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Diode Based Rectifiers

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Abstract

A two-terminal silicon-based Diode is most commonly used in various electronic applications like rectifier circuits, voltage regulators, switches, and oscillators. Starting from a single purpose diode-based Rectifier circuit to multiple diode-based bridge rectifier circuit modules, it has a wide range of uses in power supply applications. The fundamental principle of a diode is to allow unidirectional flow of current in the circuit. The rectifier circuit follows the same principle of allowing only one direction to the flow of current, which indicates that Alternating Current (AC) is converted into Direct Current (DC). This phenomenon is used in the computer power supply and rechargeable batteries. Considering such vast applications of general purpose diodes, the paper describes the fundamental principle, theory and uses of diodes with an experimental setup. The results are been summarized and explained further.

Keywords: *Diode, Rectifier, Alternating Current (AC), Direct Current (DC)*

INTRODUCTION

A two terminal Diodeis indispensable in modern industries. It is used in a variety of applications in industrial electronics and robotics that includes rectifier circuits, voltage regulators, and switches. It has low, (i.e., ideally it is zero), resistance in one direction, and has high, (i.e., ideally it has infinite) resistance on the other side. The main principle function of a diode is to allow electric current to pass in one direction, viz. called as forward direction, while blocking it in the reverse direction. This unidirectional flow of current is called as rectification and it is used to convert AC to DC.The upper limit depending on power dissipation above which it should not be operated is carried out with elaborative classification of external circuit conditions. The external circuit is nothing but the combination of the diodes with respect to load.

The combination of diodes can be carried out with even dissimilar design of diode bridges either with the star connected load (the load can be resistive or the combination of resistive, inductive or capacitive), or with the extended cascaded star connected load. The output waveform with different form factors gives an AC signal which is the ratio of the RMS (Root Mean Square) value to the average value [1]. Also, taking this into consideration of heat dissipation various methods based on the frequency domain and rectifier functions based on switching is shown in [2].The provision of turning-on and off of the unidirectional pulse of the diode can be maintained or controlled relatively by keeping constant output voltage as the AC voltage fluctuates and the load power changes. This on and off diode rectifier switching has various other control concerns like variations in rectifier power factor, switch rms per-unit current ratings, and size of AC line inductors [3]. Two predictive programming techniques to control different sinusoidal input currents at constant switching can be done for conditioning of the output DC voltage and currents [4]. The rectifier circuits are also helping the three-phase utility interface with the inverter circuits. This results in various benefits like controllable DC-voltage, unidirectional power flow [5].

The rectifier circuits can also be used in various high voltage and high-power power electronics converters, which with the combination of switching techniques could eliminate the harmonics. The principle of Stabilization and modulation of high efficiency can be adopted to any size depending upon the schemes can be carried out. In the deflection circuit, diode plays an important role in allowing a unidirectional flow of current in the high voltage trace-driven deflection circuit [6, 7].A comparative study of AC to DC rectifier topology for correction of power factor like conventional boost rectifier, half bridge rectifier, full bridge rectifier, three phase four wired rectifier [9] makes diode an important component of power electronic circuits. On the basis of the anode injection efficiency control concept, the curves of peak reverse current density, reverse recovery charge extracted and reverse dI⁄dt versus forward voltage drop showed rectifiers to have superior switching characteristics when compared with the conventional diodes [8, 10].In this paper, the fundamental concept of diode is discussed with a small hardware along with its results.

PN JUNCTION THEORY

A PN-junction is formed when an N-type material is fused together with a P-type material crating a semiconductor diode. The N-type semiconductor material is doped by a silicon atom with small amounts of antimony. The P-type semiconductor material is doped by another silicon atom with Boron.These newly doped N-type and P-type semiconductor materials are electrically neutral. But, if they are joined or merged together they behave in a very different way as a junction, known as PN Junction.

When the N-type semiconductor and P-type semiconductor materials are first joined together a very large density gradient exists between both sides of the PN junction. The result is that some of the free electrons from the donor impurity atoms begin to migrate across this newly formed junction to fill the holes in P-type material, which produces negative ions.Because, the electrons have moved across the PN junction from the N-type silicon to the P-type silicon, they leave positively charged donor ions ND behind, on the negative side and the holes from the acceptor impurity transfers across the junction in the opposite direction into the region where there are large numbers of free electrons.

Hence, the charge density of the P-type along with the junction is filled with negatively charged acceptor ions NA, and the charge density of the N-type along the junction becomes positive. This charge transfer of electrons and holes across the PN junction is known as diffusion. The width of these P and N layers depends upon how heavily each side is doped with acceptor density NA, and donor density ND, respectively.This process continues again and again like back and forth until the number of electrons which have crossed the junction have an enough electrical charges to repel or prevent any more charge carriers from crossing over the junction. A state of equilibrium which is the neutral situation will occur producing a “potential barrier” zone area around the junction as the donor atoms repel the holes and the acceptor atoms repel the electrons.

Since, no free charge carriers can stay at one position where there is a potential barrier; the region on either side of the junction now becomes completely depleted of any freer carriers in comparison to the N and P type materials further away from the junctions. This area around the PN junction is called the Depletion Layer.

The PN Junction

The total charge on each side of a PN Junction must be equal and opposite to maintain a neutral charge condition around the junction. If the depletion layer region has a distance D, it must penetrate into the silicon by a distance of D_p for the positive side, and a distance of D_n for the negative side. The relationship between positive, negative sides and distance is,

$$\mathrm{D_p \times N_A = D_n \times N_D}$$

In order to maintain charge neutrality also called as Equilibrium.

PN Junction Distance

As the N-type material has lost electrons and the P-type has lost holes, the N-type material becomes positive with respect to the P-type, then the presence of impurity ions on both sides of the junction cause an electric field to be established across this region with the N-side at a positive voltage relative to the P-side. The problem now is that a free charge requires some extra energy to overcome the barrier that now exists for it to the able to cross the depletion region junction.

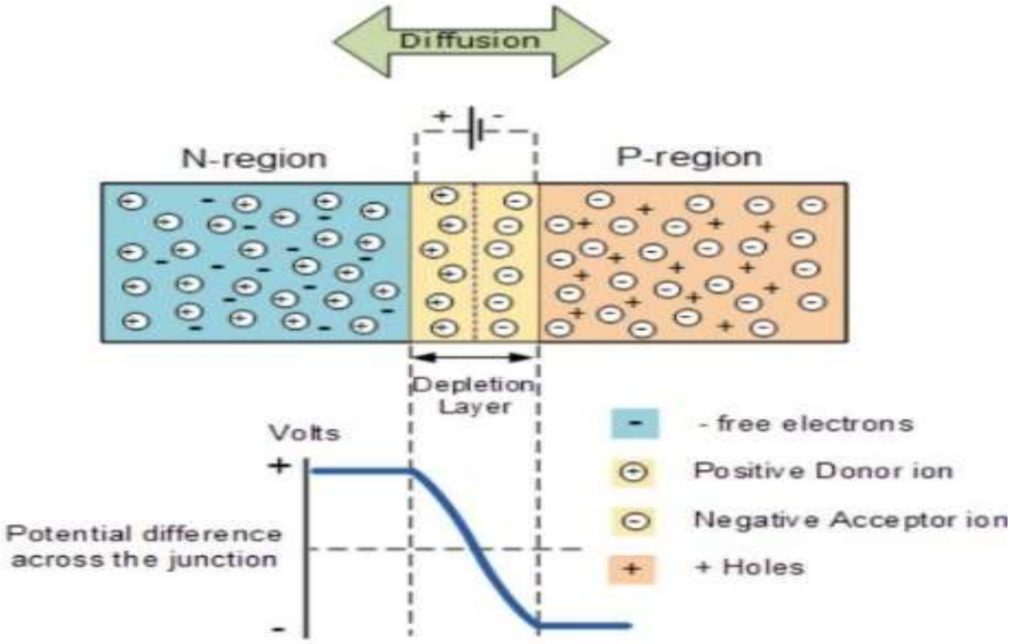

Figure 1 PN Junction with Depletion Layer

This electric filed created by the diffusion process has created a potential difference across the junction with an open-circuit potential as,

$$E_O = V_T \times \ln \frac{N_D \cdot N_A}{n_i^2}$$

Where, E_O is the zero bias junction voltage, V_T the thermal voltage of 26mV at room temperature, N_D and N_A are the impurity concentrations and n_i is the intrinsic concentration.

