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श्रद्धावान् लभते ज्ञानम्

19EEE 182 - Electrical and Electronics

Engineering Practice Manual

(EAC/CSE)

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EXPERIMENT-1

VI Characteristics of PN Junction Diode

Aim:

To study the characteristics of PN Junction Diode under forward and reverse bias conditions and the dynamic resistance.

Theory:

A diode is a two-terminal electronic component that conducts current primarily in one direction and has low resistance in one direction, and high resistance in the other direction.

A p–n junction diode is made of a crystal of a semiconductor, usually silicon, but germanium and gallium arsenide are also used. Impurities are added to it to create a region on one side that contains negative charge carriers (electrons), called an n-type semiconductor, and a region on the other side that contains positive charge carriers (holes), called a p-type semiconductor.

When the n-type and p-type materials are attached together, a momentary flow of electrons occur from the n to the p side resulting in a third region between the two where no charge carriers are present. This region is called the depletion region because there are no charge carriers (neither electrons nor holes) in it.

The diode's terminals are attached to the n-type (Cathode) and p-type (Anode) regions. The boundary between these two regions, called a p–n junction, is where the action of the diode takes place.

BIASING OF PN- JUNCTION DIODES

Forward Bias Operation

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to the P-side (Anode) and –ve terminal is connected to the N- side (Cathode), then the diode is said to be in forward biased condition. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage.

Both the holes from P-side and electrons from N-side cross the junction simultaneously thereby decreasing the depleted region. This constitutes a forward current (majority carrier movement – diffusion current).

Assuming current flowing through the diode to be very large, the diode can be approximated as short- circuited switch. Diode offers a very small resistance called forward resistance (few ohms)

Reverse Bias Operation

If –ve terminal of the input supply is connected to p-side (Anode) and +ve terminal is connected to n-side (cathode) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction.

Both the holes on P-side and electrons on N-side tend to move away from the junction there by increasing the depleted region. However, the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This current is negligible; the diode can be approximated as an open circuited switch it offers a very high resistance called reverse resistance (few Kilo Ohms).

Static Resistance: The opposition offered by a diode to the direct current flowing forward bias condition is known as its DC forward resistance or Static Resistance.

It is measured by taking the ratio of DC voltage across the diode to the DC current flowing through it at an operating point.

Dynamic Resistance: The opposition offered by a diode to the changing current flow I forward bias condition is known as its AC Forward Resistance.

It is measured by a ratio of change in voltage across the diode to the resulting change in current through it for an operating point P.

Apparatus Required:

S.N.	Name of Equipment	Specificaton
1	DC power supply	0-30V
2	Ammeter	MC
3	Voltmeter	MC
4	Resistor	100Ω,1000Ω
5	Silicon diode	IN4001

Procedure:

Forward Bias Operation

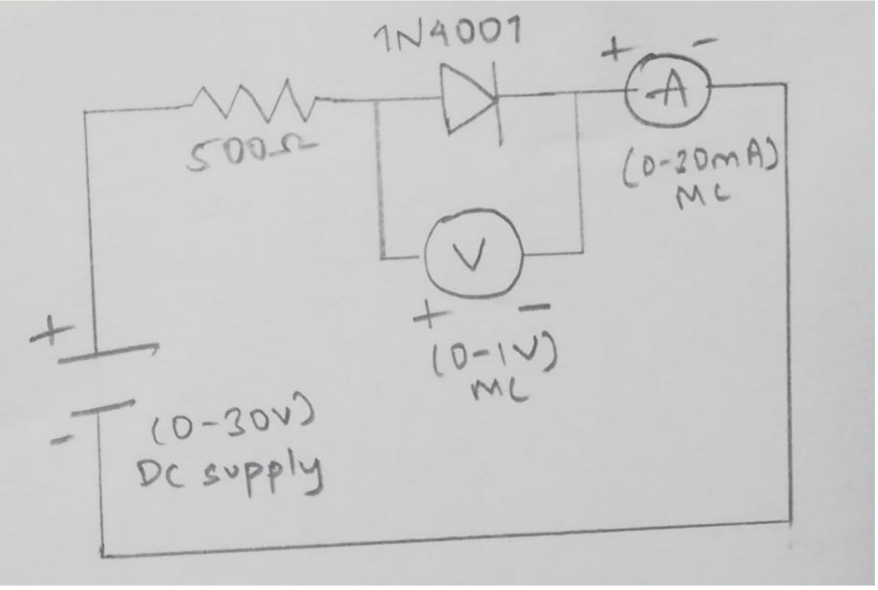
1. Connect the components as shown in the figure.
2. Click on 'Check Connection' button to verify the connections.
3. Select the 1N4001 diode using the "choose diode" drop-down option.
4. Set DC voltage to 0.2V .
5. Set the resistor.
6. Now vary the voltage upto 5V and note the Voltmeter and Ammeter reading for particular DC voltage by using “add to table” simultaneously.

7. Click on the “plot” option to reveal the V-I graph on scrolling down and observe the change.

Reverse Bias Operation

1. Connect the components as shown in the figure.
2. Click on 'Check Connection' button to verify the connections.
3. Select the 1N4007 diode using the "choose diode" drop-down option.
4. Set DC voltage to 0.2V .
5. Set the resistor.
6. Now vary the voltage upto 30V and note the Voltmeter and Ammeter reading for particular DC voltage by using “add to table” simultaneously.
7. Click on the “plot” option to reveal the V-I graph on scrolling down and observe the change.

Circuit Diagram (Forward Bias):



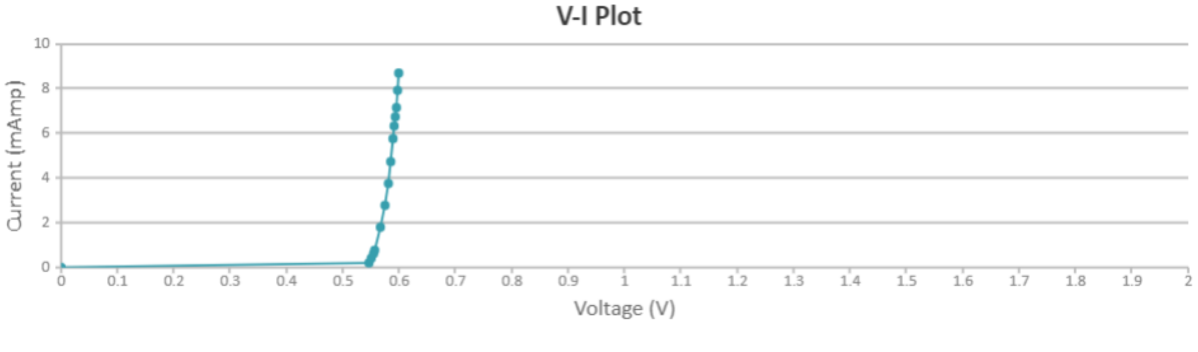
Observation Table (Forward Bias):

