Date

Expt. No. 01 Page No.

1 Objective :-

To familarize with measuring and testing equipments like multimeter, CRO, Function Generator, Power supply, etc and also famalarize with bread board, resistors and capacitors, etc. Calculate the resistance value a/c to colour band & then verify with multimeter.

2 Observation Table :-

S.No	Resistor	Colour Band	Calculated value (in kohm)	Measured value (in kohm)
1	R_1	Green Red Red Gold	$= 82 \times 10^2 \pm 5\%$ $= 8.2\,k\Omega$	$= 8.09\,k\Omega$
2	R_2	Yellow Violet Orange Gold	$= 47 \times 10^3 \pm 5\%$ $= 47\,k\Omega$	$= 46\,k\Omega$
3	R_3	White Red Blue Gold	$= 92 \times 10^1 \pm 5\%$ $\div 0.92\,k\Omega$	$= 0.8\,k\Omega$
4	R_4	Red Red Orange Gold	$= 22 \times 10^3 \pm 5$ $= 22\,k\Omega$	$= 21.6\,k\Omega$

Teacher's Signature

BEEE-Lab-Sec-24 Abhinav kumar choudhary-(21SCSE1011615)

1) Aim :- To verify the kirchhoffs current law (KCL).
2) Objective :- To objective of this lab activity is to verify kirchhoffs current law using mesh and nodal analysis.
3) Theory :- A/c to KCL, in any network of wires carrying currents, the algebraic sum of all current meeting at a junction is zero.

S.NO	Equipment	Specification	Quantity
1	Regular power DC supply	0 – 24V	1
2	PMMC Ammeter	0 – 1 A	3
3	Resistances/Rheostats		4
4	connecting wires		

4) Procedure :- Four resistance R_1, R_2, R_3 and R_4 & ammeter A_1, A_2 and A_3 are connected to DC battery or regulated DC power supply as shown in figure.
5) Working principle :- The algebraic sum of current in a network of conductors meeting at a point is zero. This principle can be stated that:–

$$\sum_{K=1}^{N} I_K = 0$$

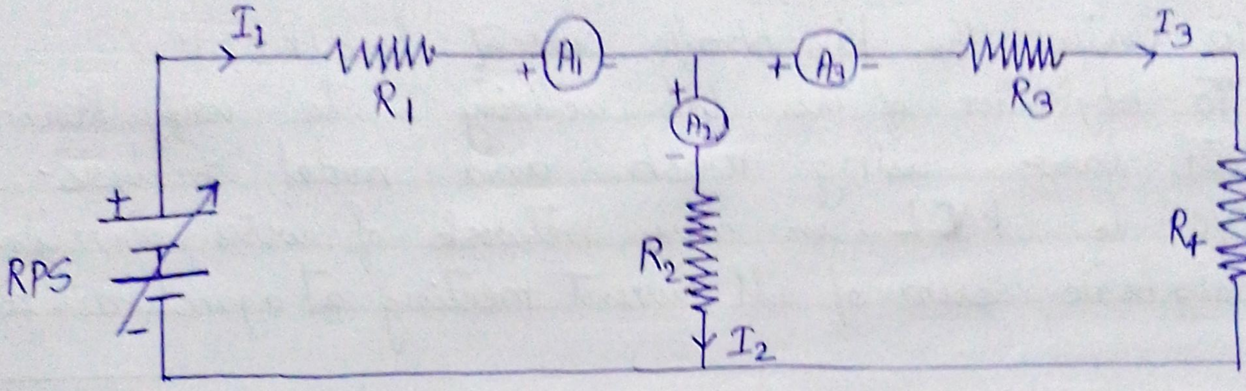
6) key Parameter :- Let $R_1 = 220\Omega, R_2 = 1k\Omega, R_3 = 330\Omega, R_4 = 330\Omega$ and also calculate :- $\text{error} = \frac{\text{Actual} - \text{Measured}}{\text{Actual}} \times 100$

7) Experimental Results :-
a) Calculate the ideal voltages and current for each element in the circuit & compare them to the measured value.
b) Compute the percentage error in the two measurements.
8) Precautions :-
- All connections should be tight.
- Reading & calculation should be taken carefully.
- Don't touch the live terminals.

Teacher's Signature

Sec-(24)-(P1) Abhinav kumar choudhary (21SCSE1011615)

*) Circuit Diagram:-



5) Observations:-

S.No	Reading of Ammeter $A_1 (I_1)$	Reading of Ammeter $A_2 (I_2)$	Reading of Ammeter $A_3 (I_3)$	$I_2 + I_3$
1	0.747	0.271	0.474	0.74
2	1.98	0.344	0.696	1.095

Date

Expt. No. 02 (B)

Page No.

1) Aim :- To verify the kirchhoff's voltage law (KVL).

2) Objective :- The objective of this lab to verify KVL using mesh and nodal analysis of the given circuit.

3) Theory :- A/c to KVL, in any closed circuit or mesh, the algebraic sum of emf acting in the circuit or mesh is equal to the algebraic sum of the products of currents & resistance of each part of the circuit or mesh.

4) Apparatus Required :-

S.No	Equipment	Specification	Quantity
1	Regulated power DC supply	0 – 24V	1
2	PMMC Voltmeter	0 – 24V	4
3	Resistances		4
4	Connecting wires		

6) Procedure :- Resistances R_1, R_2, R_3 & R_4 & Voltmeter V_1, V_2, V_3 & V_4 are connected to DC battery as shown in figure. Three rheostat are set their maximum values, supply is switched on and the reading of the voltmeters V_1, V_2, V_3 & V_4 is noted. The process may be repeated by varying either of resistances R_1, R_2, R_3 & R_4

7) Working principle :- The sum of the emfs in any closed loop is equivalent to the sum of the potential drop in that loop. Similar to KCL, it can be stated as :-

$$\sum_{k=1}^{N} V_k = 0$$

* Key parameters :- Let $R_1 = 220\Omega, R_2 = 1k\Omega, R_3 = 330\Omega, R_4 = 330\Omega$ and also calculate the error $= \frac{\text{Actual} - \text{Measured}}{\text{Actual}} \times 100$

Sec-24-P1

Abhinav kumar choudhary

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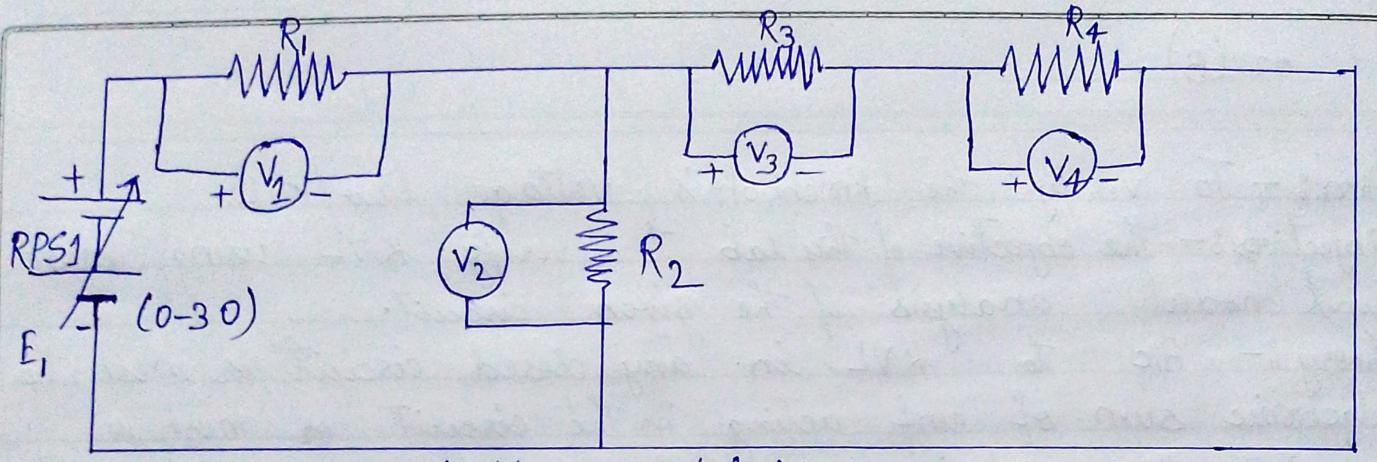

KVL Circiut Diagram

S.No	Reading of Voltmeter V_1	Reading of Voltmeter V_2	Reading of Voltmeter V_3	Reading of voltmeter V_4	$V = V_1 + V_2$	$V_2 = V_3 + V_4$
1	7.42	2.74	0.47	2.213	10.14	2.74
2	10.44	4	0.69	3.31	14.44	4

Date

Expt. No. 02 (B)

Page No.

8) Experiment Result :-

a) Calculate the ideal voltages and currents for each element in the circuit and compare them to the measured values.

b) Compute the percentage error in the two measurement and provide a brief explanation for the error.

9) Precautions :-

i) All connection should be tight.

ii) All steps should be followed carefully.

iii) Reading and calculations should be taken carefully

iv) Don't touch the five terminals.

