<u>RAMAKRISHNA MISSION VIVEKANANDA CENTENARY COLLEGE, RAHARA</u>

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COURSE **: B.Sc. Computer Science (Hons.)**

SEMESTER **: 1^{st} Semester**

ROLL NUMBER **: 715**

REGISTRATION NUMBER **: A01-1112-117-014-2021 of 2021-2022**

SUBJECT **: GE1 (Electronics)**

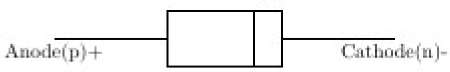
SESSION **: 2021-2022**

VI CHARACTERISTICS OF A P-N JUNCTION DIODE

AIM:
To study the VI characteristics of a p-n junction diode.

STRUCTURE OF A P-N JUNCTION DIODE:

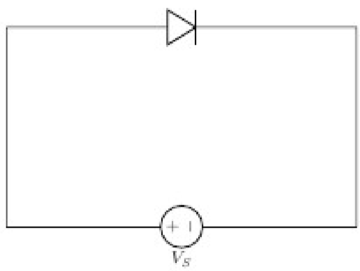
The p-n junction diode is a semiconductor device that is formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode, while the lead connected to the n-type material is called the cathode.



FUNCTION OF A P-N JUNCTION DIODE:

In forward bias:
A forward bias is established by applying positive potential to the p-type material and negative potential to the n-type material. The application of a forward-bias potential will push the electrons in the n-type material and the holes in the p-type material to recombine with the ions near the boundary and reduce the width of the depletion region. 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.

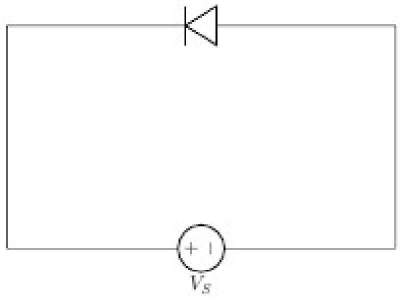
With increasing forward-bias voltage, the depletion zone eventually becomes thin enough that the zone's electric field cannot counteract charge carrier motion across the p–n junction, which as a consequence reduces electrical resistance. The electrons that cross the p–n junction into the p-type material (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.



In reverse bias:
A reverse bias is established by applying positive potential to the n-type material and negative potential to the p-type material. The number of uncovered positive ions in the depletion region of the n-type material will increase due to the large number of free electrons drawn to the positive potential of the applied voltage. Similarly, the number of uncovered negative ions will increase in the p-type material. The net effect, therefore, is widening of the depletion region. 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.

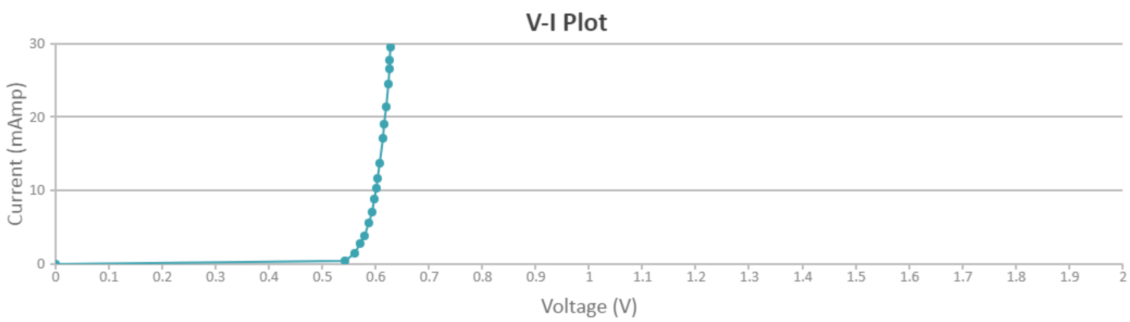
The strength of the depletion zone electric field increases as the reverse-bias voltage increases. Once the electric field intensity increases beyond a critical level, the p–n junction depletion zone breaks down and current begins to flow, usually by either the Zener or the avalanche breakdown processes. 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.



<u>FORWARD AND REVERSED BIASED CHARACTERISTICS OF A SILICON DIODE:</u>

Forward biasing:

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. The diode will conduct electricity in forward biasing because it 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. From the graph, it can be observed 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.



Reverse biasing:

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. 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.

