Name: Samaresh Samanta(RA2011003010247)
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Short Note on PN Junction Diode

A p-n junction diode is a semiconductor device that controls the flow of electric current in a circuit, It has a positive side and a negative side.A p-n Junction diode is made by adding a different impurity to each side of a silicon semiconductor to change how many extra holes or electrons are present. In a pure silicon semiconductor, there's an equal number of holes to electrons. If there are more holes than electrons, then that side is the p-side. If there are more electrons than holes, then it becomes the n-side.

There is a difference in the concentration of holes and electrons at the two sides of a junction, the holes from the p-side diffuse to the n-side and the electrons from the n-side diffuse to the p-side. These give rise to a diffusion current across the junction

As the process goes on, a layer of positive charge is developed on the n-side of the junction. Similarly, when a hole goes from the p-side to the n-side, and ionized acceptor is left behind in the p-side, resulting in the formation of a layer of negative charges in the p-side of the junction. This region of positive charge and negative charge on either side of the junction is termed as the depletion region. Due to this positive space charge region on either side of the junction, an electric field direction from a positive charge towards the negative charge is developed. Due to this electric field, an electron on the p-side of the junction moves to the n-side of the junction. This motion is called the drift.

There are three biasing conditions for p-n junction diode and this is based on the voltage applied:

- FORWARD BIAS:
  When the p-type is connected to the positive terminal of the battery and the n type to the negative terminal then the p-n junction is said to be forward-biased. When the p-n junction is forward biased, the built-in electric field at the p-n junction and the applied electric field are in opposite directions. When both the electric fields add up the resultant electric field has a magnitude lesser than the built-in electric field. This results in a less resistive and thinner depletion region. The depletion region's resistance becomes negligible when the applied voltage is large
- REVERSE BIAS:

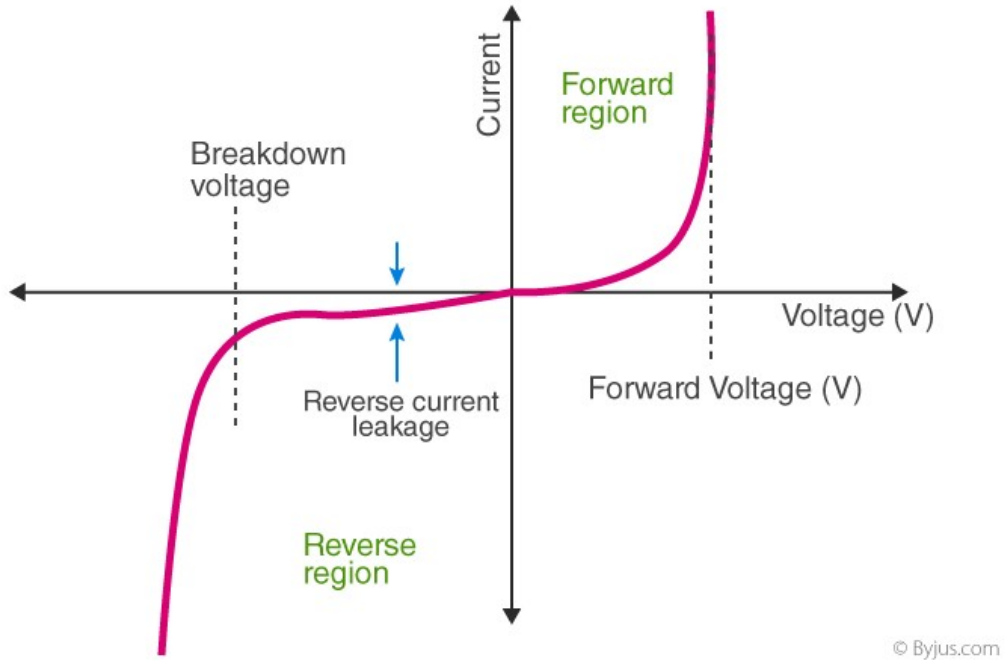
When the p-type is connected to the negative terminal of the battery and the ntype is connected to the positive side then the p-n junction is said to be reverse biased. In this case, the built-in electric field and the applied electric field are in the same direction. When the two fields are added, the resultant electric field is in the same direction as the built-in electric field creating a more resistive, thicker depletion region.

- ZERO BIAS:
  There is no external voltage applied to the p-n junction diode.

FLOW OF CURRENT IN P-N JUNCTION DIODE

The flow of electrons from the n-side towards the p-side of the junction takes place when there is an increase in the voltage. Similarly, the flow of holes from the p-side towards the n-side of the junction takes place along with the increase in the voltage. This results in the concentration gradient between both sides of the terminals. Because of the formation of the concentration gradient, there will be a flow of charge carriers from higher concentration regions to lower concentration regions. The movement of charge carriers inside the p-n junction is the reason behind the current flow in the circuit

V-I Characteristics of PN Junction Diode



VI characteristics of PN junction diode is a curve between the voltage and current through the circuit. Voltage is taken along the x-axis while the current is taken along the y-axis. The above graph is the VI characteristics curve of the PN junction diode. With the help of the curve we can understand that there are three regions in which the diode works, and they are:

- Zero bias
- Forward bias
- Reverse bias

When the PN junction diode is under zero bias condition, there is no external voltage applied and this means that the potential barrier at the junction does not allow the flow of current.

When the PN junction diode is under forward bias condition, the p-type is connected to the positive terminal while the n-type is connected to the negative terminal of the external voltage. When the diode is arranged in this manner, there is a reduction in the potential barrier. For silicone diodes, when the voltage is 0.7 V and for germanium diodes, when the voltage is 0.3 V, the potential barriers decreases and there is a flow of current.

When the diode is in forward bias, the current increases slowly and the curve obtained is non-linear as the voltage applied to the diode is overcoming the potential barrier. Once the potential barrier is overcome by the diode, the diode behaves normal and the curve rises sharply as the external voltage increases and the curve so obtained is linear.

When the PN junction diode is under negative bias condition, the p-type is connected to the negative terminal while the n-type is connected to the positive terminal of the external voltage. This results in an increase in the potential barrier. Reverse saturation current flows in the beginning as minority carriers are present in the junction.

APPLICATIONS

- It can be used as a solar cell.
- When the diode is forward-biased, it can be used in LED lighting applications.
- It is used as rectifiers in many electric circuits.