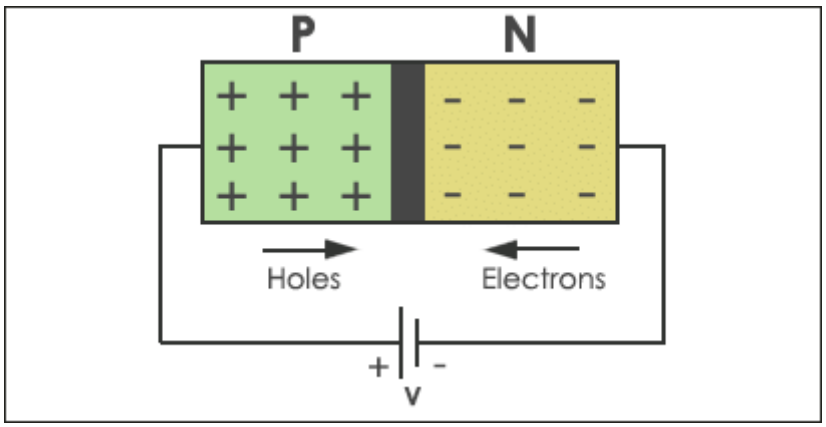
3 PN junction diode

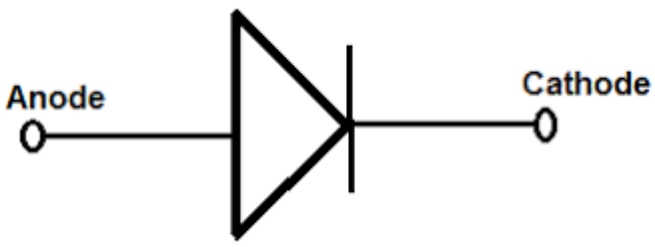
A PN junction is formed from a piece of semiconductor (Ge or Si) by diffusing p-type material (Acceptor impurity Atoms) to one half side and N type material(Donar Impurity Atoms) on other half side. The plane dividing the two zones is known as 'Junction'. The P-region of the semiconductor contains a large number of holes and N region, contains a large number of electrons. A PN junction just immediately formed is shown in Fig.



When PN junction is formed, there is a tendency for the electrons in the N-region to diffuse into the p region, and holes from P-region to N-region. This process is called diffusion. While crossing the junction, the electrons and holes recombines with each other, leaving the immobile ions in the neighbourhood of the junction neutralized as shown in Fig. These immobile + ve and –ve ions, set up a potential across the junction. This potential is called potential barrier or junction barrier. Due to the potential barrier no further diffusion of electrons and holes takes place across the junction. Potential barrier is defined as a potential difference built up across the PN junction which restricts further movement of charge carriers across the junction. The potential barrier for a silicon PN junction is about 0.7 volt, whereas for Germanium PN junction is approximately 0.3 volt.

Symbol of Diode:

The symbol of PN junction diode is shown in Fig.

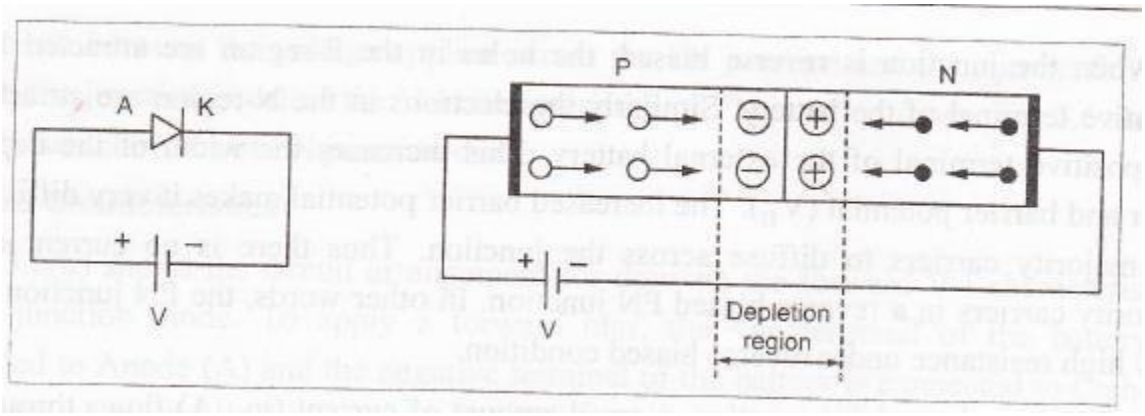


The P-type and N-type regions are referred to as Anode and Cathode respectively. The arrowhead shows the conventional direction of current flow when the diode is forward biased.

