LAB ASSIGNMENT

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1.OHM'S LAW

- **OBJECTIVE**

To plot a graph between Voltage and current for an ohmic resistor.

THEORY

The law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Such a conductor is characterized by its 'Resistance' – R measured in Ohms.

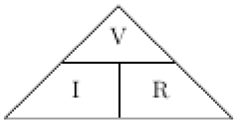
V=I×RV=I×R

V is the Voltage in Volts across the conductor.

I is the current in Amperes through the conductor.

Voltage(V) is directly proportional to current i.e V=I×RV=I×R.

Resistance(R) in inversely proportional to current(I) i.e I=VRI=VR



From the above figure, the equation may be represented by a triangle known as Ohm's Law triangle, where V (voltage) is placed on the top section, the I (current) is placed to the left section, and the R (resistance) is placed to the right. The line that divides the left and right sections indicates multiplication, and the divider between the top and bottom sections indicates division.

Therefore equations derived from Ohm's law triangle are-

V=I×R

I=V/R

R=V/I

Explanation of Ohm's Law

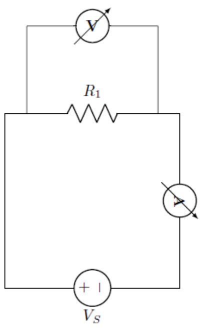


Figure 2: Current through resistor

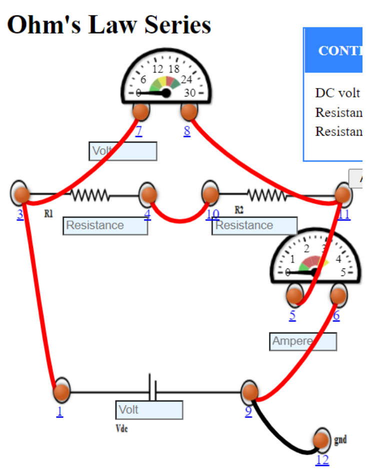
From the circuit:
The voltage across resistor is equal to source voltage: V_R=V_S

The current through the resistance is given by: I=VR/R

PROCEDURE

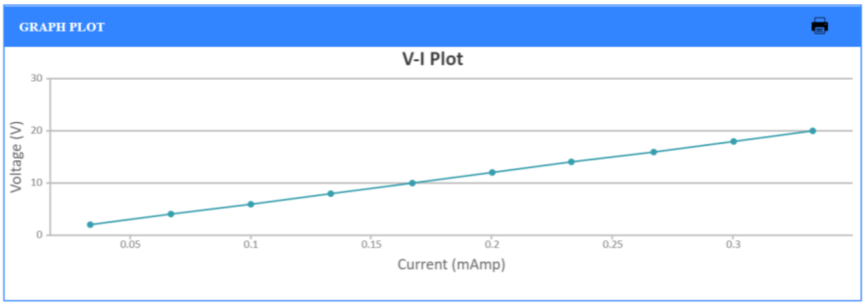
- Let us go through the experiment of confirming Ohms Law.
- Set DC voltage(0-30 V).
- Set the Resistance Value(1 Kohm - 100 Kohm) .
- Voltmeter is placed parallel to resistor and ammeter series with resistor.
- Now note the Voltmeter and Ammeter reading for DC voltage.
- Increase the DC voltage by 2 factor and note Voltmeter and Ammeter Readings. Keep resistance value constant
- Plot the V-I graph to verify Ohm's Law.
- Repeat step 2 to 6 for another set of resistance value.
- V versus I graph is a straight line.
- Therefore from the graph we see that the resistance do adhere to Ohm's law. Thus resistance is said to be an Ohmic device.

CIRCUIT DIAGRAM



OBSERVATIONS

Graph



Table

EXPERIMENTAL TABLE

Resistance(R_1): 50 KΩ

Resistance(R_2): 10 KΩ

Resistance(R_{eq}): 60 KΩ

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	2	0.0333
2	4	0.0667
3	6	0.100
4	8	0.133
5	10	0.167

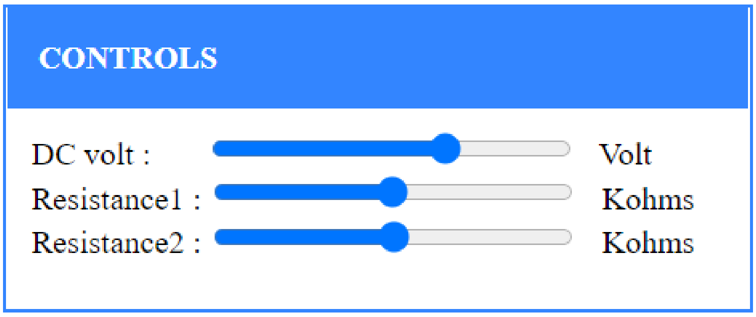
EXPERIMENTAL TABLE

Resistance(R_1): 50 KΩ

Resistance(R_2): 10 KΩ

Resistance(R_{eq}): 60 KΩ

4	8	0.133
5	10	0.167
6	12	0.200
7	14	0.233
8	16	0.267
9	18	0.300
10	20	0.333



➢ CONCLUSION

Therefore from the graph we see that the resistance do adhere to Ohm's law. Thus resistance is said to be an Ohmic device.

2.VI CHARACTERISTICS OF A DIODE

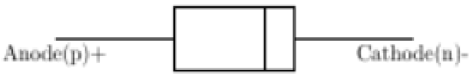
➢ OBJECTIVE

- At the end of the experiment, the student should be able to
- Explain the structure of a P-N junction diode
- Explain the function of a P-N junction diode
- Explain forward characteristics of a Silicon diode

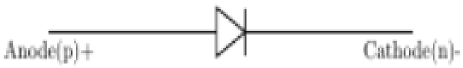
➢ THEORY

Structure of P-N junction diode

The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is the cathode. In general, the cathode of a diode is marked by a solid line on the diode.



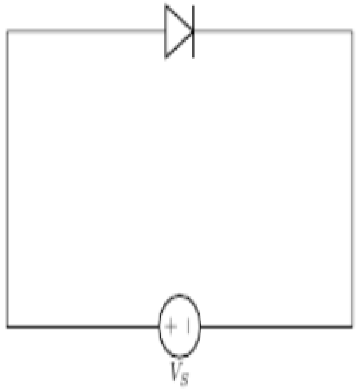
Figurer:1



Figurer:2

Function of a P-N junction diode in Forward Bias

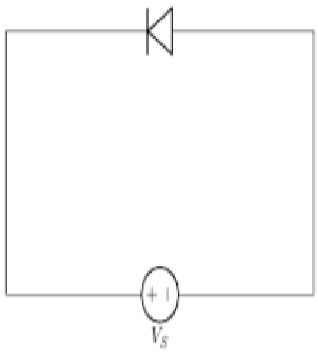
The positive terminal of battery is connected to the P side(anode) and the negative terminal of battery is connected to the N side(cathode) of a diode, the holes in the p-type region and the electrons in the n-type region are pushed toward the junction and start to neutralize the depletion zone, reducing its width. The positive potential applied to the p-type material repels the holes, while the negative potential applied to the n-type material repels the electrons. The change in potential between the p side and the n side decreases or switches sign. With increasing forward-bias voltage, the depletion zone eventually becomes thin enough that the zone's electric field cannot counteract charge carrier motion across the p–n junction, which as a consequence reduces electrical resistance. The electrons that cross the p–n junction into the p-type material (or holes that cross into the n-type material) will diffuse into the nearby neutral region. The amount of minority diffusion in the near-neutral zones determines the amount of current that may flow through the diode.



Figurer:3

Function of a P-N junction diode in Reverse Bias

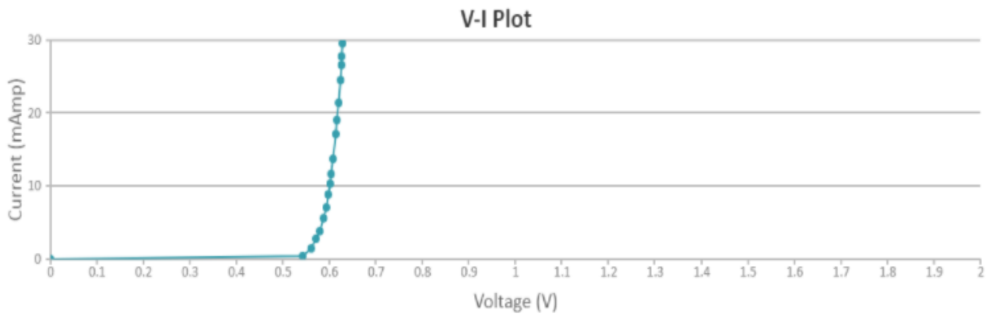
The positive terminal of battery is connected to the N side(cathode) and the negative terminal of battery is connected to the P side(anode) of a diode. Therefore, very little current will flow until the diode breaks down.



Figurer:4

The positive terminal of battery is connected to the N side(cathode) and the negative terminal of battery is connected to the P side(anode) of a diode, the 'holes' in the p-type material are pulled away from the junction, leaving behind charged ions and causing the width of the depletion region to increase. Likewise, because the n-type region is connected to the positive terminal, the electrons will also be pulled away from the junction, with similar effect. This increases the voltage barrier causing a high resistance to the flow of charge carriers, thus allowing minimal electric current to cross the p–n junction. The increase in resistance of the p–n junction results in the junction behaving as an insulator.

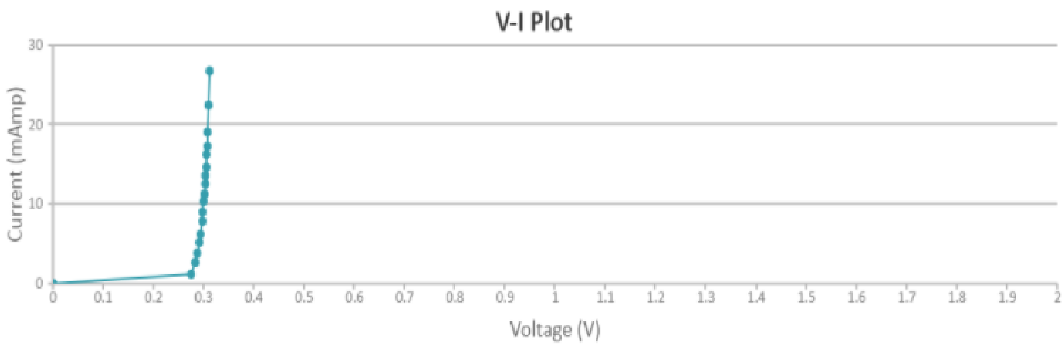
The strength of the depletion zone electric field increases as the reverse-bias voltage increases. Once the electric field intensity increases beyond a critical level, the p–n junction depletion zone breaks down and current begins to flow, usually by either the Zener or the avalanche breakdown processes. Both of these breakdown processes are non-destructive and are reversible, as long as the amount of current flowing does not reach levels that cause the semiconductor material to overheat and cause thermal damage.