Sec-24 (P1)

Abhinav kumar choudhary

(21SCSE1011615)

Teacher's Signature

Date

Expt. No. 03 Page No.

1) Aim :- To verify the Nortan's Theorem.

2) Apparatus Required :-

S.NO	Equipment	Specification	Quantity
1	Two regulated DC power supply	0-12 V & 0-5A	1
2	PMMC Voltmeter	0-10 V	1
3	PMMC Ammeter	0-5 A	1
4	Resistances/Rheostats		4/1
5	Connecting wires		

3) Brief theory :- According to this theory if a resistor of RL ohms be connected between any two terminals of a linear bilateral network, then the resulting current through load resistor will be equal to $\frac{R_{TH} I_{sc}}{R_L + R_{TH}}$ where Isc is the short circuit current through load terminal points & $R_N = R_{TH}$ is the resistance of network measured between these two points.

5) Procedure :-

i) Remove the resistance

(ii) Find the short circuit current Isc which flow through two load terminals from where resistance is removed

(iii) Compute the resistance of whole network as looked into from these two terminals after all sources of emf are treated as shorted.

(iv) Finally, calculate the current following through $RL = I_1 = \frac{R_{TH} I_{sc}}{R_L + R_{TH}}$

6) Observation :-

S.No	Short circuited current through load terminal Isc	Req across the Load R_L terminals, R_{TH}	$I_L = \frac{R_{TH} I_{sc}}{R_L + R_{TH}}$	% error ~~Measured I_1~~
1	0.42	9.48	0.401	2.69
2	0.59	9.13	0.59	3.38

Sec-24-P1

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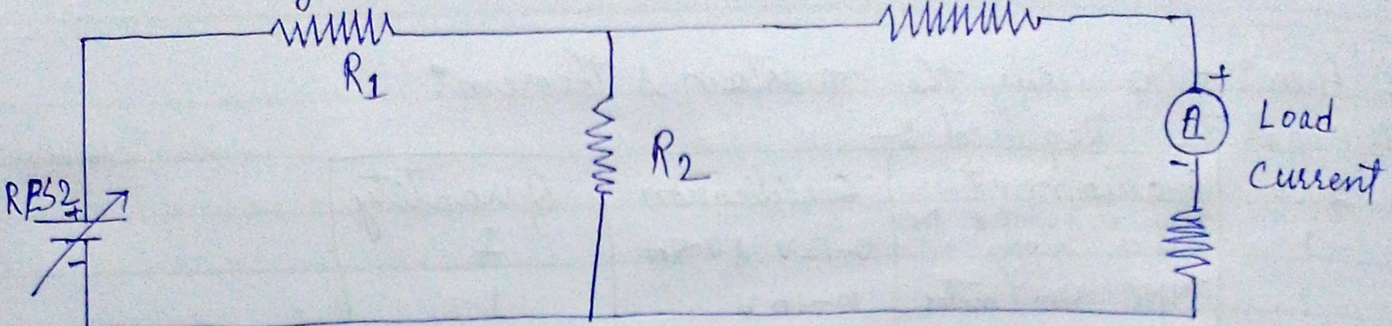
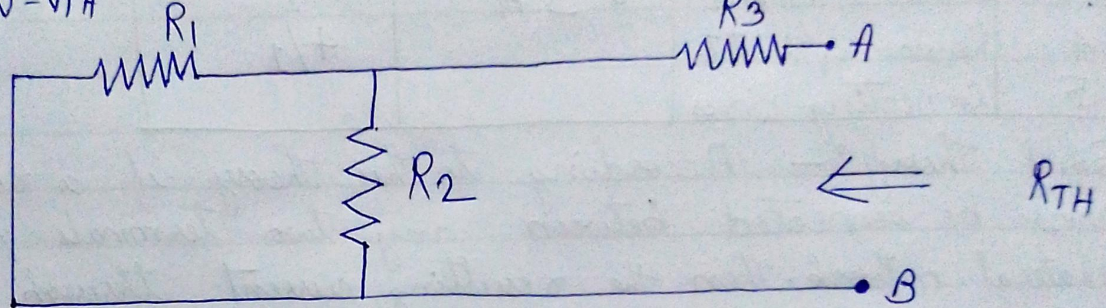
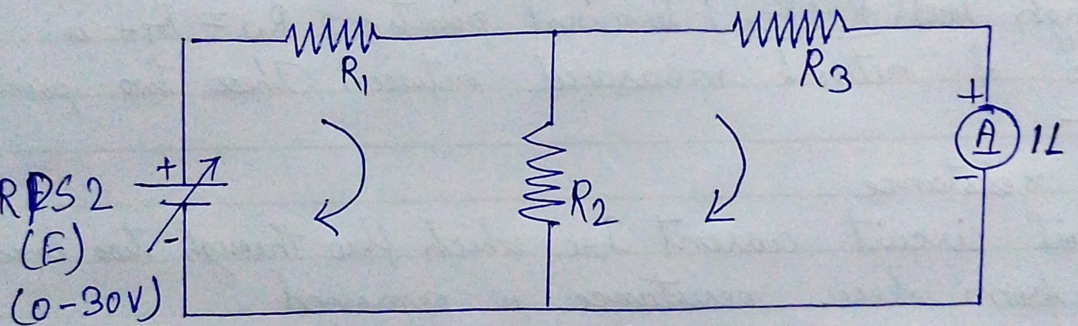
Circuit Diagram:-



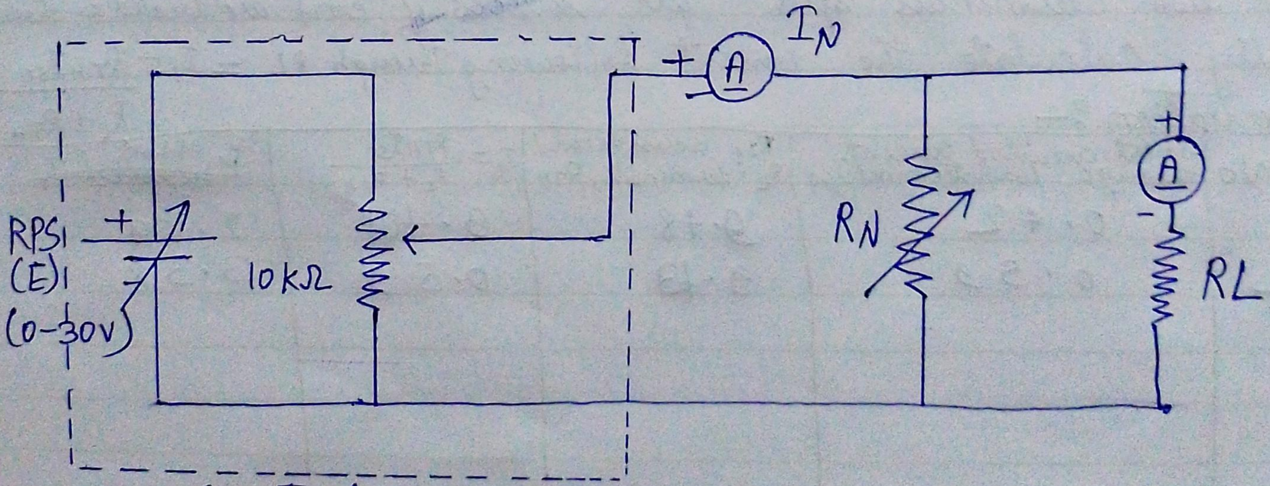
To find $V_N = V_{TH}$



To find I_{SC}



Norton's Equivalent circuit:-



constant current source

Date

Expt. No. 03 Page No.

7) Result and Discussion:-

i) The value of short circuit current Isc is 1------- Amp.

ii) The value of Norton's resistance is ______ ohms.

iii) It will be found that measured value of current flowing through the load IL is the same as determined by Norton's theorem

8) Outcomes:-

Students are able to analyze Norton's theorem in resistive circuit.

9) Precautions:-

All connection should be tight.

All steps should be followed properly.

Reading & calculation should be taken carefully.

Dont touch the live terminals.

Sec-24 (P1)

Abhinav kumar choudhary

(21SCSE1011615)

Teacher's Signature

1) Aim :- To verify the Thevenin's Theorem.

2) Apparatus Required :-

S. No	Equipment	Specification	Quantity
		~~0-12V & 0-6V~~	
1	Two Regulated DC power supply	0-12V & 0-6V	1
2	PMMC Voltmeter	0-10V	1
3	PMMC Ammeter	0-5A	1
4	Resistances/Rheostats		4/1
5	Connecting wire		

3) Brief theory :- A/c to this theorem if a resistor of R_L ohms be connected b/w any two terminals of a linear bilateral network, then the resulting current through the load resister will be equal to $\frac{V_{TH}}{R_L+R_{TH}}$ where V_{TH} is the P.d across these two points & R_{TH} is the resistance of network measured b/w two points. V_{TH} is the Open Circuit voltage across the terminals, R_{TH} is the equivalent resistance across the terminals, R_L is the load resistance.

