

4.3 VARACTOR DIODE

Varactor diode is a p-n junction diode whose capacitance is varied by varying the reverse voltage. Varactor diode operates only in reverse bias. The varactor diode acts like a variable capacitor under reverse bias.

Varactor diode is also sometimes referred to as varicap diode, tuning diode, variable reactance diode, or variable capacitance diode.

Varactor diode symbol

The symbol of a varactor diode is shown in the below figure. The circuit symbol of the varactor diode is almost similar to the normal p-n junction diode.



Fig:4.3.1 Symbol of Varactor Diode

Two parallel lines at the cathode side represents two conductive plates and the space between these two parallel lines represents dielectric.

Construction of varactor diode

The n-type semiconductor, a large number of free electrons are present and in the p-type semiconductor, a large number of holes are present. The free electrons and holes always try to move from a higher concentration region to a lower concentration region.

For free electrons, n-region is the higher concentration region and p-region is the lower concentration region. For holes, p-region is the higher concentration region and n-region is the lower concentration region.

Therefore, the free electrons always try to move from n-region to p-region similarly holes always try to move from p-region to n-region.

When no voltage is applied, a large number of free electrons in the n-region get repelled from each other and move towards the p-region.

When the free electrons reach p-n junction, they experience an attractive force from the holes in the p-region. As a result, the free electrons cross the p-n junction. In the similar

way, holes also cross the p-n junction. Because of the flow of these charge carriers, a tiny current flows across diode for some period.

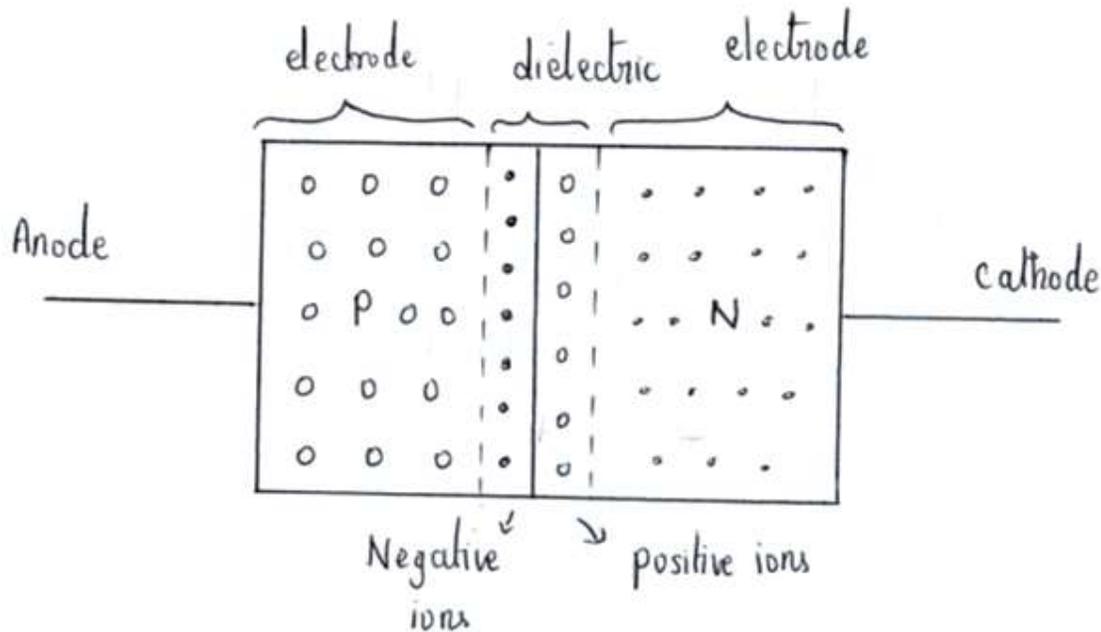


Fig:4.3.2 Construction of Varactor Diode

During this process, some neutral atoms near the junction at n-side loses electrons and become positively charged atoms (positive ions) similarly some neutral atoms near the junction at p-side gains extra electrons and become negatively charged atoms (negative ions). These positive and negative ions created at the p-n junction is nothing but depletion region. This depletion region prevents further current flow across the p-n junction.

