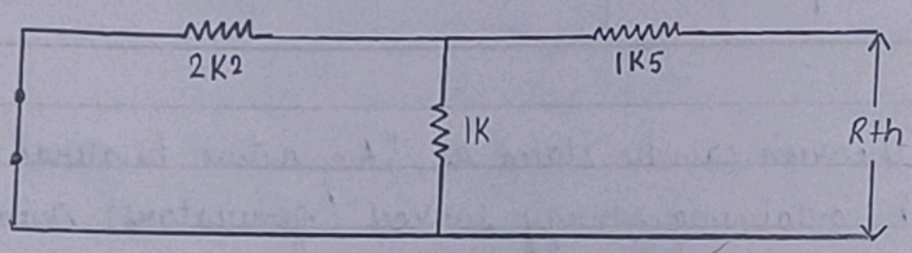
Theory:

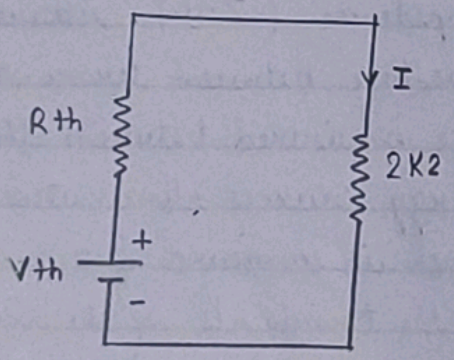
Thevenin's theorem can be stated as, "An active bilateral linear network containing energy sources (generators) and impedances can be replaced by an equivalent circuit containing a voltage source in series with an impedence (Z_{th}), where the E_{th} or V_{th} is the open ~~source~~ circuit voltage between terminals of the network and Z_{th} is the impedance measured between the terminals of this network with all energy sources eliminated." In other words", when a particular branch is removed from a circuit, the open circuit voltage appears across the terminals of the circuit, is Thevenin's equivalent voltage and the equivalent resistance of the circuit network looking back into the terminal is Thevenin's equivalent resistance.

* Circuit diagram :

1.


2.


3.


4.


"If we replace the rest of the circuit network by a single voltage source, then the voltage of the source would be Thevenin's equivalent voltage and internal resistance of the voltage source would be Thevenin's equivalent resistance which would be connected in series with the source as shown in the figure.

Procedure:

1. Measure voltage / EMF of battery → to adjust to 10V.
2. Remove the resistance (R_1 = 2KΩ) & put across voltmeter.
3. Remove supply voltage and replace it with its internal resistance or short-circuit. To find Rth replace 2KΩ with Rth.
4. Remove 2KΩ and connect it with the voltage and resistance which are connected in series with each other. Hence current:

$$I = \frac{V_{th}}{R_{th} + 2K\Omega}$$

5. Rth is brought through connection with multimeter.

Conclusion:

By understanding and stating the thevenin's theorem we found ways to solve current passing through a load resistance aiding us to solve complex circuits without getting confused in the loops or carrying out lengthy calculations of equations through KCL. This theorem has been verified with readings which match the theoretical observations, hence by ~~pos~~ proving this theorems we have accessed an easy method to solve complex circuits.

* Observation Table :

Sr. No.	Vs (V)	Vth (V)	Rth (KΩ)	I measured (mA)	I through Thevenin theorem (mA)
1.	10V	2.6V	2.17KΩ	0.6mA	0.59mA

* Conclusion:

$$I = \frac{V_{th}}{R_{th} + 2K2} \Rightarrow \frac{2.6}{2.17 + 2.2} = \frac{2.6}{4.37}$$

$$= 0.59 \approx 0.6mA$$

Questions and Answers:

1. State Thevenin's theorem.

→ Thevenin's theorem states that it is possible to simplify any linear circuit, irrespective of how complex it is to an equivalent circuit with a single voltage source and a series resistance.

2. State Maximum Power Transfer Theorem.

→ The maximum power theorem states that in a linear; bilateral DC network, maximum power is delivered to the load when the load resistance is equal to the internal resistance of a source.

3. What are Vth, Rth and R_L?

→ Vth: The voltage or potential difference b/w the opened end of the circuit found through removing the load resistance (R_L).

Rth: The equivalent resistance of the whole - remaining circuit found by removing the load resistance and short - circuiting the voltage source or open - circuiting the current source.

R_L: The resistance through which the current is to found, hence resistance which consumes current and is found at the edge/ right - hand side of ~~current~~ circuit diagram

4. For the circuit given find Rth when $R_1 = 2\,\Omega$, $R_2 = 3\,\Omega$, $R_3 = 4\,\Omega$

$R_1 = 2\,\Omega$

$R_2 = 3\,\Omega$

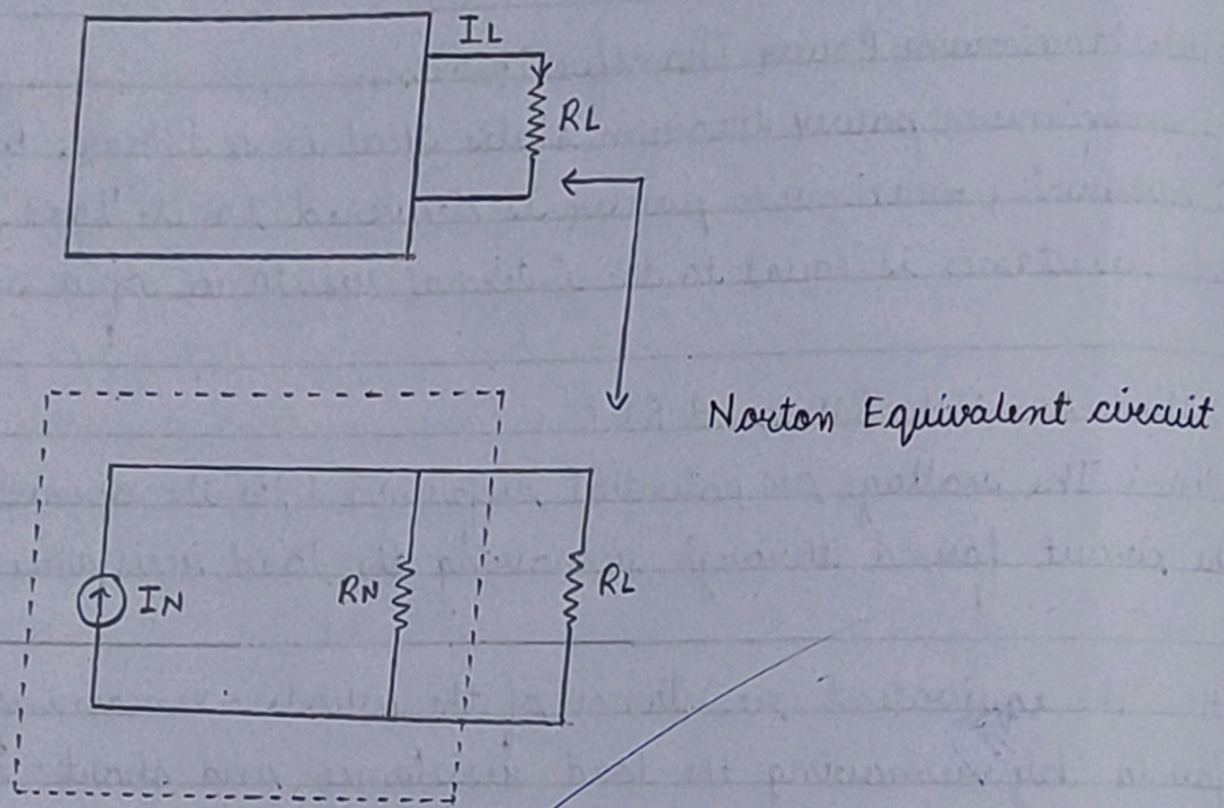
$R_3 = 4\,\Omega$

Hence; $\frac{1}{2} + \frac{1}{3} \rightarrow \frac{2+3}{6} = \frac{5}{6} = \frac{6}{5} = 1.2\,\Omega$

$\frac{6}{5} + 4 = \frac{6+20}{5} = \frac{26}{5} = 5.2\,\Omega$

38.