5) Procedure :-

a) Remove the resistance (called Load Resistance R_L).

b) Find the open circuit voltage Voc which appears across the two terminals from where resistance is removed. It is called Thevenin's voltage

c) Finally, calculate the current flowing through R_L using eqn $= \frac{V_{TH}}{R_L+R_{TH}}$

6) Observation :-

S. No	Open circuit voltage across Load R_L terminals (VOC)	Req across the load R_L terminals R_{TH}	Load current $I_L = \frac{V_{TH}}{R_L+R_{TH}}$	Measured I_1
1	9.2	130.5	~~158~~ 17.61	15.8

Sec-24 (P1)

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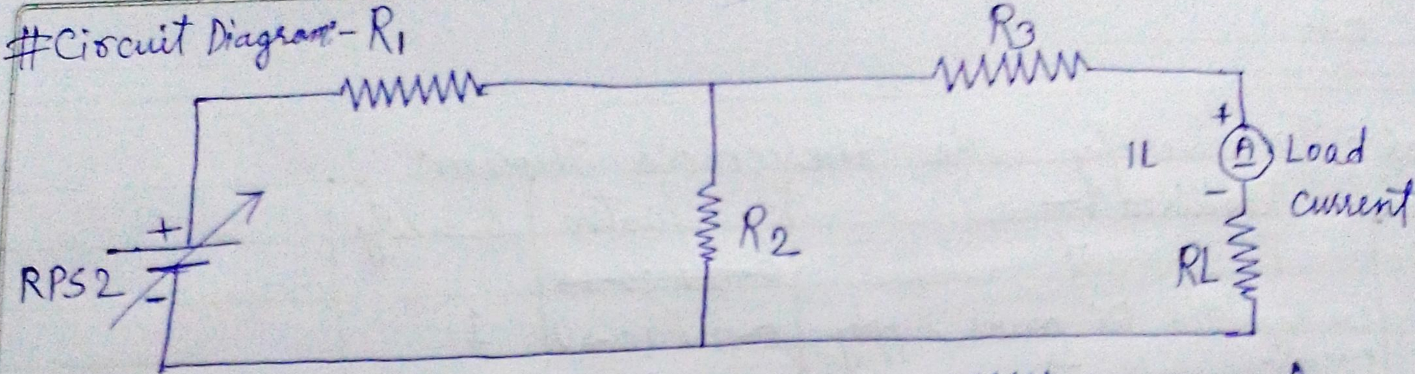
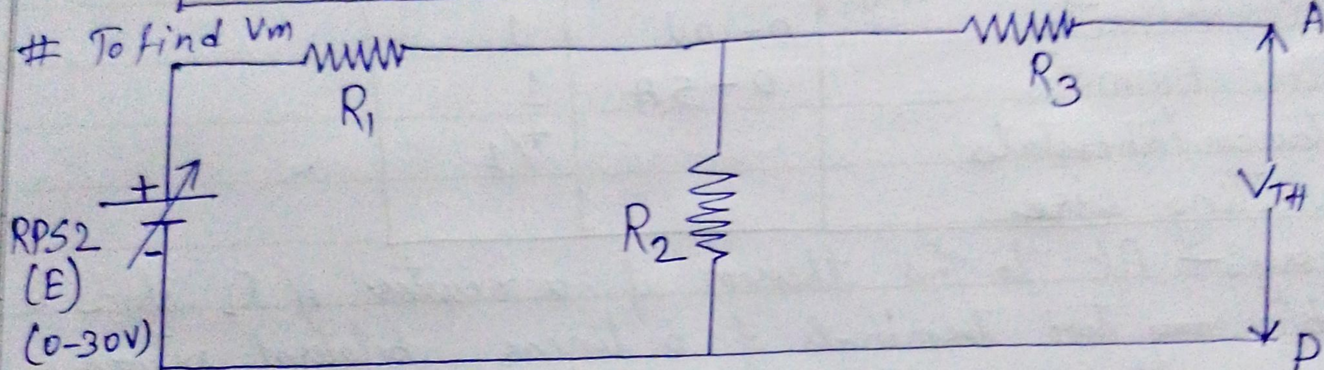
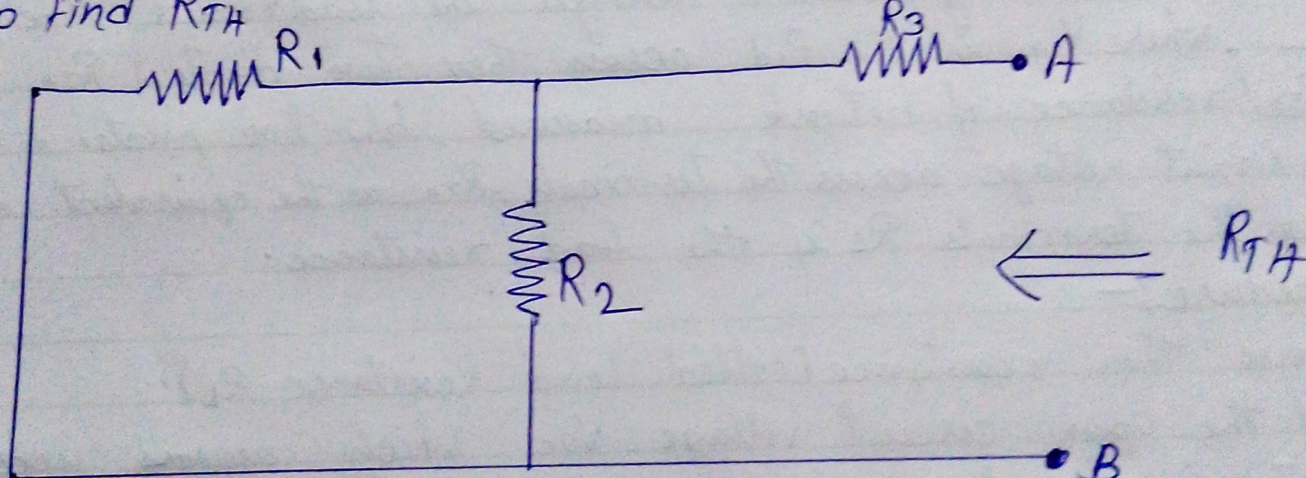
Circuit Diagram:-



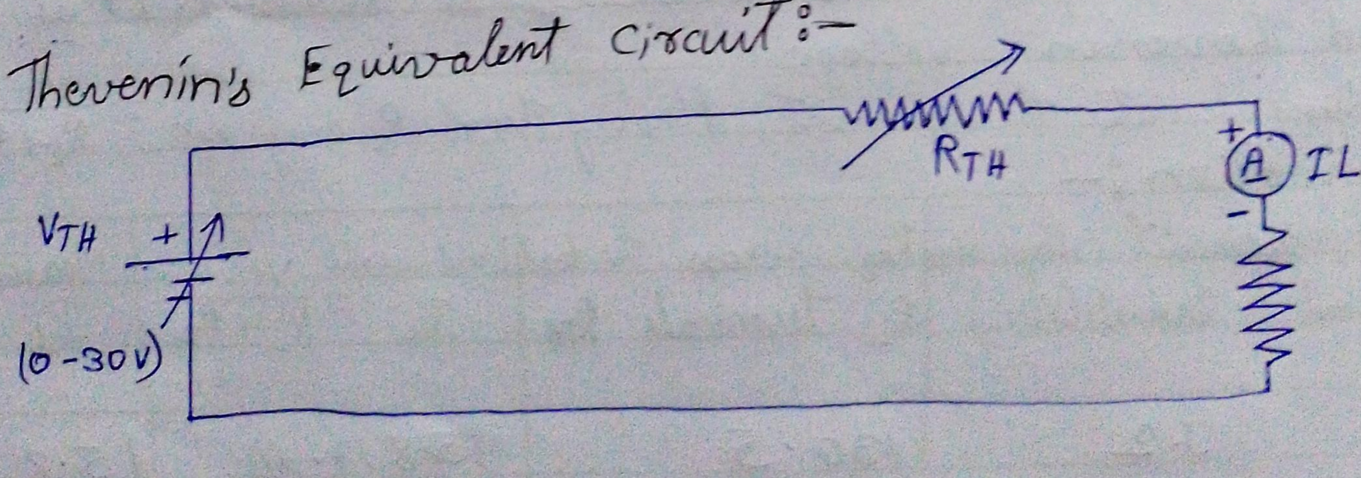
To find V_{TH}



To find R_{TH}



Thevenin's Equivalent circuit:-



7) Result and Discussion:-

a) The value of open circuit voltage(VOC) is ______ volts.
b) The value of Thevenin's resistance is ______ ohms.
c) The value of current acrossload is ______ amps.
d) It will found that measured value of current flowing through the load I_L is the same as determined by Thevenin's Theorem.

8) Outcomes:-

Students are able to analyze Thevenin Theorem in presence of DC source.

9) Precautions:-

a) All connection should be tight.
b) All steps should be followed carefully.
c) Reading and calculations should be taken carefully.
d) Dont touch the live terminals.

Sec - 24 _ P1
Abhinav kumar choudhary
(21SCSE1011615)

1) Aim:— Observe the given waveform (Sinusoidal / square / Triangular) and calculate its frequency, Peak value, Average value, RMS Value & Form factor.

