

UNIT V SPECIAL SEMICONDUCTOR DEVICES .

SCR- UJT- DIAC- TRIAC - SCHOTTY BARRIER DIODE-VARACTOR DIODE - PIN DIODE - TUNNEL DIODE - GUNN DIODE – LASER DIODE-OPERATION, CHARACTERISTICS AND APPLICATIONS

In the recent years, such semiconductor devices have been developed which can exercise fine control over the flow of large blocks of power in a system. Such devices act as controlled switches and can perform the duties of controlled rectification, inversion and regulation of power in a load.

The important semiconductor switching devices are :

- (i) Silicon controlled rectifier (SCR)
- (ii) Triac
- (iii) Diac
- (iv) Unijunction transistor (UJT)

Silicon Controlled Rectifier (SCR)

A silicon controlled rectifier is a semiconductor device that acts as a true electronic switch. It can change alternating current into direct current and at the same time can control the amount of power fed to the load. Thus SCR combines the features of a rectifier and a transistor.

Constructional details.

When a PN junction is added to a junction transistor, the resulting three pn junction device is called a silicon controlled rectifier. Fig. 1 shows its construction. It is clear that it is essentially an ordinary rectifier (pn) and a junction transistor (nnp) combined in one unit to form pnpn device. Three terminals are taken; one from the outer p-type material called anode A, second from the outer n-type material called cathode K and the third from the base of transistor section and is called gate G. In the normal operating conditions of SCR, anode is held at high positive potential w.r.t. cathode and gate at small positive potential w.r.t. cathode. Fig. (ii) shows the symbol of SCR.

The silicon controlled rectifier is a solid state equivalent of thyatron. The gate, anode and cathode of SCR correspond to the grid, plate and cathode of thyatron. For this reason, SCR is sometimes called thyristor.

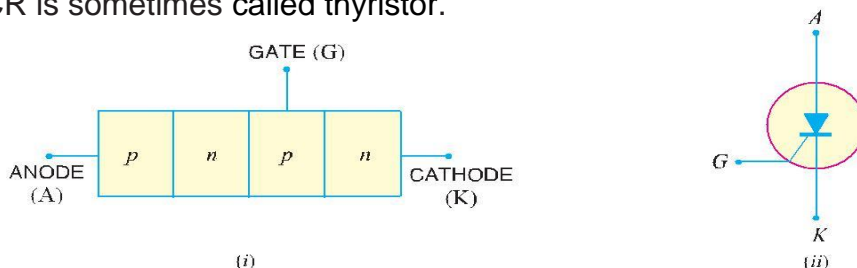


Fig1

Working of SCR

In a silicon controlled rectifier, load is connected in series with anode. The anode is always kept at positive potential *w.r.t.* cathode. The working of SCR can be studied under the following two heads:

(i) When gate is open. Fig.2 shows the SCR circuit with gate open i.e. no voltage applied to the gate. Under this condition, junction J_2 is reverse biased while junctions J_1 and J_3 are forward biased. Hence, the situation in the junctions J_1 and J_3 is just as in a npn transistor with base open. Consequently, no current flows through the load R_L and the SCR is cut off. However, if the applied voltage is gradually increased, a stage is reached when reverse biased junction J_2 breaks down. The SCR now conducts heavily and is said to be in the ON state. The applied voltage at which SCR conducts heavily without gate voltage is called Breakover voltage.

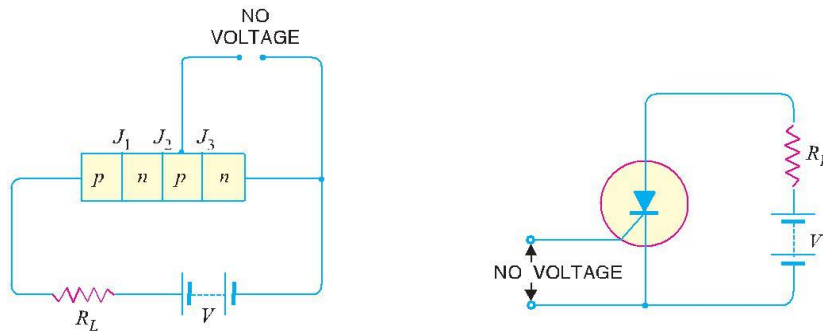


Fig 2

(ii) When gate is positive w.r.t. cathode.

The SCR can be made to conduct heavily at smaller applied voltage by applying a small positive potential to the gate as shown in Fig. 20.3. Now junction J_3 is forward biased and junction J_2 is reverse biased. The electrons from n-type material start moving across junction J_3 towards left whereas holes from p-type towards the right. Consequently, the electrons from junction J_3 are attracted across junction J_2 and gate current starts flowing. As soon as the gate current flows, anode current increases. The increased anode current in turn makes more electrons available at junction J_2 . This process continues and in an extremely small time, junction J_2 breaks down and the SCR starts conducting heavily. Once SCR starts conducting, the gate (the reason for this name is obvious) loses all control. Even if gate voltage is removed, the anode current does not decrease at all. The only way to stop conduction (i.e. bring SCR in off condition) is to reduce the applied voltage to zero.