EXPERIMENTAL TABLE

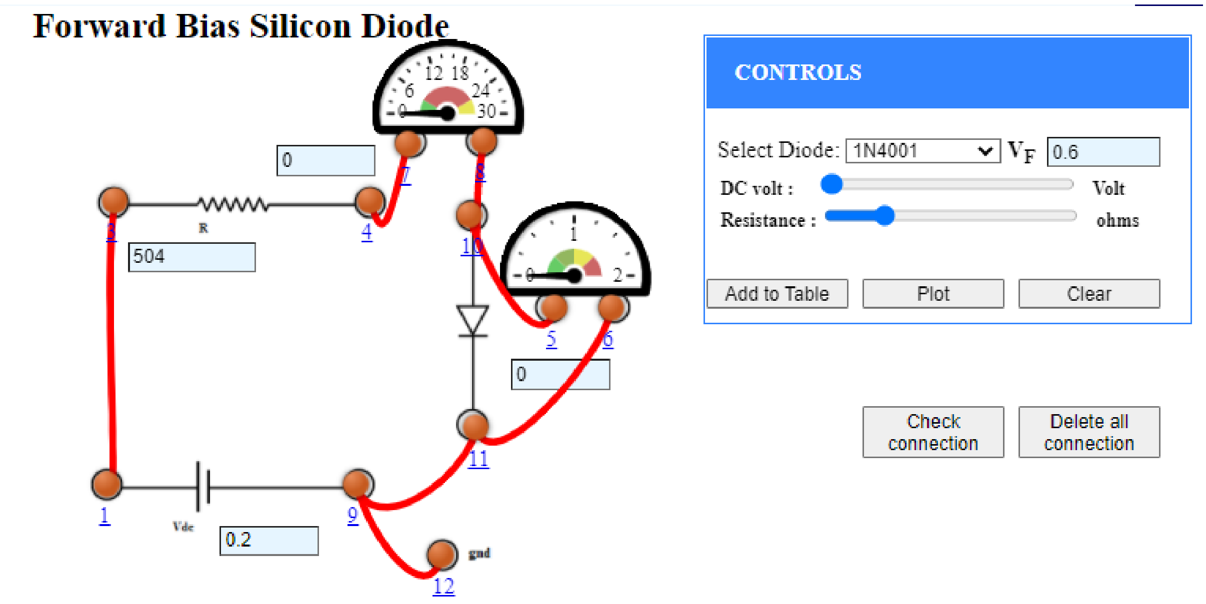
Serial No.	Forward Voltage(Volt)	Forward Current(mAmp)
1	0	0
2	0.547	0.198
3	0.551	0.397
4	0.554	0.595
5	0.557	0.793
6	0.567	1.78
7	0.575	2.78
8	0.580	3.77
9	0.585	4.76
10	0.589	5.75
11	0.591	6.35
12	0.593	6.74
13	0.594	7.14
14	0.596	7.93
15	0.598	8.72

V-I graph of forward biased Si-diode:

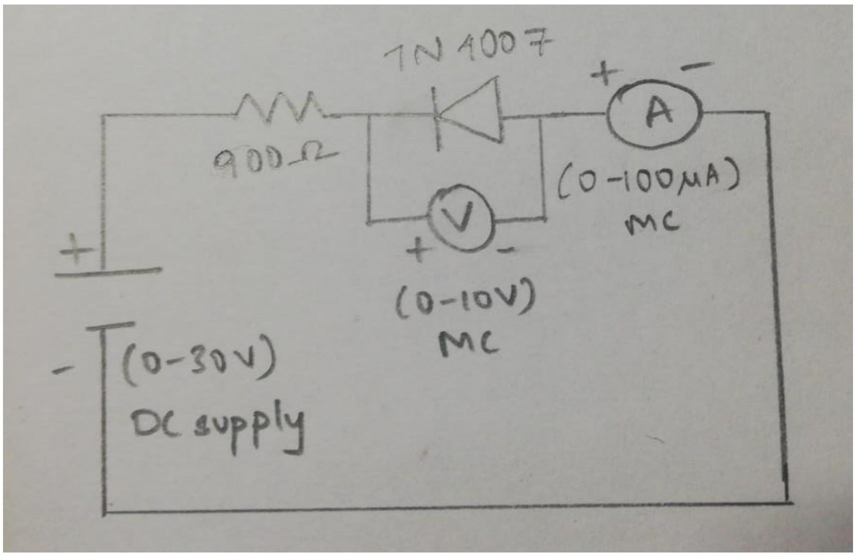
GRAPH PLOT



Simulation Screenshot (Forward Bias):



Circuit Diagram (Reverse Bias):



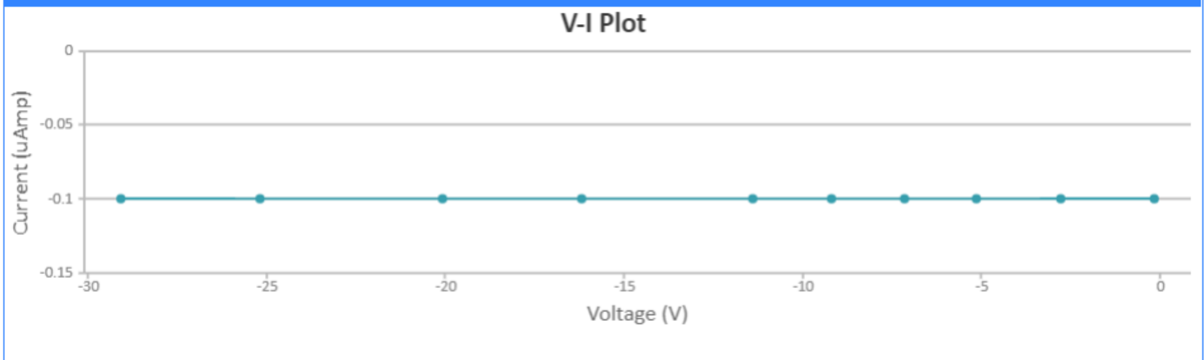
Observation Table (Reverse Bias):

EXPERIMENTAL TABLE

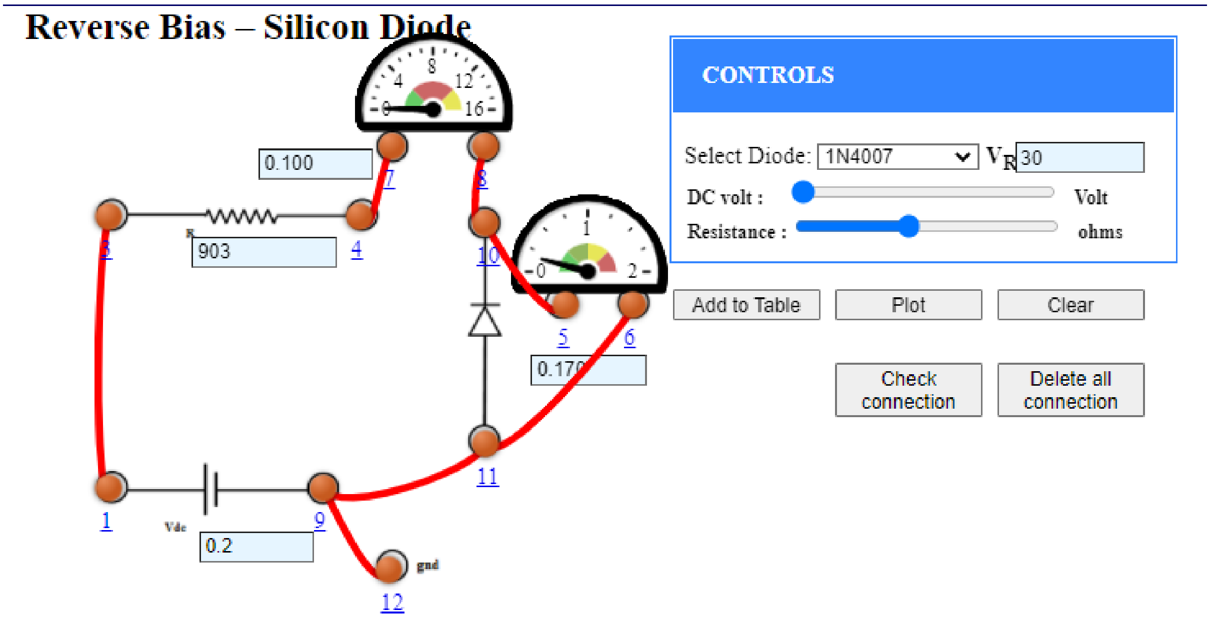
Serial No.	Reverse Voltage(Volt)	Reverse Current(μAmp)
1	0.170	0.100
2	2.80	0.100
3	5.14	0.100
4	7.17	0.100
5	9.21	0.100
6	11.4	0.100
7	16.2	0.100
8	20.1	0.100
9	25.2	0.100
10	29.1	0.100

V-I graph of reverse biased Si-diode:

GRAPH PLOT



Simulation Screenshot (Reverse Bias):



Result and Inference:

Forward Bias: The experiment is successfully conducted and the Volt-Ampere characteristics of the PN diode are studied.