Positive voltage (forward bias) applied between the two ends of the PN junction can supply free electrons and holes withextra energy. The external voltage required to overcome this potential barrier that now exists is very much dependent on the type of semiconductor material used with its actual temperature. At room temperature the voltage across the depletion layer for silicon is about 0.6 – 0.7 Volts and for germanium is about 0.3 – 0.35 Volts. This potential barrier will always exist even if the device is not connected to any external power supply.

The significance of this built-in potential across the junction is that it opposes both the flow of holes and electrons across the junction and is why it is called as the potential barrier. Basically, a PN junction is formed within a single crystal of material rather than just simply joining or fusing together two separate pieces. The result of this process is that the PN junction has rectifying current or voltage characteristics, viz. IV or I-V. Electrical contacts are fused onto either side of the semiconductor to enable an electrical connection to be made to an external circuit. The resulting electronic device that has been made is commonly called a PN junction diode or simply signals diode.

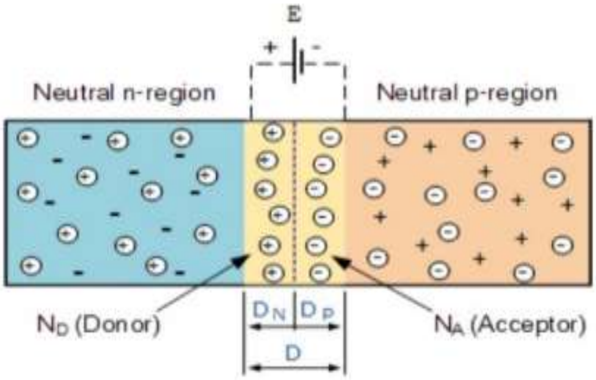

Figure 2 PN Junction representing Donor and Acceptor

PN JUNCTION DIODE A PN-junction diode is formed when a p-type semiconductor is fused to an n-type semiconductor is fused to an n-type semiconductor creating a potential barrier voltage across the diode junction.

The effect described in chapter 2, is achieved without any external voltage being applied to the actual PN junction resulting in the junction being in a state of equilibrium. However, if we were to make electrical connections at the ends of both the N-type and the P-type materials and then connect them to a battery source, an additional energy source now exists to overcome the potential barrier. The effect of adding this additional energy source results in the free electrons being able to cross the depletion region from one side to the other. The behavior of the PN junction with regards to the potential barrier's width produces an asymmetrical conducting two terminal devices, better known as the PN junction diode.

A PN Junction Diode is one of the simplest semiconductor devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we cannot describe its operation by simply using an equation such as Ohm's law.

If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN Junction is decreased. By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode.

Then the depletion layer widens with an increase in the application of a reverse voltage and narrows with an increase in the application of a forward voltage. This is due to the differences in the electrical properties on the two sides of the PN junction resulting in physical changes taking place. One of the results produces rectification as seen in the PN junction diodes static I-V characteristics. Rectification is shown by an asymmetrical current flow when the polarity of bias voltage is altered as shown below.

Junction Diode Symbol and Static I-V Characteristics

Before using the PN junction as a practical device or as a rectifying device we need to firstly bias the junction, i.e., connect a voltage potential across it. On the voltage axis above, reverse bias refers to an external voltage potential which increases the potential barrier. An external voltage which decreases the potential barrier is said to act in the forward bias direction.

There are two operating regions and three possible biasing conditions for the standard Junction Diode. They are:

a) **Zero Bias** – No external voltage potential is applied to the PN junction diode.

b) **Reverse Bias** – The voltage potential is connected negative, to the P-type material and positive, to the N-type material across the diode which has the effect of increasing the PN junction diode's width.

c) **Forward Bias** – The voltage potential is connected positive, to the P-type material and negative, to the N-type material across the diode which has tht effect of decreasing the PN junction.

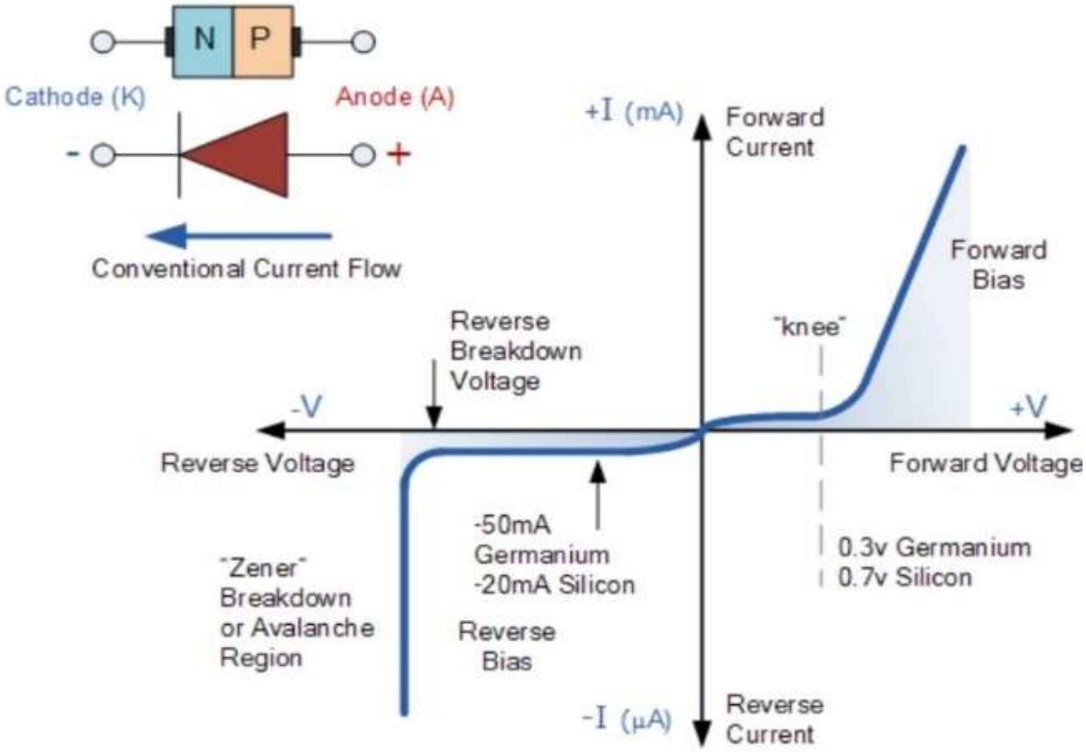

Figure 3 I-V Characteristics of Junction Diode

Zero Biased Junction Diode

When a diode is connected in a Zero Bias condition, no external potential energy is applied to the PN junction. But, if the diode terminals are shorted together, a few holes int eh P-type material with enough energy to overcome the potential barrier will move across the junction against this barrier potential. This is known as the Forward current (IF). Similarly, the holes generated in the N-type material, find this situation favorable and move across the junction in the opposite direction. This is known as the Reverse Current and is referenced as (IR). These transfer the electrons and holes back and forth across the PN junction is known as diffusion, as shown below.