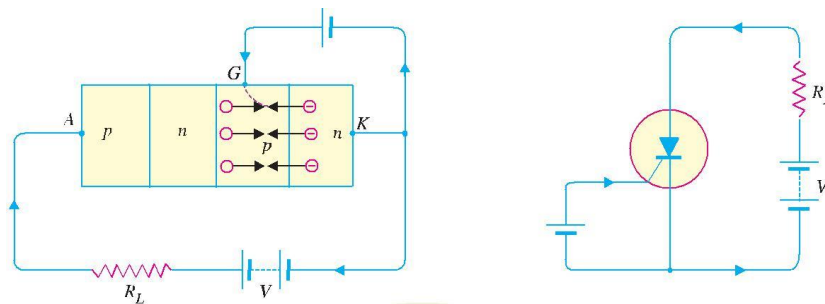


Fig.3

The whole applied voltage V appears as reverse bias across junction J_2 as junctions J_1 and J_3 are forward biased. Because J_1 and J_3 are forward biased and J_2 has broken down

Conclusion. The following conclusions are drawn from the working of SCR :

- (i) An SCR has two states i.e. either it does not conduct or it conducts heavily. There is no state in between. Therefore, SCR behaves like a switch.
- (ii) There are two ways to turn on the SCR. The first method is to keep the gate open and make the supply voltage equal to the breakover voltage. The second method is to operate SCR with supply voltage less than breakover voltage and then turn it on by means of a small voltage (typically 1.5 V, 30 mA) applied to the gate.
- (iii) Applying small positive voltage to the gate is the normal way to close an SCR because the breakover voltage is usually much greater than supply voltage.
- (iv) To open the SCR (i.e. to make it non-conducting), reduce the supply voltage to zero.

The V-I characteristics of the SCR reveal that the SCR can be operated in three modes There are three modes of operation for an SCR depending upon the biasing given to it:

1. **Forward blocking mode (off state)**
2. **Forward conduction mode (on state)**
3. **Reverse blocking mode (off state)**

Forward blocking mode

In this mode of operation, the anode is given a positive potential while the cathode is given a negative voltage, keeping the gate at zero potential i.e. disconnected. In this case junction **J1** and **J3** are forward biased while **J2** is reversed biased due to which only a small leakage current exists from the anode to the cathode

until the applied voltage reaches its breakover value, at which **J2** undergoes avalanche breakdown and at this breakover voltage it starts conducting, but below breakover voltage it offers very high resistance to the current and is said to be in the off state.

Forward conduction mode

SCR can be brought from blocking mode to conduction mode in two ways: either by increasing the voltage across anode to cathode beyond breakover voltage or by applying of positive pulse at gate. Once it starts conducting, no more gate voltage is required to maintain it in the on state. There are two ways to turn it off: 1. Reduce the current through it below a minimum value called the holding current and 2. With the Gate turned off, short out the Anode and Cathode momentarily with a push-button switch or transistor across the junction.

Reverse blocking mode

In this mode SCR is reversed biased, i.e. when anode is negative compared to cathode. The characteristic of this region are similar to those of an ordinary PN junction diode. In this region, junction J1 and J3 are reversed biased whereas J2 is forward biased. The device behaves as if two diodes are connected in series with a reverse voltage applied to them. A small leakage current of the order of milliamperes or micro amperes flows in the device. This reverse blocking mode is called the OFF state of the thyristor. When the reverse voltage of the SCR increases to a large extent, breakdown occurs and the current in the device increases rapidly. Thus when the SCR is biased in this region the power dissipated is very high, if the power dissipated is more than the rated value of the SCR, the SCR is permanently damaged. Thus in the reverse bias condition the voltage should never cross the breakdown voltage.

V-I Characteristics of SCR

It is the curve between anode-cathode voltage (V) and anode current (I) of an SCR at constant gate current. Fig. 4 shows the V-I characteristics of a typical SCR.

Forward characteristics.

When anode is positive w.r.t. cathode, the curve between V and I is called the forward characteristic. In Fig. 4, OABC is the forward characteristic of SCR at $I_G = 0$. If the supply voltage is increased from zero, a point is reached (point A) when the SCR starts conducting. Under this condition, the voltage across SCR suddenly drops as shown by dotted curve AB and most of supply voltage appears across the load resistance R_L . If proper gate current is made to flow, SCR can close at much smaller supply voltage.

Reverse characteristics.

When anode is negative w.r.t. cathode, the curve between V and I is known as reverse characteristic. The reverse voltage does come across SCR when it is operated with a.c. supply. If the reverse voltage is gradually increased, at first the anode current remains small (i.e. leakage current) and at some reverse voltage, avalanche breakdown occurs.

and the SCR starts conducting heavily in the reverse direction as shown by the curve DE. This maximum reverse voltage at which SCR starts conducting heavily is known as reverse breakdown voltage.