Figurer:5

Forward and reverse biased characteristics of a Silicon diode

In forward biasing, the positive terminal of battery is connected to the P side and the negative terminal of battery is connected to the N side of the diode. Diode will conduct in forward biasing because the forward biasing will decrease the depletion region width and overcome the barrier potential. In order to conduct, the forward biasing voltage should be greater than the barrier potential. During forward biasing the diode acts like a closed switch with a potential drop of nearly 0.6 V across it for a silicon diode. The forward and reverse bias characteristics of a silicon diode. From the graph, you may notice that the diode starts conducting when the forward bias voltage exceeds around 0.6 volts (for Si diode). This voltage is called cut-in voltage.



Figurer:6

In reverse biasing, the positive terminal of battery is connected to the N side and the negative terminal of battery is connected to the P side of a diode. In reverse biasing, the diode does not conduct electricity, since reverse biasing leads to an increase in the depletion region width; hence current carrier charges find it more difficult to overcome the barrier potential. The diode will act like an open switch and there is no current flow.

➢ PROCEDURE

- Forward Bias-Si Diode
- Set DC voltage to 0.2 V .
- Select the diode.
- Set the resistor.
- Voltmeter is placed parallel to Silicon diode and ammeter series with resistor.
- The positive side of battery to the P side(anode) and the negative of battery to the N side(cathode) of the diode.
- Now vary the voltage upto 5V and note the Voltmeter and Ammeter reading for particular DC voltage .
- Take the readings and note Voltmeter reading across Silicon diode and Ammeter reading.
- Plot the V-I graph and observe the change.
- Calculate the dynamic resistance of the diode. rd=ΔV/ΔI
- Therefore from the graph we see that the diode starts conducting when the forward bias voltage exceeds around 0.6 volts (for Si diode). This voltage is called cut-in voltage.

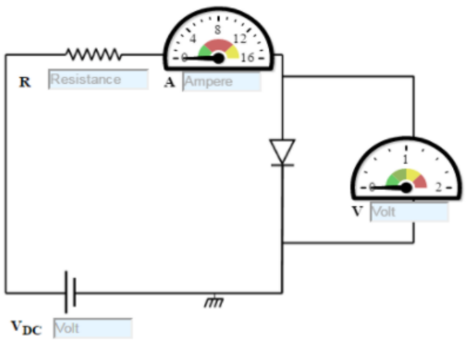
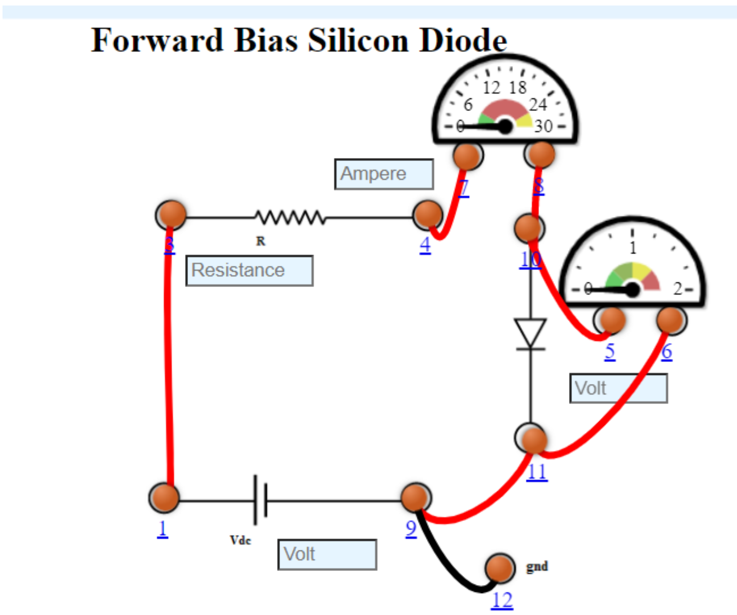


Figure:1

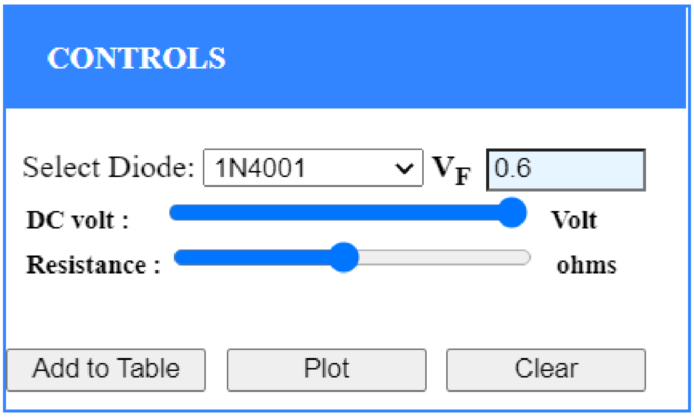
➢ CIRCUIT



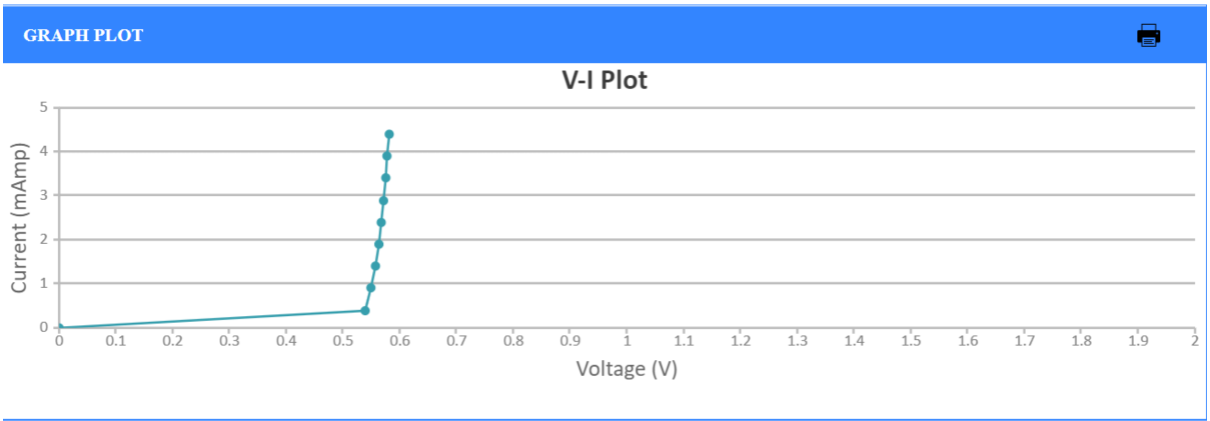
➢ OBSERVATIONS

EXPERIMENTAL TABLE

Serial No.	Forward Voltage(Volt)	Forward Current(mAmp)
1	0	0
2	0.539	0.400
3	0.549	0.900
4	0.557	1.40
5	0.563	1.90
6	0.567	2.40
7	0.571	2.90
8	0.575	3.40
9	0.578	3.90
10	0.581	4.40



PLOT



3.HALF WAVE RECTIFIER

- **OBJECTIVE**

  At the end of the module the student would be able to

- Explain Rectification
- Explain Half Wave Rectification

Rectification

Figure:4

A rectifier is a device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers are essentially of two types – a half wave rectifier and a full wave rectifier.

Half Wave Rectification

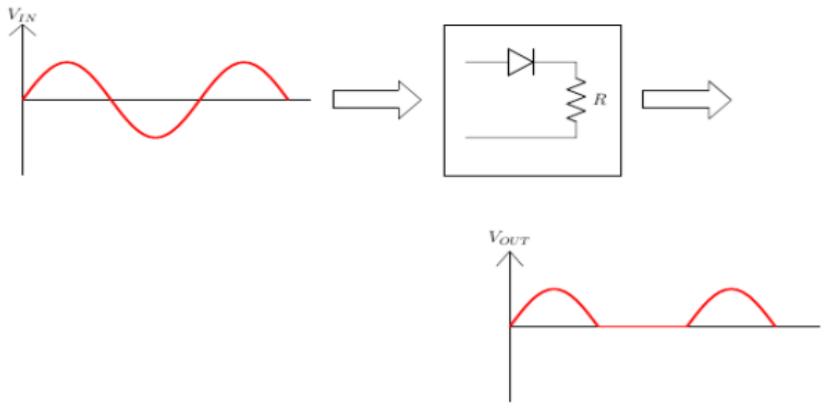


Figure:3

On the positive cycle the diode is forward biased and on the negative cycle the diode is reverse biased. By using a diode we have converted an AC source into a pulsating DC source. In summary we have 'rectified' the AC signal.

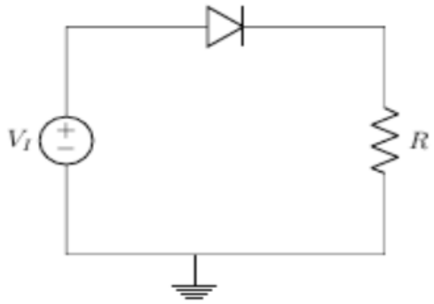
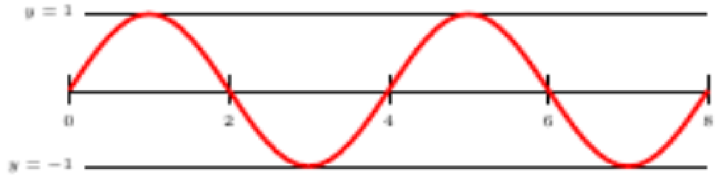
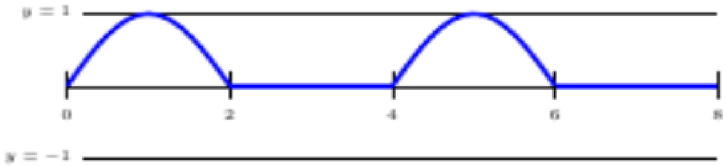


Figure:5

The simplest kind of rectifier circuit is the half-wave rectifier.The half-wave rectifier is a circuit that allows only part of an input signal to pass. The circuit is simply the combination of a single diode in series with a resistor, where the resistor is acting as a load.

