# Varactor diodes or Varicap diodes

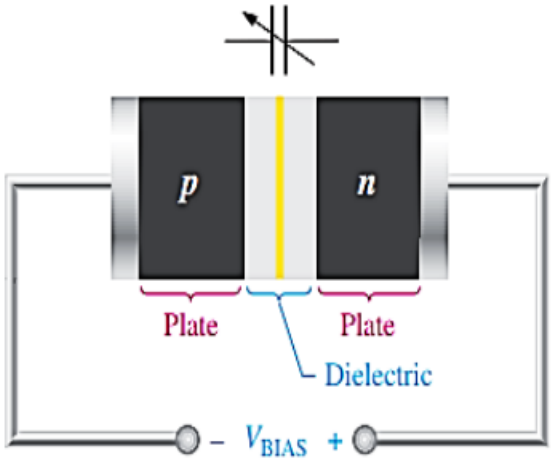
**are semiconductor devices that are widely used in the electronics industry. In this article, we will learn about the characteristics and applications of the varactor diode.**

**is a type of diode whose internal capacitance varies with respect to the reverse voltage. It always works in reverse bias conditions and is a voltage-dependent semiconductor device. Several names know varactor diode as Varicap, Varactor, Voltage variable capacitance, or Tunning diode.**

**A varactor is a diode that always operates in reverse bias and is doped to maximize the inherent capacitance of the depletion region. The depletion region acts as a capacitor dielectric because of its nonconductive characteristic. The p and n regions are conductive and act as the capacitor plates, as illustrated in Figure**

▶ FIGURE 3–21

The reverse-biased varactor diode acts as a variable capacitor.

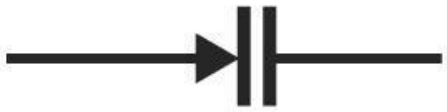



▲ FIGURE 3–23

Varactor diode symbol.