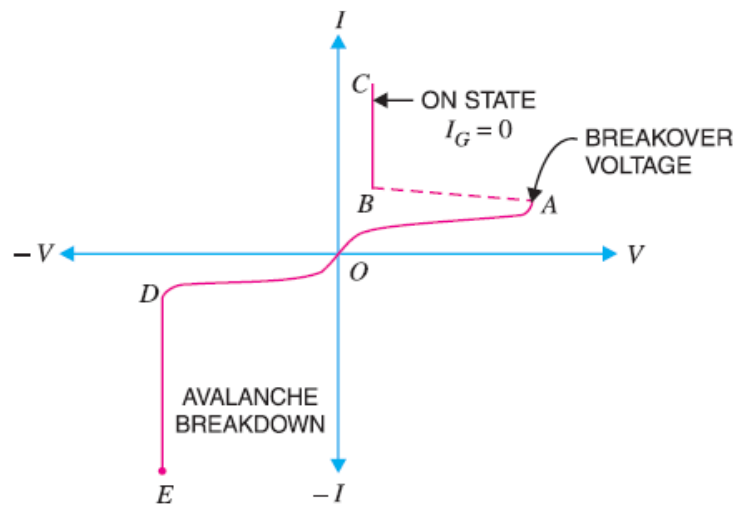


FIG:4 VI CHARACTERISTIC OF SCR

EQUIVALENT CIRCUIT OF SCR

The SCR shown in Fig. 20.4 (i) can be visualised as separated into two transistors as shown in

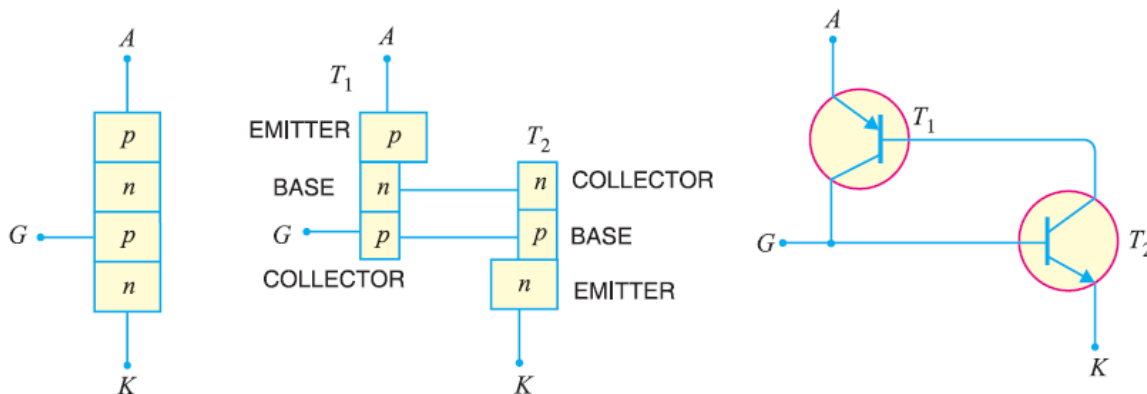


Fig 5

Fig. 5. Thus, the equivalent circuit of SCR is composed of pnp transistor and npn transistor connected as shown in Fig.5. It is clear that collector of each transistor is coupled to the base of the other, thereby making a positive feedback loop.

The working of SCR can be easily explained from its equivalent circuit. Fig. 6 shows the equivalent circuit of SCR with supply voltage V and load resistance RL . Assume the supply voltage V is less than break over voltage as is usually the case.

With gate open (*i.e.* switch S open), there is no base current in transistor T_2 . Therefore, no current flows in the collector of T_2 and hence that of T_1 . Under such conditions, the SCR is open. However, if switch S is closed, a small gate current will flow through the base of T_2 which means its collector current will increase.

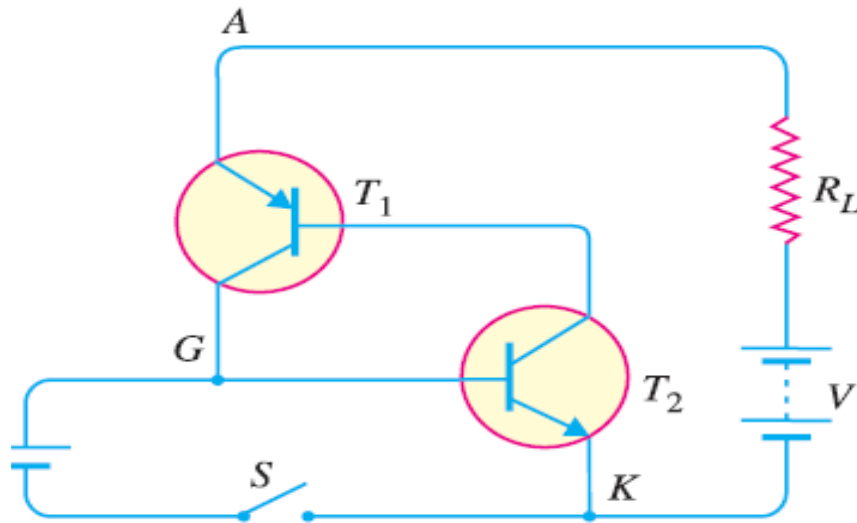


Fig 6

The collector current of T_2 is the base current of T_1 . Therefore, collector current of T_1 increases. But collector current of T_1 is the base current of T_2 . This action is accumulative since an increase of current in one transistor causes an increase of current in the other transistor. As a result of this action, both transistors are driven to saturation, and heavy current flows through the load R_L . Under such conditions, the SCR closes.

APPLICATIONS

silicon controlled rectifiers, SCRs are used in many areas of electronics where they find uses in a variety of different applications. Some of the more common applications for them are outlined below:

- AC power control (including lights, motors, etc).
- Overvoltage protection crowbar for power supplies.
- AC power switching.
- Control elements in phase angle triggered controllers.
- Within photographic flash lights where they act as the switch to discharge a stored voltage through the flash lamp, and then cut it off at the required time.