Half Wave Rectifiers – Waveforms





The output DC voltage of a half wave rectifier can be calculated with the following two ideal equations.

$$V_{peak} = V_{rms} \times \sqrt{2}$$

$$V_{dc} = \frac{V_{peak}}{\Pi}$$

Half Wave Rectification:For Positive Half Cycle

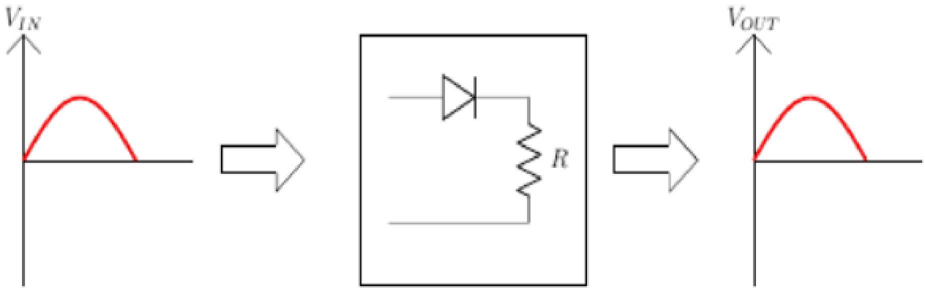


Figure:1

Diode is forward biased, acts as a short circuit, passes the waveform through.

For positive half cycle:

$$V_I - V_b - I \times r_d - I \times R = 0$$

where,
V_I is the input voltage,
V_b is barrier potential,
r_d is diode resistance,
I is total current,
R is resistance

$$I = \frac{V_I - V_b}{r_d + R}$$

$$V_O = I \times R$$

$$V_O = \frac{V_I - V_b}{r_d + R} \times R$$

For $r_d << R$,

$$V_O = V_I - V_b$$

V_b is 0.3 for Germanium ,
V_b is 0.7 for Silicon

For $V_I < V_b$,

The diode will remain OFF.The Output voltage will be,

$$V_O = 0$$

For $V_I > V_b$,

The diode will be ON.The Output voltage will be,

$$V_O = V_I - V_b$$

Half Wave Rectification: For Negative Half Cycle

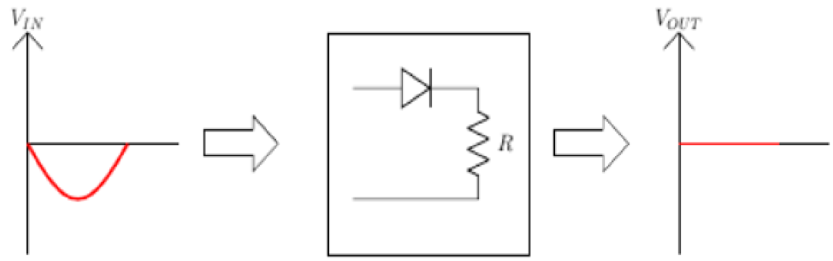


Figure:2

Diode is reverse biased, acts as a open circuit, does not pass the waveform through.

For negative half cycle:

$$V_O = 0 \quad Since, \quad I = 0$$

Half wave Rectification: For an Ideal Diode

For Ideal Diode,

$$V_b = 0$$

For positive half cycle,

$$V_O = V_I$$

For negative half cycle,

$$V_O = 0$$

Average output voltage

$$V_O = V_m \times \sin wt \quad for \quad 0 \leq wt \leq \pi$$

$$V_O = 0 \quad for \quad \pi \leq wt \leq 2\pi$$

$$V_{av} = \frac{V_m}{\pi} = 0.318V_m$$

RMS load voltage

$$V_{rms} = I_{rms} \times R = \frac{V_m}{2}$$

Average load current

$$I_{av} = \frac{V_{av}}{R} = \frac{\frac{V_m}{\pi}}{R}$$

$$I_{av} = \frac{V_m}{\pi \times R} = \frac{I_m}{\pi}$$

RMS load current

$$I_{rms} = \frac{I_m}{2}$$

Form factor: It is defined as the ratio of rms load voltage and average load voltage.

$$F.F = \frac{V_{rms}}{V_{av}}$$

$$F.F = \frac{\frac{V_m}{2}}{\frac{V_{av}}{2}} = \frac{\pi}{2} = 1.57$$

$$F.F \geq 1$$
$$rms \geq av$$

Ripple Factor

$$\gamma = \sqrt{(F.F^2} - 1 \times 100\%$$

$$\gamma = \sqrt{(1.57^2 - 1)} \times 100\% = 1.21\%$$

Efficiency: It is defined as ratio of dc power available at the load to the input ac power.

$$n\% = \frac{P_{load}}{P_{in}} \times 100\%$$

$$n\% = \frac{I_{dc}^2 \times R}{I_{rms}^2 \times R} \times 100\%$$

$$n\% = \frac{\frac{I_m^2}{\pi^2}}{\frac{I_m^2}{4}} \times 100\% = \frac{4}{\pi^2} \times 100\% = 40.56\%$$

Peak Inverse Voltage

For rectifier applications, peak inverse voltage (PIV) or peak reverse voltage (PRV) is the maximum value of reverse voltage which occurs at the peak of the input cycle when the diode is reverse-biased.The portion of the sinusoidal waveform which repeats or duplicates itself is known as the cycle. The part of the cycle above the horizontal axis is called the positive half-cycle, the part of the cycle below the horizontal axis is called the negative half cycle. With reference to the amplitude of the cycle, the peak inverse voltage is specified as the maximum negative value of the sine-wave within a cycle's negative half cycle.

$$PIV = V$$

$$-V_m + V = 0 \Rightarrow V = V_m$$

$$PIV \geq V_m$$

➢ PROCEDURE

- Set the resistor RL.
- Click on 'ON' button to start the experiment.
- Click on 'Sine Wave' button to generate input waveform
- Click on 'Oscilloscope' button to get the rectified output.
- Vary the Amplitude, Frequency, volt/div using the controllers.
- Click on "Dual" button to observe both the waveform.
- Channel 1 shows the input sine waveform, Channel 2 shows the output rectified waveform.
- Calculate the Ripple Factor.Theoretical Ripple Factor= 1.21.

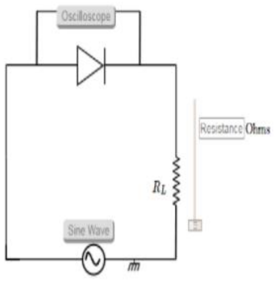


Figure:1

➢ CALCULATION

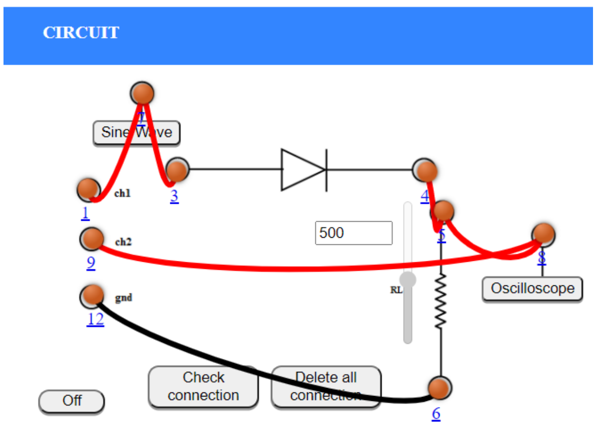
Measure the V_m

$$V_{rms} = \frac{V_m}{2}$$

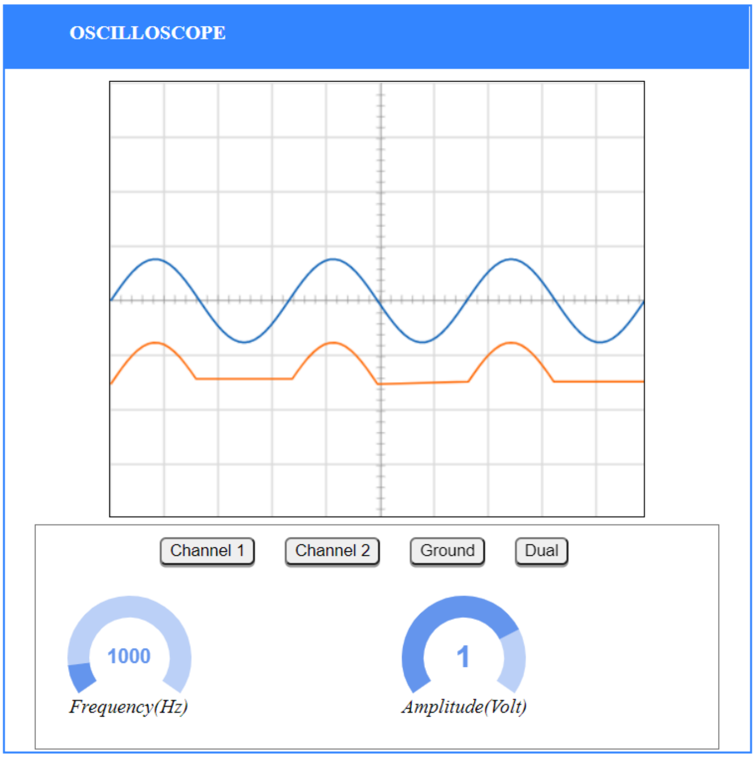
$$V_{dc} = \frac{V_m}{\pi}$$

Ripple Factor= $\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

➢ CIRCUIT



➢ GRAPH



➢ CALCULATION/CONCLUSION

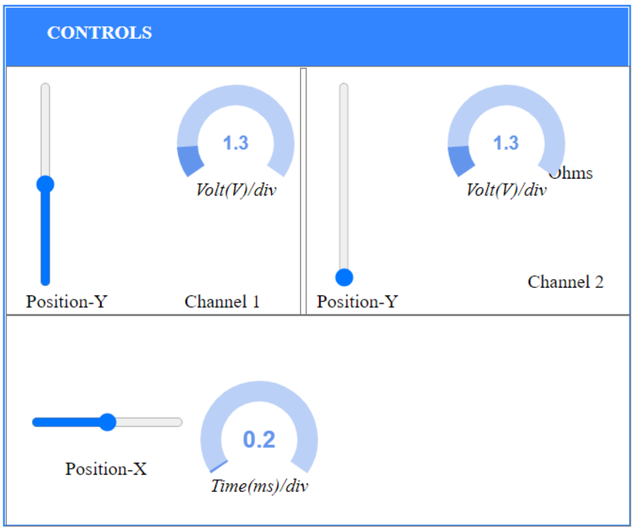
CALCULATION

$V_{rms} = \frac{V_m}{2}$, V_m is the peak voltage

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

Ripple Factor=$\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

Peak Current: 0.5999999978538282 mA



4.FULL WAVE RECTIFIER

➢ OBJECTIVE

At the end of the module the student would be able to

Explain Rectification

Figure :1

A rectifier is a device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers are essentially of two types – a half wave rectifier and a full wave rectifier.

