Diode

A **diode** is defined as a two-terminal electronic component that only conducts current in one direction (so long as it is operated within a specified voltage level). The name diode is derived from "di–ode" which means a device that has two electrodes. An ideal diode will have zero resistance in one direction, and infinite resistance in the reverse direction.

Although in the real world, diodes cannot achieve zero or infinite resistance. Instead, a diode will have negligible resistance in one direction (to allow current flow), and a very high resistance in the reverse direction (to ***prevent*** current flow). A diode is effectively like a valve for an electrical circuit.

Semiconductor diodes are the most common type of diode. These diodes begin conducting electricity only if a certain threshold voltage is present in the forward direction (i.e. the "low resistance" direction). The diode is said to be "***forward biased***" when conducting current in this direction. When connected within a circuit in the reverse direction (i.e. the "high resistance" direction), the diode is said to be "***reverse biased***".

A diode only blocks current in the reverse direction (i.e. when it is reverse biased) while the reverse voltage is within a specified range. Above this range, the reverse barrier breaks. The voltage at which this breakdown occurs is called the "reverse breakdown voltage". When the voltage of the circuit is higher than the reverse breakdown voltage, the diode is able to conduct electricity in the reverse direction (i.e. the "high resistance" direction). This is why in practice we say diodes have a high resistance in the reverse direction – not an infinite resistance.

Working Principle of Diode

A diode's working principle depends on the interaction of n-type and p-type semiconductors. An n-type semiconductor has plenty of free electrons and a very few numbers of holes. In other words, we can say that the concentration of free electrons is high and that of holes is very low in an n-type semiconductor. Free electrons in the n-type semiconductor are referred as majority charge carriers, and holes in the n-type semiconductor are referred to as minority charge carriers.

A p-type semiconductor has a high concentration of holes and a low concentration of free electrons. Holes in the p-type semiconductor are majority charge carriers, and free electrons in the p-type semiconductor are minority charge carriers.

Different types of diodes have different voltage requirements. For silicon diodes the forward voltage is 0.7v and for germanium it is 0.3v. In silicon diode, the dark band indicates the cathode terminal and the other terminal is anode.

A PN junction is the simplest form of the semiconductor diode. In ideal conditions, this PN junction behaves as a short circuit when it is forward biased, and as an open circuit when it is in the reverse biased.

Rectifier Diode

A rectifier diode is a type of P-N junction diode, whose P-N junction area is very large. This results in high capacitance in reverse direction. It has low switching speed.

Rectifier Diode

This is the most common and most used type of a diode. These types of diodes can handle heavy current and are used in converting AC into DC (**Rectification**).

Schottky Diode

The Schottky diode is named after a German physicist Walter H. Schottky. In this type of diode the junction is formed by contacting the semiconductor material with metal. Due to this the forward voltage drop is decreased to min. The semiconductor material is N-type silicon which acts as an anode and the metal acts as a cathode whose materials are chromium, platinum, tungsten etc.

Schottky Diode

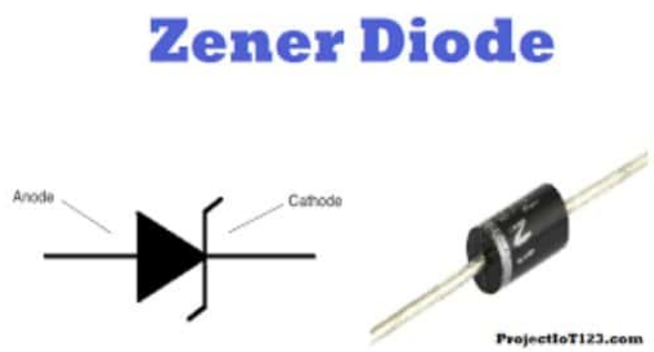
Due to the metal junction these diodes have high current conducting capability thus the switching time reduces. So, Schottky has greater use in switching applications. Mainly because of the metal- semiconductor junction the voltage drop is low which in turn increase the diode performance and reduces power loss. So, these are used in high frequency rectifier applications. The plus point of the Schottky diode is that it has very **low forward voltage** drop and **fast switching**. As there is no capacitive junction (P-N junction), the Schottky diode switching speed is very fast.