Thyristors are able to switch high voltages and withstand reverse voltages making them ideal for switching applications, especially within AC scenarios.

TRIAC

The major drawback of an SCR is that it can conduct current in one direction only. Therefore, an SCR can only control d.c. power or forward biased half-cycles of a.c. in a load. However, in an a.c. system, it is often desirable and necessary to exercise control over both positive and negative half-cycles. For this purpose, a semiconductor device called triac is used

A triac is a three-terminal semiconductor switching device which can control alternating current in a load. Triac is an abbreviation for triode a.c. switch. 'Tri'—indicates that the device has three terminals and 'ac' means that the device controls alternating current or can conduct current in either direction.

The key function of a triac may be understood by referring to the simplified Fig.7(i) . The control circuit of triac can be adjusted to pass the desired portions of positive and negative half cycle of a.c. supply through the load R_L . Thus referring to Fig. 7 (ii), the triac passes the positive half-cycle of the supply from θ_1 to 180° i.e. the shaded portion of positive half-cycle. Similarly, the shaded portion of negative half-cycle will pass through the load. In this way, the alternating current and hence a.c. power flowing through the load can be controlled

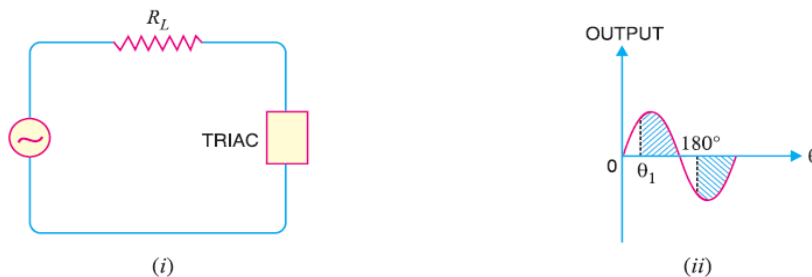


Fig 7

Since a triac can control conduction of both positive and negative half-cycles of a.c. supply, it is sometimes called a bidirectional semi-conductor triode switch. The above action of a triac is certainly not a rectifying action (as in an *SCR) so that the triac makes no mention of rectification in its name

Triac Construction

A triac is a three-terminal, five-layer semiconductor device whose forward and reverse characteristics are identical to the forward characteristics of the SCR. The three terminals are designated as main terminal MT1, main terminal MT2 and gate G.

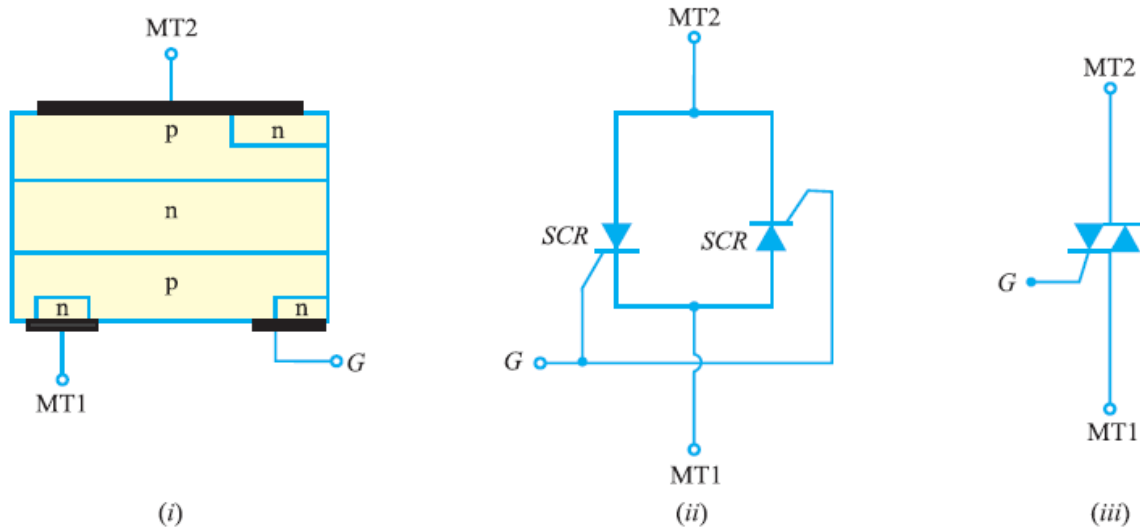


Fig 8

Fig. 8 (i) shows the basic structure of a triac. A triac is equivalent to two separate SCRs connected in inverse parallel (i.e. anode of each connected to the cathode of the other) with gates commoned as shown in Fig. 8 (ii).

Therefore, a triac acts like a bidirectional switch i.e. it can conduct current in either direction. This is unlike an SCR which can conduct current only in one direction. Fig. 8 (iii) shows the schematic symbol of a triac.

The symbol consists of two parallel diodes connected in opposite directions with a single gate lead. It can be seen that even the symbol of triac indicates that it can conduct current for either polarity of the main terminals (MT1 and MT2) i.e. it can act as a bidirectional switch. The gate provides control over conduction in either direction

Then a triac has four possible triggering modes of operation as follows.