## Symbol of Varactor Diode

**From the diagram given below, it is evident that the symbol of the varactor diode is similar to that of the PN-**



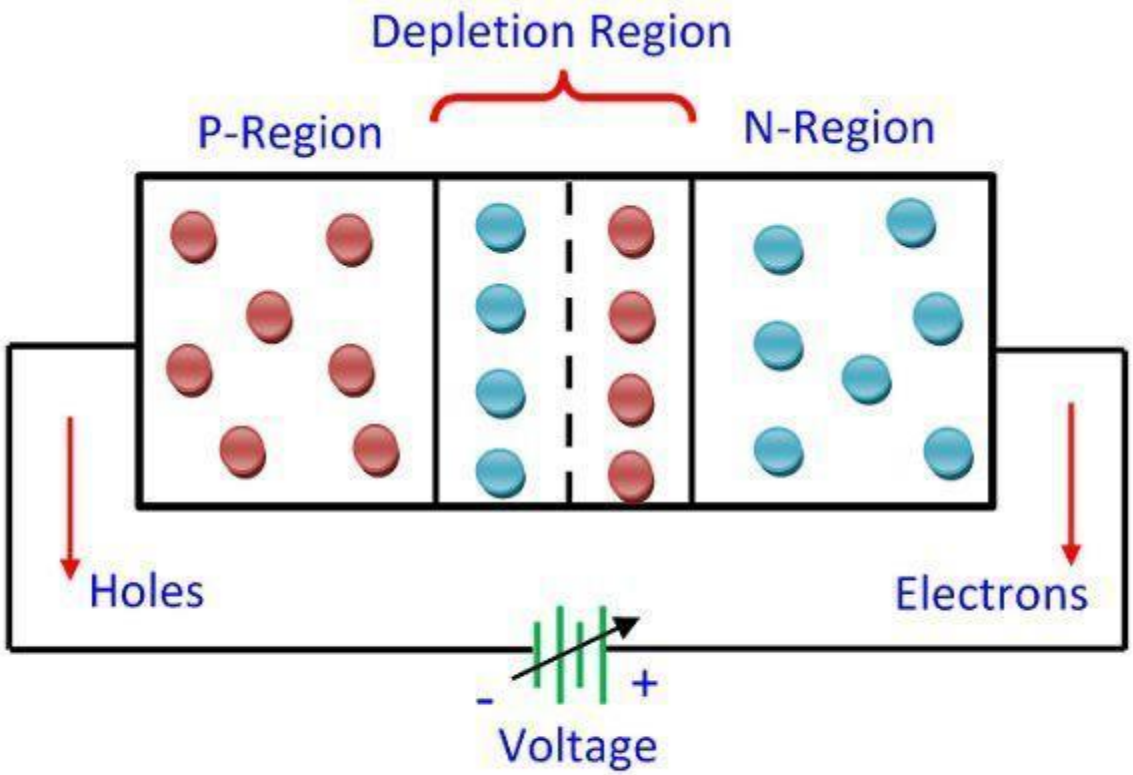
Symbol of Varactor Diode

**junction diode. The diode has two terminals: anode and cathode. One end of the symbol consists of the diode, and the other has two parallel lines representing the capacitor's conductive plates. The gap between the plates shows their dielectric.**

## Basic Operation of Varactor Diodes

## Working of Varactor Diode

**The Varactor diode is made up of n-type and p-type semiconductor material. In an n-type semiconductor material, the electrons are the majority charge carrier and in the p-type material, the holes are the majority carriers. When the p-type and n-type semiconductor material are joined together, the p-n junction is formed, and the depletion region is created at the PN-junction. The positive and negative ions make the depletion region. This region blocks the current to enter from the PN-region.**




Depletion Region in a Reverse Biased P-N junction

Circuit Globe

**The varactor diode operates only in reverse bias. Because of reverse bias, the current does not flow. If the diode is connected in forward biasing the current starts flowing through the diode and their depletion region become decreases. The depletion region does not allow the ions to move from one place to another.**

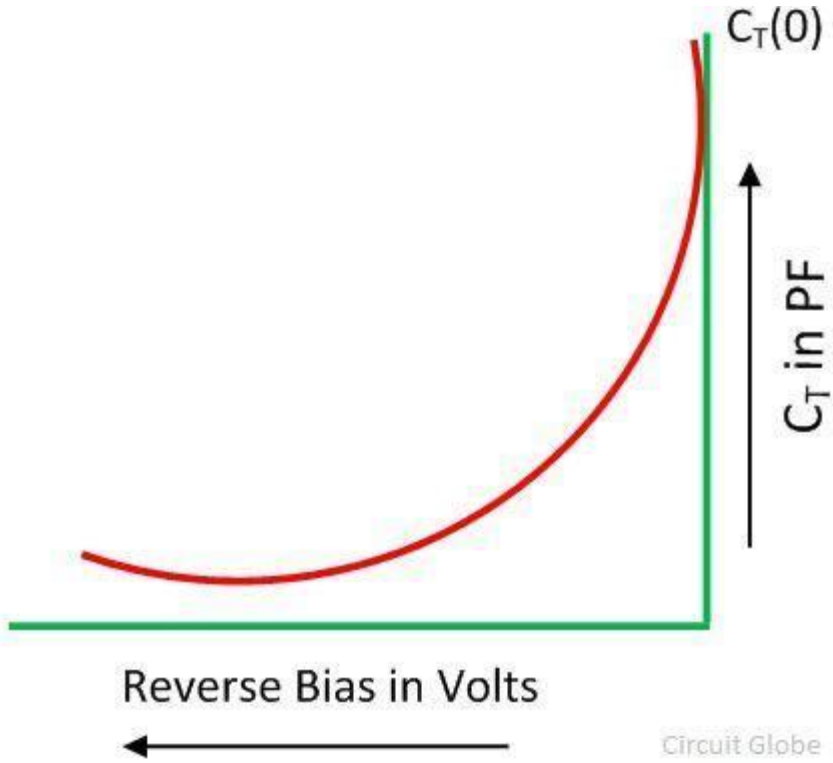
**he Varactor diode is used for storing the charge not for flowing the charge. In the forward bias, the total charge stored in the diode becomes zero, which is undesirable. Thus, the Varactor diode always operates in the reverse bias.**

**The formula gives the capacitance of varactor diode,**

$$C_T = \frac{\in A}{W}$$

## Characteristic of Varactor Diode

**The characteristic curve of the varactor diode is shown in the figure below. The graph shows that when the reverse bias voltage increases the depletion region increases, and the capacitance of the diode reduces**