* Theory diagram:



Experiment No. 5

Aim: To perform and verify Norton's Theorem.

Apparatus:

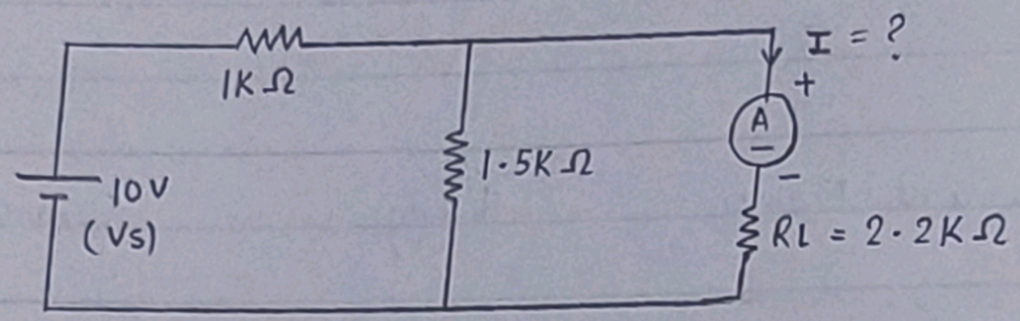
Sr. No.	Equipment Name	Range	Quantity
1.	Voltmeter	(0-150V)	
2.	Ammeter	(0-200mA)(0-10mA)	
3.	Multimeter		
4.	Resistances	1K, 2.2K, 1.5K(Ω)	
5.	Connecting wires	–	
	variable DC battery	(0-10V)	

Theory:

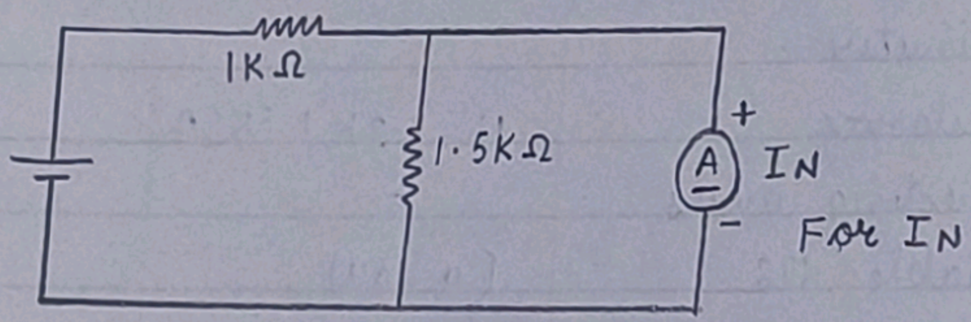
- In Norton's theorem, the network with different active sources is reduced to single current source whose internal resistance is nothing but the looking back resistance, connected in parallel to the derived source.
- The looking back resistance of the network is the equivalent electrical resistance of the network when someone looks back into the network from the terminals where said branch is connected. During calculating this equivalent resistances all sources are removed leaving their internal resistances in the network.

* Circuit diagram :

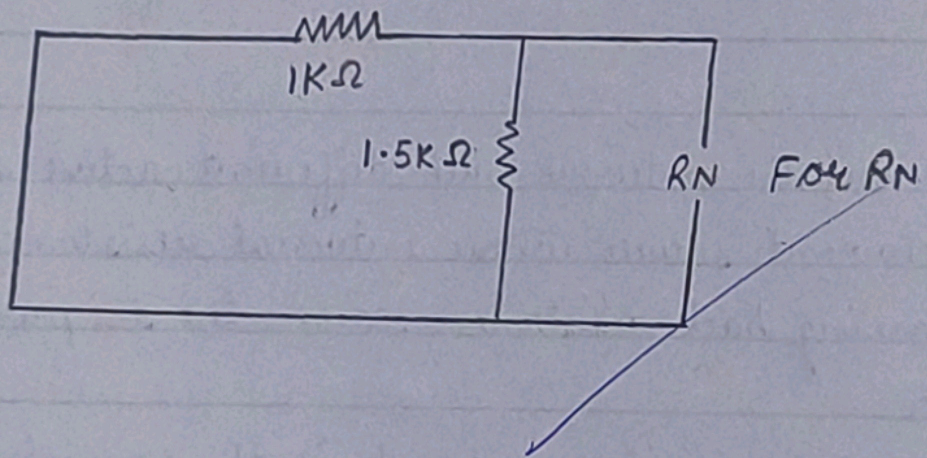
a.



b.



c.



- In Norton's theorem, the branch of the network through which we need to find the current, is removed from the network. After removing it, we short circuit that disconnected branch. Then we calculate the short circuit current that flows b/w the terminals - this is Norton's equivalent current I_N of the source. The equivalent resistance between the said terminals with all the sources removed leaving their internal resistances in the circuit is calculated - R_N. Now form a current source that's current is I_N Amp. & internal shunt resistance is R_N Ω.

*** Procedure:**

1. Battery (+) → 1KΩ (+) → 1KΩ (-) → Ammeter (+) → Ammeter (-) → 2.2KΩ (+) → 2.2KΩ (-) → Battery (-).
   1KΩ (-) → 1.5KΩ (+) → 1.5KΩ (-) → 2.2KΩ (-).

2. Short circuit load resistance and measure current → I_N.
3. Short circuit voltage source/open circuit current source and find equivalent resistance (R_N) with the help multimeter in place of load resistance.
4. Calculate values for I through R_L and verify.

Conclusion:

By following the simple systematic steps of the Norton's theorem to find I_N & R_N and hence I through R_N we have verified Norton's theorem since I found = I calculated.

* Observation Table:

Sr. No.	Supply Voltage V_S (V)	Norton's Current I_N (mA)	Norton's Resistance R_N (KΩ)	Current through (R_L) (mA)	Current through 2.2K without applying Norton's theorem
1.	10V	9.7 mA	0.6KΩ	2.05 mA	2 mA

* Calculation:

Through current divider rule I (through 2.2KΩ) through Norton's theorem:-

$$I = \frac{I_N \times R_N}{R_N + R_L} = \frac{9.7 \times 0.6 \times 10^{-3} \times 10^{3}}{0.6 \times 10^{3} + 2.2 \times 10^{3}} = \frac{5.76}{2.8 \times 10^{3}}$$

$$= 2.05\,mA \approx \boxed{2\,mA}$$

Thus now we have another easy method to find current through a resistance without having to foil in solving various KVL equations.

Questions & Answers:

1. State Norton's theorem.

→ Norton's theorem states that any 2 terminal linear network or circuit containing several energy sources and resistances can be replaced by an equivalent circuit containing a single current source (I_N) in parallel & resistance (R_N).

2. Define Norton's current and Norton's Resistance.

→ I_N : Short-circuit current at the terminals to which the load resistance is connected.

R_N : Resistance measured b/w the terminals with all energy sources replaced by their internal resistance.