- I + Mode = MT₂ current positive (+ve), Gate current positive (+ve)
- I – Mode = MT₂ current positive (+ve), Gate current negative (-ve)
- III + Mode = MT₂ current negative (-ve), Gate current positive (+ve)
- III – Mode = MT₂ current negative (-ve), Gate current negative (-ve)

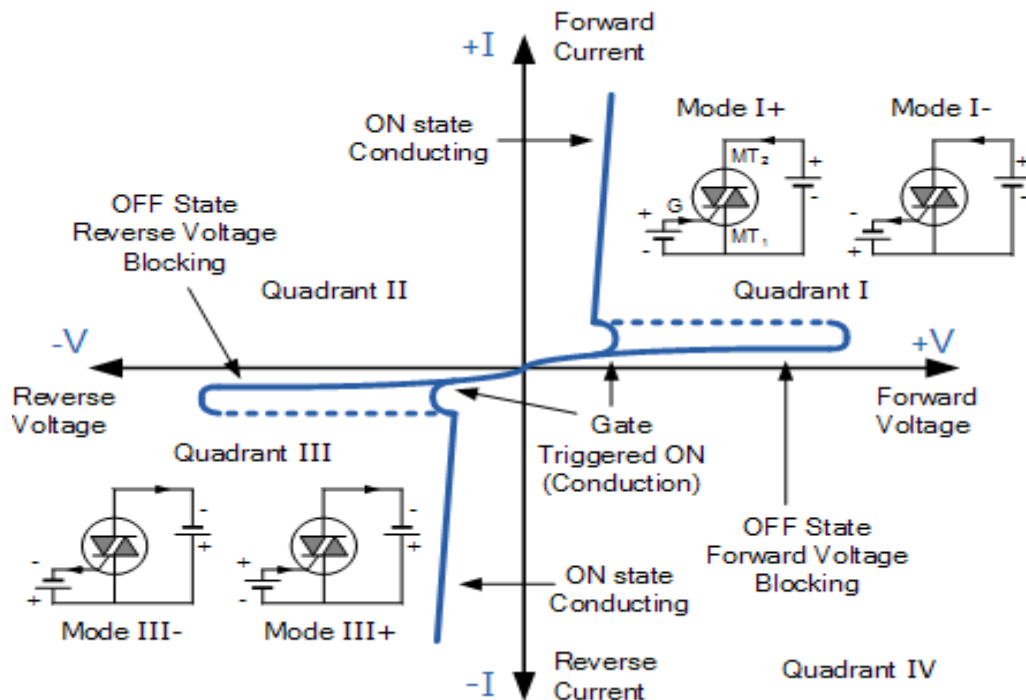


Fig 9 VI Characteristics of TRIAC

In Quadrant I, the triac is usually triggered into conduction by a positive gate current, labelled above as mode I+. But it can also be triggered by a negative gate current, mode I-. Similarly, in Quadrant III, triggering with a negative gate current, $-I_G$ is also common, mode III- along with mode III+. Modes I- and III+ are, however, less sensitive configurations requiring a greater gate current to cause triggering than the more common triac triggering modes of I+ and III-.

TRIAC OPERATION

Since a Triac is a bidirectional device and can have its terminals at various combinations of positive and negative voltages, there are four possible electrode potential combinations as given below

The triggering sensitivity is highest with the combinations 1 and 3 and are generally used. However, for bidirectional control and uniform gate trigger mode sometimes trigger modes 2 and 3 are used. Trigger mode 4 is usually averted. Fig 10 (a) and (b) explain the conduction mechanism of a triac in trigger modes 1 & 3 respectively.

In trigger mode-1 the gate current flows mainly through the $P_2 N_2$ junction like an ordinary thyristor. When the gate current has injected sufficient charge into P_2 layer the triac starts conducting through the $P_1 N_1 P_2 N_2$ layers like an ordinary thyristor.

In trigger mode-2 the junction $P_2 N_3$ is forward biased, thus the electron is injected from N_3 into P_2 . a current that flows in P_2 towards the N_3 gate and thus $P_1 N_1 P_2 N_3$ turns on as the gain of $N_3 P_2 N_1$ transistor raises. this supplies current to N_2 thus $P_1 N_1 P_2 N_2$ conducts.

In trigger mode-3 the gate current I_g forward biases the $P_2 P_3$ junction and a large number of electrons are introduced in the P_2 region by N_3 . Finally the structure $P_2 N_1 P_1 N_4$ turns on completely.

In trigger mode-4 junction $P_2 N_3$ is forward biased and the electron are injected from N_3 TO P_2 .the potential in N_1 decreases and holes are injected from p_2 to n_1 this turns on the SCR $P_2 N_1 P_1 N_4$