The concept of cut-in voltage is understood. The cut-in voltage of the 1N4001 is 0.6 V.

Reverse Bias: The experiment is successfully conducted and the Volt-Ampere characteristics of the PN diode are studied. The concept of breakdown voltage and leakage current is understood in the case of reverse bias.

EXPERIMENT-2

VI Characteristics of Zener Diode

Aim:

To study the function of zener diode and to investigate zener diode as voltage regulator.

Theory:

Zener diode is a heavily doped PN junction diode. Due to heavily doped, It’s depletion layer is very thin and is order of micrometer. The forward bias characteristic of Zener diode is same as the normal PN junction diode but in reverse bias it has different characteristic .Initially, a negligible constant current flow through the zener diode in its reverse bias but atcertain voltage, the current becomes abruptly large. This voltage is called as zener voltage. This sudden and sharp increase in zener current is called as zener breakdown.

Zener diode is popularly used as a shunt regulator or voltage regulator.The Zener diode will conduct in the reverse direction for any output voltage (Vo) greater than zener voltage (Vz), Vo can never exceed Vz. As the load current changes the Zener diode will conduct sufficient current to maintain a voltage drop of E – Vo across the series dropping resistor, Rs.

Line Regulation:

In this type of regulation, series resistance and load resistance are fixed, only input

voltage is changing. Output voltage remains the same as long as the input voltage is

maintained above a minimum value.

Load Regulation:

In this type of regulation, input voltage is fixed and the load resistance is varying. Output

voltage remains same, as long as the load resistance is maintained above a minimum

value.

Apparatus Required:

S.No.	Name of the equipment	Specification
1	DC power supply	0-30V
2	Ammeter	MC
3	Voltmeter	MC
4	Resistor	1KΩ-5KΩ
5	Zener diode	

Procedure:

1) Zener Diode - Line Regulation:

1. Set the Zener Voltage(VZ)

2. Set the Series Resistance (RS) value.

3. Set the Load Resistance (RL) value.

4. Vary DC voltage.

5. Voltmeter is placed parallel to load resistor and ammeter series with

the series resistor.

6. Choose appropriate DC voltage such that zener diode is 'on'.

7. Now note the Voltmeter and Ammeter reading for various DC voltage.

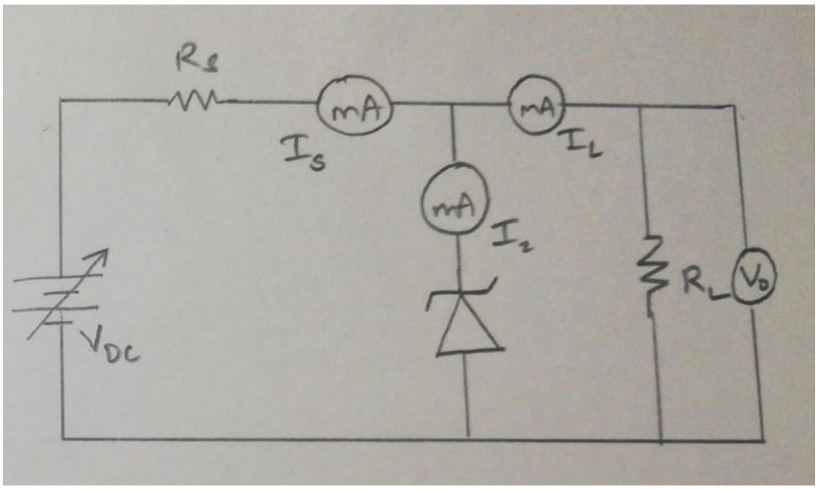
8. Note the Load current(IL), zener current(IZ), Output voltage(VO)

9. Calculate the voltage regulation.

2) Zener Diode - Load Regulation:

1. Set DC voltage.
2. Set the Series Resistance (RS) value.
3. 1W D0-41 Glass Zener Diode 1N4740A, Zener voltage is 5.1 V.
4. Vary the Load resistance(Rs) value.
5. Voltmeter is placed parallel to load resistor and ammeter series with the series resistor.
6. Choose Load resistance in such a manner, such that Zener diode is on.
7. Now note the Voltmeter and ammeter reading for various Load resistance.
8. Increase the load resistance(RL).
9. Note the load current(IL), zener current(IZ), output voltage(VO).
10. Calculate the voltage regulation.

Circuit Diagram (Line Regulation):



Observation Table (Line Regulation):

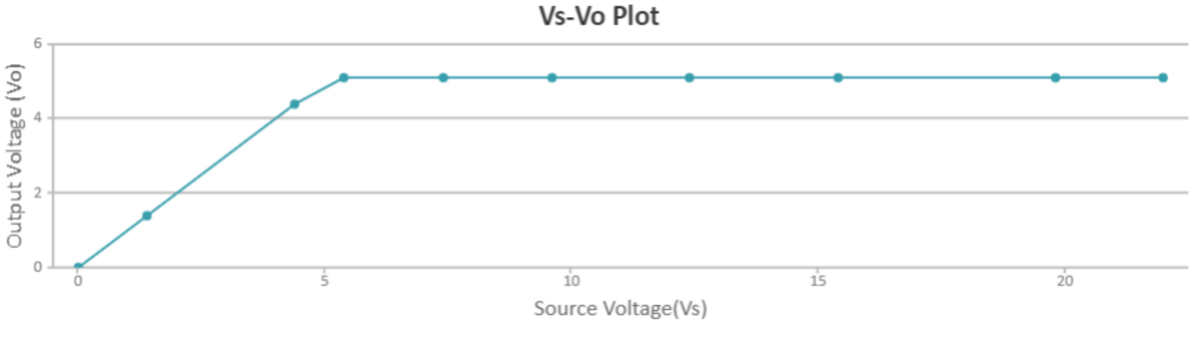
EXPERIMENTAL TABLE

Zener Voltage(V_Z): 5.1 V
Series Resistance(R_S): 1 KΩ
Load Resistance (R_L): 2 KΩ