Full Wave Rectifier

A full-wave rectifier is exactly the same as the half-wave, but allows unidirectional current through the load during the entire sinusoidal cycle (as opposed to only half the cycle in the half-wave). A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Let us see our half wave rectifier example and deduce the circuit.

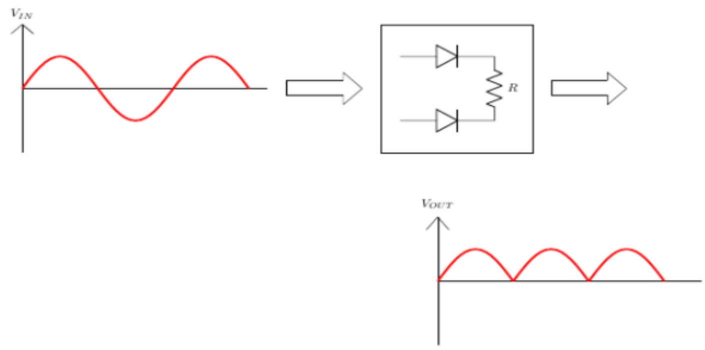


Figure:2

For a half wave Rectifier this is what we have observed

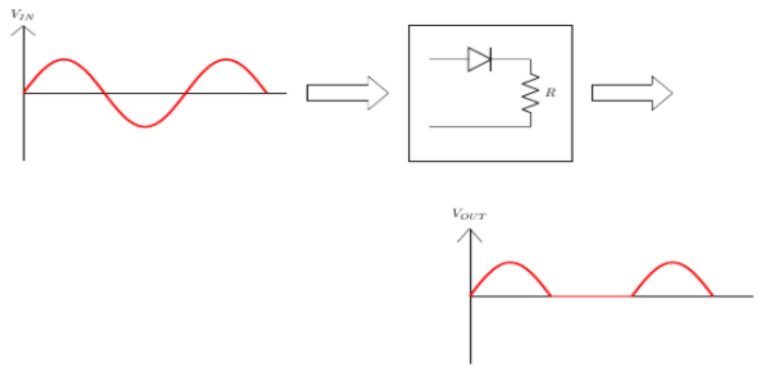


Figure:3

If we change the phase of the input waveform by 180 degrees

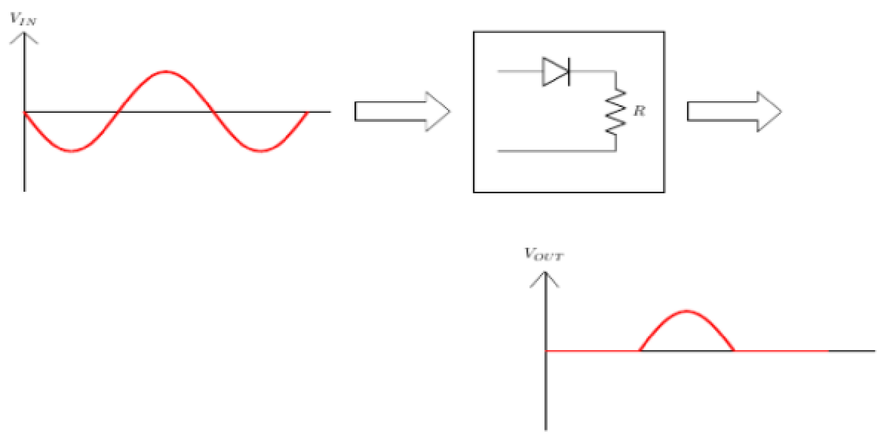


Figure:4

Now if we add these two circuits, we would get

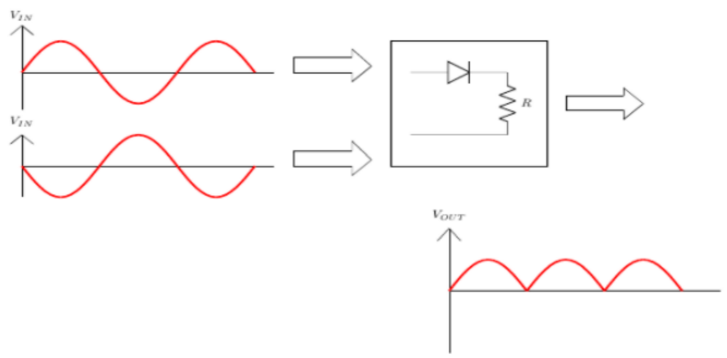
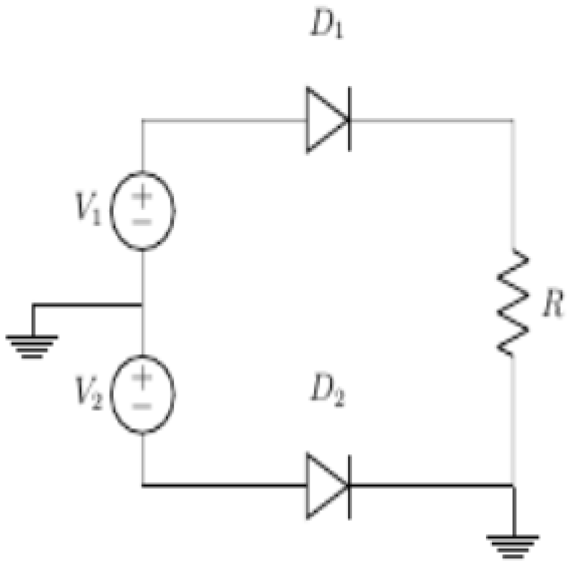


Figure:5

Full Wave Rectifier - Circuit

So, we have seen that this rectifier circuit consists of two sources which have a phase difference along with two diodes. When V1 is positive, V2 is negative. Hence the top diode(D1) will be a short and the bottom diode(D2) will be an open. On the other hand, when V1 is negative, V2 is positive. Hence the bottom diode(D2) will be on and the top diode(D1) will be an open circuit.



Full Wave Rectifier – Waveforms

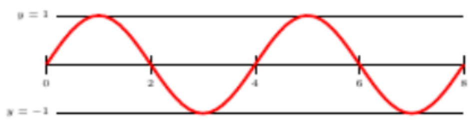


Figure:7

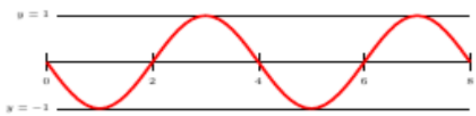


Figure:8

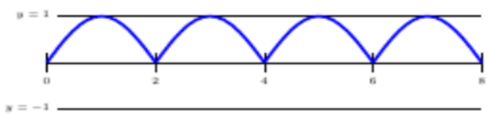


Figure:9

The resulting waveform of the schematic is shown above. This configuration is rarely used because sometimes it may be impractical to obtain two voltage sources and it is difficult to SYNC the sources. Let us see how a single source can be used.

Bridge Rectifier

Bridge rectifier uses 4 rectifying diodes connected in a "bridged" configuration to produce the desired output but does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