3. State its Necessity.

→ They allow us to replace complicated circuit with a simple equivalent circuit containing only a current source and a parallel connected resistors. Hence, problem solving becomes easy and less tedious.

4. Give application of this theorem.

→ Replacement of a large part of the network to a simple circuit.

• Simplication of a network in terms of current instead of voltage.

• Helps to accomplish a maximum transfer of power.

5. Find R_N for the given circuit when $R_1 = 3\Omega$, $R_2 = 4\Omega$ and $R_3 = 5\Omega$.

→ $R_1 = 3\Omega$, $R_2 = 4\Omega$, $R_3 = 5\Omega$

then → $\frac{1}{3} + \frac{1}{4} = \frac{4+3}{12} = \frac{7}{12} = \frac{12}{7}\Omega = 1.7\Omega$

$1.7 + 5 = 6.7\Omega$

$R_N = 6.7\Omega$

Theory diagram:

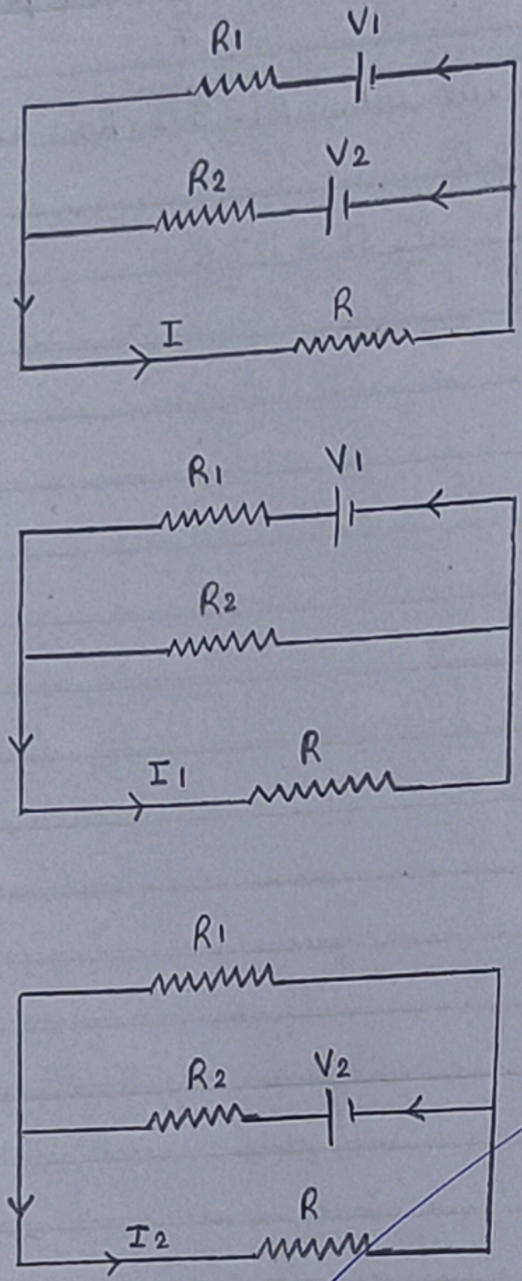


Figure: Superposition Theorem

Experiment No. 6

Aim: Verification of Superposition Theorem

Apparatus:

Sr. No.	Equipment Name	Range	Quantity
1.	Voltage Source	0 – 10 V	2
2.	Resistance	1, 1K5, 2K2	3
3.	Ammeter	0 – 10 mA	1
4.	Voltmeter	0 – 150 V	1

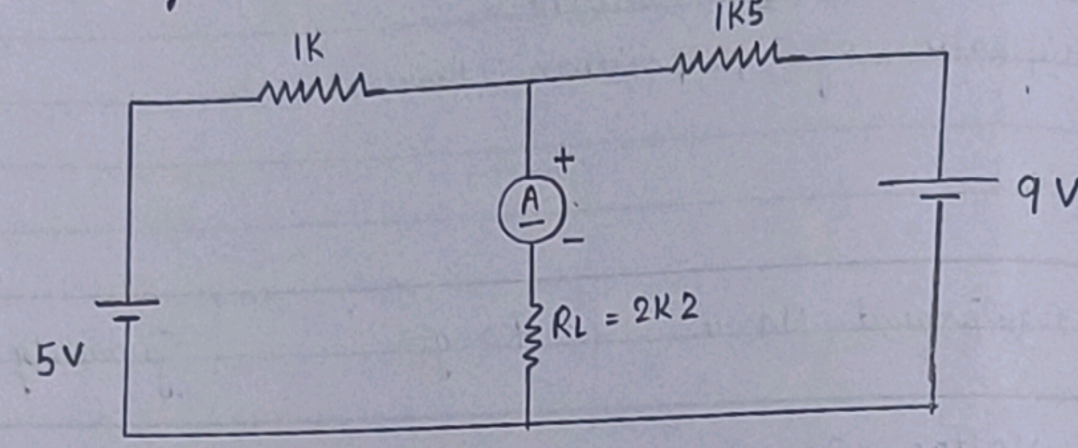
Theory:

Superposition Theorem: The total current in any part of a linear circuit equals the algebraic sum of the currents produced by each source separately. To evaluate the separate currents to be combined, replace all other voltage sources by short circuits and all other current sources by open circuits.

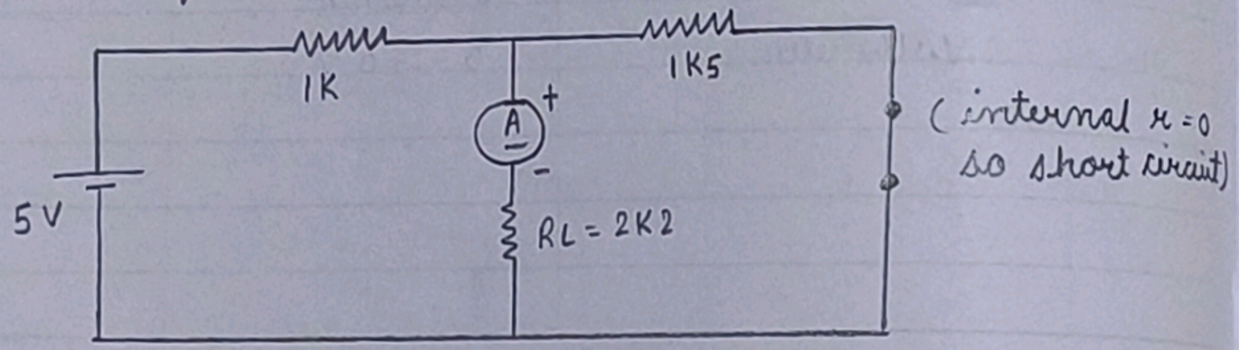
Suppose there are two voltage sources V_1 and V_2 acting simultaneously on the circuit. Because of these two voltage sources, say current I flows through the resistance R.