# Advantages of Varactor Diode

**The following are the advantages of the varactor diode.**

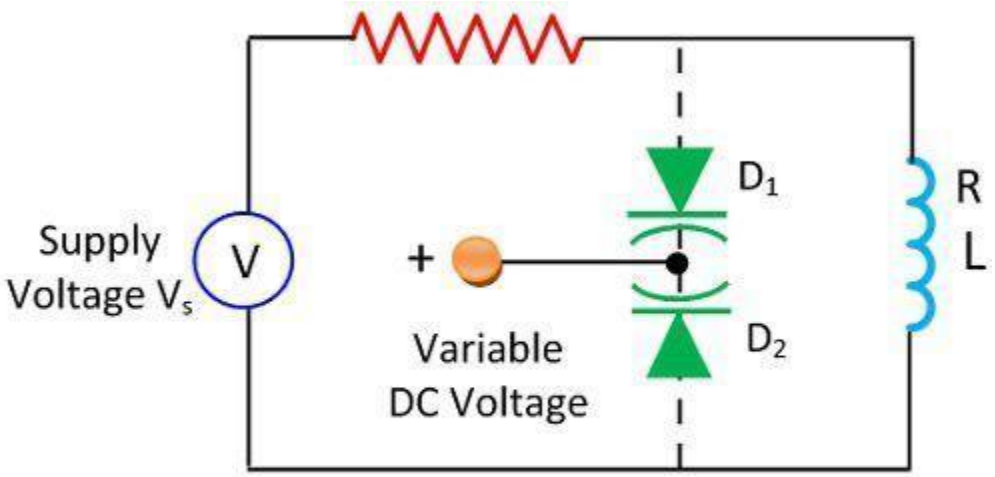
**The varactor diode produces less noise as less compared to the other diode.**

**It is less costly and more reliable.**

**The varactor diode is small in size and less in weight.**

# Varactor diode in tunning Circuit

**The figure below shows that D1 and D2 are the two Varactor diode. These diodes provide the variable resistance in the parallel resonance circuit. The Vc is the DC voltage used for controlling the reverse voltage of the diode.**




Varactor Diode in Tunning Circuit

Circuit Globe

$$f_0 = \frac{1}{2\pi\sqrt{LC_T}}$$

$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

**he L is the inductance of the circuit, and it is measured in Henry. The resonant frequency of the circuit is expressed as C1 and C2 is the maximum voltage capacitance of the diode**

# Varactor Datasheet Information

**Tuning characteristics at $T_{amb}$ = 25°C**

| Part | Capacitance (pF) | | | Min Q $V_R$ = 3V f = 50MHz | Capacitance ratio $C_2$ / $C_{20}$ @ f = 1MHz | |
|---|---|---|---|---|---|---|
| | Min. | Nom. | Max. | | Min. | Max. |
| 829A | 7.38 | 8.2 | 9.02 | 250 | 4.3 | 5.8 |
| 829B | 7.79 | 8.2 | 8.61 | 250 | 4.3 | 5.8 |
| 830A | 9.0 | 10.0 | 11.0 | 300 | 4.5 | 6.0 |
| 830B | 9.5 | 10.0 | 10.5 | 300 | 4.5 | 6.0 |
| 831A | 13.5 | 15.0 | 16.5 | 300 | 4.5 | 6.0 |
| 831B | 14.25 | 15.0 | 15.75 | 300 | 4.5 | 6.0 |
| 832A | 19.8 | 22.0 | 24.2 | 200 | 5.0 | 6.5 |
| 832B | 20.9 | 22.0 | 23.1 | 200 | 5.0 | 6.5 |
| 833A | 29.7 | 33.0 | 36.3 | 200 | 5.0 | 6.5 |
| 833B | 31.35 | 33.0 | 34.65 | 200 | 5.0 | 6.5 |
| 834A | 42.3 | 47.0 | 51.7 | 200 | 5.0 | 6.5 |
| 834B | 44.65 | 47.0 | 49.35 | 200 | 5.0 | 6.5 |
| 835A | 61.2 | 68.0 | 74.8 | 100 | 5.0 | 6.5 |
| 835B | 64.6 | 68.0 | 71.4 | 100 | 5.0 | 6.5 |
| 836A | 90.0 | 100.0 | 110.0 | 100 | 5.0 | 6.5 |
| 836B | 95.0 | 100.0 | 105.0 | 100 | 5.0 | 6.5 |