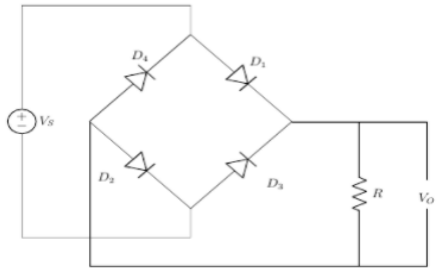


Figure:14

➢ PROCEDURE

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

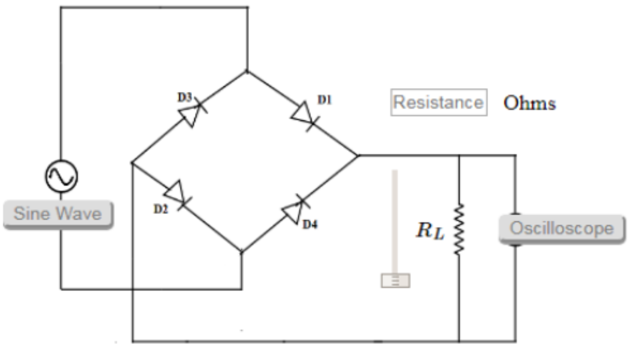


Figure:1

Calculation

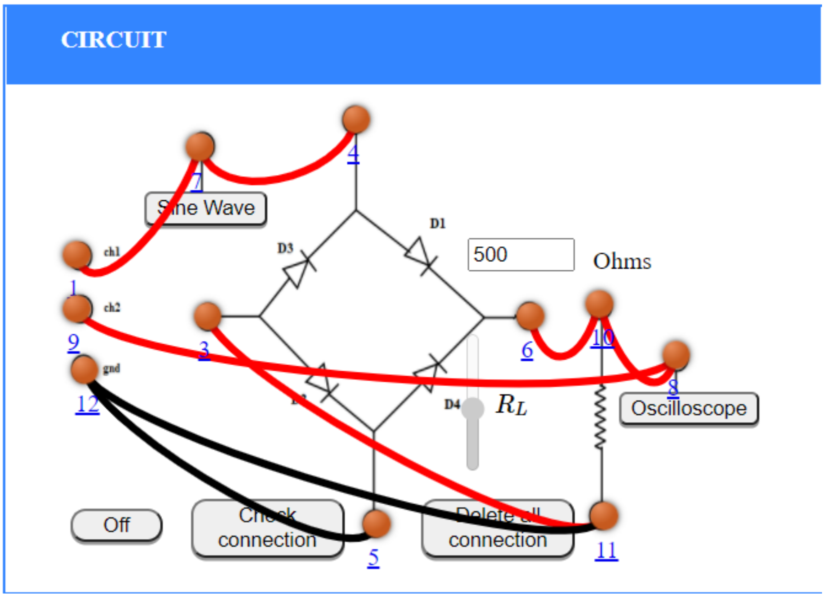
Measure the V_m

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

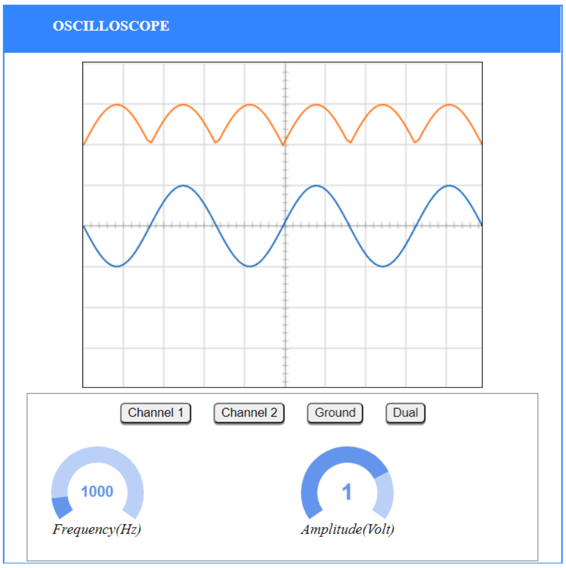
$$V_{dc} = \frac{2\times V_m}{\pi}$$

Ripple Factor= $\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

➢ CIRCUIT



GRAPH



➢ CALCULATION/CONCLUSION

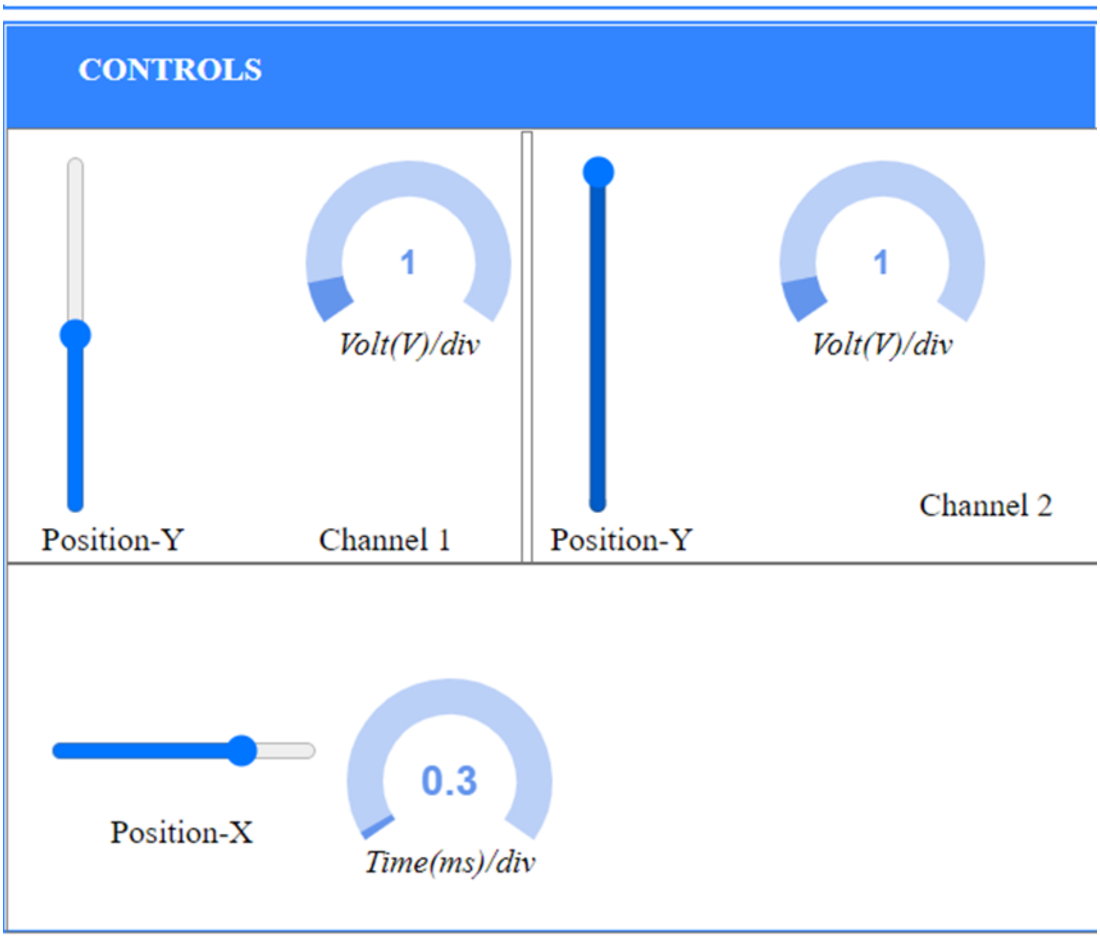
CALCULATION

$V_{rms} = \frac{V_m}{\sqrt{2}}$, V_m is the peak voltage

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

Ripple Factor=$\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

Peak Current: 0.5999999978538282 mA



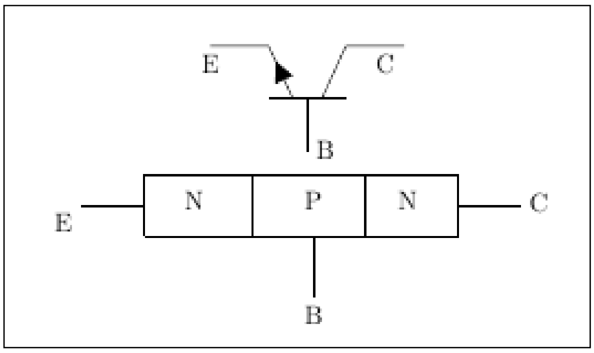
5. BJT COMMON EMITTER CHARACTERISTICS

➢ OBJECTIVE:

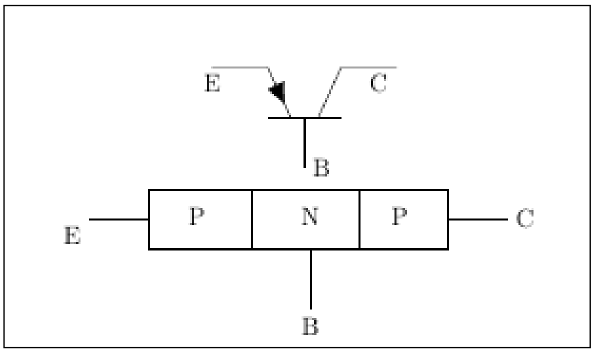
- Explain structure of Bipolar Junction Transistor
- Explain Operation of Bipolar Junction Transistor
- Explain Common Emitter characteristics of a BJT

➢ THEORY:

A bipolar junction transistor, BJT, is a single piece of silicon with two back-to-back P-N junctions. BJTs can be made either as PNP or as NPN.



They have three regions and three terminals, emitter, base, and collector represented by E, B, and C respectively. The direction of the arrow indicates the direction of the current in the emitter when the transistor is conducting normally. An easy way to remember this is NPN stands for "Not Pointing iN".



Emitter (E): It is the region to the left end which supply free charge carriers i.e., electrons in n-p-n or holes in p-n-p transistors. These majority carriers are injected to the middle region i.e. electrons in the p region of n-p-n or holes in the n region of p-n-p transistor. Emitter is a heavily doped region to supply a large number of majority carriers into the base.

Base (B): It is the middle region where either two p-type layers or two n-type layers are sandwiched. The majority carriers from the emitter region are injected into this region. This region is thin and very lightly doped.

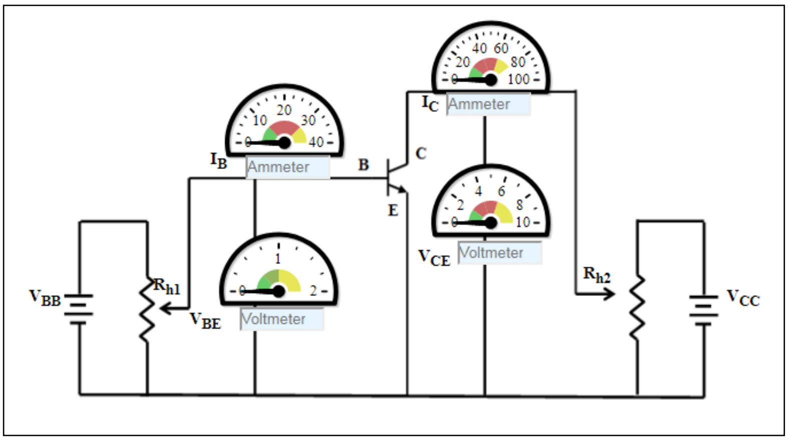
Collector (C): It is the region to right end where charge carriers are collected. The area of this region is largest compared to emitter and base region . The doping level of this region is intermediate between heavily doped emitter region and lightly doped base region.

Note:

1. In digital electronics applications, the transistors are used as a switch
2. Most bipolar switching circuits use NPN transistors.