Circuit Diagrams :

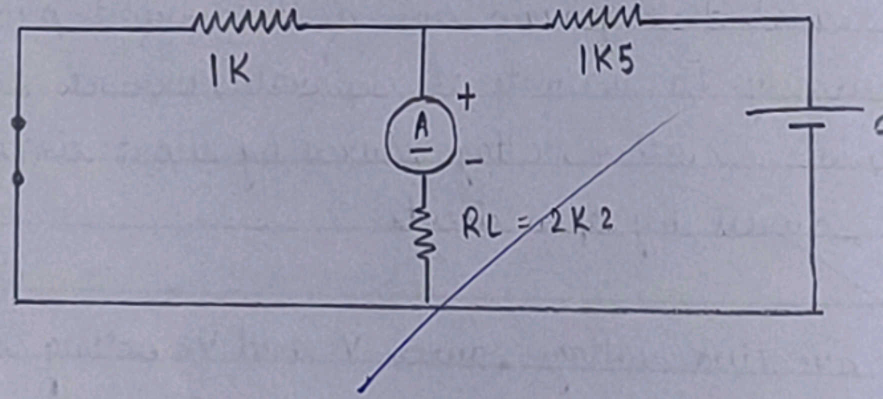
a.



b. with only 5V:



c. with only 9V:



Now replace V_2 by short circuit, keeping V_1 at its position and measure current through the resistance, R. Say it is I_1. Then replace, V_1 by short circuit, reconnect V_2 to its original position and measure current through the same resistance R and say it is I_2.
Now if we add these two currents, I_1 and I_2 we will get the current which is equal to the current - was actually flowing through R, when both voltage sources V_1 and V_2 were acting on the circuit simultaneously. That is $I_1 + I_2 = I$.

Procedure :

1. Assemble the circuit according to the circuit diagram.
2. [Make sure you connect 2nd voltage source with an external / separate source], connect voltmeter in parallel with the voltage source and set the potential to 5V & 2nd source to 9V.
3. Only after both voltages are set - measure the current.
4. Short circuit 9V (by inserting wires in each other) then measure current.
5. Short circuit 5V then measure current (but remember to re-connect 9V).
6. Through current divider rule measure I branch.

Conclusion:

By superposition theorem we can avoid solving large no. of long loop equations for current through ~~brac~~ branches. Since, superposition principal replaces a voltage source/ current source with its internal resistance (0, ∞ respectively)

Observation Table:

Sr. No.	Current through R_L with both 5V & 9V. (M Amp.)	Current through R_L with only 5V (m Amp.)	Current thru R_L with only 9V (m Amp.)	Theoretical observations (m Amp.)
1.	2.2 m Amp	1 m Amp	1.2 m Amp	2.33 m Amp ~ 2.2 m Amp

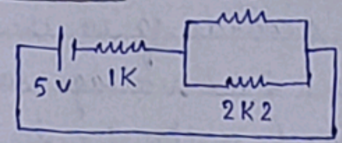
Calculations:

- **Experimental:**

$1 + 1.2 = 2.2$

- **Theoretical:**

b.



$$\frac{1}{Req_1} = \frac{1}{1.5} + \frac{1}{2.2} = \frac{3.7}{3.3}$$

$$Req_1 = \frac{3.3}{3.7} = 0.89\,K\Omega$$

$$Req_2 = 1 + 0.89 = 1.89\,K\Omega$$

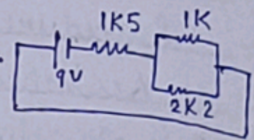
$$V = IR \rightarrow I = \frac{V}{R} \rightarrow \frac{5}{1.89} = 2.6\,mAmp$$

(Circuit current)

$$\text{Branch current} = \frac{2.6 \times 1.5}{1.5 + 2.2}$$

$$= 1.05\,mAmp \approx 1\,mAmp$$

c.



$$Req_1 = \frac{1}{Req_1} = \frac{1}{1} + \frac{1}{2.2}$$

$$= \frac{2.2+1}{2.2}$$

$$= \frac{3.2}{2.2}$$

$$Req_1 = \frac{2.2}{3.2} = 0.68\,\Omega$$

$$Req_2 = 1.5 + 0.68 = 2.18\,\Omega$$

$$I = \frac{9}{2.18} = 4.12\,mAmp$$

$$I_{2.2} = \frac{4.12 \times 1}{1+2.2} = \frac{4.12}{3.2} = 1.28\,mAmp \approx 1.2\,mAmp$$

Hence, theoretical = experimental, proved.

to provide us with a single loop to solve Ibranch.
It is a really efficient way to solve Ibranch for such circuits which has 2 or more voltage sources which causes complications if we solve it directly through KVL.

Questions & Answers:

1. State Superposition Theorem.

→ Superposition theorem states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately and all other sources are replaced by their internal resistance. The superposition theorem is used to solve the network where two or more sources are present and connected.

2. Explain importance of superposition Theorem.

→ The superposition theorem is very important in circuit analysis because it converts a complex circuit into a Norton or Thevenin equivalent circuit.

3. Explain merits and demerits of superposition Theorem.

→ Advantages: It is applicable to the elements of the network as well as to the sources. Useful for circuit analysis. Utilised to convert any circuit into its Thevenin or Norton equivalent.

Disadvantage: Superposition is applicable to current and voltage but not to power.

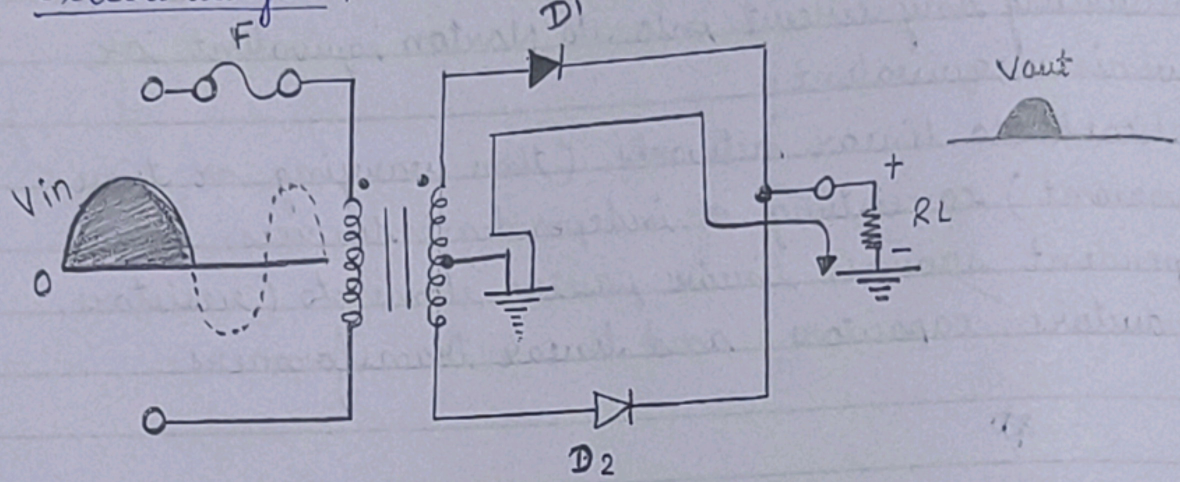
4. Give application of this theorem.

→ Converting any circuit into its Norton equivalent or Thevenin equivalent.

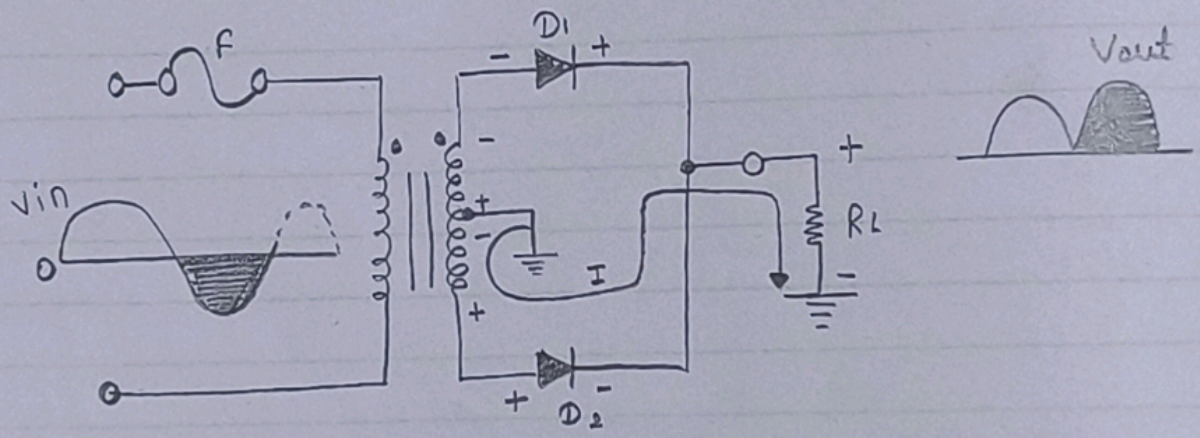
Applicable to linear networks (time varying or time invariant) consisting of independent sources, linear dependent sources, linear passive elements (resistors, inductors, capacitors) and linear transformers.