Zener Diode

It is a passive element works under the principle of zener breakdown. First produced by Clarence zener in 1934. Zener diode is basically like an ordinary PN junction diode but normally operated in reverse biased condition. But ordinary PN junction diode connected in reverse biased condition is not used as Zener diode practically. A Zener diode is a specially designed, highly doped PN junction diode.

Working Principle of Zener Diode

When a PN junction diode is reverse biased, the depletion layer becomes wider. If this reverse biased voltage across the diode is increased continually, the depletion layer becomes more and more wide. At the same time, there will be a constant reverse saturation current due to minority carriers.

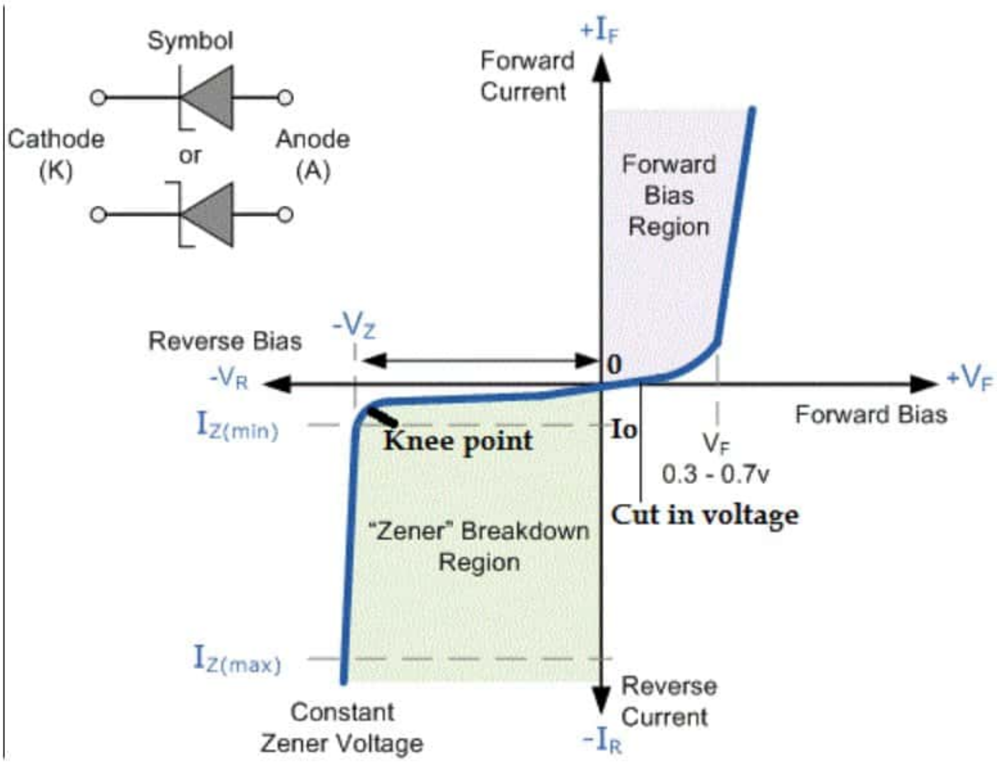


After certain reverse voltage across the junction, the minority carriers get sufficient kinetic energy due to the strong electric field. Free electrons with sufficient kinetic energy collide with stationary ions of the depletion layer and knock out more free electrons. These newly created free electrons also get sufficient kinetic energy due to the same electric field, and they create more free electrons by collision cumulatively. Due to this commutative phenomenon, very soon, huge free electrons get created in the depletion layer, and the entire diode will become conductive. This type of breakdown of the depletion layer is known as avalanche breakdown, but this breakdown is not quite sharp. There is another type of breakdown in depletion layer which is sharper compared to avalanche breakdown, and this is called **Zener breakdown**. When a PN junction is diode is highly doped, the concentration of impurity atoms will be high in the crystal. This higher concentration of impurity atoms causes the higher concentration of ions in the depletion layer hence for same applied reverse biased voltage, the width of the depletion layer becomes thinner than that in a normally doped diode.