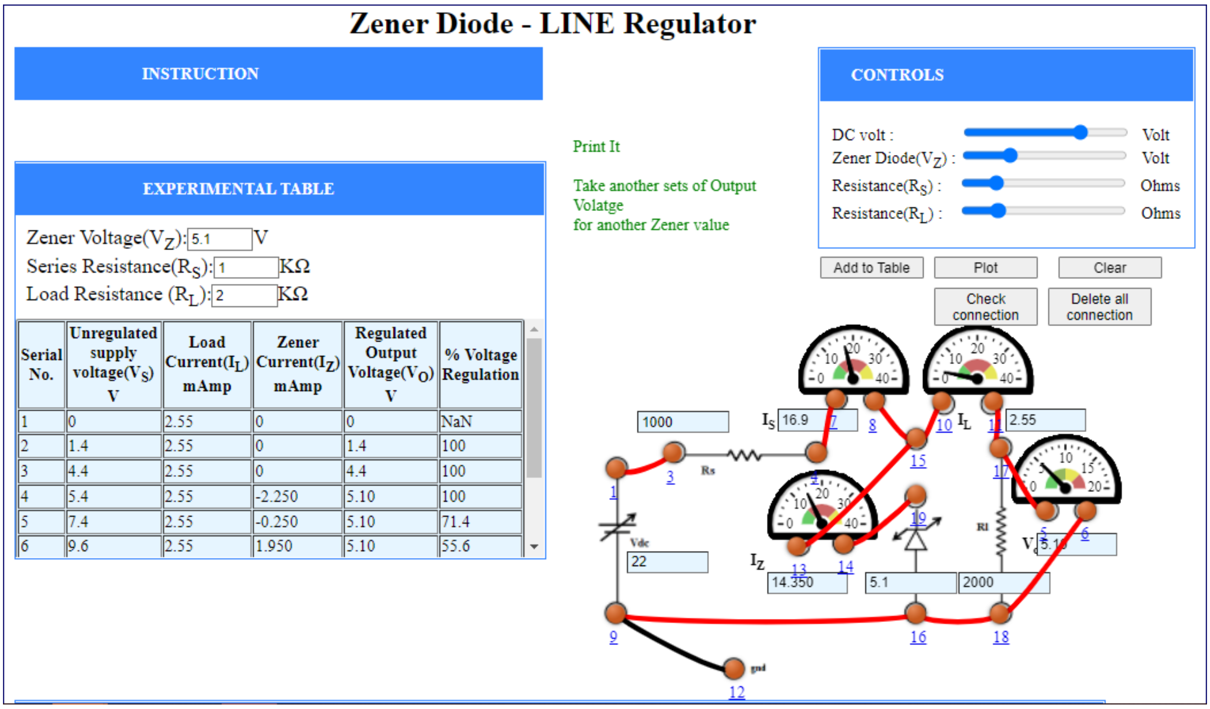
Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	2.55	0	0	NaN
2	1.4	2.55	0	1.4	100
3	4.4	2.55	0	4.4	100
4	5.4	2.55	-2.250	5.10	100
5	7.4	2.55	-0.250	5.10	71.4
6	9.6	2.55	1.950	5.10	55.6
7	12.4	2.55	4.750	5.10	41.7
8	15.4	2.55	7.750	5.10	33.3
9	19.8	2.55	12.150	5.10	26.3
10	22	2.55	14.350	5.10	22.7

Graph (Line Regulation):

GRAPH PLOT

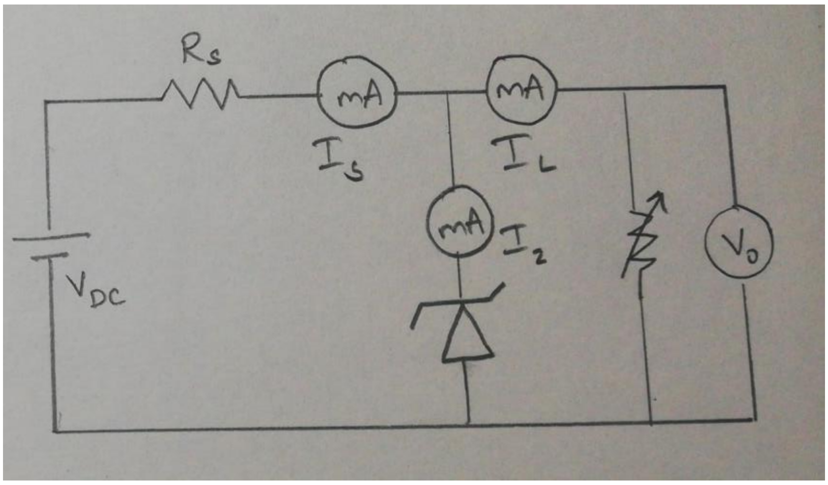


Simulation (Line Regulation):



Serial No.	Unregulated supply voltage(V_S) V	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	0	2.55	0	0	NaN
2	1.4	2.55	0	1.4	100
3	4.4	2.55	0	4.4	100
4	5.4	2.55	-2.250	5.10	100
5	7.4	2.55	-0.250	5.10	71.4
6	9.6	2.55	1.950	5.10	55.6

Circuit Diagram (Load Regulation):



Observation Table (Load Regulation):