Full wave rectifier without filter:

Circuit diagram:



(a) During positive half-cycles, D_1 is forward-biased and D_2 is reverse-biased.



(b) During negative half-cycles, D_2 is forward-biased and D_1 is reverse-biased.

Experiment-7

Aim: Full wave rectifier circuit (a) without capacitor filter
(b) with capacitor filter.

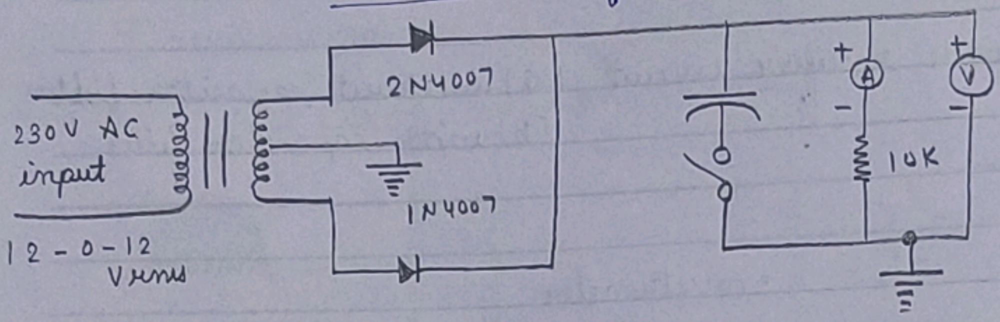
Apparatus:
- 2 diodes
- Resistance
- AC input voltage
- multimeter
- capacitance
- connecting wires

Theory:

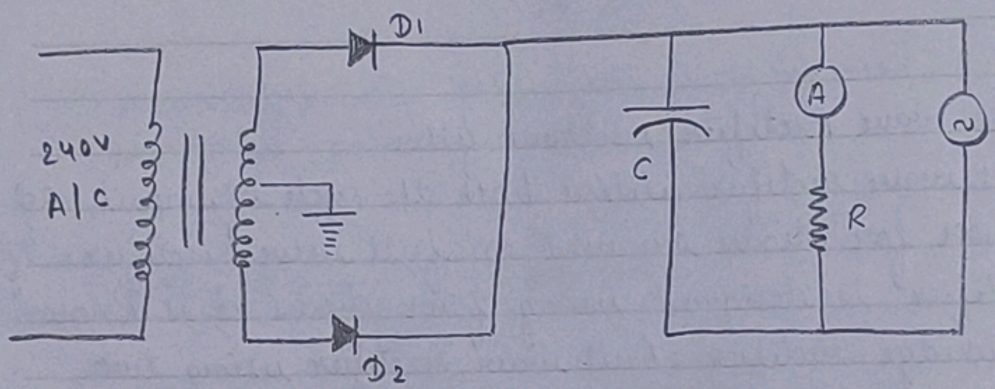
Full wave Rectifier without filter.

Full wave rectifier utilize both the cycle of input AC voltage. Two or for diodes are used in full wave rectifier. If full wave rectifier is designed using four diodes it is known as full wave bridge rectifier. Full wave rectifier using two diode without capacitor is shown in the following figure. center tapped transformer is used in this full wave rectifier. During the positive cycle diode D1 conducts and it is available at the output. During negative cycle diode D1 remains off but diode D_2 is in forward bias hence it conducts and negative cycle is available as a positive cycle at the output as shown in the following figure. Note that direction of current in the load resistance is same during both the cycles hence output is only positive cycles.

Full wave rectifier with capacitor filter



* Circuit diagram:



Advantages :

- The rectification efficiency is double than half wave rectifier.
- Ripple factor is less and ripple frequency is double hence easy to filter out.
- DC output voltage and current is higher hence output power is higher.
- Better transformer utilization factor.
- There is no DC saturation of core intransformer because the DC currents in two halves of secondary flowing opposite directions.

Disadvantages :

- Requires center tap transformer.
- Requires two diodes compared to one diode in half wave rectifier.

Full wave rectifier with filter

Full wave rectifier without filter capacitor convert AC voltage into pulsating DC voltage. ~~The average voltage with full wave capr~~ Filter capacitor is used to obtain smooth DC voltage. The average voltage with full wave capacitor filter is higher than the average voltage with half wave capacitor filter construct following circuit to perform this practical.

* Observation table:

(a) without filter:

Sr. No.	Resistance (R)	VAC (input)	VDC	VAC (output) (ripple voltage)	Ripple factor VAC/VDC
1.	400 Ω	27.4 Ω	11.52 V	5 V	0.43

(b) with filter:

Sr. No.	Resistance (R)	VAC (input)	VDC	VAC (output)	Ripple factor (VAC/VDC)
1.	400 Ω	27.3 V	15.09 V	1.45 V	0.096

Calculation:

Ripple factor – (a) $\therefore \frac{5V}{11.52V} = 0.43$

Ripple factor – (b) $\therefore \frac{1.45V}{15.09V} = 0.096$

$\Rightarrow$ After filtering ripple factor (b) < ripple factor (a) which means AC components have been filtered out.

Procedure:

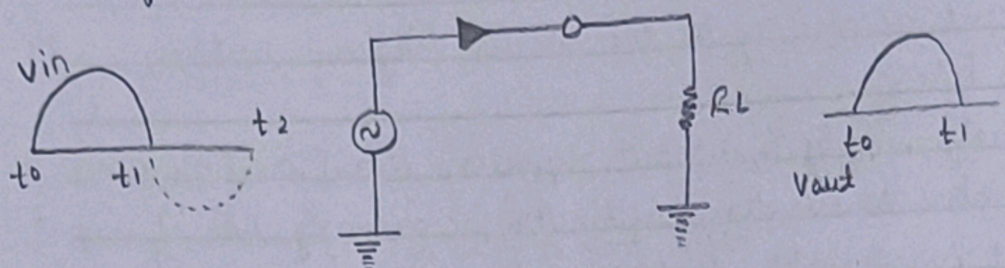
1) Connect the circuit according to the circuit diagram within the rectangular box.
2) Turn on the main supply (without capacitor filter) and measure VAC input remember to use the multimeter accordingly like if input is high always set multimeter higher than it or in its ~~on 200. If it is less than that~~ ranges. Ex. Vin = 150V, so set multimeter on 200. If it is less than that it will show OL (over loading).
3) Record the DC voltage value through multimeter and VAC output also and find ripple factor for it VAC/VDC. Remember to use VAC output for ripple factor.
4) Repeat same process for finding ripple factor with filter.