Due to this thinner depletion layer, voltage gradient or electric field strength across the depletion layer is quite high. If the reverse voltage is continued to increase, after a certain applied voltage, the electrons from the covalent bonds within the depletion region come out and make the depletion region conductive. This breakdown is called **Zener breakdown**. The voltage at which this breakdown occurs is called **Zener voltage**. If the applied reverse voltage across the diode is more than Zener voltage, the diode provides a conductive path to the current through it hence, there is no chance of further avalanche breakdown in it. Theoretically, Zener breakdown occurs at a lower voltage level then avalanche breakdown in a diode, especially doped for Zener breakdown. The Zener breakdown is much sharper than avalanche breakdown. The Zener voltage of the diode gets adjusted during manufacturing with the help of required and proper doping. When a **zener diode** is connected across a voltage source, and the source voltage is more than Zener voltage, the voltage across a Zener diode remain fixed irrespective of the source voltage. Although at that condition current through the diode can be of any value depending on the load connected with the diode. That is why we use a Zener diode mainly for controlling voltage in different circuits.

Characteristics of a Zener Diode

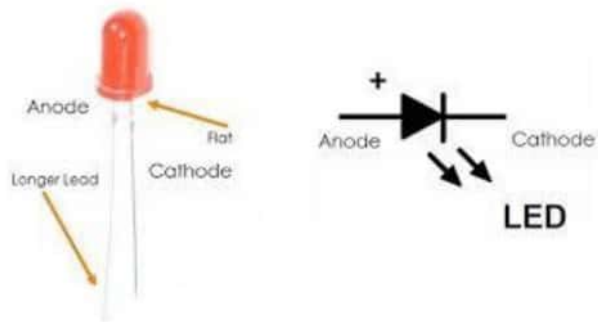
Now, discussing about the diode circuits we should look through the graphical representation of the operation of the **zener diode**. Normally, it is called the V-I characteristics of a Zener diode.



The above diagram shows the V-I characteristics of a zener diode. When the diode is connected in forward bias, this diode acts as a normal diode but when the reverse bias voltage is greater than zener voltage, a sharp breakdown takes place. In the V-I characteristics above V_z is the zener voltage. It is also the knee voltage because at this point the current increases very rapidly.

Light Emitting Diode (LED)

These diodes convert the electrical energy in to light energy. First production started in 1968. It undergoes electroluminescence process in which holes and electrons are recombined to produce energy in the form of light in forward bias condition. This is the type of diodes that operate during forwarding bias operating region. As the diode starts conducting during this region there is a flow of the current. This current is referred to as forwarding current. During this process, the light gets emitted from the diode.



These include various types in LED, namely blinking one that can act as on and off for a certain amount of time. They can be tricolor led where more than two colors get emitted based on the amount of received a positive amount of voltage.

Further, there are LED's that emits infrared light. The practical application of it can be seen in remote controls. Earlier they were used in inductor lamps but now in recent applications they are using in environmental and task handling. Mostly used in applications like aviation lighting, traffic signals, camera flashes.

Light Emitting Diodes are almost everywhere. One can find LEDs in Cars, Bikes, Street Lights, Home Lighting, Office Lighting, Mobile Phones, Televisions and many more.

The reason for such wide range of implementation of LEDs is its advantages over traditional incandescent bulbs and the recent compact fluorescent lamps (CFL). Few advantages of LEDs over incandescent and CFL light sources are mentioned below:

- Low Power Consumption
- Small Size
- Fast Switching
- Physically Robust
- Long Lasting