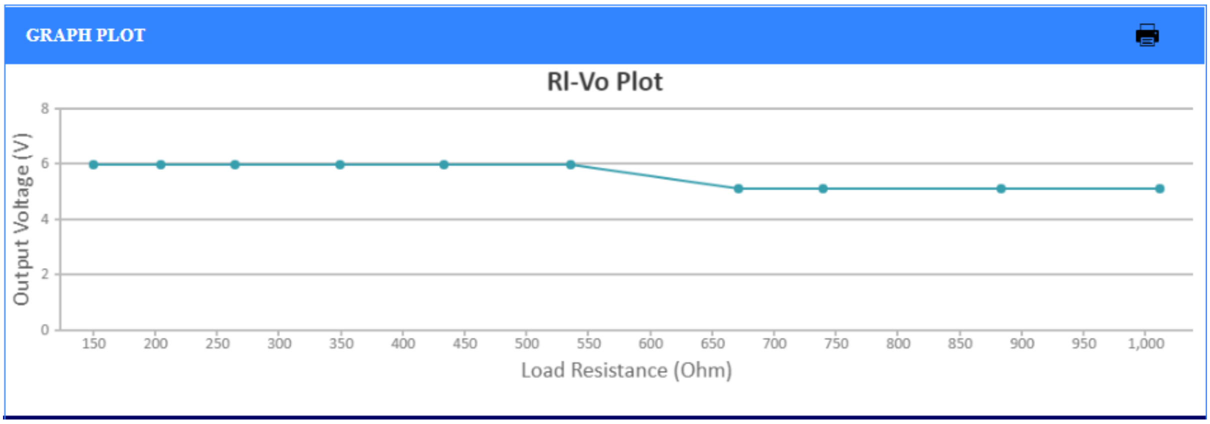
EXPERIMENTAL TABLE

DC Voltage (V_{DC}): 6 V Zener Voltage(V_Z): 5.1 V

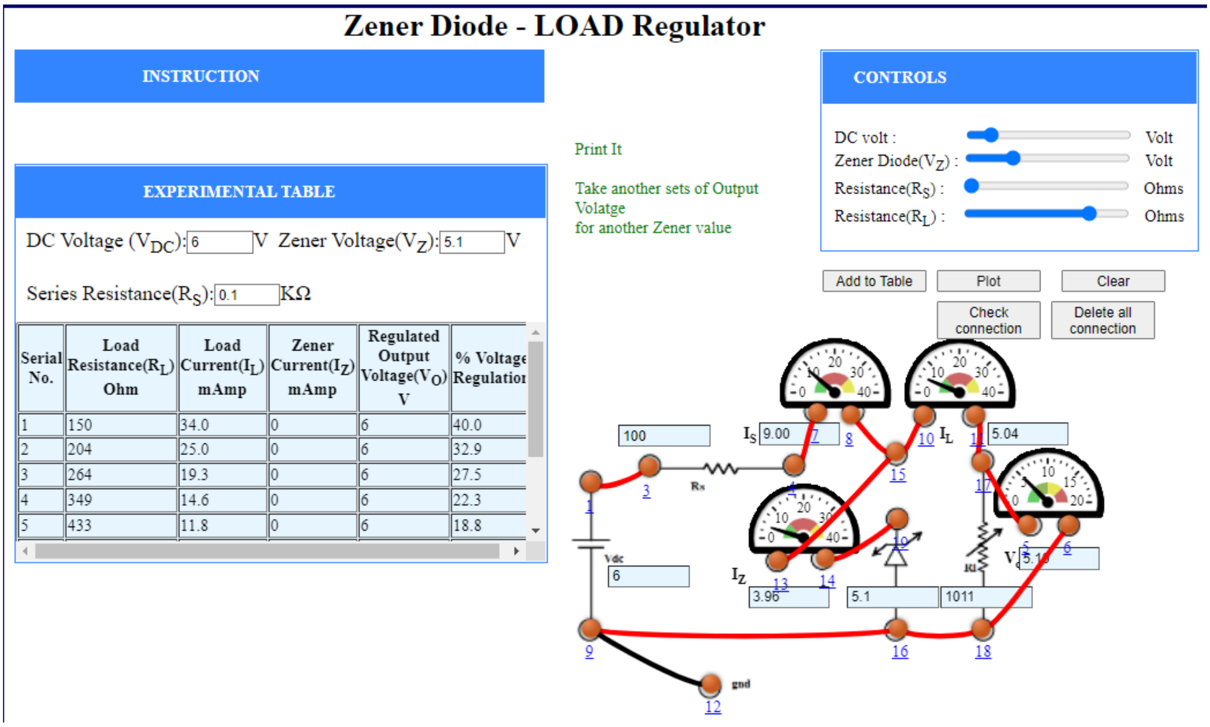
Series Resistance(R_S): 0.1 KΩ

Serial No.	Load Resistance(R_L) Ohm	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulatior
1	150	34.0	0	6	40.0
2	204	25.0	0	6	32.9
3	264	19.3	0	6	27.5
4	349	14.6	0	6	22.3
5	433	11.8	0	6	18.8
6	535	9.53	0	6	15.7
7	671	7.60	1.40	5.10	13.0
8	739	6.90	2.10	5.10	11.9
9	883	5.78	3.22	5.10	10.2
10	1011	5.04	3.96	5.10	9.00

Graph (Load Regulation):



Simulation (Load Regulation):



Serial No.	Load Resistance(R_L) Ohm	Load Current(I_L) mAmp	Zener Current(I_Z) mAmp	Regulated Output Voltage(V_O) V	% Voltage Regulation
1	150	34.0	0	6	40.0
2	204	25.0	0	6	32.9
3	264	19.3	0	6	27.5
4	349	14.6	0	6	22.3
5	433	11.8	0	6	18.8

Calculation:

Line Regulator:

Minimum V required to turn on the zener diode:

$$V_{min} = \frac{V_Z \times (R_S + R_L)}{R_L} = \frac{5.1\,(1000 + 2000)}{2000} = 7.65\,V$$

Load Regulator:

Minimum load resistance R_L required to turn on the zener diode:

$$R_{L\,min} = \frac{V_Z \times R_S}{V_T - V_Z} = \frac{5.1 \times 100}{6 - 5.1} = 566.67\,\Omega$$

Result and Inference:

For line regulation we varied the voltage supply by keeping the load resistance constant. On crossing the zener voltage (5.1V) regulation is facilitated.

For load regulation we varied load resistance by keeping the input voltage constant. On crossing the load resistance value of 6.67 ohm, regulation is facilitated.

EXPERIMENT- 3

Verification of Kirchhoff's Laws

Aim:

To verify Kirchhoff's laws for D.C circuits

Statement:

a) Kirchhoff's current law (KCL): The sum of currents at any node is zero.

OR

At any node, the sum of the incoming currents is equal to the sum of the outgoing currents

b) Kirchhoff's Voltage law (KVL): The Algebraic sum of applied voltage and the voltage drops is zero in any closed circuit

OR

In any closed circuit, the sum of the applied voltages is equal to sum of the voltage drops.

Apparatus Required:

Sl.No	Name of the Equipment	Specification
1	Dc power supply	(0-30)V
2	Resistor	21Ω, 11Ω,
3	Ammeters	MC
4	Voltmeter	MC
5	Display Block	

6	Scope	

Procedure:

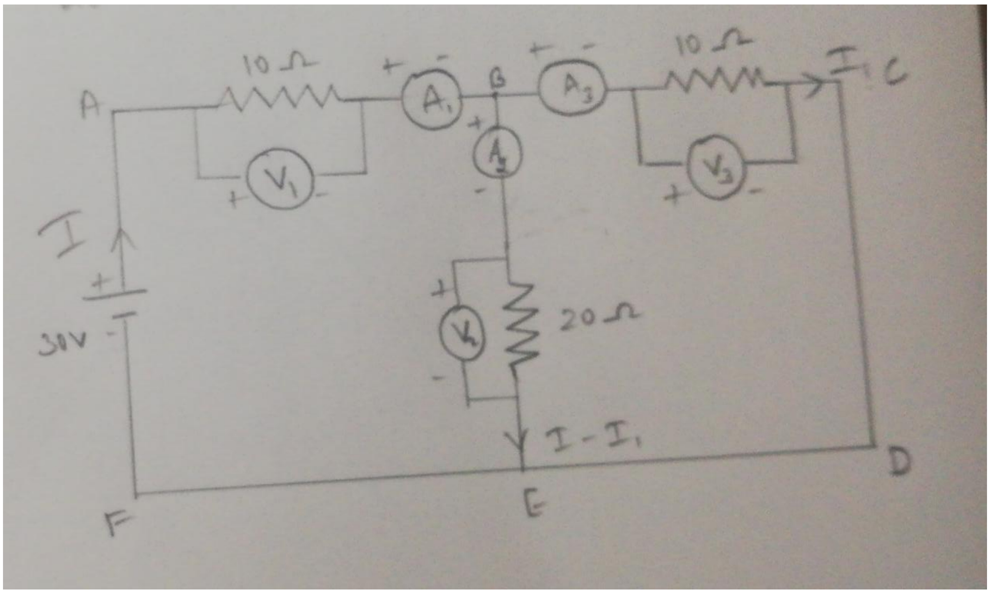
1. Analyse the circuit and choose appropriate (type and rating) ammeter and voltmeter.

2. Make the connections as per the circuit diagram in the simulation platform

3. Simulate the circuit and observe the current and voltage

4. Repeat the experiment for different resistance values and input voltages.

Circuit Diagram:



Observation Table:

Sl No	Supply Voltage (V)	I_1 (A)		I_2 (A)		I_3 (A)		$I_1 = I_2+I_3$ (A)		V_1 (v)		V_2 (v)		V_3 (v)		V= V_1+V_2 (v)		V= V_1+V_3 (v)	
		Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr
1	30	1.8A	1.8A	0.6A	0.6A	1.2A	1.2A	1.8A	1.8A	18V	18V	12V	12V	12V	12V	30V	30V	30V	30V

Calculation:

Loop 1 → ABEFA
Loop 2 → ABCDEFA

Loop 1
Applying KVL
$30 - 10I - 20(I - I_1) = 0$
$\Rightarrow -30I_1 + 20I = -30$ — (1)

Loop 2
Applying KVL
$30 - 10I - 10I_1 = 0$
$-10I - 10I_1 = 30$ — (2)