The width of depletion region depends on the number of impurities added (amount of doping).

A heavily doped varactor diode has a thin depletion layer whereas a lightly doped varactor diode has a wide depletion layer.

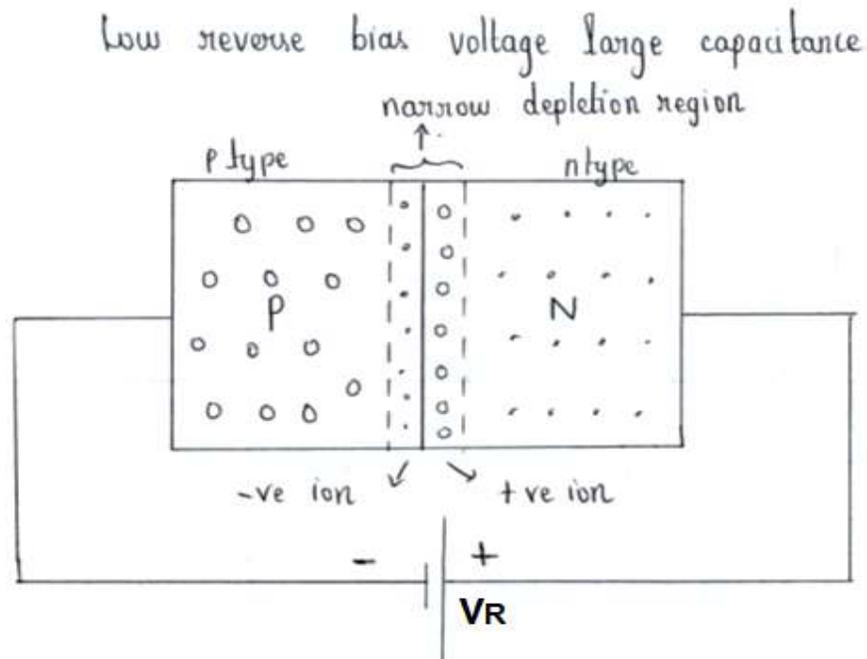


Fig:4.3.3 Low Reverse Bias of Varactor Diode

An insulator or a dielectric does not allow electric current through it. The depletion region also does not allow electric current through it. So the depletion region acts like a dielectric of a capacitor.

Electrodes or conductive plates easily allow electric current through them. The p-type and n-type semiconductor also easily allow electric current through them. So the p-type and n-type semiconductor acts like the electrodes or conductive plates of the capacitor. Thus, varactor diode behaves like a normal capacitor.

In an unbiased varactor diode, the depletion width is very small. So the capacitance (charge storage) is very large.

The varactor diode should always be operated in reverse bias. Because in reverse bias, the electric current does not flow. When a forward bias voltage is applied, the electric current flows through the diode. As a result, the depletion region becomes negligible. Depletion region consists of stored charges. So stored charges becomes negligible which is undesirable.

A varactor diode is designed to store electric charge not to conduct electric current. So varactor diode should always be operated in reverse bias.

When a reverse bias voltage is applied, the electrons from n-region and holes from p-region moves away from the junction. As a result, the width of depletion region increases and the capacitance decreases.