The potential barrier that now exists discourages the diffusion of any more majority carriers across the junction. However, the potential barrier helps minority carriers (few free electrons in the P-region and few holes in the N-region) to drift across the junction. Then an “Equilibrium” or balance will be established when the majority carriers are equal and both moving in opposite directions, so that the net result is zero current flowing in the circuit. When this occurs, the junction is said to be in a state of dynamic equilibrium. The minority carriers are constantly generated due to thermal energy so this state of equilibrium can be broken by raising the temperature of the PN junction causing an increase in the generation of minority carriers, thereby resulting in an increase in leakage current but an electric current cannot flow since no circuit has been connected to the PN junction.

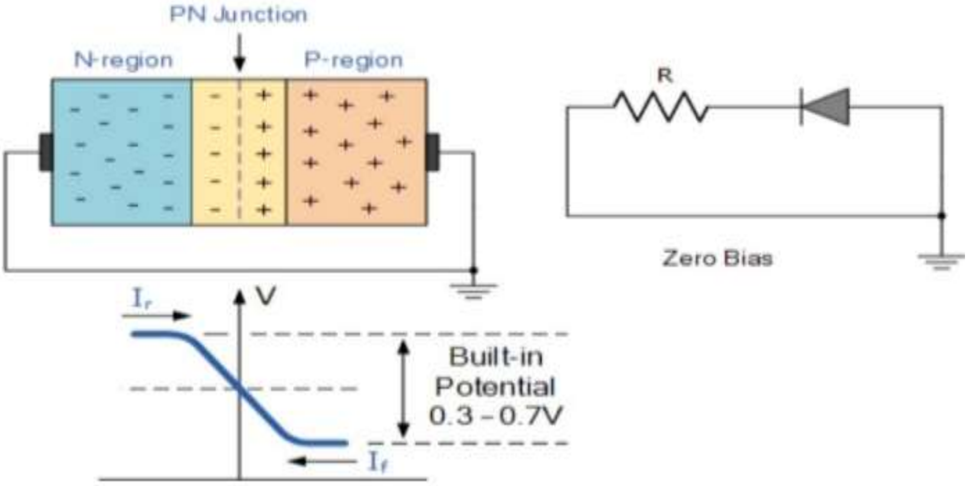

Figure 4: Zero Biased PN Junction Diode

Reverse Biased PN Junction Diode

When a diode is connected in a reverse bias condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material. The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrodes.

The net result is that the depletion layer grows sider due to a lack of electrons and holes and presents a high impedance path, almost an insulator. The result is that high potential barrier is created thus preventing current from flowing though the semiconductor material.

This condition represents a high resistance value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small leakage current does flow through the junction which can be measured in microamperes (μA). Also, if the reverse bias voltage Vr applied to the diode is increase to a sufficiently high enough value, it will cause the diode's PN junction to overheat and fail due to the avalanche effect around the junction. This may cause the diode to become shorted and will result in the flow of maximum circuit current, and this is shown as a step downward slope in the reverse static characteristic curve as shown below.

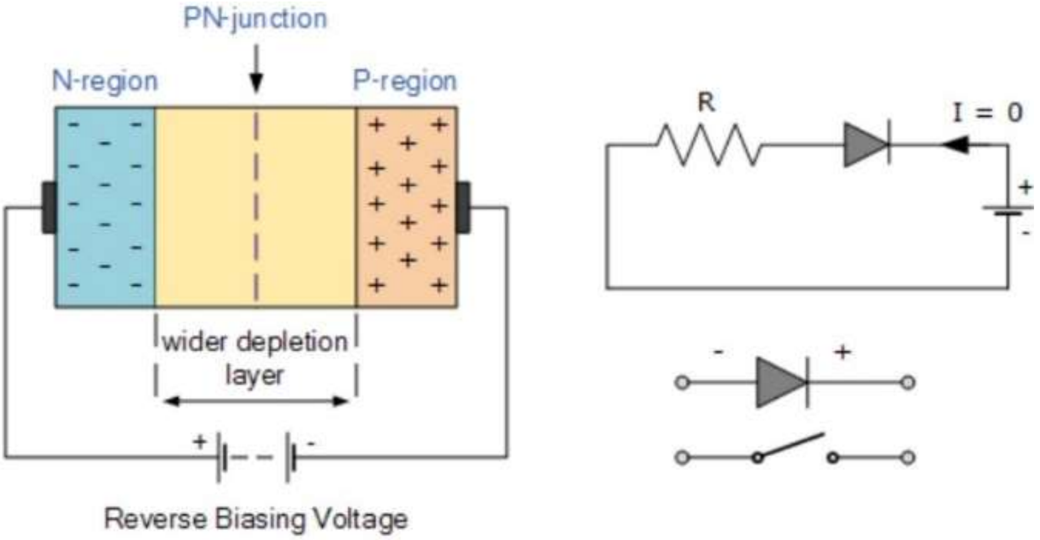

Figure 5: Increases in the Depletion Layer due to Reverse Bias

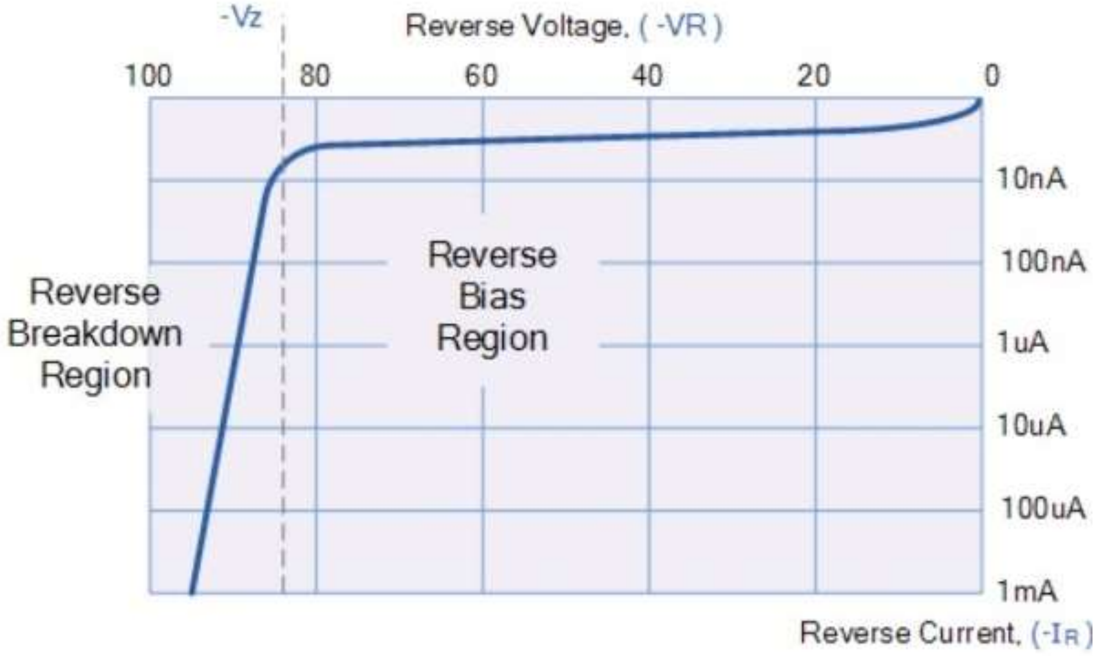

Figure 6: Reverse Characteristics Curve for a Junction diode

Sometimes this avalanche effect has practical applications in voltage stabilizing circuits where a series limiting resistor is used with the diode to limit this reverse breakdown current to a preset maximum value thereby producing a fixed voltage output across the diode.