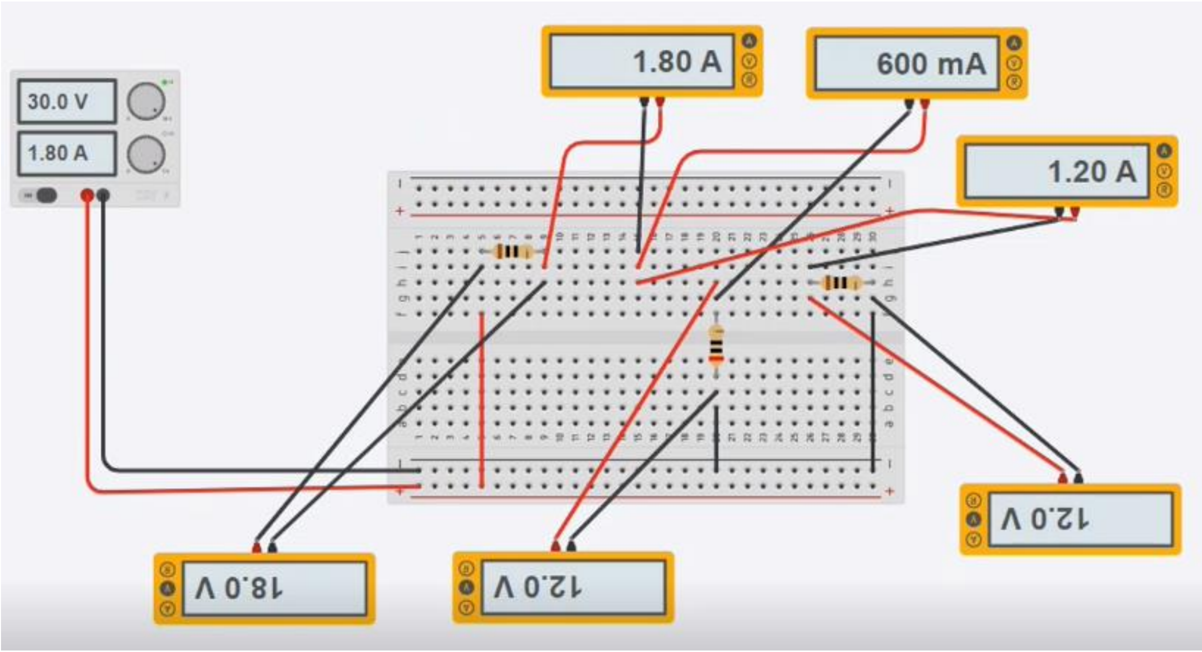
Solving (1) and (2)
$I = 1.8A$, $I_1 = 1.2A$, $I - I_1 = 0.6A$

KVL
$V_1 = IR_1 = 18V$; $V_2 = I_2R_2 = 12V$; $V_3 = I_3R_3 = 12V$

$V_t = V_1 + V_3 = 18 + 12 = 30V$
$V_t = V_1 + V_2 = 18 + 12 = 30V$
$V_3 - V_2 = 12 - 12 = 0$

KCL
Applying at point B:
$I_t = I + I_1 - I_1$
$1.8 = 1.2 + 0.6$
$= 1.8$

Simulation (Tinker Cad):



Result and Inference:

Kirchhoff's Laws are verified using Tinker CAD.

KCL → Current through the 20 ohm resistor is 0.6A, and current through the second 10 ohm resistor is 1.2 A. The sum of these two currents is equal to the current I through the first 10 ohm resistor, which is 1.8A.

KVL → V=30V is equal to the sum of (V1 & V3) and (V2 & V1), hence verifying KVL.

EXPERIMENT- 4

Study of Half-Wave Rectifier

Aim:

To determine the output wave form from Half-wave rectifier.

Apparatus Required:

1. A function generator
2. Regular power supply
3. diode
4. Supply resistor
5. Connecting wires

Theory:

The process of converting the AC into DC is called rectification and it is obtained through rectifier circuits, which use diodes as circuit element. For a half wave rectifier during the positive half cycle, the diode is forward biased and it conducts and hence a current flows through the load resistor. During the negative half-cycle, the diode is reverse biased and it is equivalent to an open circuit. Hence the current through the load resistance is zero. Thus the diode conducts for one half cycles and results in a half wave rectified output.

A Full wave rectifier is a circuit, which converts an AC voltage into a pulsating dc voltage using both half cycles of the applied voltage. It uses two diodes of which one conducts during one half cycle while the other conducts during the other half cycle of the applied ac voltage. During the positive cycle of the input voltage, diode D_1 becomes forward biased and D_2 becomes reverse biased. Hence D_1 conducts and D_2 remains off. The load current flows through D_1 and the voltage drop across R_L will be equal to the input voltage. During negative half cycle of the input voltage, diode D_1 becomes reverse biased and D_2 becomes forward biased. Hence D_1 remains off and D_2 conducts. The load current flows through D_2 and the voltage drop across R_L will be equal to the input voltage.

To obtain a pure DC voltage at the output, filtering is done where the AC is removed and the DC is obtained. For that capacitor is used as a filter. We can connect a high value capacitor in shunt with the load. The capacitor offers a low impedance path to the ac components of current. Most of the ac current passes through the shunt capacitor. All the dc current passes through the load resistor. The capacitor tries to maintain the output voltage constant at V_m.

The practical application of any rectifier (be it half wave or full wave) is to be used as a

component in building DC power supplies. In order to build an efficient & smooth DC power supply, a full wave rectifier is always preferred. However, for applications in which a constant DC voltage is not very essential, we can use power supplies with half wave rectifier.

Procedure:

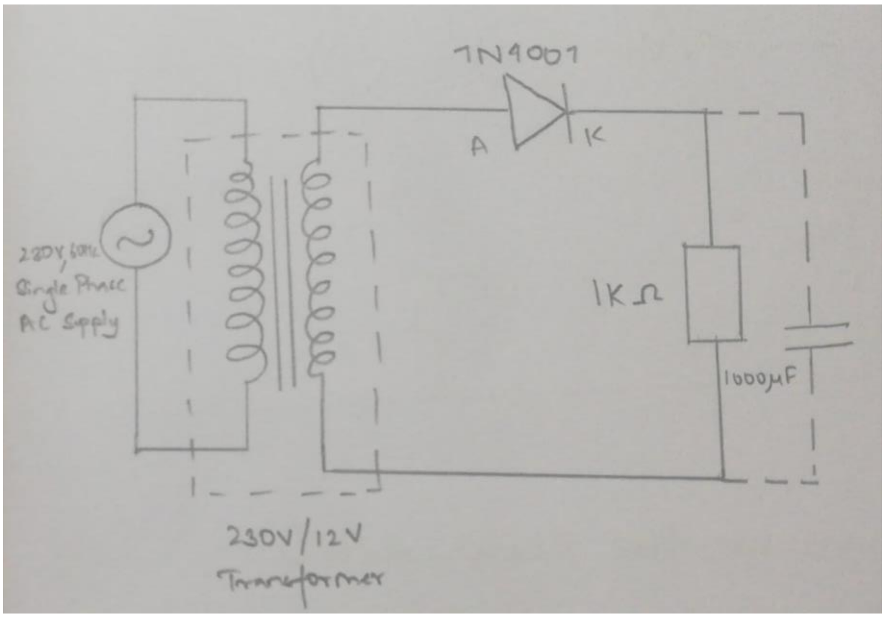
1. Set the resistor RL.
2. Click on 'ON' button to start the experiment.
3. Click on 'Sine Wave' button to generate input waveform
4. Click on 'Oscilloscope' button to get the rectified output.
5. Vary the Amplitude, Frequency, volt/div using the controllers.
6. Click on "Dual" button to observe both the waveform.