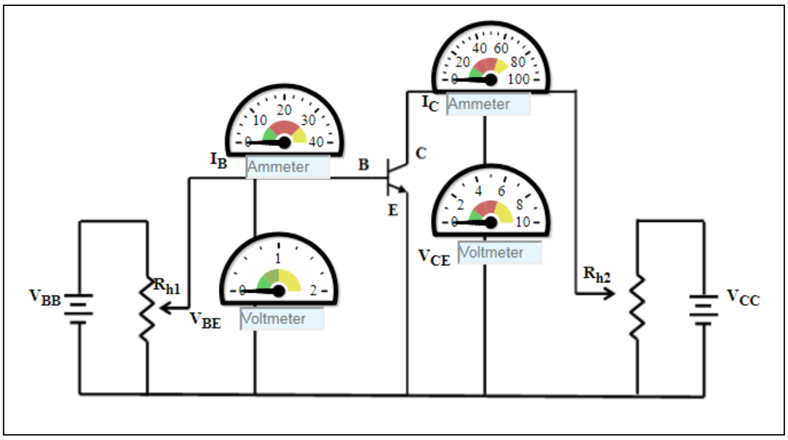
➢ PROCEDURE:

- BJT Common Emitter – Input Characteristics
- Initially set rheostat R_{h1} = 1 Ω and rheostat R_{h2} = 1 Ω
- Set the Collector-Emitter Voltage (V_{CE}) to 1 V by adjusting the rheostat R_{h2}
- Base Emitter Voltage (V_{BE}) is varied by adjusting the rheostat R_{h1}.
- Note the reading of Base current (I_B)in microAmpere.
- Click on 'Plot' to plot the I-V characteristics of Common-Emitter configuration. A graph is drawn with V_{BE} along X-axis and I_B along Y-axis.
- Click on 'Clear' button to take another set of readings
- Now set the Collector-Emitter Voltage (V_{CE}) to 2 V, 3 V, 4 V



- BJT Common Emitter – Output Characteristics
- Initially set rheostat R_{h1} = 1 Ω and rheostat R_{h2} = 1 Ω
- Set the Base current (I_B)15 uA by adjusting the rheostat R_{h1}

- Vary the Collector-Emitter Voltage (V_{CE})is varied by adjusting the rheostat R_{h2}.
- Note the reading of Collector current (I_C).
- Click on 'Plot' to plot the I-V characteristics of Common-Emitter configuration. A graph is drawn with V_{CE} along X-axis and I_C along Y-axis.
- Click on 'Clear' button to take another set of readings
- Now set the Base Current (I_B) to 20 uA

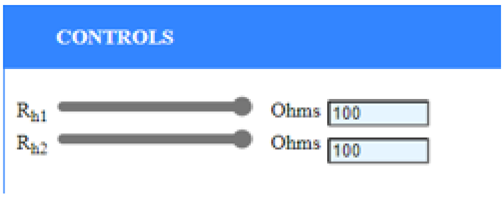


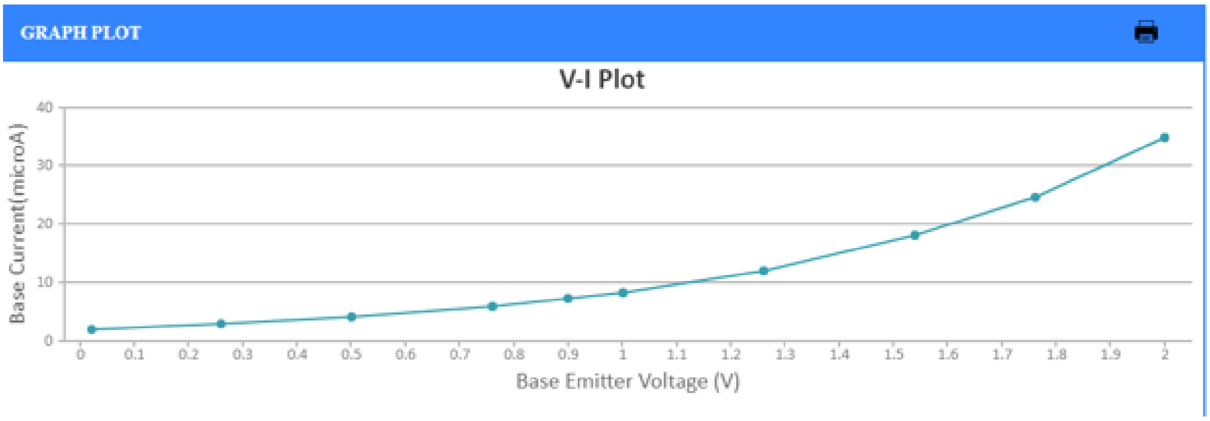
➢ GRAPHS AND CALCULATIONS:

BJT-CE Input Characteristic

EXPERIMENTAL TABLE

Serial No.	Collector-Emitter Voltage 10.00 V	
	Base-Emitter Voltage V	Base Current(μA)
1	0.02000	2.058
2	0.2600	2.900
3	0.5000	4.085
4	0.7600	5.923
5	0.9000	7.235
6	1.000	8.345
7	1.260	12.10
8	1.540	18.05
9	1.760	24.72
10	2.000	34.82

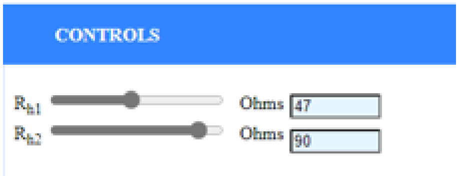


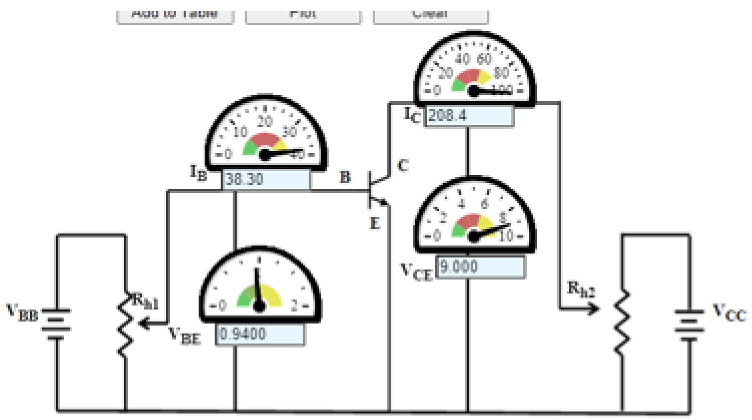


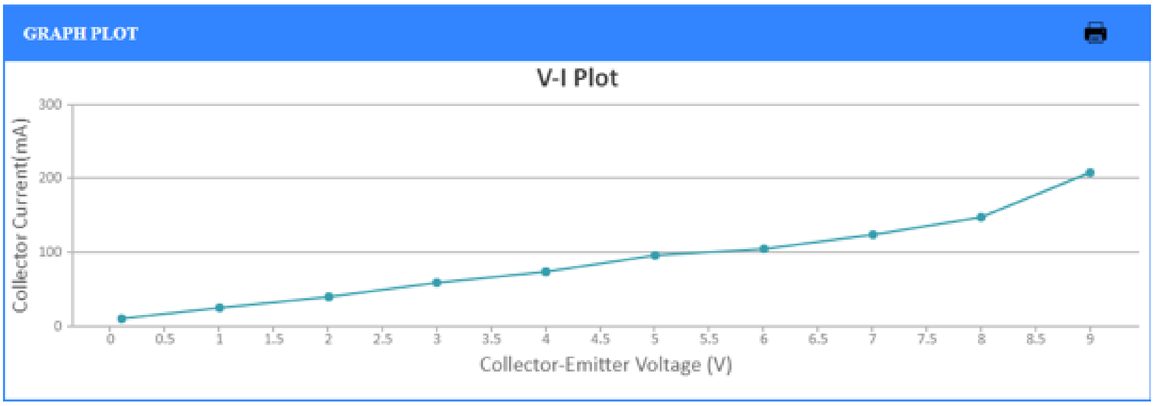
BJT-CE Output Characteristics

EXPERIMENTAL TABLE

Serial No.	Base-Current 38.30 µA	
	Collector-Emitter Voltage V	Collector Current mA
1	0.1000	10.92
2	1.000	25.14
3	2.000	39.42
4	3.000	59.85
5	4.000	74.47
6	5.000	96.36
7	6.000	105.0
8	7.000	124.6
9	8.000	147.9
10	9.000	208.4






GRAPH PLOT
V-I Plot
Collector Current(mA)
300
200
100
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Collector-Emitter Voltage (V)

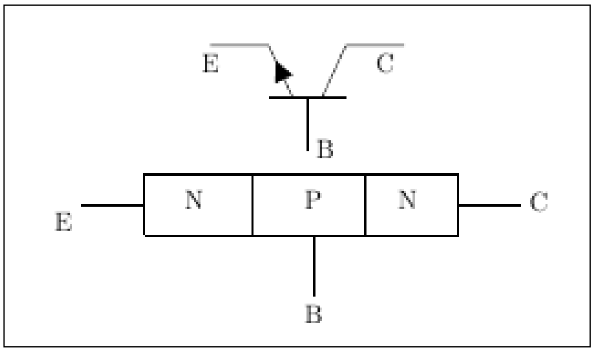
6. ZENER DIODE

➢ OBJECTIVE:

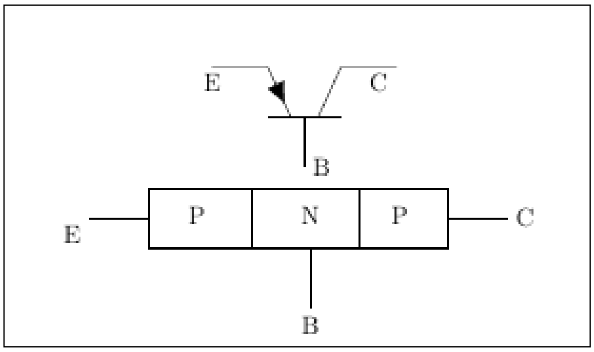
- Explain structure of Bipolar Junction Transistor
- Explain Operation of Bipolar Junction Transistor
- Explain Common Base characteristics of a BJT

THEORY:

A bipolar junction transistor, BJT, is a single piece of silicon with two back-to-back P-N junctions. BJTs can be made either as PNP or as NPN.



They have three regions and three terminals, emitter, base, and collector represented by E, B, and C respectively. The direction of the arrow indicates the direction of the current in the emitter when the transistor is conducting normally. An easy way to remember this is NPN stands for "Not Pointing iN".



Emitter (E): It is the region to the left end which supply free charge carriers i.e., electrons in n-p-n or holes in p-n-p transistors. These majority carriers are injected to the middle region i.e., electrons in the p region of n-p-n or holes in the n region of p-n-p transistor. Emitter is a heavily doped region to supply a large number of majority carriers into the base.

Base (B): It is the middle region where either two p-type layers or two n-type layers are sandwiched. The majority carriers from the emitter region are injected into this region. This region is thin and very lightly doped.