Forward Biased PN Junction Diode

When a diode is connected in a forward bias condition, a negative voltage is applied to the N-type material and positive voltage is applied to the P-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.

This is because the negative voltage attracts or repels electrons towards the junction giving them the energy to cross over and combine with the holes being pushed in the opposite direction towards the junction by the positive voltage. This results in the characteristic curve of zero current flowing up to this voltage point, called the knee on the static curves and then a high current flow through the diode with little increase in the external voltage as shown below.

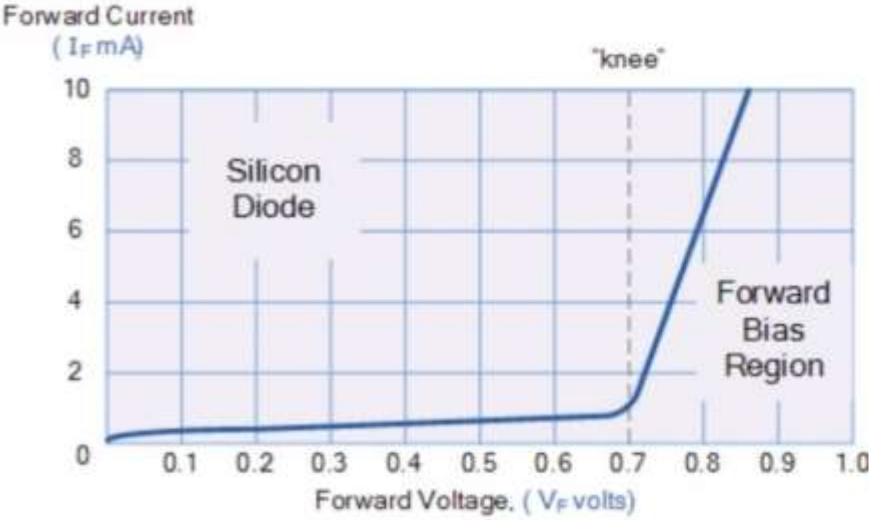

Figure 7 Forward Characteristics Curve for a Junction Diode

The application of a forward biasing voltage on the junction diode results in the depletion layer becoming very thin and narrow which represents a low impedance path through the junction thereby allowing high currents to flow. The point at which this sudden increase in current takes place is represented on the static I-V characteristics curve above as the knee point.

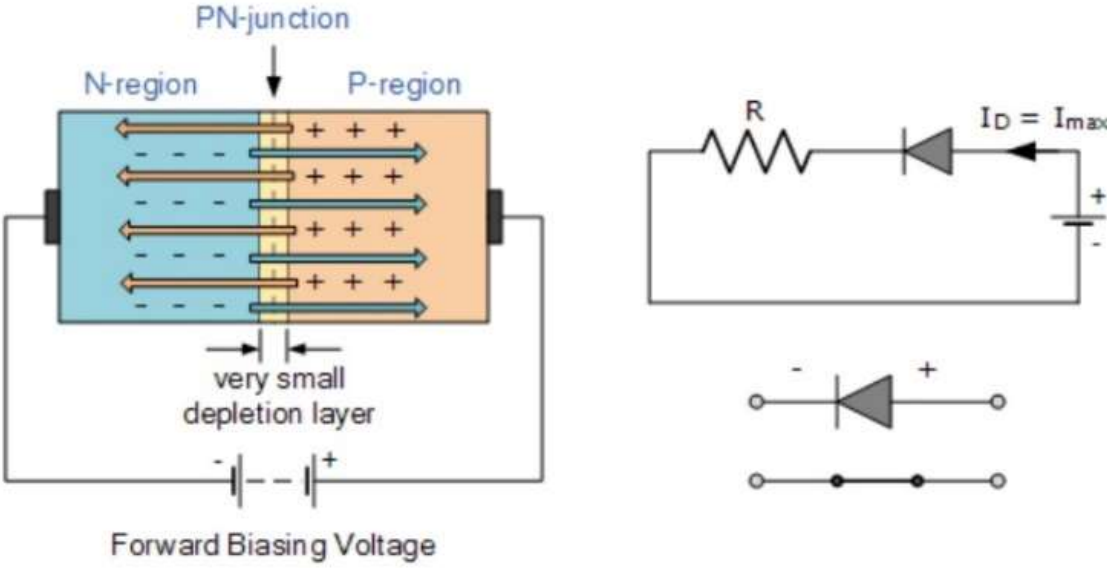

Figure 8: Reductions in the Depletion Layer due to Forward Bias

This condition represents the low resistance path through the PN junction allowing very large currents to flow through the diode with only a small increase in bias voltage. The actual potential difference across the junction or diode is kept constant by the action of the depletion layer at approximately 0.3 volts for germanium and approx. 0.7 volts for silicon junction diodes.

Since the diode can conduct ‘infinite’ current above this know point as it effectively becomes a short circuit, therefore resistors are used in series with the diode to limit its current flow. Exceeding its maximum forward current specification causes the device to dissipate more power in the form of heat than it was designed for resulting in a very quick failure of the device.

Characteristics of Junction Diode

i. The PN junction region of a junction diode has the following important characteristics:

ii. Semiconductors contain two types of mobile charge carriers, holes and electrons.

iii. The holes are positively charged while the electrons negatively charged.

iv. A semiconductor may be doped with donor impurities such as Antimony (N-type doping), so that it contains mobile charges which are primarily electrons.

v. A semiconductor may be doped with acceptor impurities such as Boron (P-type doping), so that it contains mobile charges which are mainly holes.

vi. The junction region itself has no charge carriers and is known as the depletion region.

vii. The junction (depletion) region has a physical thickness that varies with the applied voltage.

viii. When a diode is zero biased no external energy, source is applied and a natural potential barrier is developed across a depletion layer which is approximately 0.5v to 0.7v for silicon diodes and approximately 0.3 v for a germanium diode.

ix. When a junction diode is forward biased the thickness of the depletion region reduces and the diode acts like a short circuit allowing full current to flow.

x. When a junction diode is reverse biased the thickness of the depletion region increases and the diode acts like an open circuit blocking any current flow, (only a very small leakage current).

The diode is a two terminal non-linear device whose I-V characteristic are polarity dependent as depending upon the polarity of the applied voltage, V_D the diode is either forward biased, $V_D > 0$ or Reverse biased, $V_D < 0$. Either way we can model these I-V characteristics for both an ideal diode and for a real silicon diode as shown below.