Conclusion:

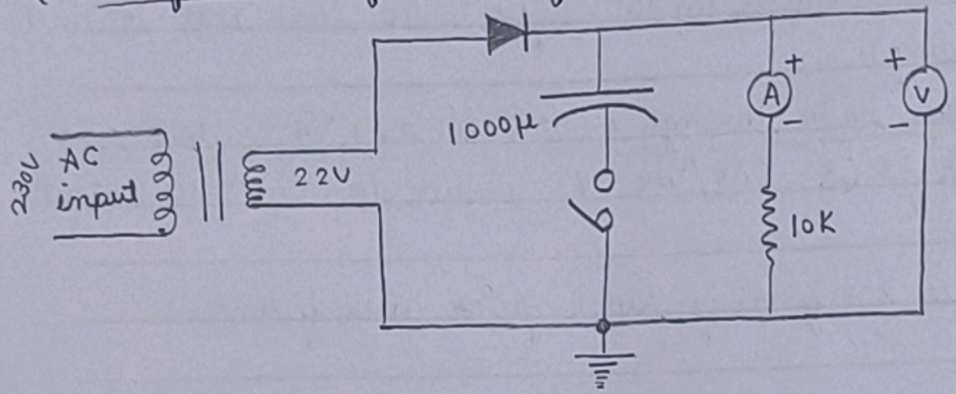
- with a full wave rectifire we get power in both the positive and the negative half wave for DC circuit. The load on AC source is evenly distributed and not just on one half-wave we still need to stabilize ~~thro~~ the rectified signal to get a constant DC voltage.
- A capacitor is included in the rectifier circuit to act as a filter the AC signal but blocks the DC signal and hence capacitor is used in rectifier circuit.
- Finally, we use a filter in rectifier (a device which converts AC into DC) to remove all AC components in the pulsating output (contains both AC component & DC component).
- The experiment conducted verifies according value for ripple factor.

Theory Diagram

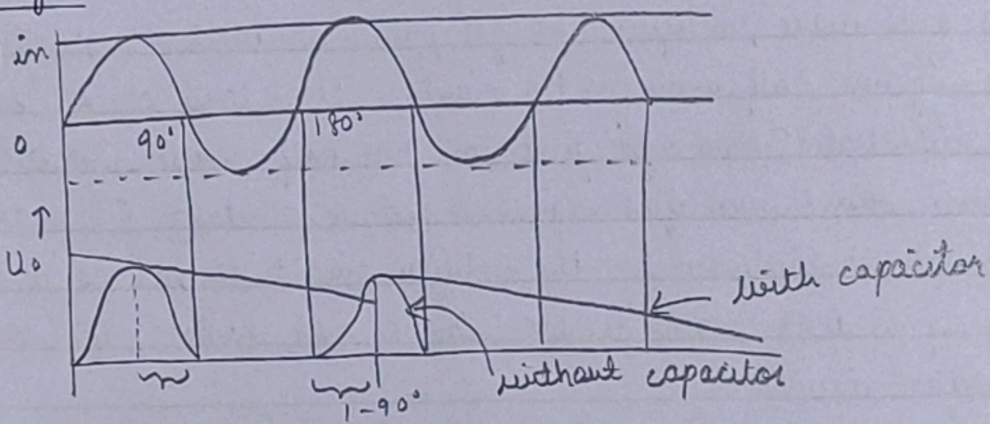
(1) Half wave rectifier without filter:



(2) Half wave rectifier with filter:

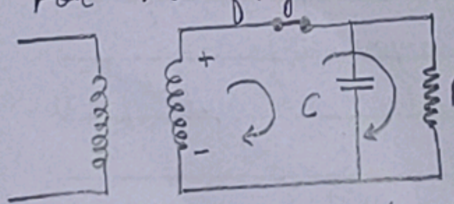


Circuit diagram:

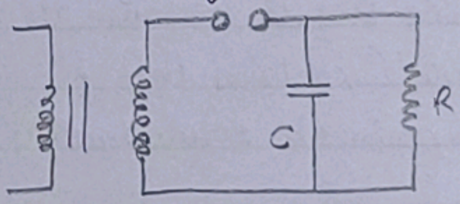


with capacitor:

For '+' half cycle [0-90]



for '-' half cycle [90-180]



Experiment 8

Aim: To perform half wave rectifier
(a) without capacitor filter
(b) with capacitor filter

Apparatus: 1 diode, capacitance [CRO (cathod ray oscillator)]; multimeter, ~~a~~ AC input voltage, resistance, rectifier board.

Theory:

Half wave rectifier without filter.

One of the very important applications of diode is in DC power supply as a rectifier to convert AC into DC. DC power supply is the important element of any electronic equipment. Rectifiers are of two types; Half wave rectifier & full wave rectifier.

In half wave rectifier only half cycle of applied AC voltage is used. Only one diode is used which conducts during +ve cycle.

Half wave rectifier with capacitor filter

Theory:

Half wave rectifier without filter capacitor convert AC voltage into pulsating DC voltage.

Procedure:

Observation table

(a) without capacitor (filter):

Sr. No.	Resistance (R)	Vin rms	Vo rms	Vo DC	Ripple factor $\frac{V_o\,rms}{V_o\,DC}$
1.	400 Ω	14.38	7.43	6.04	1.23

(b) with capacitor (filter):

Sr. No.	resistance (R)	Vin rms	Vo rms	Vo DC	Ripple factor $\frac{V_o\,rms}{V_o\,DC}$
1.	400 Ω	14.17	3.13	13.00	0.286

* Calculation :

Ripple factor – (a) $= \frac{7.43}{6.04} = 1.23$

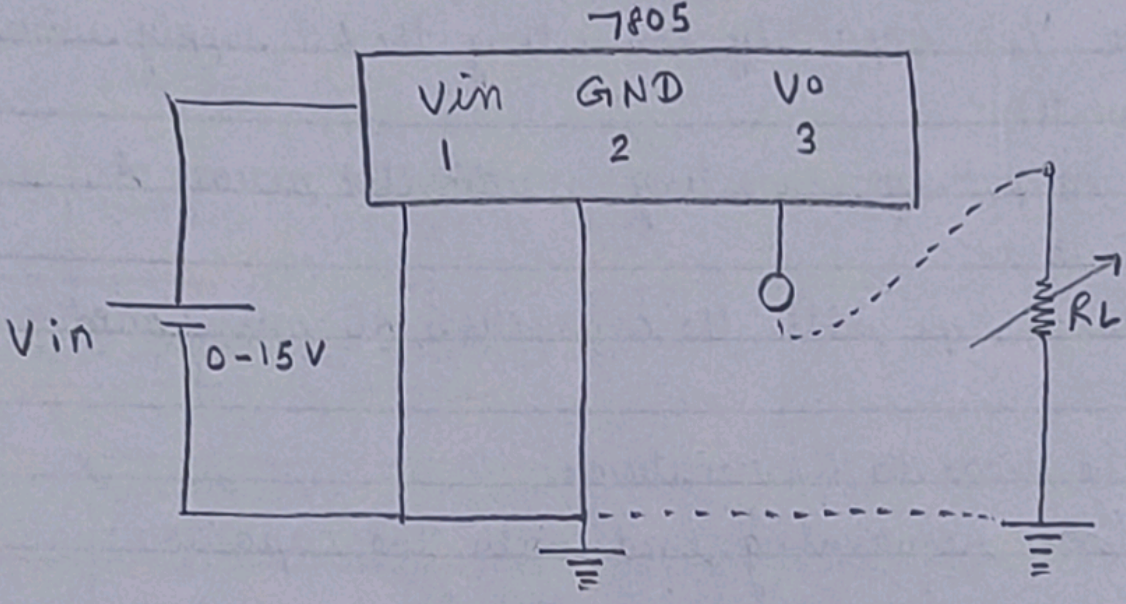
Ripple factor – (b) $= \frac{3.73}{13} = 0.286$

After filtering ripple factor – (b) < ripple factor – (a) which me ans components have been ~~altered~~ filtered out.