DIODE EQUATION:

In the forward biased and reverse biased regions,

$I = I_0\left(e^{qV/nKT} - 1\right)$, or

$I = I_0\left(e^{V/nkT/q}\right)$

where,

I = current of semiconductor diode

I_0 = reverse saturation current / leakage current

q = electronic charge (1.6 x 10^{-19} C)

V = forward voltage

k = Boltzmann’s constant

n = emperical constant (between 0.5 and 2)

T = temperature in Kelvin

But,

$V_T = kT/q$

where,

V_T = thermal voltage

Hence,

$I = I_0\left(e^{V/nV_T} - 1\right)$

HALF WAVE RECTIFIER

AIM:

To study the rectified waveform of a half wave rectifier.

OBJECTIVE:

The objective of this experiment is to understand the working of a half wave rectifier and the effect it produces on a sinusoidal curve.

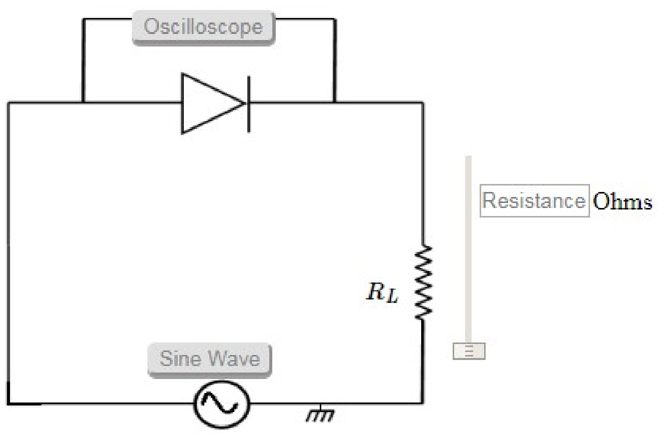
APPARATUS REQUIRED:

- A p-n junction diode
- Few connecting wires
- An alternating current source
- A resistor
- An oscilloscope
- A capacitor

THEORY:

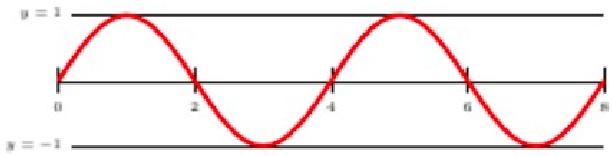
The device by which an alternating current can be converted into direct current is known as a rectifier. There are two types of rectifiers, half wave rectifier and full wave rectifier.
The simplest kind of a rectifier circuit is the half wave rectifier. The half wave rectifier is a circuit that allows 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. An AC voltage is applied on the primary side and the secondary voltage is applied to the diode. During the positive half cycle, the diode is forward biased and during negative half cycle it is reverse biased.
If we replace the coils with a voltage source in a half wave rectifier we can observe some results. In forward bias the diode acts like a closed switch. But when in reverse bias, it works dfferently. In negative half cycle of AC volltage the diode becomes an open circuit and hence output voltage becomes 0, while in positive half cycle of the forward bias it works as a closed switch.

CIRCUIT DIAGRAM:

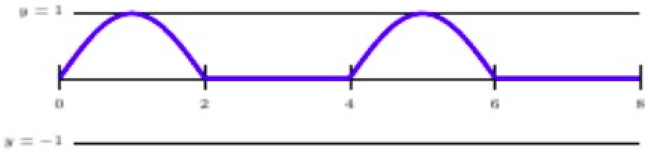


EXPERIMENT:

The resistance is set at 200 ohm, the frequency of the oscilloscope at 1500 Hz, and the amplitude at 1.5 V. The following curves were obtained:



Input waveform



Output waveform

RESULT:

From the oscilloscope we get the peak value of the AC current V_m which is 3.999 V.

$V_{rms}=V_m/2=3.999/2=1.995\,V$

$V_{dc}=V_{rms}/\pi=3.999/3.147=1.270\,V$

$V_{ac}=\sqrt{(V_{rms}{}^2-V_{dc}{}^2)}=0.6217$

Therefore, the ripple factor will be $V_{ac}/V_{dc}=0.4895$

PRECAUTIONS:

1. Connection must be verified before AC supply is turned on.
2. There should be no leakage of current.

REFERENCES:

1. Virtual labs, IITKGP http://vlabs.iitkgp.ac.in/be/exp6/index.html

FULL WAVE RECTIFIER

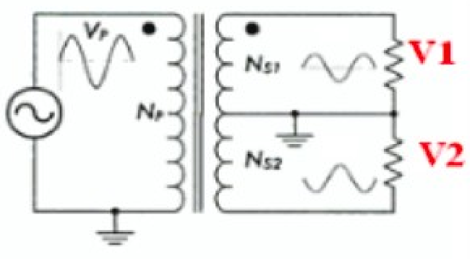
AIM:
To study the rectified waveform of a full wave rectifier.

