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Study of Signal Diode and its Parameters

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Abstract : The semiconductor **Signal Diode** is a small non-linear semiconductor devices generally used in electronic circuits, where small currents or high frequencies are involved such as in radio, television and digital logic circuits.

Signal diodes, also sometimes known by its older name of the **Point Contact Diode** or the **Glass Passivated Diode**, are physically very small in size compared to their larger Power Diodes. Generally, the PN junction of a small signal diode is encapsulated in glass to protect the PN junction, and usually have a red or black band at one end of their body to help identify which end is the cathode terminal. The most widely used of all the glass encapsulated signal diodes is the very common *1N4148* and its equivalent *1N914* signal diode.

Small signal and switching diodes have much lower power and current ratings, around 150mA, 500mW maximum compared to rectifier diodes, but they can function better in high frequency applications or in clipping and switching applications that deal with short-duration pulse waveforms.

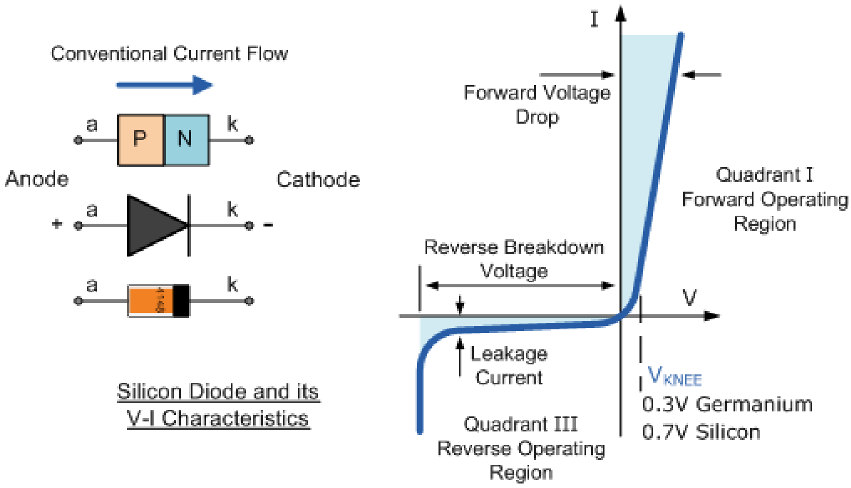
Key Words : Signal Diode, PN Junction, Forward and Reverse Bias

The characteristics of a signal point contact diode are different for both germanium and silicon types and are given as:

- 1. Germanium Signal Diodes – These have a low reverse resistance value giving a lower forward volt drop across the junction, typically only about 0.2 to 0.3v, but have a higher forward resistance value because of their small junction area.
- 2. Silicon Signal Diodes – These have a very high value of reverse resistance and give a forward volt drop of about 0.6 to 0.7v across the junction. They have fairly low values of forward resistance giving them high peak values of forward current and reverse voltage.

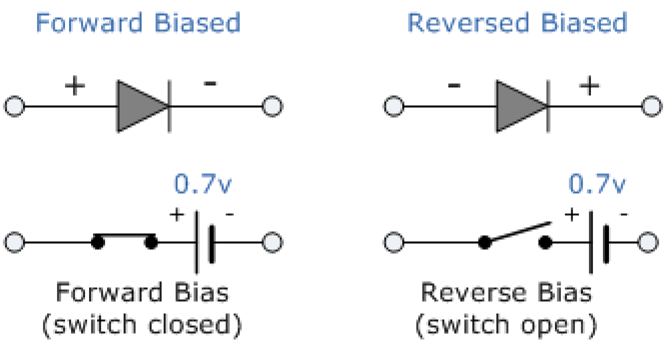
The electronic symbol given for any type of diode is that of an arrow with a bar or line at its end and this is illustrated below along with the Steady State V-I Characteristics Curve.

Silicon Diode V-I Characteristic Curve



The arrow always points in the direction of conventional current flow 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). However, 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.

Forward and Reversed Biased Diode



Then we can say that an ideal small signal diode conducts current in one direction (forward-conducting) and blocks current in the other direction (reverse-blocking). Signal Diodes are used in a wide variety of applications such as a switch in rectifiers, current limiters, voltage snubbers or in wave-shaping circuits.

Signal Diode Parameters

Signal Diodes are manufactured in a range of voltage and current ratings and care must be taken when choosing a diode for a certain application. There are a bewildering array of static characteristics associated with the humble signal diode but the more important ones are.

1. Maximum Forward Current

The **Maximum Forward Current** ($I_{F(max)}$) is as its name implies the *maximum forward current* allowed to flow through the device. When the diode is conducting in the forward bias condition, it has a very small "ON" resistance across the PN junction and therefore, power is dissipated across this junction (Ohm´s Law) in the form of heat.

Then, exceeding its ($I_{F(max)}$) value will cause more heat to be generated across the junction and the diode will fail due to thermal overload, usually with destructive consequences. When operating diodes around their maximum current ratings it is always best to provide additional cooling to dissipate the heat produced by the diode.

For example, small 1N4148 signal diode has a maximum current rating of about 150mA with a power dissipation of 500mW at 25^{o}C. Then a resistor must be used in series with the diode to limit the forward current, ($I_{F(max)}$) through it to below this value.

2. Peak Inverse Voltage

The **Peak Inverse Voltage** (PIV) or *Maximum Reverse Voltage* ($V_{R(max)}$), is the maximum allowable **Reverse** operating voltage that can be applied across the diode without reverse breakdown and damage occurring to the device. This rating therefore, is usually less than the "avalanche breakdown" level on the reverse bias characteristic curve. Typical values of $V_{R(max)}$ range from a few volts to thousands of volts and must be considered when replacing a diode.

The peak inverse voltage is an important parameter and is mainly used for rectifying diodes in AC rectifier circuits with reference to the amplitude of the voltage were the sinusoidal waveform changes from a positive to a negative value on each and every cycle.

3. Total Power Dissipation

Signal diodes have a **Total Power Dissipation**, ($P_{D(max)}$) rating. This rating is the maximum possible power dissipation of the diode when it is forward biased (conducting). When current flows through the signal diode the biasing of the PN junction is not perfect and offers some resistance to the flow of current resulting in power being dissipated (lost) in the diode in the form of heat.

As small signal diodes are non-linear devices the resistance of the PN junction is not constant, it is a dynamic property then we cannot use Ohms Law to define the power in terms of current and resistance or voltage and resistance as we can for resistors. Then to find the power that will be dissipated by the diode we must multiply the voltage drop across it times the current flowing through it: $P_D = V*I$

4. Maximum Operating Temperature

The **Maximum Operating Temperature** actually relates to the *Junction Temperature* (T_J) of the diode and is related to maximum power dissipation. It is the maximum temperature allowable before the structure of the diode deteriorates and is expressed in units of degrees centigrade per Watt, ($^oC/W$).

This value is linked closely to the maximum forward current of the device so that at this value the temperature of the junction is not exceeded. However, the maximum forward current will also depend upon the ambient temperature in which the device is operating so the maximum forward current is usually quoted for two or more ambient temperature values such as 25^oC or 70^oC.

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