1) Set your multimeter voltage for 20V and connect the diode with the load resistance. [Remember: do not connect capacitor].
2) First measure V_{AC} input by connecting the AC supply wires to multimeter (white).
Now ~~A~~ V_{AC} output by connecting multimeter across AC supply and load resistance.
3) Repeat the above steps with the connection AC mentioned below:
→ connect the diode to R_L resistance.
→ and the diodes remaining end with the capacitor.
(prepared for filter).

Conclusion:
A half wave rectifier transforms an AC signal to DC by allowing one half-cycle of the waveform to pass while blocking the other.
Half wave rectifiers are simple to build using only one diode, but they are inefficient compared to full-wave rectifier.

Circuit diagram:



Experiment . 9

Aim: To design / perform and verify operation of voltage - regulator . IC - 7805.

Apparatus: Voltage regulator kit
Digital multimeter (2)
Connecting wires

Theory:

*** Fixed positive voltage regulator:**

→ This IC regulator provides a fixed +ve output voltage. The 7805 series of IC regulators is the most popular. The last two digits in the part member indicates the DC output voltage. For ex, the 7812 is a +12V regulator where as the 7805 is a +5V regulator . Note that this series (7800 series) regulator provides fixed regulated voltage from +5V to +24V.

*** Fixed negative voltage regulator:**

This IC regutor provides a fixed negative output voltage. The 7900 series of IC regulators is commonly used for this purpose. Note 7900 series provides fixed regulated voltage from 5V to 24V.

procedure:

1) Connecting the circuit, multimeter on load resistance side (Vout) & voltage supply side (Vin).
2) Set multimeter on 20V both sides (yellow).

* Observation Table:

① Line regulation ($R_L = 500\Omega$)

Sr. No.	Input voltage (V)	Output voltage (V)
1.	2.10V	0.01V
2.	4.18V	2.9V
3.	5.13V	4.08V
4.	7.42V	4.94V
5.	13.43V	4.94V

② Load regulation ($V_{in} = 10V$)

Sr. No.	Load Resistance (R_L, Ω)	Output Voltage (V_0, V)	Load resistance
1.	open	5V	
2.	500Ω	4.97V	
3.	400Ω	5.01V	
4.	500Ω	5.02V	

* Calculations:

% load resistance regulation

$$\frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$

$V_{NL} = V$ (No load)
$V_{FL} = V$ (full load)

% line regulation

$$\frac{V_{o\,max} - V_{o\,min}}{V_{o\,rated}} \times 100$$

$V_{o\,min} = 5V$,
$V_{o\,max} = 13.43V$

$$= \frac{4.94 - 4.08}{5} \times 100$$

$= 17.2\%$

3) For line regulation fix the RL through its rotating knob on the RHS to 500 Ω.

4) Change values on variable voltage supplier and note reading.

5) For load regulation fix Vin = 10V on LHS & vary the VRL on RHS.

Note Voutput (multimeter - 2) for diff values of R.

Conclusion:

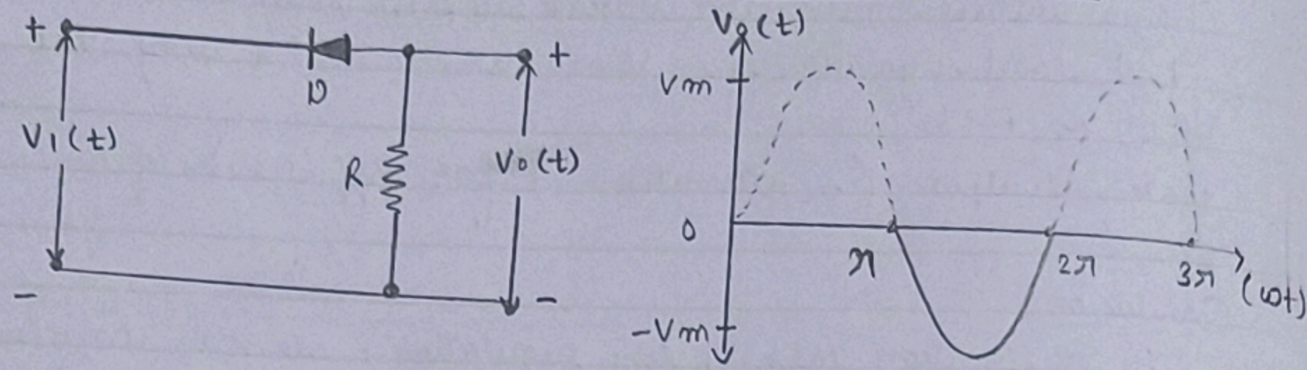
→ The observation table of line regulation, we can conclude that the voltage regulator of 5V regulates any input voltage larger than 5V to 5V again.

The voltage regulator does not perform any variation the output voltage is shown as 5V always.

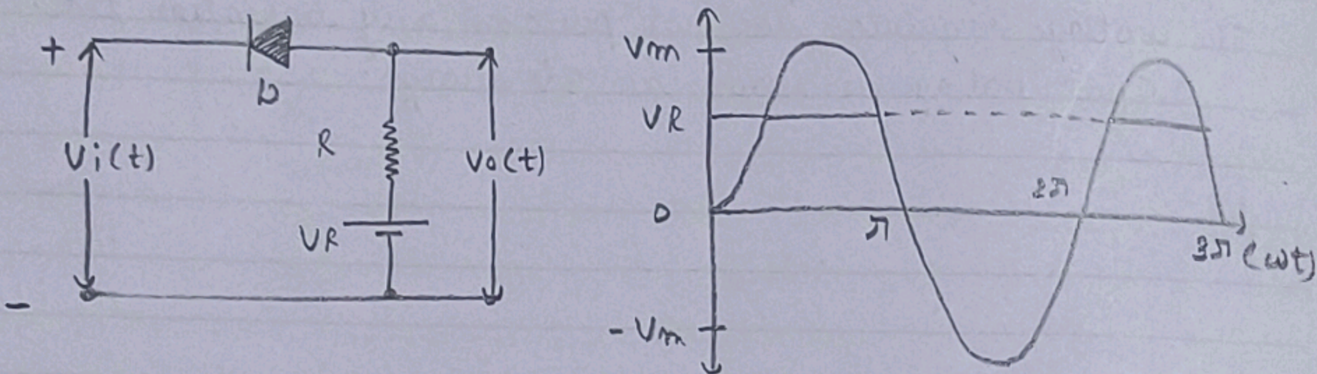
Circuit diagram:

{clipper circuit}

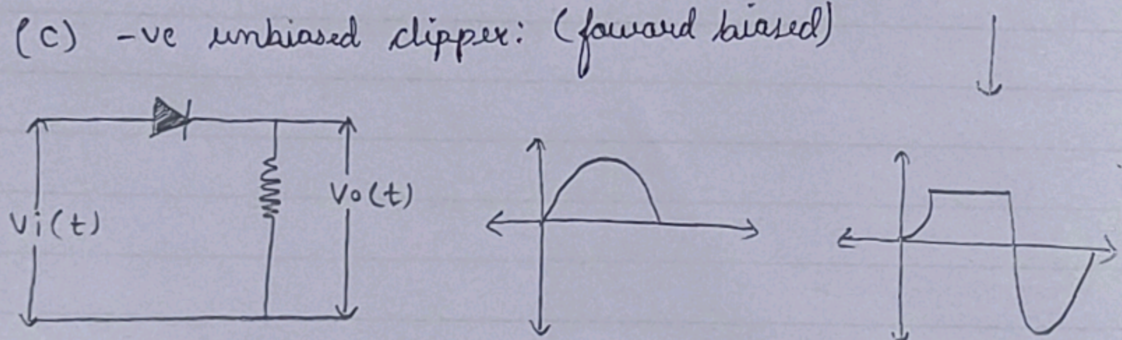
(a) +ve series un-bias clipper circuit (reversed biased diode):



(b) +ve series bias clipper circuit : [reversed biased diode]



(c) −ve unbiased clipper: (forward biased)



Experiment - 10

Aim: To observe response of clipping and clamping circuits using diodes.
(a) +ve clipper & -ve clipper
(b) +ve clamper & -ve clamper.