OBJECTIVE:
The objective of this experiment is to understand the working of a half wave rectifier and the effect it produces on a sinusoidal curve.

APPARATUS REQUIRED:
- A p-n junction diode
- Few connecting wires
- An alternating current source
- A resistor
- An oscilloscope
- A capacitor

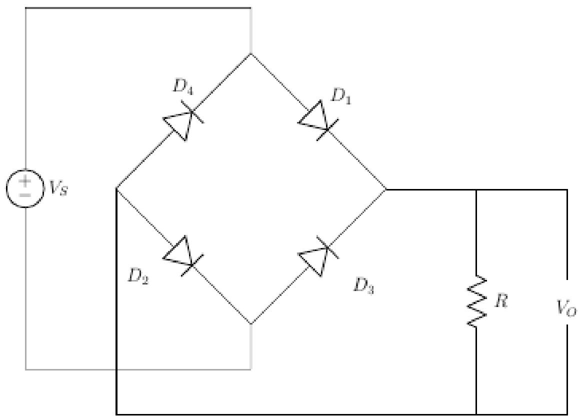
THEORY:
The device by which an alternating current can be converted into direct current is known as a rectifier. There are two types of rectifiers, half wave rectifier and full wave rectifier. There are different constructions of full wave rectifiers like bridge rectifier and centre tapped rectifier.

Centre tapped rectifier:
A Full-Wave Rectifier can be constructed using Center-Tapped transformer – which give us two shifted sinusoids so that exactly one of the waveforms is positive at one time and two diodes. As compared to the half wave rectifier we use two diodes instead of one, one of the two diodes remains in conduction in both of the half cycles. At any point in time, only one of the diodes is forward biased. This allows for continuous conduction through load.

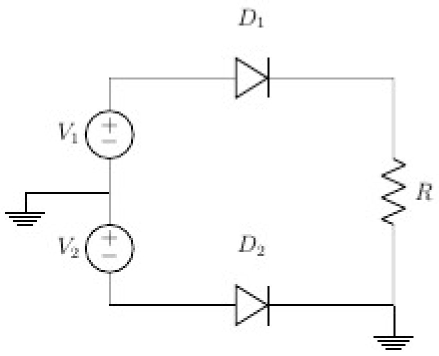


Secondary voltages are 180° out of phase with each other.

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.

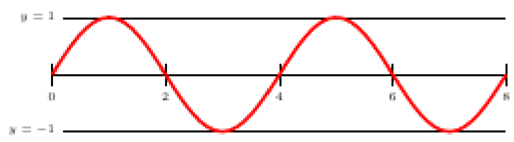


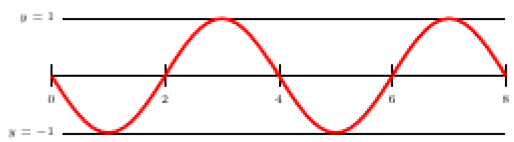
CIRCUIT DIAGRAM:



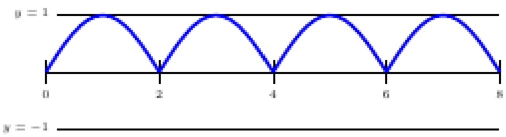
EXPERIMENT:

The resistance is set at 200 ohm, the frequency of the oscilloscope at 1500 Hz, and the amplitude at 1.5 V. The following curves were obtained:





Input waveforms



Output waveform

RESULT:

From the oscilloscope we get the peak current = 3.999 mA.

$V_{rms} = V_m / \sqrt{2} = 3.999 / \sqrt{2} = 2.82$

$V_{dc} = 2 \times V_m / \pi = (2 \times 3.999) / 3.14 = 2.54$

$V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)} = 1.03$

Therefore the ripple factor will be $V_{ac} / V_{dc} = 1.03 / 2.54 = 0.40$

PRECAUTIONS:

3. Connection must be verified before AC supply is turned on.
4. There should be no leakage of current.

REFERENCES:

1. Virtual labs, IITKGP http://vlabs.iitkgp.ac.in/be/exp7/index.html