3) Apparatus required ~~Peak value = Vp~~

S.No.	Equipment	Specification	Quantity
1	Function generator		
2	CRO		

4) Procedure:—

i) Connect the CRO probes to output of function generator.

ii) Switch on the function generator and CRO.

iii) Observe the Sine waveform and measure its peak voltage, time period. Calculate frequency, peak value, Av. value, RMS value using formulae.

iv) Repeat the experiment for different type of wave form.

5) Observations:—

S.No.	Sine wave	Triangular wave	Square wave
Peak voltage			
Time period			

6) Precautions:—

- All connection should be tight.
- All steps should be followed carefully.
- Readings and calculation should be taken carefully.

Sec-24 (P1)
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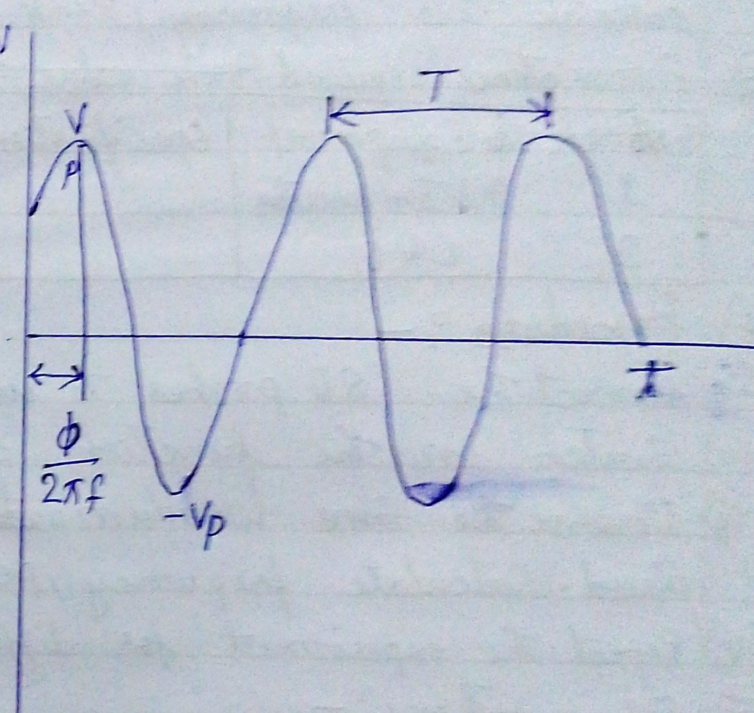
2) # Theory

Peak Value $= V_p$
Peak to peak value $= V_{pp} = 2V_p$
Period $= T$ [S]
Frequency $= F = \frac{1}{T}$ [HZ]
Angular frequency
$\omega = 2\pi f$ [rad/s]
Phase ϕ



Formula
$V = V_p \cos(2\pi f t - \phi) = V_p \cos(\omega t - \phi)$

Date

Expt. No. 06 Page No.

1) Aim:- To verify the functionality of PN-junction diode in forward and reverse bias.

2) Objective :- To study Volt-Ampere Characteristics of P-N Diode and also find cut in voltage for PN Junction diode.

3) Theory:- A P-N junction diode is formed when a single crystall of semiconductor is doped with acceptors impurities on one sides and donor impurities on the other side. It has two terminals called electrodes, one each from P-region and N-region. Due to two electrodes it is called diode.

4) Biasing of PN junction Diode:-

Applying external D.C voltage to any electronic device is called biasing. There is no current in the unbaised PN junction at equiliboium. Depending upon the polarity of the D.C voltage externally applied to diode, the biasing is classified as forward biasing and reverse biasing.

5) Forward bias Operation:- The PN junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode & -ve terminal of the input supply to the cathode. Then diode is said to be forward biased. In this condition the heigh of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side & electron from n-side cross the junction simultaneously and constitute a forward current from n sides cross the junction simultaneously and constitute a foward current. Assuming current flowing through the diode to be vary large, the diode can be approximated as short-circuited switch

Sec-24 (P1)
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(21SCSE1011615)

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6 Reverse bias operation :- If +ve terminal of the ~~point~~ input supply is connected to anode (P-side) and -ve terminal of the input supply is connected to cathode then the diode is said to be reversed biased. In this condition an amount equal to reverse biasing voltage increases the heigh of the potential barries at the junction. Both the holes on P-side and electrones on N-side tend to move away from the junction there by increasing the depleted region. This current is negligible; the diode can be approximated as an open circuited switch.

7) Diode current equation :- The volt-ampere characteristics of a dipole explained by the following equation:-

$$I = I_0 (e^{V/\eta V_T} - 1)$$ where

I = current folowing in the diode, I_0 = reverse saturation current

V = Voltage applied to the diode

V_T = Volt-equivalent to the diode

$\eta = 1$ (For Ge) 2 (For Si). It is observed that Ge diodes has smaller cut-in-voltage when compared to Si diode. The reversed saturation current in current in Ge dide is larger in magnitude when compared to silicon diode.

8) Apparatus Required :-

S.No	Components / Equipments	Quantity
1	Diode	1 ~~Quantity~~
2	Resistor	1
3	Dual DC Regulated Power supply (0-30V)	1
4	Digital Ammeter (0-200 mA, 0-200 μA)	1
5	Digital Voltmeter (0-20V)	1
6	connecting wires	1
7	Bread board	1

Sec - 24 (P1)
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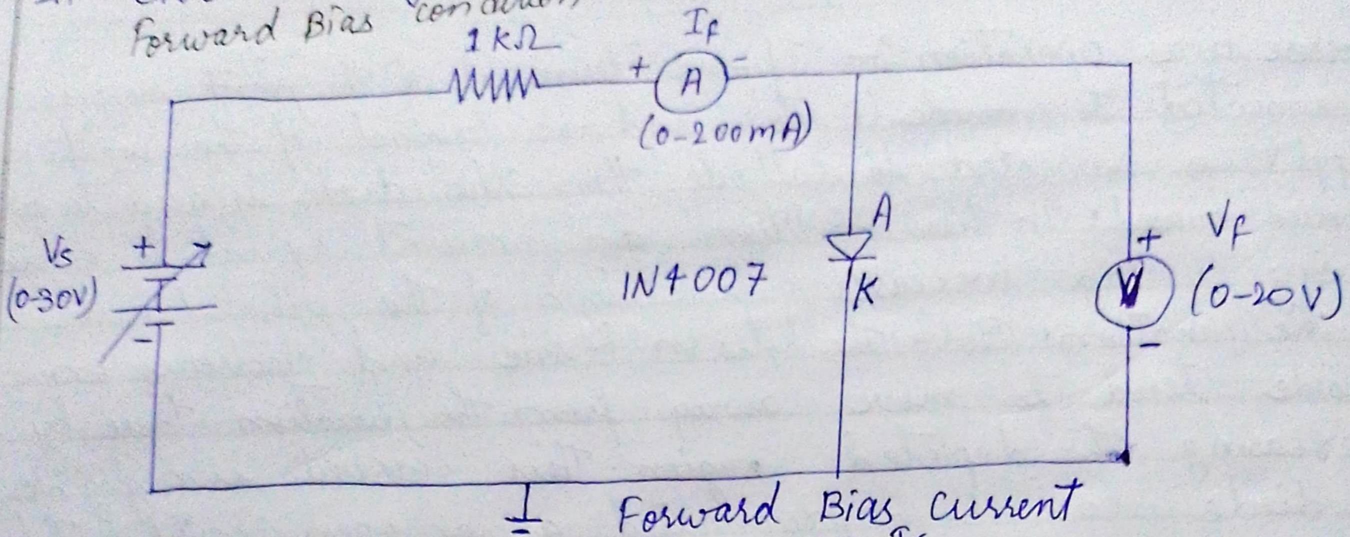
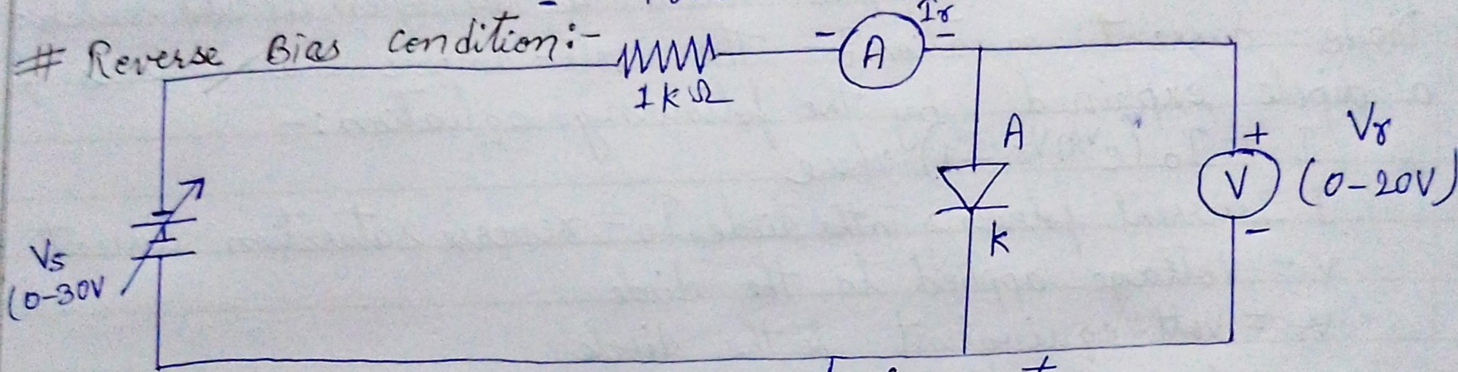
Circuit Diagram :-

Forward Bias condition



Forward Bias current

Reverse Bias condition:-



Reverse Biased Connection

Reverse Bias condition:-

RPS Voltage V_s (Volts)	Reverse Voltage across the diode V_r(volts)	Reverse current through the diode (I
1	5V	0.8A
2	6V	0.9A
3	10V	1A
4	12V	1.2A
5	16V	1.4A
6	18V	1.6A
7	20V	1.8A

Date

Expt. No. Page No.