Apparatus:
- Function Generator
- Oscilloscope
- Breadboard
- Diodes
- Resistors
- Capacitors
- DC power supply
- CRO (70 MHz)

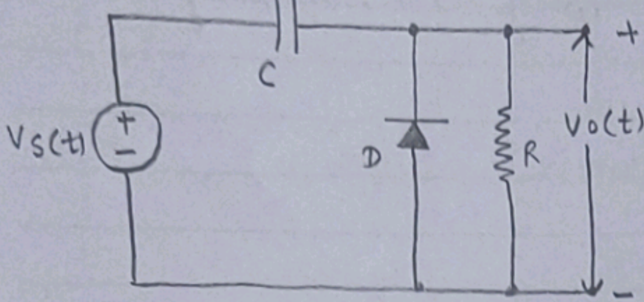
A) Clipper Circuit:

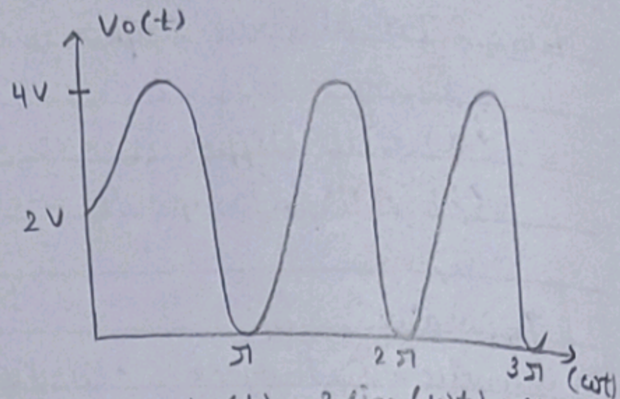
In +ve series un-bias clipper circuit, when $V_i(t) > 0$, diode D is in ON condition. when $V_i(t) > 0$, diode D is in OFF condition. In +ve series bias clipper circuit, DC ~~is~~ reference voltage is used. when $V_i(t) < V_R$, Diode D is in ON condition, and when $V_i(t) > V_R$, diode D is in OFF condition.

Procedure:
1) Build the circuit on a breadboard. ~~Show~~ See the diagram.
2) Connect I/P & O/P to oscilloscope. Observe both I/P & O/P waveform.
3) Adjust input amplitude; see how the output waveform clips at a certain level determined by the diode voltage drop.

Circuit Diagram (Clamper circuit)

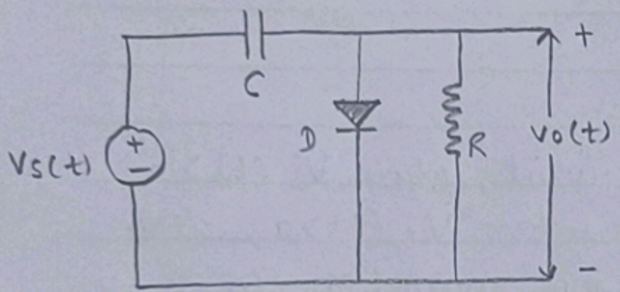
(a) +ve clamper circuit

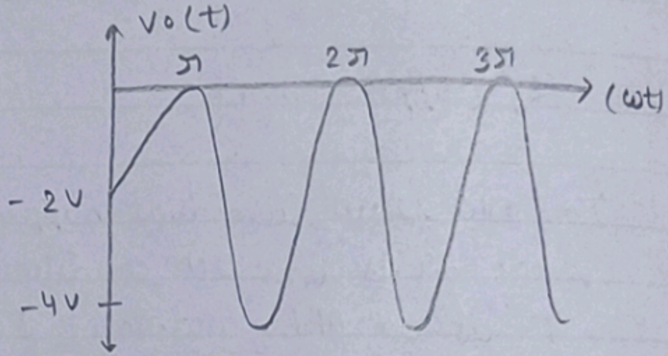




$V_o(t) = 2 \sin(\omega t) + 2V$

(b) −ve clamper circuit :





$V_o(t) = 2 \sin(\omega t) - 2V$

4) Experiment with DC voltage (clamps only); shift the output waveform vertically by adjusting the DC voltage level.

5) Analysis & compare waveforms.

Conclusion:

The clipping circuit limits or flattens the voltage at a certain level. The clipping can be obtained for both cycles by the inclusion of two diodes.

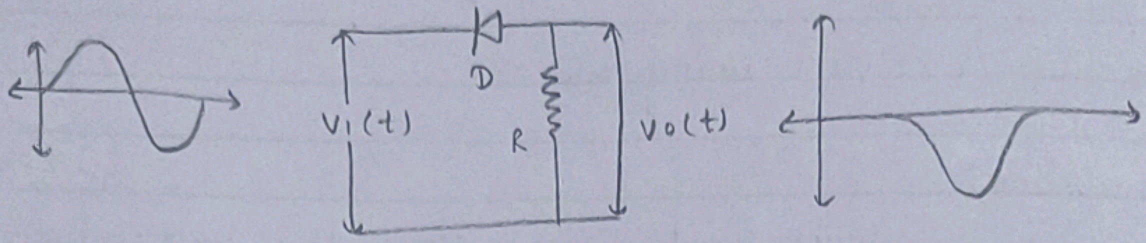
(B) Clamper circuit:

In +ve clamper circuit, consider that 4V peak to peak signal with 0 offset is applied at the input of the clamping circuit. On first -ve half cycle of the input signal, diode D turns ON because anode voltages > voltage cathode. After completion of -ve cycle, +ve cycle starts & diode turns OFF. We can consider that during the +ve cycle capacitor acts like a battery and adds +2V in +2V in input.

In -ve clamping circuit polarity of diode is reverse than in +ve clamping. Diode turns ON during the +ve cycle and charge is stored in the capacitor. Capacitor with charge up to +2V in our example. During the -ve cycle this voltage will be in series with input voltage and gives total output -4V during -ve peak of input signal.

I> Clipping

(i) +ve clipper (unbiased)



Procedure:

1) Chose your clamp type : +ve or -ve; ~~d~~
2) Build the circuit : wire the diode, resistor (s) & DC voltage source (clamps only) based on your chosen type.
3) Connect I/P & O/P to oscilloscope: observe both waveforms
4) Adjust input amplitude: watch how the output waveforms clamps at a desired ~~of~~ level set up the ~~divide~~ diode.
5) Experiment with DC voltage (clamps only).
6) Analyze & compare waveform.

Conclusion:

we obtain the +ve clamper if the diode in the circuit points in the upward direction & we get a -ve clamper when the diode points in the downward direction.