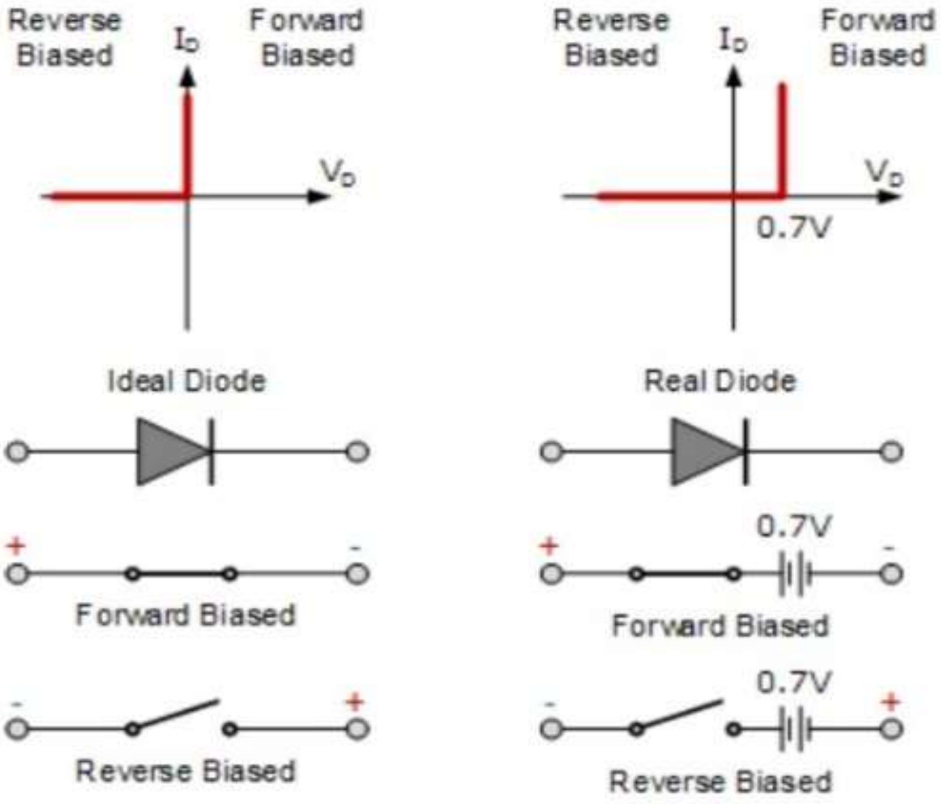

Figure 9 Junction Diode Ideal and Real Characteristics

SILICON DIODE V-I CHARACTERISTIC CURVE

The arrow always points in the direction of conventional current low through the diode meaning that the diode will only conduct if a positive supply is connected to the Anode (a) terminal and a negative supply is connected to the cathode (k) terminal thus only allowing current to flow through it in one direction only, acting more like a one-way electrical valve, (forward biased condition). It shows that, if we connect the external energy source in the other direction the diode will block any current flowing through it and instead will act like an open switch, (reversed biased condition), as shown below,

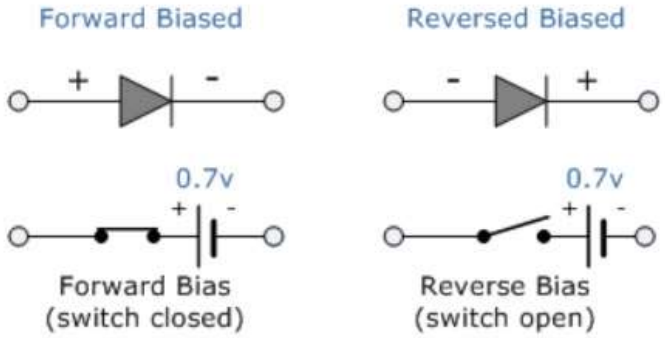

Figure 11 Forward and Reversed Biased Diode

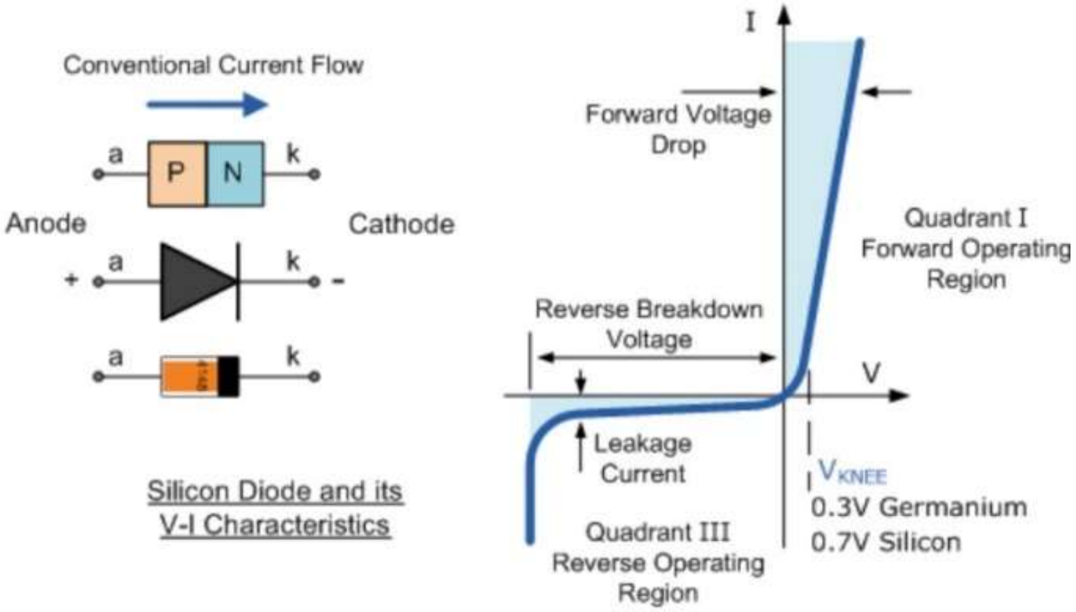

Figure 10 Diode V-I Characteristic Curve

An ideal small signal diode conducts current in one direction (forward-conducting) and blocks current in the other direction (reverse-blocking).

Freewheeling Diodes

Diodes can also be used in a variety of clamping, protection and wave shaping circuits with the most common form of clamping diode circuit being one which uses a diode connected in parallel with a coil or inductive load to prevent damage to the delicate switching circuit by suppressing the voltage spikes and transients that are generated when the load is suddenly turned off. This type of diode is known as free-wheeling diode or flywheel diode or simply freewheel diode. It is used to protect solid state switches such as power transistors and MOSFET's from damage by reverse battery protection as well as protection from highly inductive loads such as relay coils or motors, and an example of its connection is shown below.

Modern fast switching, power semiconductor devices require fast switching diodes such as freewheeling diodes to protect them from inductive loads such as motor coils or relay windings. Every time the switching device above is turned on, the freewheel diode changes from a conducting state to a blocking stage as it becomes reversed biased. But, when the device rapidly turns off the diode becomes forward biased and the collapse of the energy stored in the coil causes a current to flow through the freewheel diode. Without the protection of the freewheel diode high di⁄dt currents would occur causing a high voltage spike or transient to flow around the circuit possibly damaging the switching device.