9) Procedure: Forward Bias condition

(i) Connect the circuit as shown in figure (i) using PN junction diode.

(ii) Initially vary Regulated Power Supply (RPS) voltage V_s in steps of 0.1V. Once the current starts increasing vary V_s from 1V to 12V in steps & note down the corresponding reading V_f and I_f.

iii) Tabulate different forward current obtained for different forward voltage.

10) Reverse Bias condition:-

(i) connect the circuit as shown in figure (2) using PN junction diode.

(ii) Vary V_s in the Regulated Power Supply (RPS) gradually in steps of 1V from 0V to 12V & note down corresponding reading V_r and I_r

(iii) Tabulate different reverse current obtained for different reverse voltages.

(iv) To get the graph in reverse region, remove voltmeter and with reference to the supply voltage note down the reverse currents in Ammeter because current always selects low reactange path. To get the graph in reverse region, replate voltmeter with nano ammeter - Voltmeter has less load resistance with when compared to diode. Current conducts in load resistance path.

11) Observation: Forward Bias condition:—

RPS Voltage V_s (Volts)	Forward Voltage across the diode V_f (Volts)	Forward current through the diode I_f (mA)
1	10V	1A
2	20V	1.5A
3	30V	1.8A
4	40V	2A
5	50V	2.1A
6	60V	2.3A
7	65V	2.5A

Sec-24 (P1)
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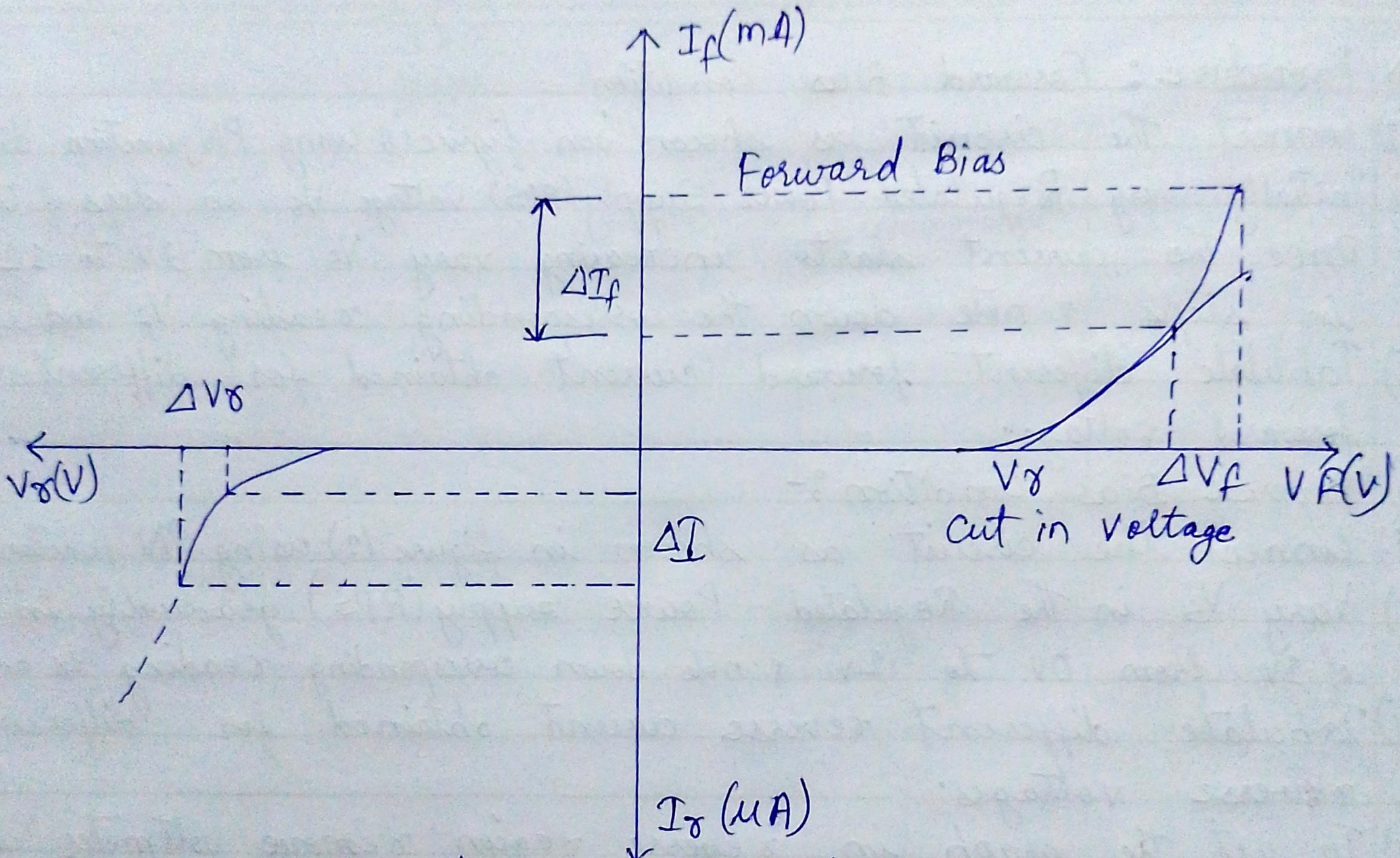

V-I characteristics of PN junction diode under Forward & Reverse Bias Conditions

12) Graph:-

i) Take the graph sheet & divide it into 4 equal parts. Make origin a centre.

ii) Now mark +ve X-axis as V_f, -ve as V_r, +ve Y-axis as I_f & -ve as I_r.

iii) Mark the reading tabulated for Si forward biased condition is Ist quad & Si reverse biased condition in III^rd quadrant.

13) Key Parameters:-

List of Parameter	Silicon Diode(IN4007)
Maximum forward current	1A
Maximum Reverse current	5.0 μA
Maximum	0.8V
Maximum	1000V
Maximum	30mW
Temperature	-65 to 200°C

14 Precautions:-

i) While doing the experiment donot exceed the reading of the diode. This may lead to damaging of the diode.

(ii) Connect voltmeter & ammeter in correct polarities as shown in the circuit diagram.

iii) Do not switch ON the power supply unless you have checked the circuit connections as per circuit diagram.

Sec-24 (P.1)
Abhinav kumar choudhary
(21SCSE1011615)

1) Aim :- To plot the V-I characteristics and ~~vef~~ verify the functionality the regulation action of zener diode.

2) Objective :- To plot the Volt-Ampere characteristics of zener Diode & also find Zener Breakdown Voltage in Reverse Biased conditions & observe the regulation action.

3) Theory :-

Zener diode are special kind of diode which permits current to flow in the forward direction. We make them different from other diode is that zener diode will also alow current to flow in the current to flow in the reverse direction when the voltage is above a certain value. This breakdown voltage is known as ~~be~~. zener voltage. In a standered diode, the zener voltage is high, and the diode is permanently damaged if a reverse current above that value is allowed to pass through it. Zener diode are designed in a way where the zener voltage is a much lower value. There is a controlled breakdown which doesnot damage the diode when a reverse current above the zener voltage passes through a zener diode.

The most common ~~diode~~ values for nominal working voltage are 5.1V, 5.6V, 6.2V, 12V & 15V. We also carry zener diodes with nominal working voltage upto 1KV. Forward current can have a range from 200μA to 200A, with the most common forward current being 100mA or 200mA. In forward bias zener diode behave like a ordinary silicon diode.