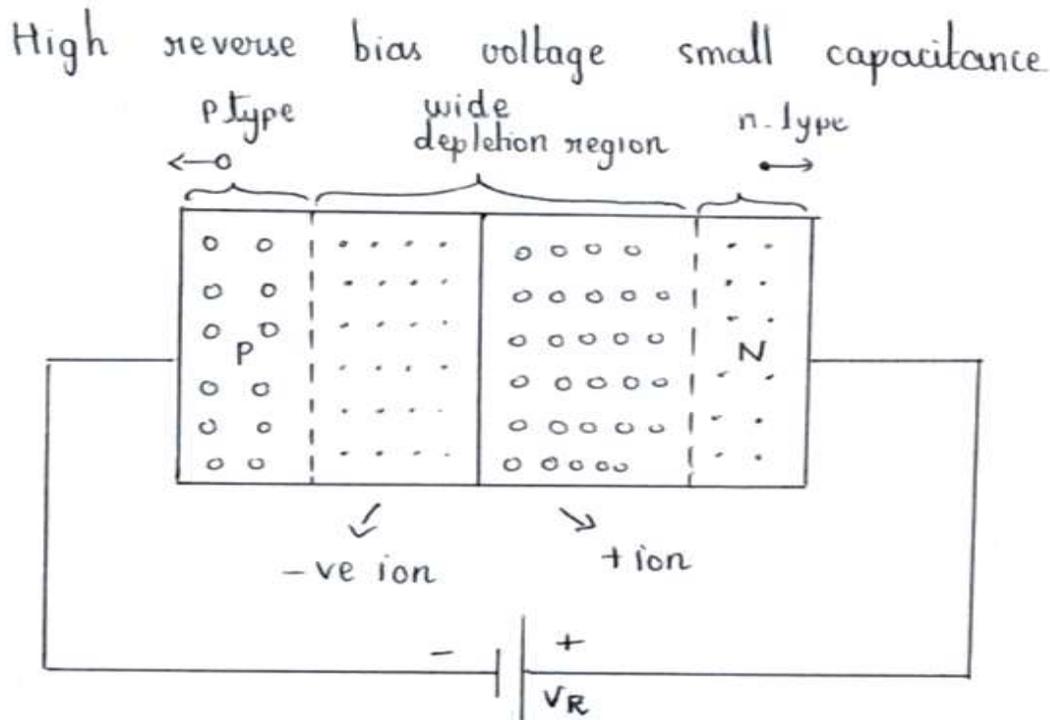


Fig:4.3.4 High Reverse Bias of Varactor Diode

However, if the applied reverse bias voltage is very low the capacitance will be very large.

The capacitance is inversely proportional to the width of the depletion region and directly proportional to the surface area of the p-region and n-region. So the capacitance decreases as the as the width of depletion region increases.

If the reverse bias voltage is increased, the width of depletion region further increases and the capacitance further decreases.

On the other hand, if the reverse bias voltage is reduced, the width of depletion region decreases and the capacitance increases.

Thus, an increase in reverse bias voltage increases the width of the depletion region and decreases the capacitance of a varactor diode.

The decrease in capacitance means the decrease in storage charge. So the reverse bias voltage should be kept at a minimum to achieve large storage charge. Thus, capacitance or transition capacitance can be varied by varying the voltage.

In a fixed capacitor, the capacitance will not be varied whereas, in variable capacitor, the capacitance is varied.

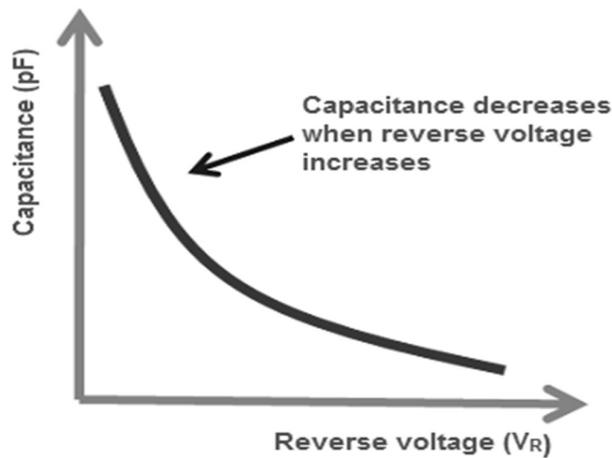


Fig:4.3.5 Characteristics of Varactor Diode

In a varactor diode, the capacitance is varied when the voltage is varied. So the varactor diode is a variable capacitor. The capacitance of a varactor diode is measured in picofarads (pF).

Applications of varactor diode

- Varactor diode is used in frequency multipliers.
- Varactor diode is used in parametric amplifiers.
- Varactor diode is used in voltage-controlled oscillators.

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