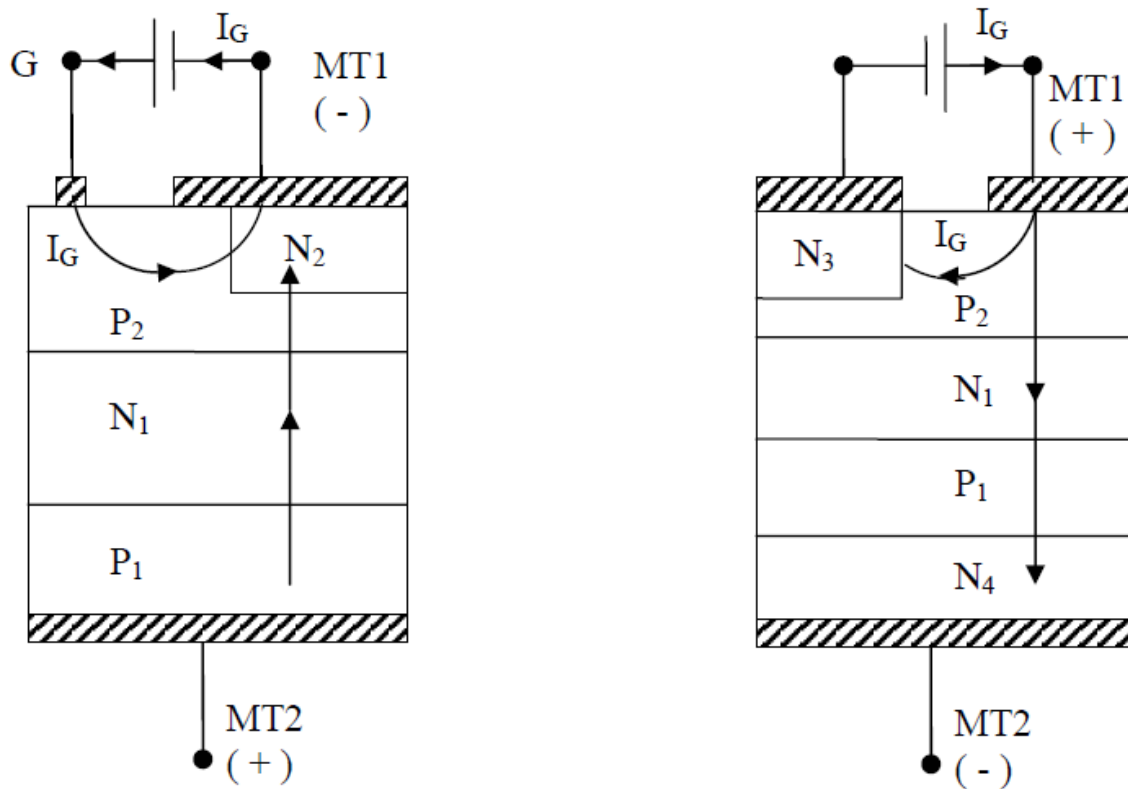


Fig 10

APPLICATIONS

The TRIAC as a bidirectional thyristor has various applications. Some of the popular applications of the

- (i) In speed control of single-phase ac series or universal motors.
- (ii) In food mixers and portable drills.
- (iii) In lamp dimming and heating control.
- (iv) In zero-voltage switched ac relay

(v) Triacs are extensively used at power frequency ac load (eg heater, light, motors) control applications.

DIAC (Diode for Alternating Current)

A diac is a two-terminal, three layer bidirectional device which can be switched from its OFF state to ON state for either polarity of applied voltage the diac can be constructed in either npn or pnp form. the DIAC is a diode that conducts electrical current only after its breakover voltage, V_{BO} ,

The DIAC is a five layers and contains two terminal, anode A1 (or main terminal MT1) and anode A2 (or main terminal MT2) like a TRIAC just without a gate terminal.

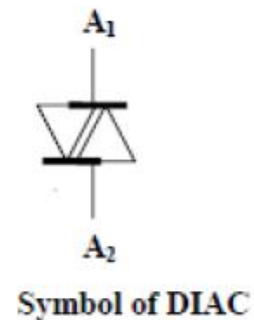
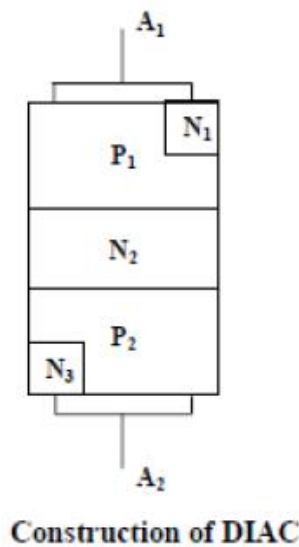


Fig 11

Fig. 11 shows the basic structure of a diac in pnp form. The two leads are connected to p-regions of silicon separated by an n-region. The structure of diac is very much similar to that of a transistor.

However, there are several important differences:

(i) There is no terminal attached to the base layer.

(ii) The three regions are nearly identical in size.

(iii) The doping concentrations are identical (unlike a bipolar transistor) to give the device symmetrical properties. Fig. 11(ii) shows the symbol of a diac

OPERATION.

When a positive or negative voltage is applied across the terminals of a diac, only a small leakage current I_{BO} will flow through the device. As the applied voltage is increased, the leakage current will continue to flow until the voltage reaches the breakover voltage V_{BO} . At this point, avalanche breakdown of the reverse-biased junction occurs and the device exhibits negative resistance i.e. current through the device increases with the decreasing values of applied voltage. The voltage across the device then drops to 'breakback' voltage V_W .