In the reverse bias direction, there is no reverse current flow until the breakdown voltage is reached. When this occurs, there is a sharp increase in

Sec-24 (P1)
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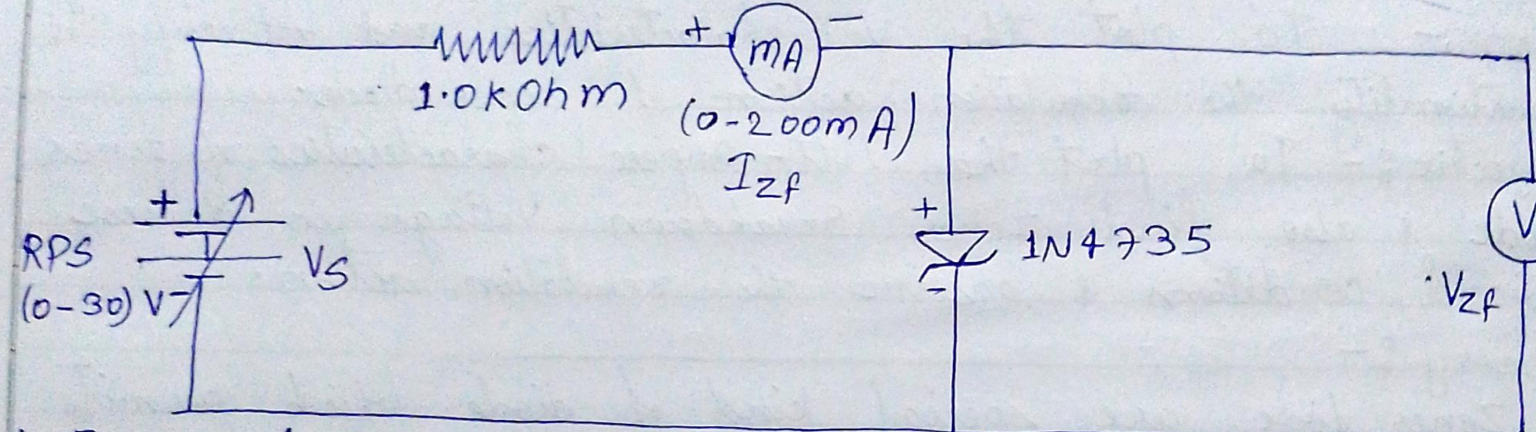
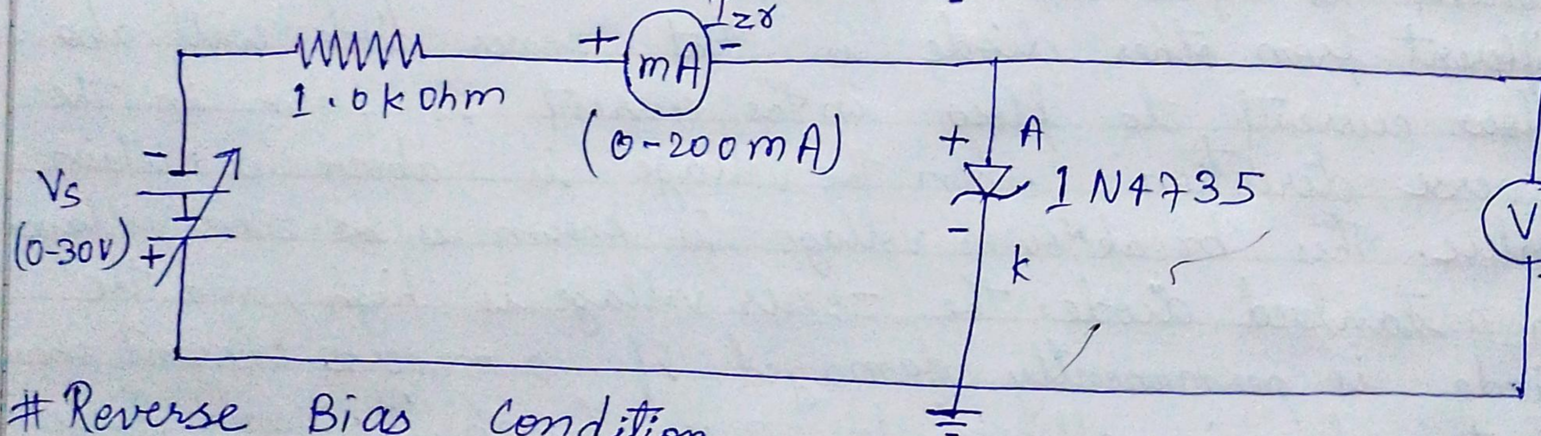
circuit diagram:-



Forward Bias Condition



Reverse Bias Condition

Observation:-

Table 1- Forward Bias condition:-

RPS Voltage V_S(Volts)	Forward voltage across the diode V_{Zf} (volts)	Forward current through the diode I_{Zf} (mA)
0	0	2.55
4.4	4.4	2.55
10.2	5.10	2.55
13.2	5.10	2.55
19.8	5.10	2.55

Date

Expt. No. 07 Page No.

reverse current, varying amount of reverse current can pass through the diode without damaging it. The maximum reverse current is limited. However, by the wattage rating of diode.

• Avalanche Break down :-

when the diode is in the reverse bias condition, the width of the depletion region at the junction widens is more. If both p-side and n-side of the diode are lightly doped, depletion region is more. In reverse bias, the minority charge carrier current flows through junction. This process becomes cumulative and leads to the generation of large number of charge carriers resulting in Avalanche Breakdown.

• Zener Break down :-

If both p-side & n-side of the diode are heavily doped, depletion region at the junction reduces compared to the width of normal doping. Sudden increase in the number of charge carriers due to rupture of covalent bonds under the influence of strong electric field is termed as zener breakdown.

• Zener Diode as Voltage Regulator :-

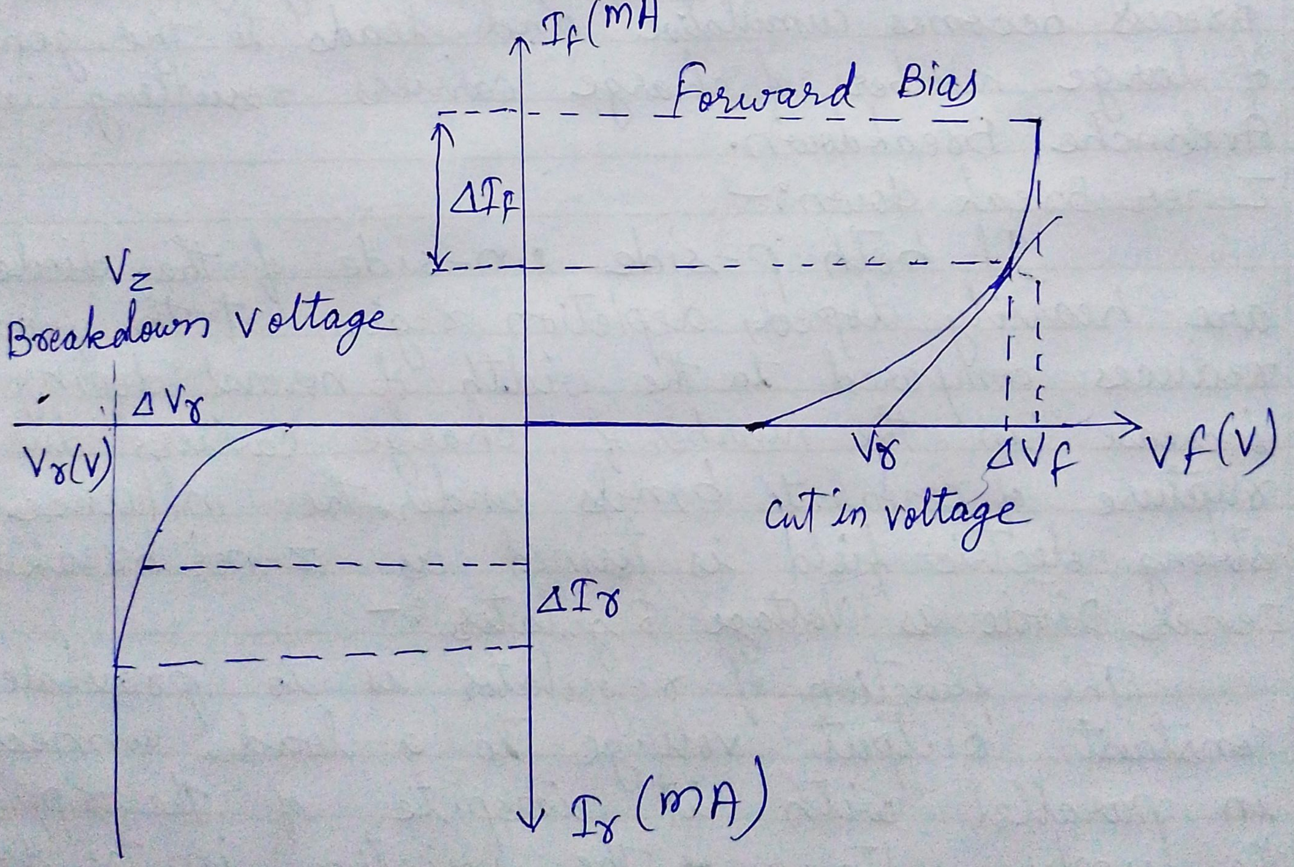
The function of regulator is to provide a constant output voltage to a load connected in parallel with it inspite of the ripples in the supply voltage or the variation in the load current & the zener diode will continue to regulate the voltage until the diodes current falls below the minimum I_Z (min) value in the reverse breakdown voltage.