7. Channel 1 shows the input sine waveform; Channel 2 shows the output rectified

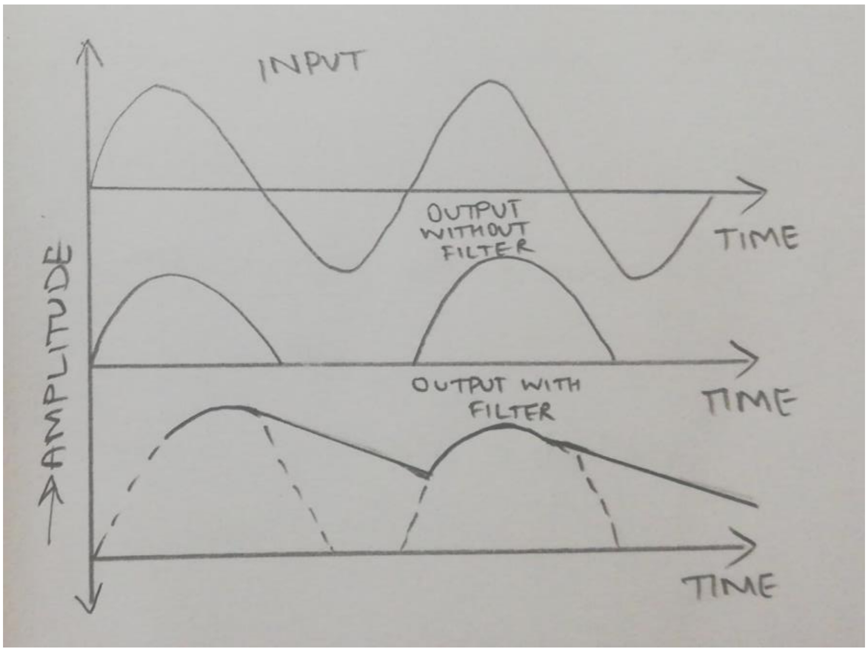
waveform.

8. Calculate the Ripple Factor. Theoretical Ripple Factor= 1.21.

Circuit Diagram:



Graph of sin wave Function:



Calculation:

Peak Voltage $(V_m) = 1\ V$

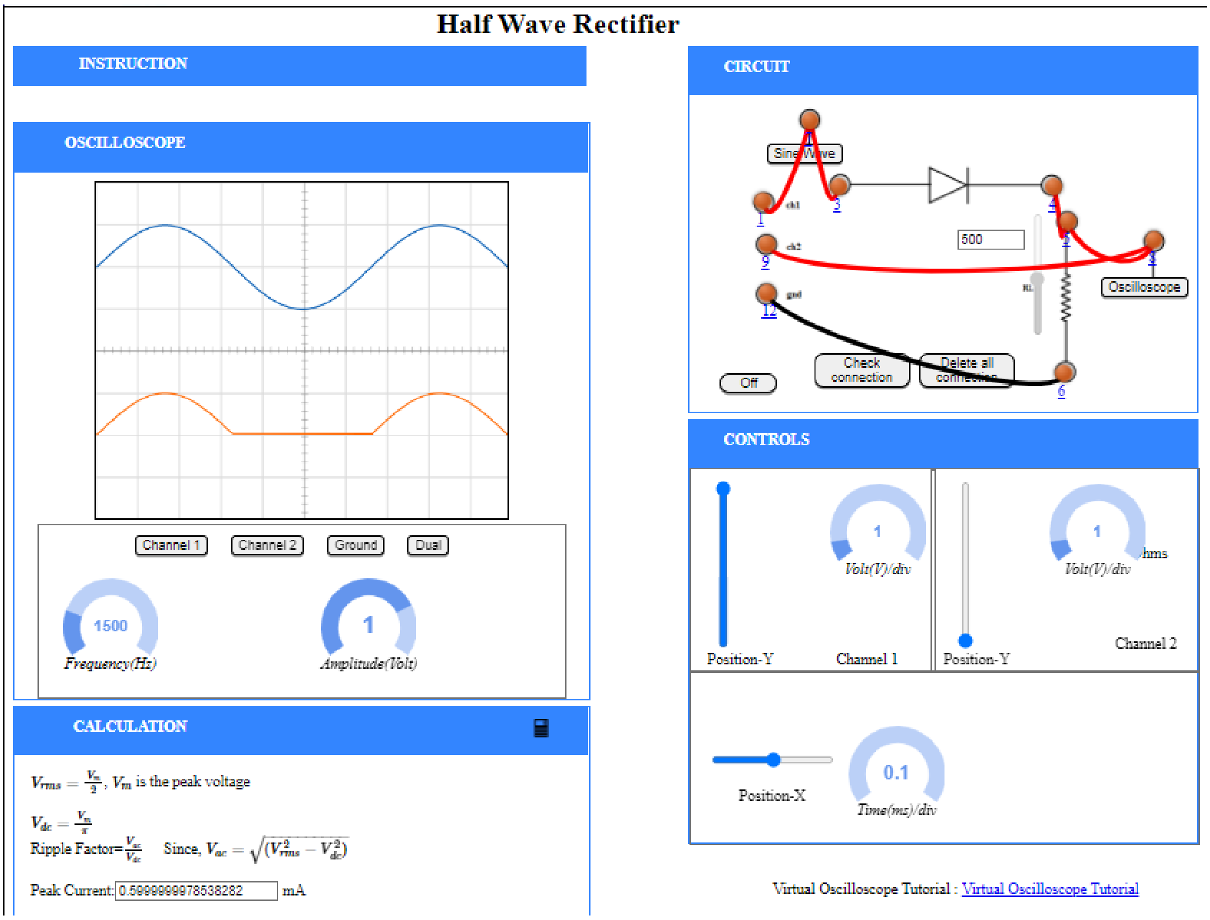
$V_{rms} = \frac{V_m}{2} = \frac{1}{2} = 0.5\ V$

$V_{dc} = \frac{V_m}{\pi} = 0.318\ V$

$V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)} = \sqrt{(0.5)^2 - (0.318)^2} = 0.3858$

$\text{Ripple factor} = \frac{V_{ac}}{V_{dc}} = \frac{0.3858}{0.318} = 1.2133$

Simulation Screenshot:



Result & Inference:

The Half Wave Rectifier circuit design output waveforms have been studied and the required parameters are calculated.

EXPERIMENT- 5

Study of Full-Wave Rectifier

Aim:

To determine the output wave form of Full wave rectifier.

Apparatus Required:

1. A transformer
2. Regulator power supply
3. Diode
4. Supply resistor
5. Voltmeter
6. Ammeter
7. Connecting wires

Theory:

A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output.

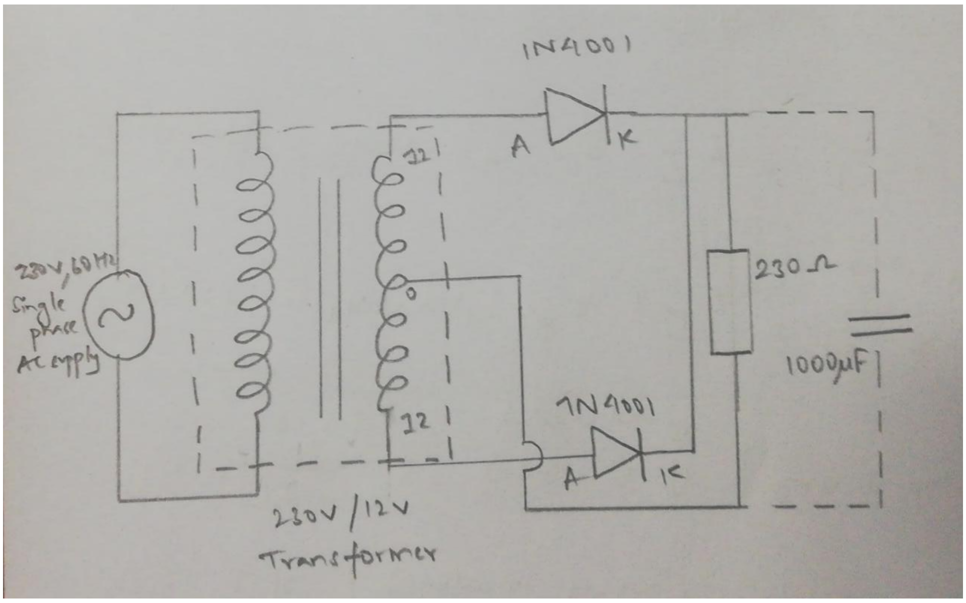
Centre tapped rectifier:
During the positive cycle of the input voltage, diode D1 becomes forward biased and D2 becomes reverse biased. Hence D1 conducts and D2 remains off.
The load current flows through D1 and the voltage drop across RL will be equal to the input voltage.
During negative half cycle of the input voltage, diode D1 becomes reverse biased and D2 becomes forward biased. Hence D1 remains off and D2 conducts. The load current flows through D2 and the voltage drop across RL will be equal to the input voltage.