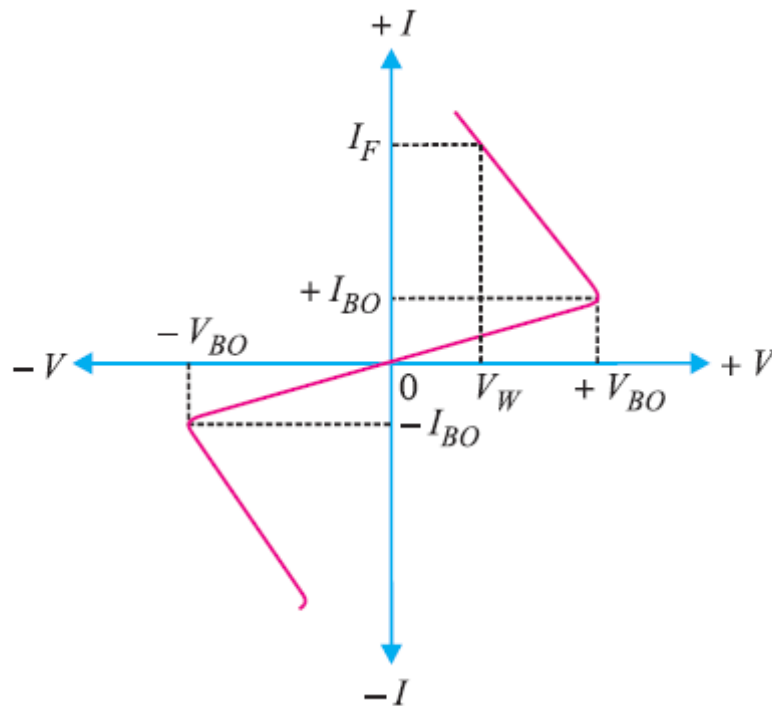


Fig 12

Fig. 12 shows the V-I characteristics of a diac. For applied positive voltage less than $+V_{BO}$ and negative voltage less than $-V_{BO}$, a small leakage current ($\pm I_{BO}$) flows through the device. Under such conditions, the diac blocks the flow of current and effectively behaves as an open circuit. The voltages $+V_{BO}$ and $-V_{BO}$ are the breakdown voltages and usually have a range of 30 to 50 volts. When the positive or negative applied voltage is equal to or greater than the breakdown voltage, diac begins to conduct and the voltage drop across it becomes a few volts. Conduction then continues until the device current drops below its holding current. Note that the breakover voltage and holding current values are identical for the forward and reverse regions of operation.

Diacs are used primarily for triggering of triacs in adjustable phase control of a.c. mains power. Some of the circuit applications of diac are

- (i) light dimming
- (ii) (ii) heat control and
- (iii) (iii) universal motor speed control.

UNI JUNCTION TRANSISTOR (UJT)

A unijunction transistor (abbreviated as UJT) is a three-terminal semiconductor switching device. This device has a unique characteristic that when it is triggered, the emitter current increases regeneratively until it is limited by emitter power supply. Due to this characteristic, the unijunction transistor can be employed in a variety of applications e.g., switching, pulse generator, saw-tooth generator etc

CONSTRUCTION.

Fig. 13 (i) shows the basic *structure of a unijunction transistor. It consists of an n-type silicon bar with an electrical connection on each end. The leads to these connections are called base leads base-one B1 and base two B2. Part way along the bar between the two bases, nearer to B2 than B1, a pn junction is formed between a p-type emitter and the bar. The lead to this junction is called the emitter lead E.

Fig. 13 (ii) shows the symbol of unijunction transistor. Note that emitter is shown closer to B2 than B1.

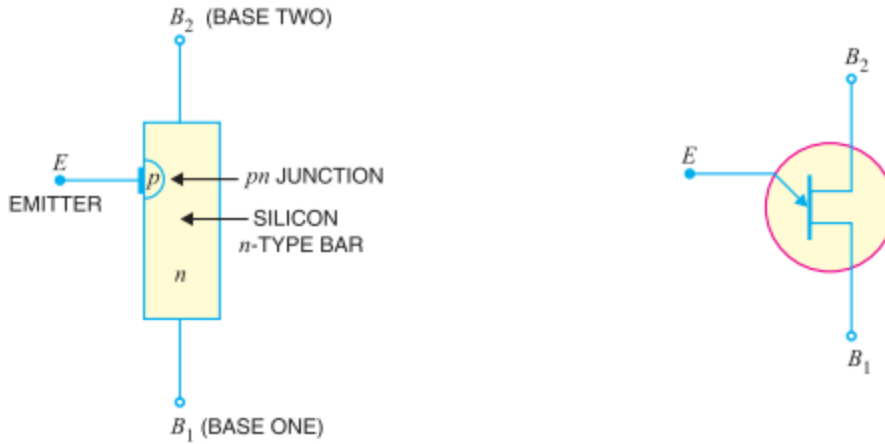


FIG13

(i) Since the device has one pn junction and three leads, it is commonly called a unijunction transistor (uni means single).

(ii) With only one pn-junction, the device is really a form of diode. Because the two base terminals are taken from one section of the diode, this device is also called double-based diode.

(iii) The emitter is heavily doped having many holes. The n region, however, is lightly doped. For this reason, the resistance between the base terminals is very high (5 to 10 kΩ) when emitter lead is open.

OPERATION.