Sec-24 (P1)
Abhinav kumar choudhary
(21SCSE1011615)

Teacher's Signature

Reverse Bias condition:

RPS Voltage V_s (volts)	Reverse voltage across the diode V_{zr} (volts)	Reverse current through the diode I_{zr} (mA)



Characteristics of zener Diode under Forward & Reverse Bias conditions.

6) Apparatus Required :-

S.N	Components/Equipments	Quantity
1	Zener Diodes(1N4735A)	1
2	Resistors (1kΩ, 3.3kΩ)	1
3	Dual DC Regulated Power Supply (0-30V)	1
4	Digital Ammeters (0-200mA, 0-200μA)	1
5	Digital Voltmeter (0-20V)	1
6	Connecting wires	1
7	Bread board.	1

7) Key Parameters :-
- Breakdown voltage = 5.1V
- Power dissipation = 0.75W
- Maximum Forward current = 1A

8) Precautions :-

i) While dooing the experiment donot exceed the reading of diode. This may lead to damaging of the diode.

(ii) Connect voltmeter & ammeter in correct polarities as shown in the circuit diagram.

iii) Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

Sec-24 (P1)
Abhinav kumar choudhary
(21SCSE1011615)

Teacher's Signature

Date

Expt. No. 08

Page No.

1) Aim:- To study working of the half/Full wave bridge rectifier & calculate its efficiency.

2) Objective:- To verify the working of full wave Rectifiers circuit (Bridge Rectifiers) & calculate its efficiency.

3) APPARATUS Required:-

S.No	Component / Equipments	Quantity
1	CRO	1
2	Multimeter	1
3	Trainer kit	1
4	Bread Board	1
5	connecting wires	
6	Diode	4
7	Power supply	1

4) Working:-

The full wave bridge rectifier circuit contains diodes D_1, D_2, D_3 & D_4, connected to form a bridge as shown figure. The a.c supply to be rectified is applied to the diagonally opposite ends of the bridge through the transformer. Between other two ends of the bridge, the load resistance RL is connected.

5) Observation:-

During the +ve half-cycle of secondary-voltage, the end P of the secondary winding becomes +ve & end Q -ve. This makes diodes D_1 & D_3 forward biased while D_2 & D_4 are reverse biased. Hence, only diodes D_1 & D_3 conducts.

These two diodes will be in series through the load RL as shown in figure.

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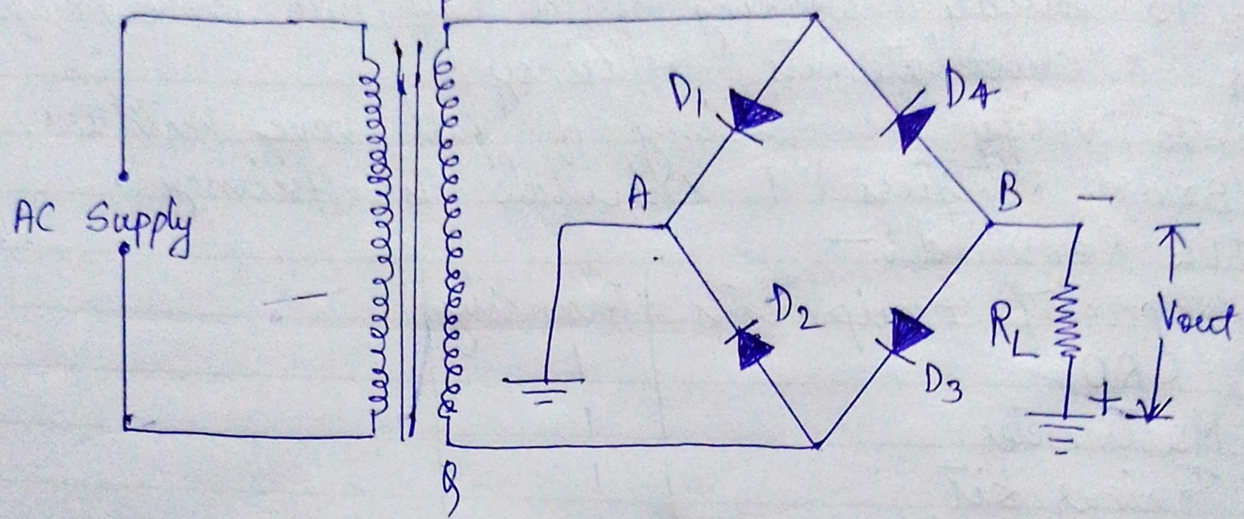
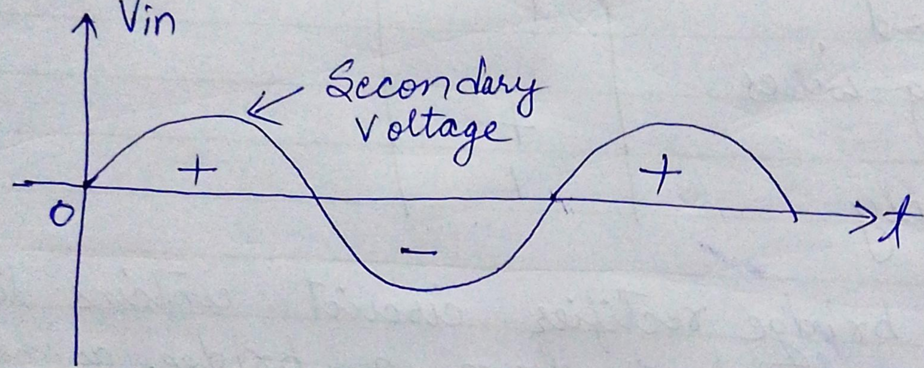
Abhinav Kumar Choudhary
(21SCSE1011615)

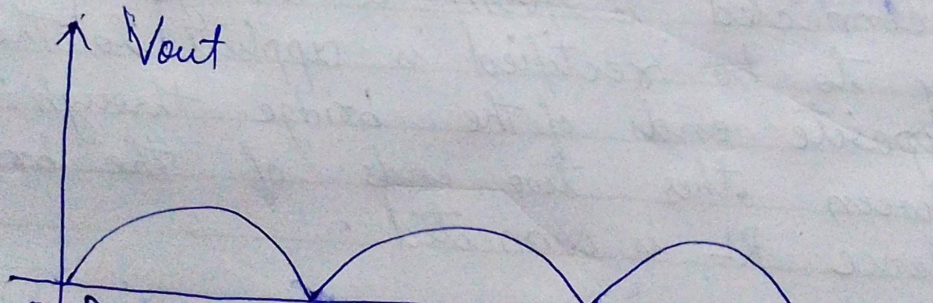
Teacher's Signature

THEORY :-

→ Full wave Bridge Rectifier circuit diagram







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The conventional current flow through load R_L is shown by the ~~solid~~ dotted arrows. It may be seen that current flows from A to B through the load RL.

The conventional current flow through load R_L is shown by the solid arrows.

Peak Inverse Voltage

The peak inverse voltage (PIV) of each diode is equal to the maximum secondary voltage of Transformer.

Suppose during +ve half cycle of input a.c, end of secondary is +ve and end of negative. Under such condition, diodes D1 and D3 are forward biased while diodes D2 and D4 are reverse biased. Since the diodes are considered ideal, diodes D1 and D3 can be replaced by wires as shown in figure.

From the figure it is clear that two reverse biased diodes (i.e D2 and D4) & the secondary of transformer are in parallel. Hence PIV of each diode (D2 and D4) is equal to the maximum voltage (Vm) across the secondary. Similarly, during the nex half cycle, D2 and D4 are forward biased while D1 and D3 will be reverse biased. It is easy to see that reverse voltage across D1 and D3 is equal to Vm. Hence, PIV = Vm

7) Procedure :-

Connect the primary of center-tapped transformer to main supply. At the output points of full wave rectifier circuit, connect the vertical plates of CRO & by adjusting its knobs, get a stationary pattern

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Abhinav kumar Choudhary

(21SCSE1011615)