Bridge rectifier:
In Bridge rectifier, 4 diodes are arranged in the form of a bridge. The transformer secondary is connected to two diametrically opposite points of the bridge at points A & C. The load resistance RL is connected to bridge through points B and D. During the first half cycle of the input voltage, the upper end of the transformer secondary winding is positive with respect to the lower end.
Thus during the first half cycle diodes D1 and D3 are forward biased and current flows through arm AB, enters the load resistance RL, and returns back flowing through arm DC.
During this half of each input cycle, the diodes D2 and D4 are reverse biased and current is not allowed to flow in arms AD and BC. During the second half cycle of the input voltage, the lower end of the transformer secondary winding is positive with respect to the upper end.
Thus diodes D2 and D4 become forward biased and current flows through arm CB, enters the load resistance RL, and returns back to the source flowing through arm DA.

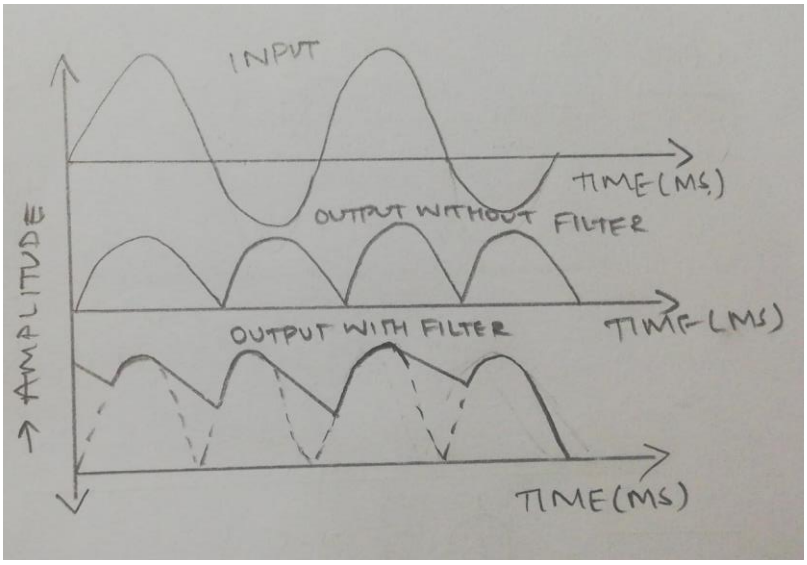
Procedure:

1. Set the resistor RL.
2. Click on 'ON' button to start the experiment.
3. Click on 'Sine Wave' button to generate input waveform
4. Click on 'Oscilloscope' button to get the rectified output.
5. Vary the Amplitude, Frequency, volt/div using the controllers.
6. Click on "Dual" button to observe both the waveform.
7. Channel 1 shows the input sine waveform, Channel 2 shows the output rectified waveform.
8. Calculate the Ripple Factor. Theoretical Ripple Factor=0.483.

Circuit Diagram:



Graph:



Calculation:

Peak voltage $(V_m) = 2V$

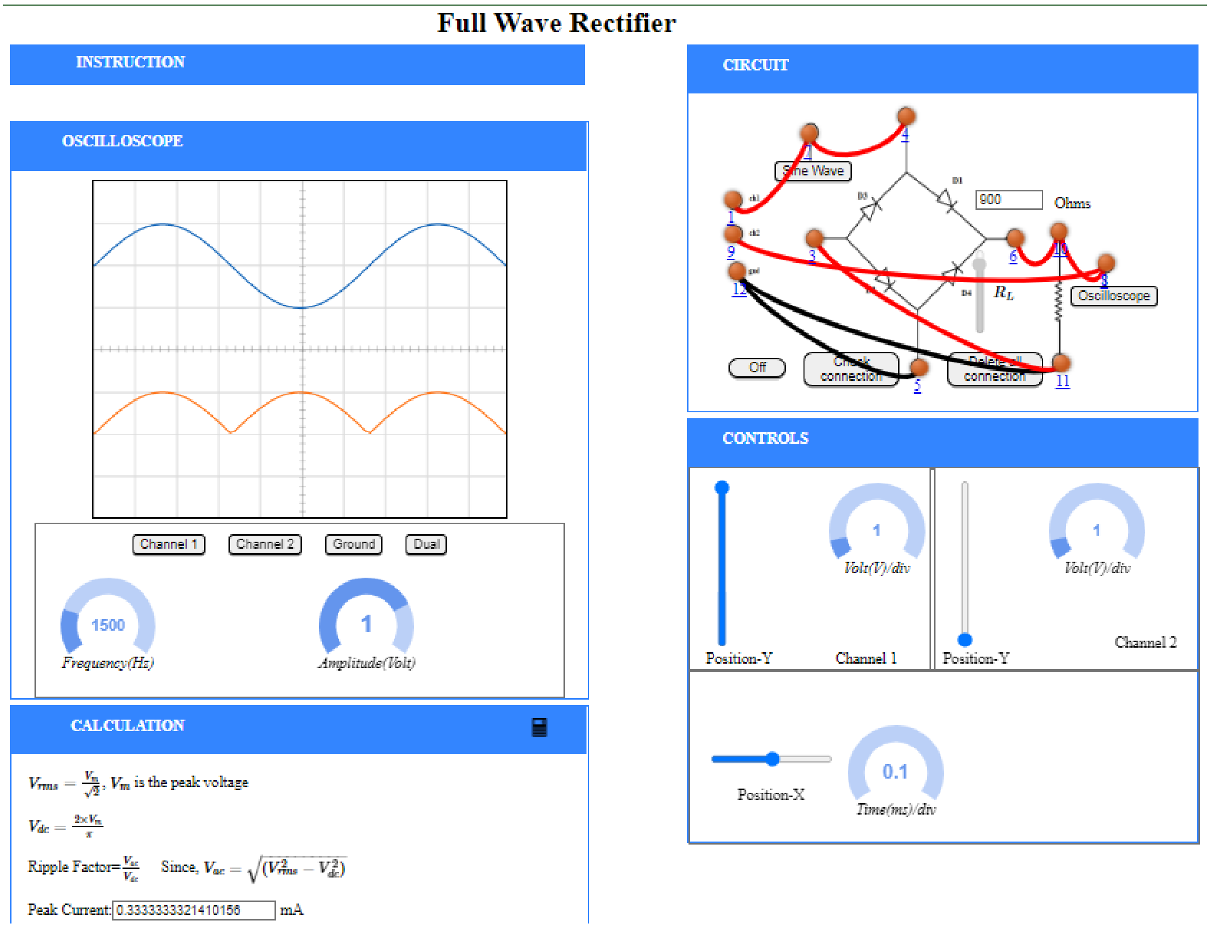
$$V_{rms} = \frac{V_m}{\sqrt{2}} = 1.4142\,V$$

$$V_{dc} = \frac{2 \times V_m}{\pi} = 1.2732\,V$$

$$V_{ac} = \sqrt{\left(V_{rms}^2 - V_{dc}^2\right)} = \sqrt{0.3789} = 0.6156$$

$$\text{Ripple factor} = \frac{V_{ac}}{V_{dc}} = \frac{0.6156}{1.2732} = 0.48$$

Simulation:



Result and Inference:

In this experiment, a continuous current is produced by one pair of diodes conducting alternatively in each half-cycle. From the study of the full-wave rectifier, the obtained value of the ripple factor matches the practical value.