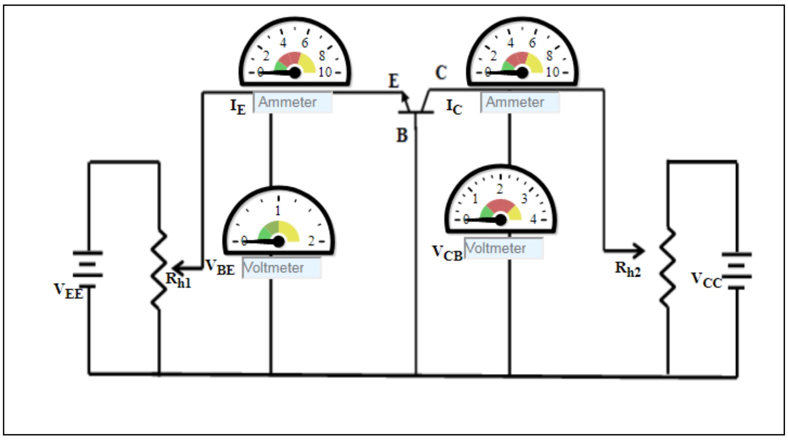
Collector (C): It is the region to right end where charge carriers are collected. The area of this region is largest compared to emitter and base region. The doping level of this region is intermediate between heavily doped emitter region and lightly doped base region.

Note:

1. In digital electronics applications, the transistors are used as a switch
2. Most bipolar switching circuits use NPN transistors.

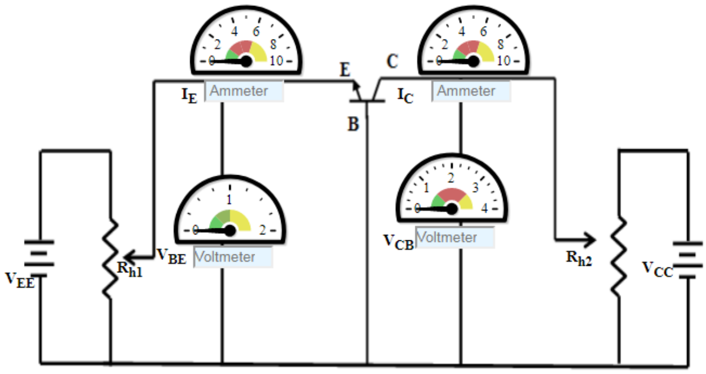
➢ PROCEDURE:

- BJT Common Base – Input Characteristics
- Initially set rheostat R_{h1} = 1 Ω and rheostat R_{h2} = 1 Ω
- Set the Collector-Base Voltage (V_{CB}) to 1 V by adjusting the rheostat R_{h2}
- Base Emitter Voltage (V_{BE}) is varied by adjusting the rheostat R_{h1}.
- Note the reading of emitter current (I_E)in m Ampere.
- Click on 'Plot' to plot the I-V characteristics of Common-Base configuration. A graph is drawn with VBE along X-axis and IE along Y-axis.
- Click on 'Clear' button to take another set of readings
- Now set the Collector-Emitter Voltage (V_{CB}) to 2 V, 3 V, 4 V



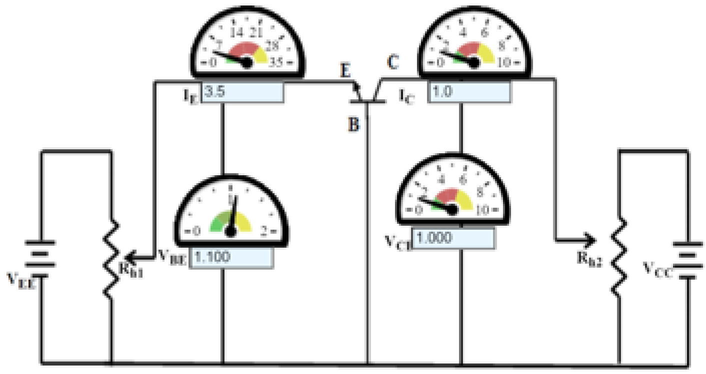
- BJT Common Base – Output Characteristics
- Initially set rheostat R_{h1} = 1 Ω and rheostat R_{h2} = 1 Ω

- Set the Emitter current (I_E)1 mA by adjusting the rheostat R_{h1}
- Vary the Collector-Base Voltage (V_{CB})is varied by adjusting the rheostat R_{h2}.
- Note the reading of Collector current (I_C).
- Click on 'Plot' to plot the I-V characteristics of Common-Base configuration. A graph is drawn with V_{CB} along X-axis and I_C along Y-axis.
- Click on 'Clear' button to take another set of readings
- Now set the Emitter Current (I_E) to 2 mA



➢ GRAPHS AND CALCULATIONS:

BJT – CB – INPUT CHARACTERISTICS



EXPERIMENTAL TABLE

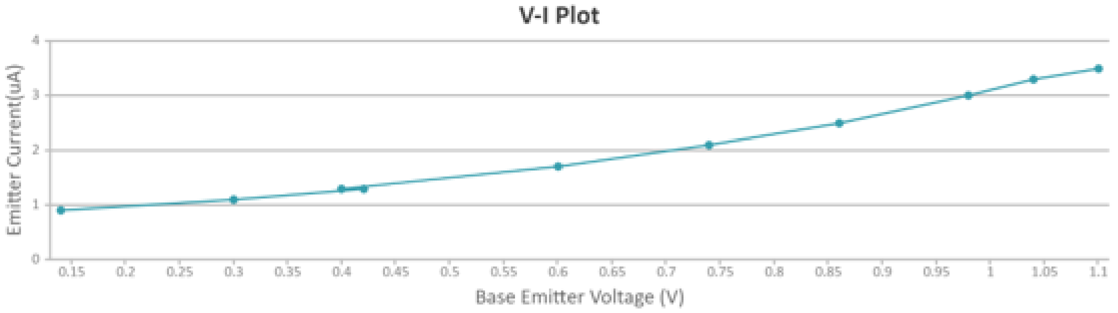
Serial No.	Base-Collector Voltage 1.000 V	
	Base-Emitter Voltage V	Emitter Current mA
1	0.1400	0.90
2	0.3000	1.1
3	0.4200	1.3
4	0.4000	1.3
5	0.6000	1.7
6	0.7400	2.1
7	0.8600	2.5
8	0.9800	3.0
9	1.040	3.3
10	1.100	3.5

CONTROLS

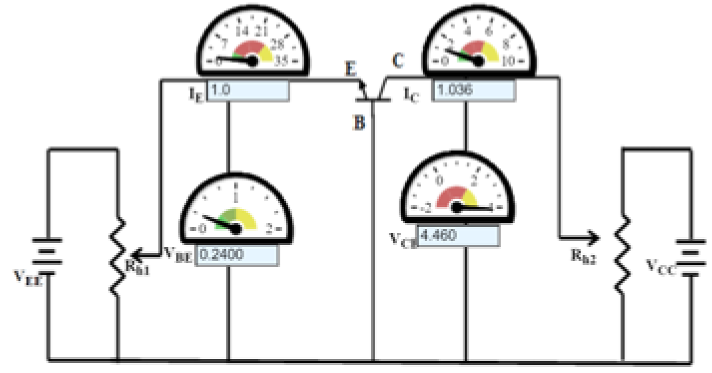
R_{h1} Ohms 55

R_{h2} Ohms 10

GRAPH PLOT



BJT – CB – OUTPUT CHARACTERISTICS



EXPERIMENTAL TABLE

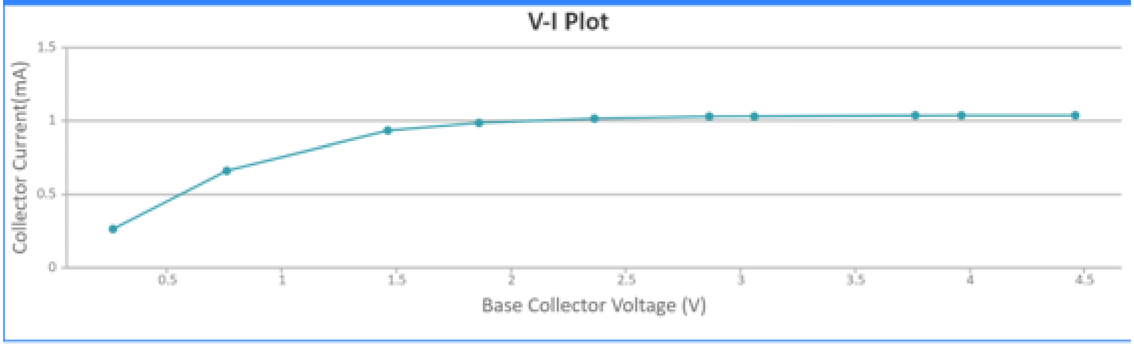
Serial No.	Emitter Current 1.0 mA	
	Base-Collector Voltage V	Collector Current mA
1	0.2600	0.2636
2	0.7600	0.6645
3	1.460	0.9305
4	1.860	0.9875
5	2.360	1.018
6	2.860	1.030
7	3.760	1.035
8	3.060	1.032
9	3.960	1.036
10	4.460	1.036

CONTROLS

R_{h1} Ohms 12

R_{h2} Ohms 47

GRAPH PLOT



7. ZENER DIODE

➢ OBJECTIVE

- At the end of the experiment, the student will be able to
- Explain the function of a Zener diode
- Explain Zener Diode as Voltage Regulator

➢ THEORY

A Zener Diode is a special kind of diode which permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above the breakdown voltage or 'zener' voltage.
Zener diodes are designed so that their breakdown voltage is much lower - for example just 2.4 Volts.

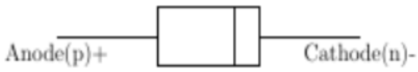


Figure:1

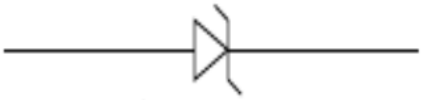


Figure:2

Function of Zener Diode

Zener diodes are a special kind of diode which permits current to flow in the forward direction.

Zener diodes will also allow current to flow in the reverse direction when the voltage is above a certain value. This breakdown voltage is known as the Zener voltage. In a standard 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.

In the reverse bias direction, there is practically no reverse current flow until the breakdown voltage is reached. When this occurs there is a sharp increase in reverse current. Varying amount of reverse current can pass through the diode without damaging it. The breakdown voltage or zener voltage (VZ) across the diode remains relatively constant.

Zener Diode As A Voltage Regulator

A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations. A Zener diode of break down voltage VZ is reverse connected to an input voltage source VI across a load resistance RL and a series resistor RS. The voltage across the zener will remain steady at its break down voltage VZ for all the values of zener current IZ as long as the current remains in the break down region. Hence a regulated DC output voltage V0=VZ is obtained across RL, whenever the input voltage remains within a minimum and maximum voltage. Basically there are two type of regulations such as:

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 volt remains same, as long as the load resistance is maintained above a minimum value.