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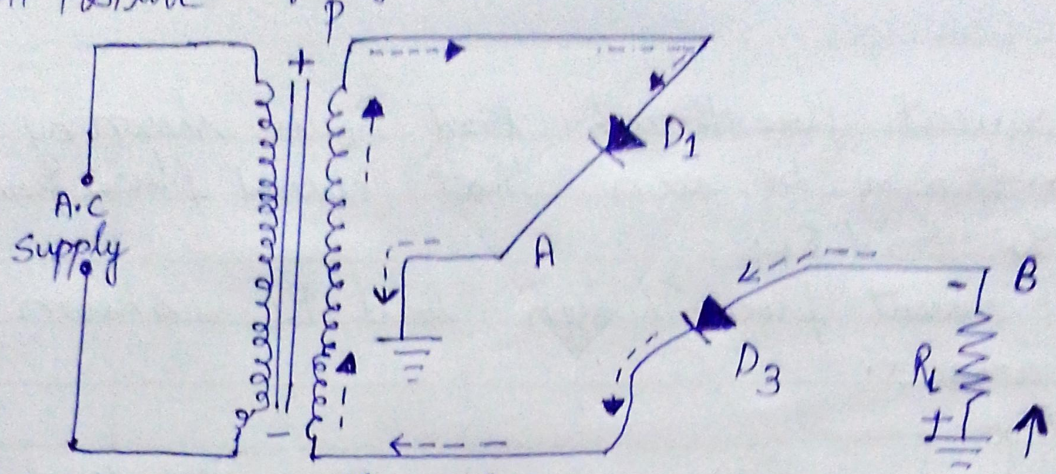
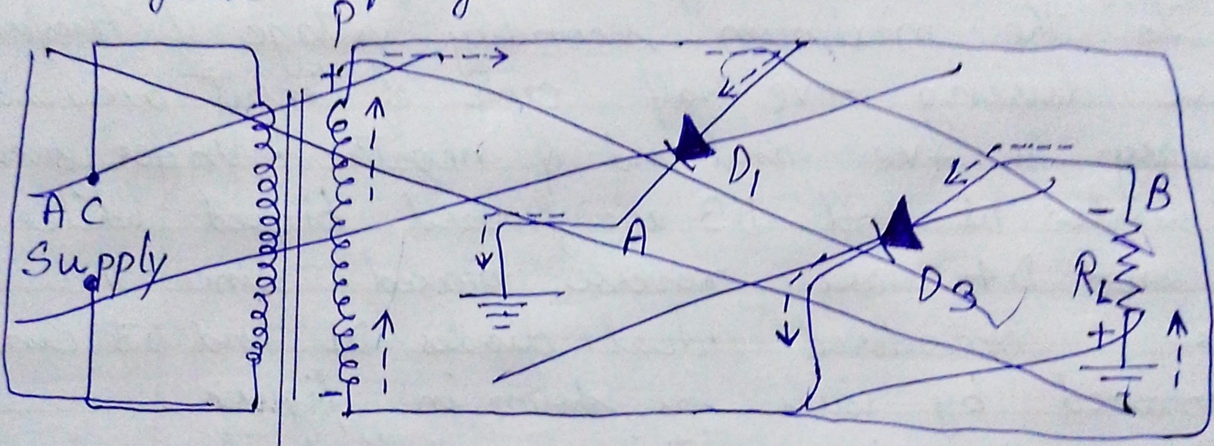
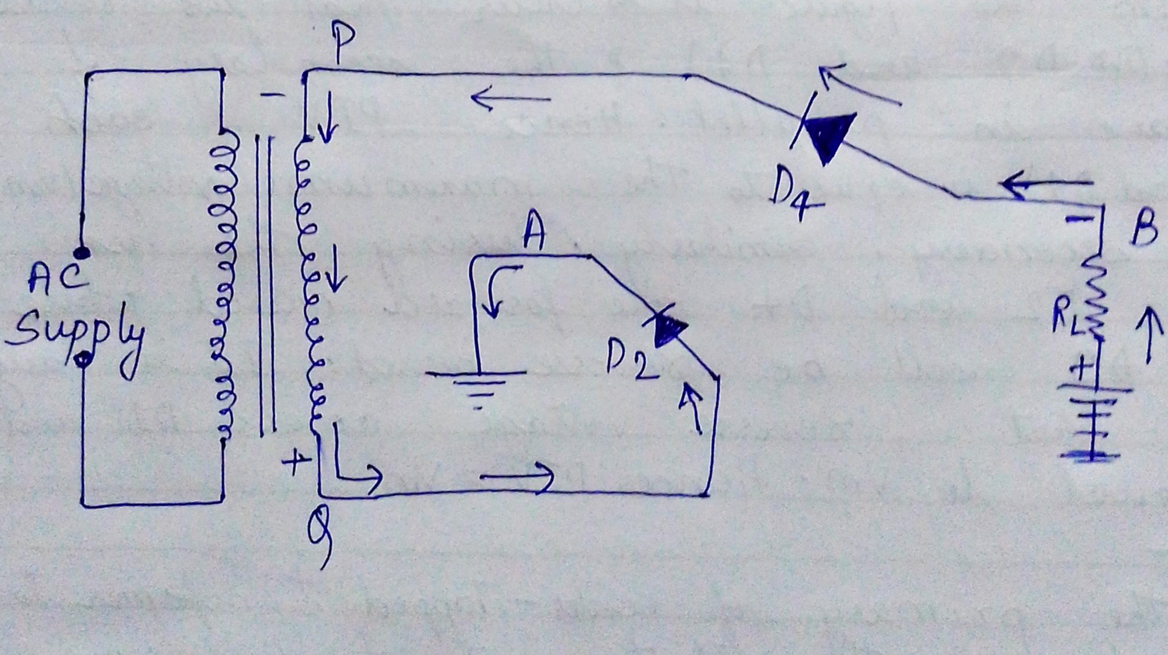
Positive half cycle:-



Negative half-cycle:-





on the screen. Now touch the CRO probes at the centre tab and one of the diodes. Observe the waves shapes on CRO compare the two wave shapes.

(ii) By Multimeter, measure the AC voltage at the input and Output points. Also measure the dc voltage at the output point

(iii) Calculate the dc voltage by $V_{dc} = V_m/\pi$. Compare this theoretical value with the practical value.

(iv) Calculate the ripple factor by using formula.

(v) Measure the PIV across the diode. It should be $2V_m$

8) Observation :-

Observe the wave shape of output signal of FWR on the CRO

9) Calculation :-

Ripple factor of FWR = ac voltage at o/p / dc voltage at o/p = ...

10) Results :-

(i) The output dc voltage is little ~~less~~ than the theoretical & measured value of ripple factor.

(ii) The output dc vollage is little less than the theoretical value.

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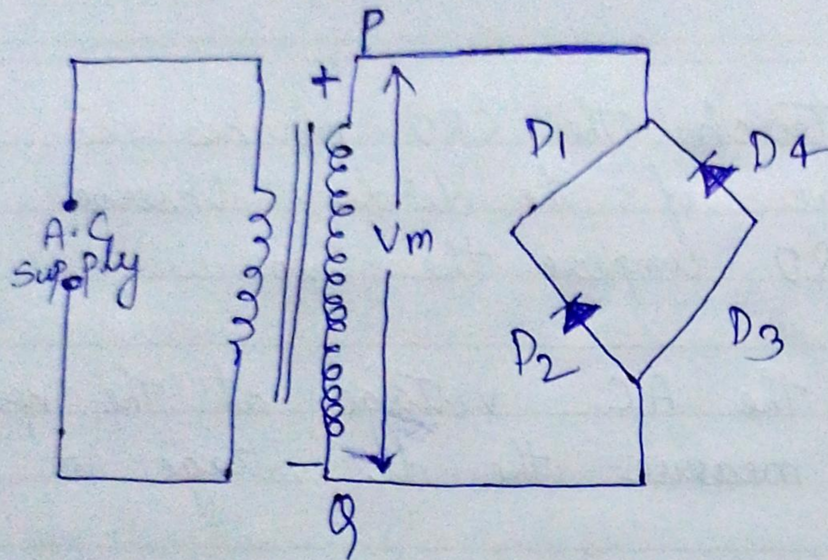

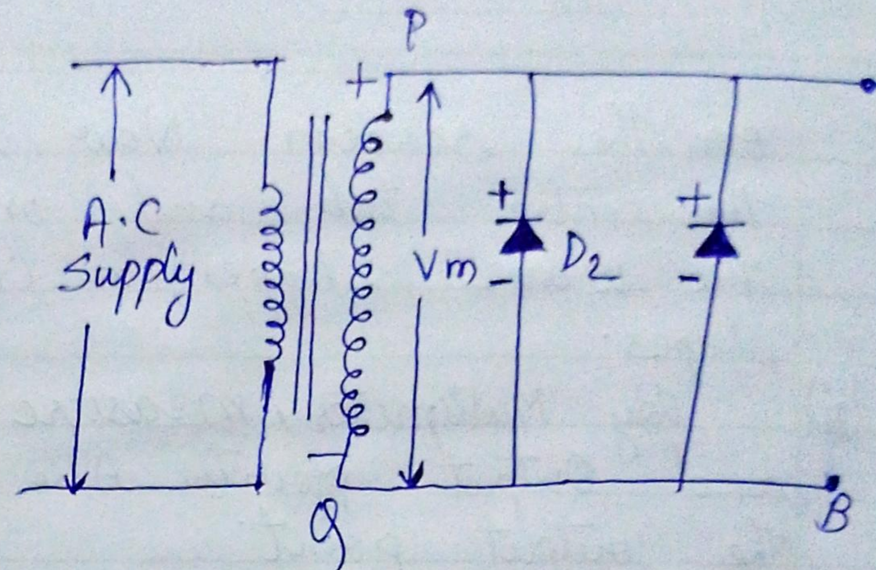

Observation table

SR NO	Applied in voltage	Observe γ ~~Output Voltage~~	Output voltage
1)	$V_{rms} = \frac{V_m}{2}$	$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$	$V_{dc} = \frac{V_m}{\pi}$
2)	$V_{rms} = \frac{V_m}{\sqrt{2}}$	$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)}$	$V_{dc} = \frac{2V_m}{\pi}$
3)	$V_{rms} = \frac{V_m}{\sqrt{2}}$	$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$	$V_{dc} = \frac{2V_m}{\pi}$