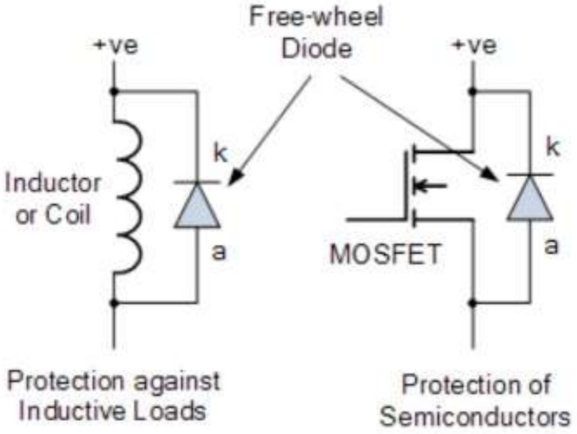

Figure 12 Freewheel Diode

POWER DIODES AND RECTIFIERS

The Power diode has semiconductor PN junction, which has the capability of passing large currents at high voltage values which can be used in rectifier circuits. A widely used application of this feature and diodes in general is in the conversion of an alternating voltage AC into a continuous voltage DC. But, small signal diodes can also be used as rectifiers in low-power, low current viz., less than 1A, rectifiers or applications, but where larger forward bias currents are higher, reverse bias blocking voltages are involved, the PN junction of a small signal diode start overheating and eventually melting, so larger or more robust power diodes are used.

The power diode has a much larger PN junction area compared to its smaller signal diode, resulting in a high forward current capability of up to several hundred amps (KA) and reverse blocking voltage of up to several thousand volts (KV).
Since, the power diode has a large PN junction, it is not suitable for high frequency applications above 1MHz, but special and expensive high frequency, high current diodes are available. The power diodes provide uncontrolled rectification of power and are used in applications such as battery charging and DC power supplies as well as AC rectifiers and inverters. Because of high current and voltage characteristics they can also be used as free-wheeling diodes and snubber networks.If an alternating voltage is applied across a power diode, during the positive half cycle the diode will conduct passing current and during the negative half cycle the diode will not conduct blocking the flow of current. Then conduction through the power diode only occurs during the positive half cycle and is therefore unidirectional, i.e., DC as shown below,

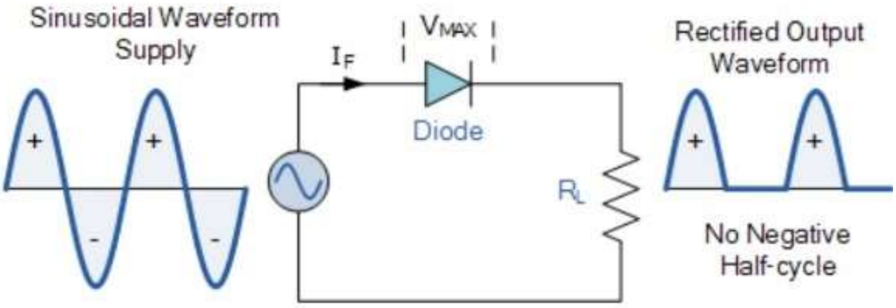

Figure 13 Power Diode Rectifiers

Power diodes can be used individually as above or connected together to produce a variety of rectifier circuits such as Half-Wave, Full-Wave or as a Bridge Rectifiers. Each type of rectifier circuit can be classed as uncontrolled, half-controlled or fully controlled where an uncontrolled rectifier uses only power diodes, a fully controlled rectifier uses thyristors (SCRs) and a half-controlled rectifier is a mixture of both diodes and thyristors.

The most commonly used individual power diode for basic electronics applicationsis the general purpose 1N400x series Glass passivated type rectifying diode with standard ratings of continuous forward rectified current of about 1A and reverse blocking voltage ratings from 50voltsfor the 1N4001 up to 1000volts for the 1N4007, with the most popular for general purpose main voltage rectification.

Half-Wave Rectification

A rectifier is a circuit which converts AC input power into a DC output power. The input power supply may be either a single-phase or a multi-phase supply with the simplest of all the rectifier circuits being that of a Half-Wave Rectifier. The power diode in a half wave rectifier circuit passes just one half of each complete sine wave of the AC supply in order to convert it into a DC supply. Then this type of circuit is called half-wave rectifier because it passes only half of the incoming AC power supply as shown in the figure below,

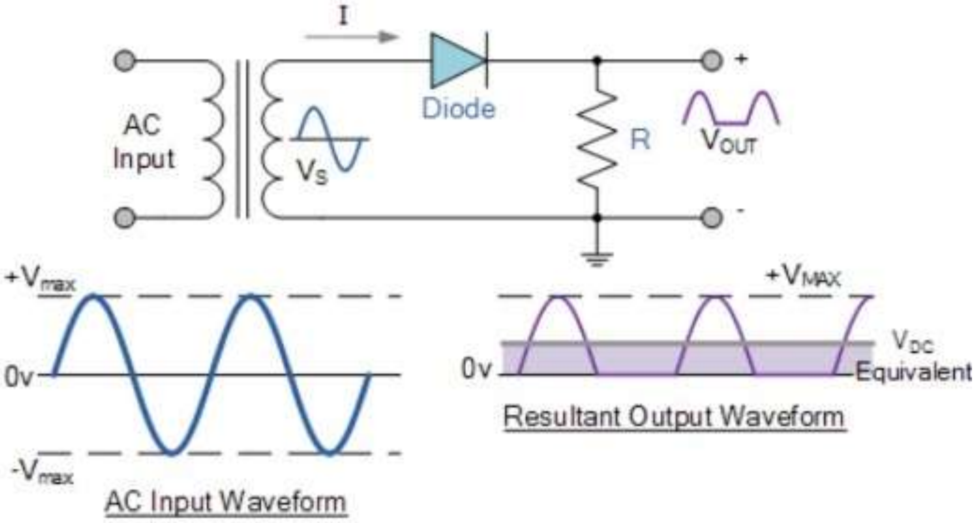

Figure 14 Half-Wave Rectifier Circuit

During each positive half cycle of the AC sine wave, the diode is forward biased as the anode is positive with respect to the cathode resulting in current flowing though the diode. Since, the DC load is resistive (R), the current flowing in the load resistor is therefore proportional to the voltage (ohm’s law) and the voltage across the load resistor will therefore be the same as the supply voltage (V_S), that is the DC voltage across the load is sinusoidal for the first half cycle only so $V_{out} = V_s$.

During each negative half cycle of the AC sinusoidal input waveform, the diode is reverse biased as the anode is negative with respect to the cathode. Therefore, NO current flows through the diode or circuit. Then in the negative half cycle of the supply, no current flows in the load resistor as no voltage appears across it, so therefore, $V_{out} = 0$. The current on the DC side of the Circuit flows in one direction only making the circuit Unidirectional. As the load resistor receives from the diode, a positive half of the waveform, zero volts, again the positive half of the waveform, zero volts, and so on values of this irregular voltage would be equal in value to an equivalent DC voltage of $0.318 \times V_{max}$ of the input sinusoidal waveform or $0.45 \times V_{rms}$ of the input sinusoidal waveform.