**Tuning characteristics at $T_{amb}$ = 25°C**

| Part | Capacitance (pF) | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| 829A | 7.38 | 8.2 | 9.02 |
| 829B | 7.79 | 8.2 | 8.61 |
| 830A | 9.0 | 10.0 | 11.0 |
| 830B | 9.5 | 10.0 | 10.5 |
| 831A | 13.5 | 15.0 | 16.5 |
| 831B | 14.25 | 15.0 | 15.75 |
| 832A | 19.8 | 22.0 | 24.2 |
| 832B | 20.9 | 22.0 | 23.1 |
| 833A | 29.7 | 33.0 | 36.3 |
| 833B | 31.35 | 33.0 | 34.65 |
| 834A | 42.3 | 47.0 | 51.7 |
| 834B | 44.65 | 47.0 | 49.35 |
| 835A | 61.2 | 68.0 | 74.8 |
| 835B | 64.6 | 68.0 | 71.4 |
| 836A | 90.0 | 100.0 | 110.0 |
| 836B | 95.0 | 100.0 | 105.0 |

**Capacitance Tolerance Range The minimum, nominal, and maximum values of capacitance are shown on the datasheet. For example, when reverse-biased at 3 V, the 832A can exhibit a capacitance anywhere between 19.8 pF and 24.2 pF**

**Capacitance Ratio The varactor capacitance ratio is also known as the tuning ratio. It is the ratio of the diode**

**capacitance at a minimum reverse voltage to the diode capacitance at a maximum reverse voltage. For the 832A, the minimum capacitance ratio is 5.0. This means that the capacitance value decreases by a factor of 5.0 as VR is increased from 2 V to 20 V. The following calculation illustrates how to use the capacitance ratio (CR) to find the capacitance range for the 832A. If C2=22 pF and the minimum CR= C2/C20 =5.0**

| Part | Capacitance ratio $C_2 / C_{20}$ @ f = 1MHz | |
|---|---|---|
| | Min. | Max. |
| 829A | 4.3 | 5.8 |
| 829B | 4.3 | 5.8 |
| 830A | 4.5 | 6.0 |
| 830B | 4.5 | 6.0 |
| 831A | 4.5 | 6.0 |
| 831B | 4.5 | 6.0 |
| 832A | 5.0 | 6.5 |
| 832B | 5.0 | 6.5 |
| 833A | 5.0 | 6.5 |
| 833B | 5.0 | 6.5 |
| 834A | 5.0 | 6.5 |
| 834B | 5.0 | 6.5 |
| 835A | 5.0 | 6.5 |
| 835B | 5.0 | 6.5 |
| 836A | 5.0 | 6.5 |
| 836B | 5.0 | 6.5 |

## Back-to-Back Configuration

**1. One of the drawbacks of using just a single varactor diode in certain**

**applications, such as RF tuning, is that if the diode is forward-biased by the**

**RF signal during part of the ac cycle, its reverse leakage will increase**

**momentarily.**

**2. Also, a type of distortion called harmonic distortion is produced if the**

**varactor is alternately biased positively and negatively. To avoid harmonic**

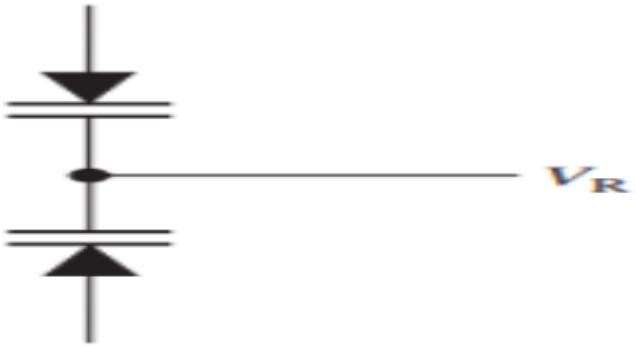
**distortion, you will often see two varactor diodes back to back, as shown in**

**Figure with the reverse dc voltage applied to both devices simultaneously.**

**3. The two tuning diodes will be driven alternately into high and low**

**capacitance, and the net capacitance will remain constant and is unaffected**

**by the RF signal amplitude.**




## Varactor Diode Applications

**Some applications of varactor diode are given in the points mentioned below.**

**They are used in the RF design arena and provide a method of varying the capacitance within a circuit by applying control voltage. It provides them with special capability, due to which varactor diodes are used in the RF industry.**

**A major application of varactors is in tuning circuits.**

**Voltage-controlled oscillators (VCOs) – VCOs are used for many applications, and oscillators within a phase-locked loop are the major region. VCOs are present in almost all wireless receivers and radios.**