Line Regulation

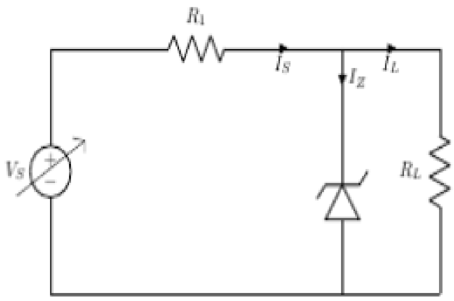


Figure:3

In Line Regulation, Load resistance is constant and input voltage varies. VI must be sufficiently large to turn the Zener Diode ON.

$$V_L = V_Z = \frac{V_{Imin} \times R_L}{(R_S + R_L)}$$

So, the minimum turn-on voltage V_{Imin} is :

$$V_{Imin} = \frac{V_Z \times (R_S + R_L)}{R_L}$$

The maximum value of V_I is limited by the maximum zener current I_{Zmax}

$$I_{Rmax} = I_{Zmax} + I_L$$

I_L is fixed at :

$$\frac{V_Z}{R_L} \qquad Since, V_L = V_Z$$

So maximum V_I is

$$V_{Imax} = V_{Rmax} + V_Z$$

or,

$$V_{Imax} = I_{Rmax} \times R + V_Z$$

For $V_I < V_Z$,

$$V_O = V_I$$

For $V_I > V_Z$,

$$V_O = V_I - I_S \times R_S$$

Load Regulation

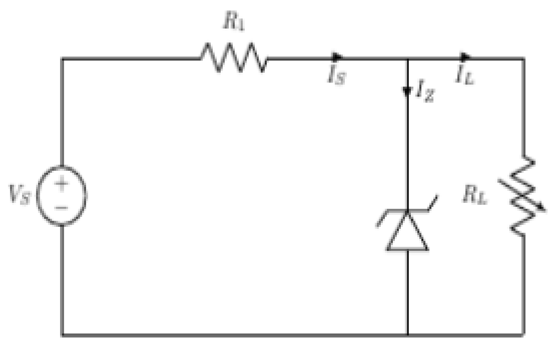


Figure:4

In Load Regulation , input voltage is constant and Load resistance varies. Too small a Load Resistance RL ,will result in VTh<VZ and Zener Diode will be OFF.

VL=VZ=VImin×RL / (RS+RL)

So the minimum load resistance RL

RLmin=VZ×RS / VI−VZ

Any load resistance greater than RLmin will make Zener Diode ON

IS=IL+IZ

RLmin will establish maximum IL as

ILmax=VL / RLmin=VZ / RLmin Since, VL=VZ

V_S is the voltage drop across R_S

$$V_S = V_{Imin} - V_Z$$

$$I_S = \frac{V_{Imin} - V_Z}{R_S}$$

For $R_L < R_{Lmin}$,

$$V_O = V_I$$

For $R_L > R_{Lmin}$,

$$V_O = V_I - I_S \times R_S$$

➢ PROCEDURE

- Zener Diode - Line Regulation
- Set the Zener Voltage(VZ)
- Set the Series Resistance (RS) value.
- Set the Load Resistance (RL) value.
- Vary DC voltage.
- Voltmeter is placed parallel to load resistor and ammeter series with the series resistor.
- Choose appropriate DC voltage such that zener diode is 'on'.
- Now note the Voltmeter and Ammeter reading for various DC voltage.
- Note the Load current(IL), zener current(IZ), Output voltage(VO)
- Calculate the voltage regulation.

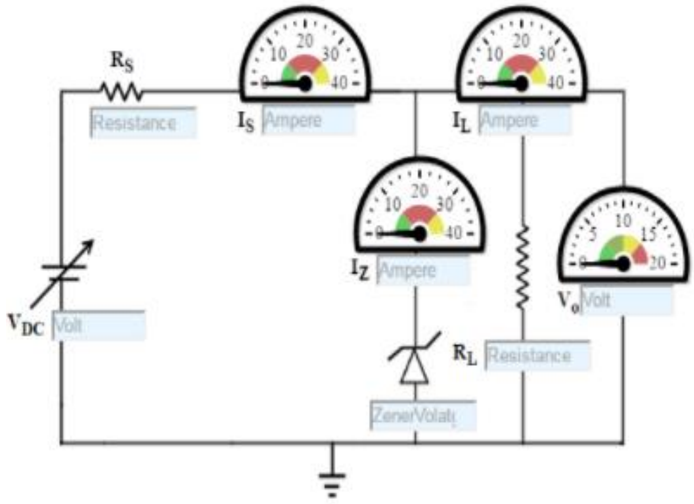


Figure:1

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

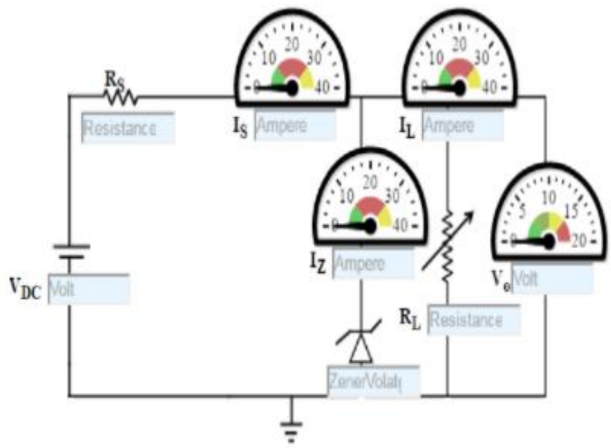


Figure:2

- Zener Characteristics
- Select the diode
- Set the rheostat Rh=1 Ω
- By adjusting the rheostat, voltmeter reading is increased from 0 and in each time note the corresponding reading in milliammeter.
- Take the readings and note Voltmeter reading across Zener diode and Ammeter reading.
- Plot the V-I graph and observe the change.

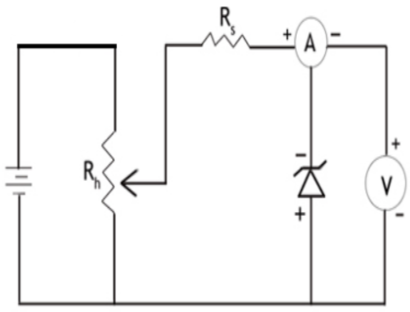
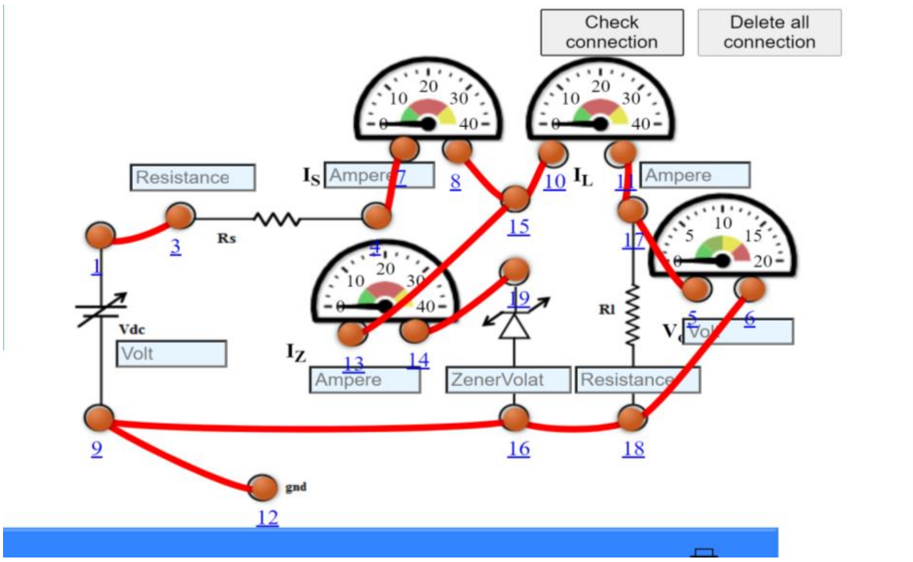


Figure:3

CIRCUIT



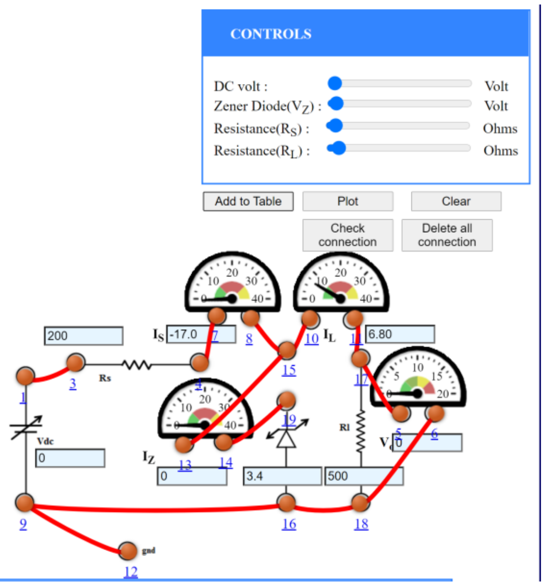
INITIAL VALUES

INSTRUCTION

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 3.4 V
Series Resistance(R_S): 0.2 KΩ
Load Resistance (R_L): 0.5 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	6.80	0	0	NaN



OBSERVATION TABLES

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 3.4 V
Series Resistance(R_S): 0.2 KΩ
Load Resistance (R_L): 0.5 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	6.80	0	0	NaN
2	2.2	6.80	0	2.2	100
3	4.4	6.80	-1.800	3.40	75.0
4	6.8	6.80	10.200	3.40	50.0
5	9.4	6.80	23.200	3.40	33.3
6	12.4	6.80	38.200	3.40	25.0

EXPERIMENTAL TABLE

Zener Voltage(V_Z): 3.4 V
Series Resistance(R_S): 0.2 KΩ
Load Resistance (R_L): 0.5 KΩ

3	4.4	6.80	-1.800	3.40	75.0
4	6.8	6.80	10.200	3.40	50.0
5	9.4	6.80	23.200	3.40	33.3
6	12.4	6.80	38.200	3.40	25.0
7	16.6	6.80	59.200	3.40	18.8
8	19.6	6.80	74.200	3.40	15.8
9	22	6.80	86.200	3.40	13.6
10	25.6	6.80	104.200	3.40	12.0
11	28.4	6.80	118.200	3.40	10.7

PLOT