Then the equivalent DC voltage, V_{DC} across the load resistor is calculated as follows,

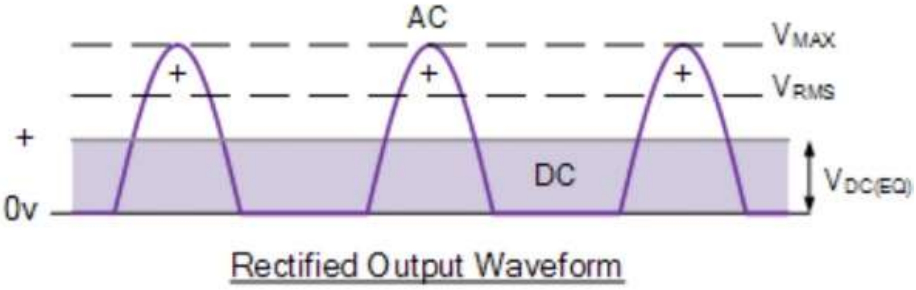

Figure 15: Rectified Output Waveform

$$V_{dc} = \frac{V_{max}}{\pi} = 0.318V_{max} = 0.45V_s$$

V_{DC} and the current I_{DC}, flowing through a 100Ω resistor connected to a 240 V_{rms} single phase half-wave rectifier as shown above. Also, calculating further the DC power consumed by the load is,

$$V_{MAX} = V_{RMS} \times 1.414 \text{ or } V_{RMS} = V_{MAX} \times 0.7071$$

$$V_{DC} = 0.45V_{RMS} = 0.45 \times 240 = 108 \text{ Volts}$$

or

$$V_{DC} = 0.318V_{MAX} = 0.318 \times (240 \times 1.414) = 108 \text{ Volts}$$

$$I_{DC} = \frac{V_{DC}}{R} = \frac{108V}{100\Omega} = 1.08 \text{ Amps}$$

$$\text{Power} = I^2R = 1.08^2 \times 100 = 116 \text{ Watts}$$

During the rectification process the resultant output DC voltage and current are therefore both on and off during every cycle. As the voltage across the load resistor is only present during the positive half of the cycle (50% of the input waveform), this results in a low average DC value being supplied to the load. The variation of the rectified output waveform between this on and off condition produces a waveform which has large amounts of ripple which is an undesirable feature. The resultant DC ripple has a frequency that is equal to that of the AC supply frequency. Very often when rectifying an alternating voltage, we wish to produce a steady and continuous DC voltage frees from any voltage variations or ripple. One way of doing this is to connect a large value capacitor across the output voltage terminals in parallel with the load resistor as shown below. This type of capacitor is called as a reservoir orsmoothing capacitor.

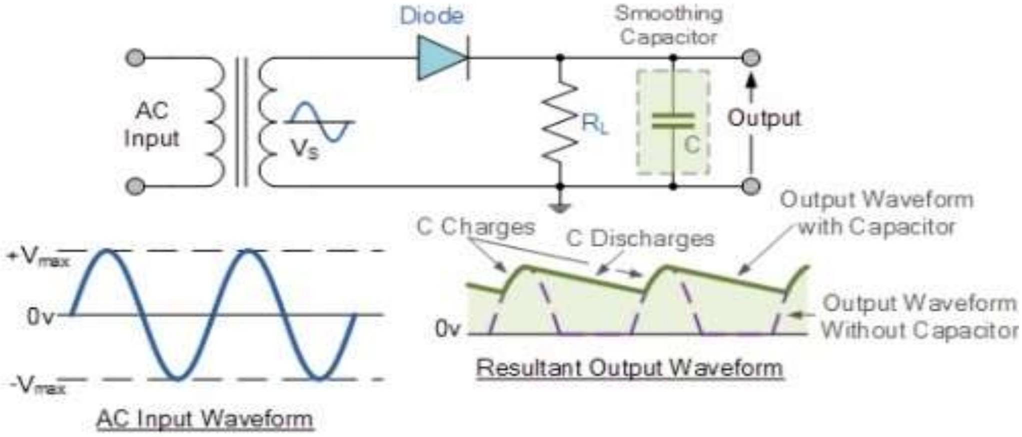

Figure 16: Half-Wave Rectifiers with Smoothing Capacitor

When rectification is used to provide a direct voltage (DC) power supply from an AC source, the amount of ripple voltage can be further reduced by using larger value capacitors but here are limits both on cost and size to the types of smoothing capacitors used. For a given capacitor value, a greater load current (smaller load resistance) will discharge the capacitor more quickly (RC Time Constant) and so increases the ripple obtained. Then for single phase, half-wave rectifier circuit using a power diode it is not very practical to try and reduce the ripple voltage by capacitor smoothing alone. In this instance it would be more practical to use Full-wave rectification.

EXPERIMENTAL SETUP

The experimental setup as shown in the figure 17 above is mounted on the breadboard. 0-12V, 500mA transformer is used to give 230V, 50Hz AC supply to the breadboard. 1N4007 diode is used here for rectification. A 100Ω resistor with Red LED is also used, to check the intensity of current flow through the path. As the wavelength of Red LED is between 620nm (min) to 625nm (max), the peak emission wavelength is 625nm.Typically, 623nm of red LED is in use. The forward current (I_F) is 20mA, peak forward current (I_{PF}) (Duty Cycle = 1/10,10 KHz) is 30mA and reverse current (I_R) (when, V_R = 5V) is 10µA. The operating (T_{OPR}) and storage temperature (T_{STG}) of it is -25ºC to 85ºC and -30ºC to 85ºC, respectively.

The features of 1N4007 type diodes are as follows: -

i. Diffused Junction,
ii. High current capability and low forward voltage drop,
iii. Surge Overload Rating to 30A peak,
iv. Low Reverse leakage current, and
v. Lead free finish.

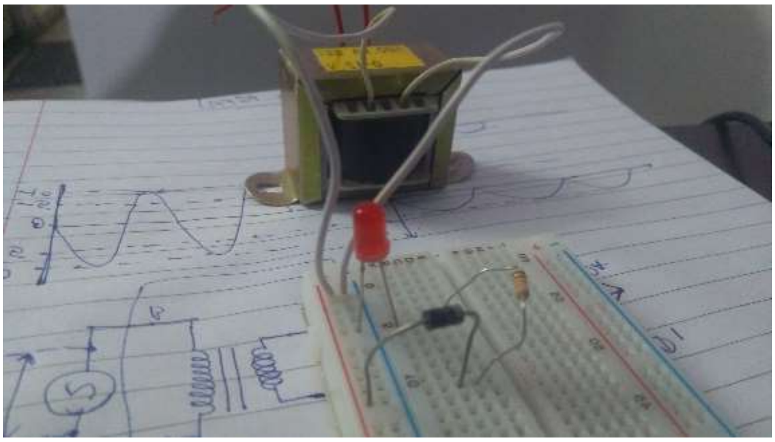

Figure 17 Half-wave bridge rectifiers

From [11], the peak repetitive reverse voltage (V_{RRM}), working peak reverse voltage (V_{RWM}) and DC blocking voltage (V_R) of 1N4007 is 1000V (for all the parameters). The RMS reverse voltage ($V_{R(RMS)}$) is 700V, average rectified output (I_O) is 1.0A, non-repetitive peak forward surge current 8.3ms single half sine-wave superimposed on rated load (I_{FSM}) is 30A, forward Voltage at I_F = 1.0A is (V_{FM}) 1.0V. The peak reverse current at rated DC Blocking voltage (I_{RM}) is 5.0μA to 50μA. The maximum DC Blocking voltage temperature (T_A) is +150ºC.

EXPERIMENTAL RESULTS

The experimental results are shown in figure 18 and 19, showing experimental rectified output voltage waveform and waveform across resistor, respectively.