Working of PN Junction Diode:

Forward Bias:

When the positive terminal of the external battery is connected to the P-region and negative terminal to the N-region, the PN junction is said to be forward biased as shown in Fig.



When the junction is forward biased, the holes in the p-region are repelled by the positive terminal of the battery and are forced to move towards the junction. similarly, the electrons in the N-region are repelled by the negative terminal of the battery and are forced to move towards the-junction. This reduces the width of the depletion layer and barrier potential.

If the applied voltage is greater than the potential barrier vr, then the majority carriers namely holes in P-region and electrons in N-region, cross the barrier. During crossing some of the charges get neutralized the remaining charges after crossing, reach the other side and constitute current in the forward direction.

The PN junction offers very low resistance under forward biased condition. Since the barrier potential is very small (nearly 0.7 V for silicon and 0.3 V for Germanium junction), a small forward voltage is enough to completely eliminate the barrier. once the potential barrier is eliminated by the forward voltage, a large current start flowing through the PN junction.

Reverse Bias:

When the positive terminal of the external battery is connected to the N-region and negative terminal to the p-region, the PN junction is said to be reverse biased. When the junction is reverse biased, the holes in the P-region are attracted by the negative terminal of the battery.

Similarly, the electrons in the N-region are attracted by the positive terminal of the external battery. This increases the width of the depletion layer and barrier potential (Vs).
The increased barrier potential makes it very difficult for the majority carriers to diffuse across the junction. Thus, there is no current due to majority carriers in a reverse biased PN junction.

In other words, the PN junction offers very high resistance under reverse biased condition. In a reverse biased PN junction, a small amount of current (in μA) flows through the junction because of minority carriers. (i.e., electrons in the P-region and holes in the N region).The reverse current is small because the number of majority carrier in both regions is small.

V-l characteristics of PN-Junction Diode:

Forward Characteristics:

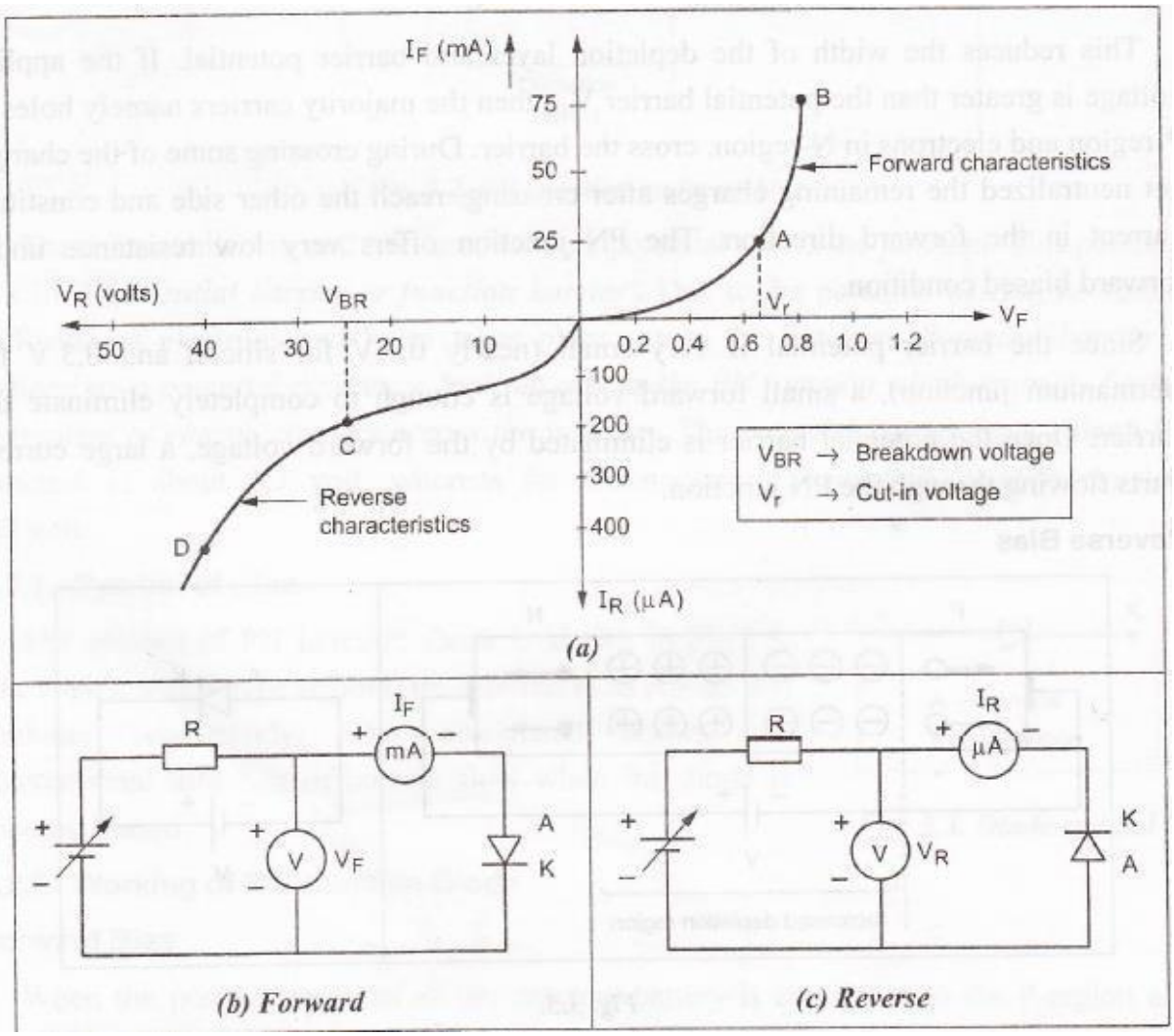


Fig. (a) shows the circuit arrangement for drawing the forward V-I characteristics of PN junction diode. To apply a forward bias, the +ve terminal of the battery is connected to Anode (A) and the negative terminal of the battery is connected to Cathode (K) of diode.. Now, when supply voltage is increased the circuit current increases very slowly and the curve is nonlinear (region-OA). The slow rise in current in this region is because the external applied voltage is used to overcome the barrier potential (0.7 V for Si; 0.3V for Ge) of the PN junction' However once the potential barrier is eliminated and the external supply voltage is increased further, the current flowing through the PN junction diode increases rapidly (region AB). This region of the curve is almost linear. The applied voltage should not be increased beyond a certain safe limit, otherwise the diode will burnout. The forward voltage at which the current through the PN junction starts increasing rapidly is called by knee voltage. It is denoted by the letter V_B.

Reverse Characteristics:

Fig (c) shows the circuit arrangement for drawing the reverse V-I characteristics of PN junction diode. To apply a reverse bias, the +ve terminal of the battery is connected to cathode (K) and - ve terminal of the battery is connected to anode (A) of diode. Under this condition the potential buried at the junction is increased. Therefore, the junction resistance becomes very high and practically no. current flows through the circuit. However, in actual practice, a very small current (of the order of μA) flows in the circuit. This current is called reverse current and is due to minority carriers. It is also called as reverse saturation current (I). The reverse current increases slightly with the increase in reverse bias supply voltage. If the reverse voltage is increased continuously at one state (marked by point C on the reverse characteristics) breakdown of junction occurs and the resistance of the barrier regions falls suddenly. Consequently, the reverse current increases rapidly (as shown by the curve CD in the current) to a large value. This may destroy the junction permanently. The reverse voltage at which the PN junction breaks is called as break down voltage.