The V_{max} is 18V. The no-load DC output voltage of an ideal half-wave rectifier for a sinusoidal input voltage is $V_{rms} = \frac{V_{peak}}{2} = \frac{18}{2} = 9V$ and $V_{dc} = \frac{V_{peak}}{\pi} = \frac{18}{\pi} = 5.7295V$ where, V_{dc}, V_{ac} is the DC or average output voltage, V_{peak} is the peak value of the phase input voltages, V_{rms} is the root mean square (RMS) value of output voltage.

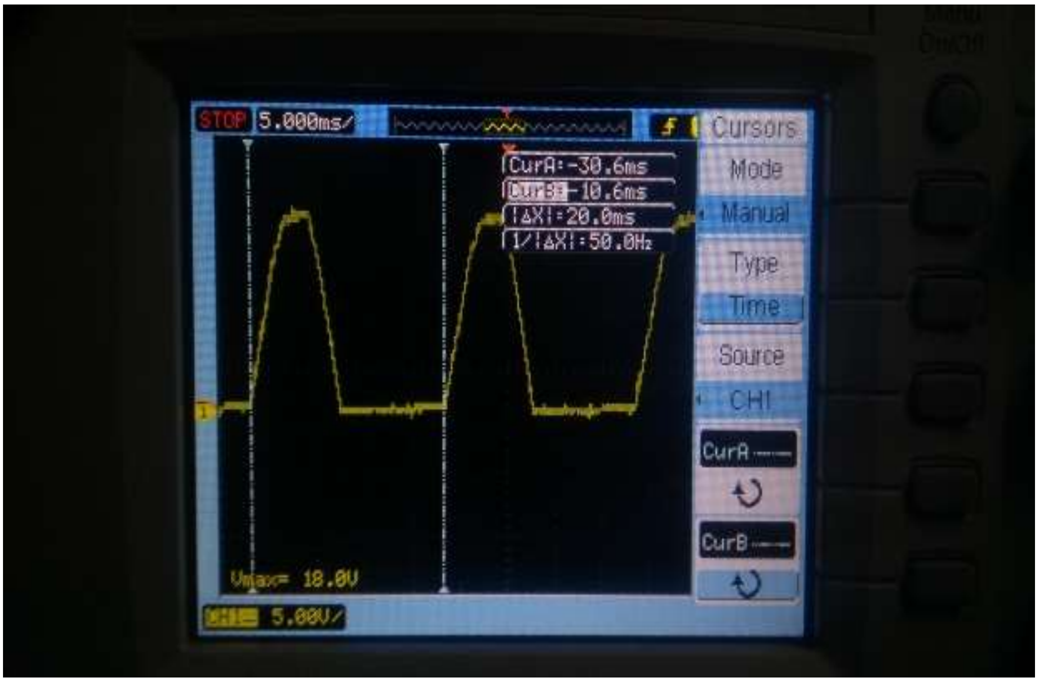

Figure 18: Experimental Rectified Output Waveform

Figure 19: Waveformacross Resistor

RATINGS

Sr. No.	By Average Rectified Current-Max	By Reverse Voltage-Max	By Peak Current-Max	By Forward Voltage	By Reverse Current-Max
1.	120mA	12V	600mA	1.1mV	100nA
2.	1A	30V	30A	900mV	1nA
3.	1.5A	40V	40A	950mV	5nA
4.	2A	50V	45A	1V	10nA
5.	3A	60V	50A	1.05V	50nA
6.	5A	100V	60A	1.1V	100nA
7.	6A	200V	100A	1.15V	500nA
8.	8A	400V	125A	1.2V	1mA
9.	10A	600V	150A	1.25V	9mA
10.	16A	800V	200A	1.3V	10mA
11.	20A	1000V	300A	1.35V	15mA
12.	40A	1200V	400A	1.4V	10A
13.	70A	1600V	595A	1.6V	12A
14.	400A	8000V	1.25kA	1.7V	20A

Featured Standard Rectifier Products

Manufacture	Part Number	Description
Diodes Inc.	S1G-13-F	S1G Series 400 V 1 A Surface Mount Glass Passivated Rectifier - DO-214AC
Diodes Inc.	S1G-13-F	S1M Series 1000 V 1 A Surface Mount Glass Passivated Rectifier - DO-214AC
Diodes Inc.	1N4007-T	1N4007 Series 1000 V 1 A Through Hole High Current Standard Rectifier - DO-41
Diodes Inc.	1N4004-T	1N4004 Series 400 V 1 A Through Hole High Current Standard Rectifier - DO-41
Diodes Inc.	1N5404-T	1N5404 Series 400 V 3 A Through Hole High Current Standard Rectifier - DO-201AD
Fairchild	1N4007	1N400 Series 1.1 V 1 A 1000 V Max Reverse Voltage Standard Rectifier - DO-41
Fairchild	1N4003	1N400 Series 1.1 V 1 A 200 V Max Reverse Voltage Standard Rectifier - DO-41
Fairchild	1N4001	1N400 Series 1.1 V 1 A 50 V Max Reverse Voltage Standard Rectifier - DO-41
Micro Commercial Comp	1N4007-TP	1N4007 Series 1 A 1000 V Through-Hole Rectifying Diode - DO-41
Micro Commercial Comp	1N4004-TP	1N4004 Series 1 A 400 V Through-Hole Rectifying Diode - DO-41
Micro Commercial Comp	1N4002-TP	1N4002 Series 1 A 100 V Through-Hole Rectifying Diode - DO-41
ON Semiconductor	MRA4007T3G	MRA Series 1 A 1000 V Surface Mount Standard Recovery Power Rectifier CASE 403D
ON Semiconductor	1N4007RLG	N4007 Series 1 A 1000 V Axial Lead Standard Recovery Rectifier - CASE 59-10
Vishay	S1G-E3/5AT	S1G Series 400 V 1 A Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	S1M-E3/61T	S1M Series 1 A 1000 V Surface Mount Glass Passivated Rectifier - DO-214AC

Vishay	S1G-E3/61T	S1G Series 1 A 400 V Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	S1D-E3/61T	S1B Series 1 A 200 V Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	S1A-E3/61T	S1A Series 1 A 50 V Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	1N4004-E3/54	1N4004 Series 100 V 45 A Through Hole General Purpose Plastic Rectifier - DO-41
Vishay	S1GHE3/5AT	S1G Series 1 A 400 V Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	RS1G-E3/61T	RS1D Series 400 V 1 A Surface Mount Fast Switching Rectifier - DO-214AC
Vishay	1N4007-E3/61T	1N4007 Series 1000 V 1 A Through Hole General Purpose Plastic Rectifier - DO-41
Vishay	S1J-E3/61T	S1J Series 1 A 600 V Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	S1JHE3/5AT	S1J Series 600 V 1 A Surface Mount Glass Passivated Rectifier - DO-214AC
Vishay	RS1J-E3/61T	RS1D Series 600 V 1 A Surface Mount Fast Switching Rectifier - DO-214AC

CONCLUSION

Diode is a two-terminal component that has low resistance to current flowing in one direction and high resistance to current in the opposite direction. Is can also play the role of a protector. Assuming that the resistor in this circuit is an expensive gadget, the diode guards it from a user inserting a battery the wrong way. Flip the voltage source polarity by selecting it and clicking the flip button.

Rectifier is a circuit designed to convert AC to DC. It is also called as AC to DC converter. In half-wave rectifier, the diode allows the current to flow only during the positive half of the AC wave. When the input voltage is negative the diode blocks the current. Although the resulting current is unidirectional, only half of the input AC wave reaches the output.

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