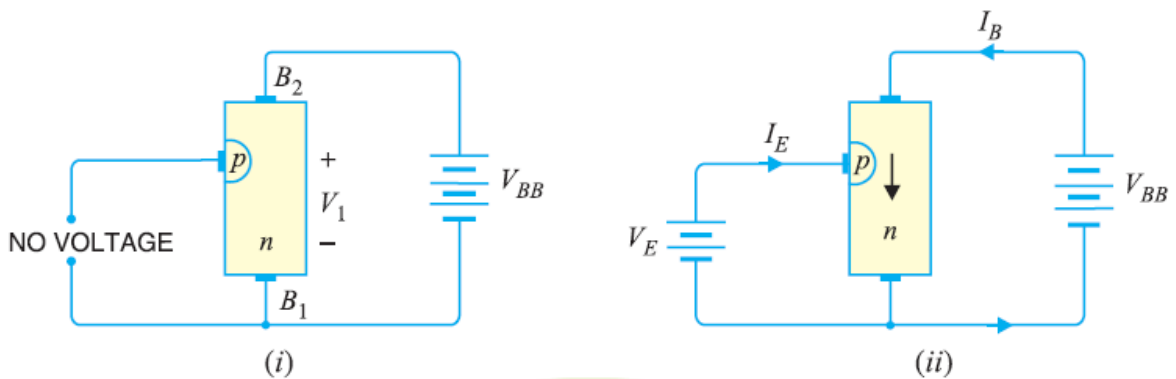


FIG 14

Fig. 14 shows the basic circuit operation of a unijunction transistor.

The device has normally B2 positive w.r.t. B1.

(i) If voltage V_{BB} is applied between B2 and B1 with emitter open [See Fig. 14 (i)], a voltage gradient is established along the n-type bar. Since the emitter is located nearer to B2, more than half of V_{BB} appears between the emitter and B1. The voltage V_1 between emitter and B1 establishes a reverse bias on the pn junction and the emitter current is cut off. Of course, a small leakage current flows from B2 to emitter due to minority carriers.

(ii) If a positive voltage is applied at the emitter [See Fig. 14 (ii)], the pn junction will remain reverse biased so long as the input voltage is less than V_1 . If the input voltage to the emitter exceeds V_1 , the pn junction becomes forward biased. Under these conditions, holes are injected from p-type material into the n-type bar. These holes are repelled by positive B2 terminal and they are attracted towards B1 terminal of the bar. This accumulation of holes in the emitter to B1 region results in the decrease of resistance in this section of the bar. The result is that internal voltage drop from emitter to B1 is decreased and hence the emitter current I_E increases. As more holes are injected, a condition of saturation will eventually be reached. At this point, the emitter current is limited by emitter power supply only. The device is now in the ON state.

(iii) If a negative pulse is applied to the emitter, the pn junction is reverse biased and the emitter current is cut off. The device is then said to be in the OFF state.

CHARACTERISTICS OF UJT

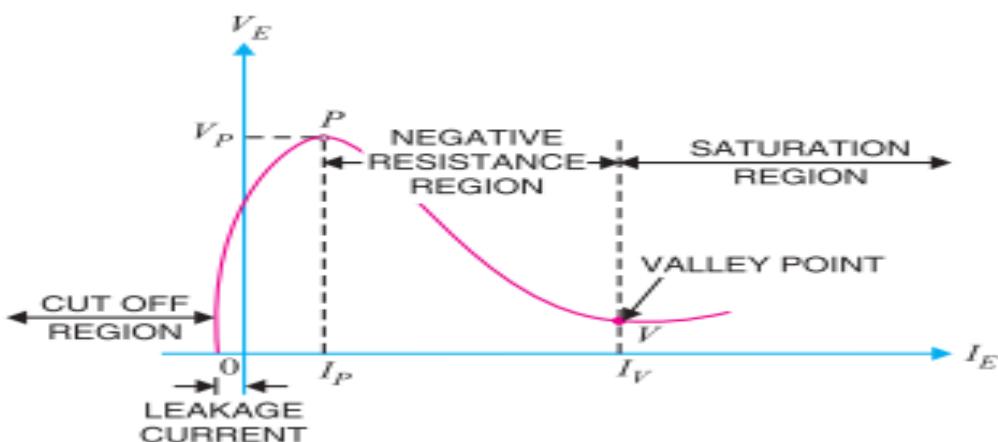


Fig 15

Fig. 15 shows the curve between emitter voltage (V_E) and emitter current (I_E) of a UJT at a given voltage V_{BB} between the bases. This is known as the emitter characteristic of UJT. The following points may be noted from the characteristics :

(i) Initially, in the cut-off region, as V_E increases from zero, slight leakage current flows from terminal B2 to the emitter. This current is due to the minority carriers in the reverse biased diode.

(ii) Above a certain value of V_E , forward I_E begins to flow, increasing until the peak voltage V_P and current I_P are reached at point P.

(iii) After the peak point P, an attempt to increase V_E is followed by a sudden increase in emitter current I_E with a corresponding decrease in V_E . This is a negative resistance portion of the curve because with increase in I_E , V_E decreases. The device, therefore, has a negative resistance region which is stable enough to be used with a great deal of reliability in many areas e.g., trigger circuits, sawtooth generators, timing circuits

ADVANTAGES OF UJT

The UJT was introduced in 1948 but did not become commercially available until 1952. Since then, the device has achieved great popularity due to the following reasons :

- (i) It is a low cost device.
- (ii) It has excellent characteristics.
- (iii) It is a low-power absorbing device under normal operating conditions.

APPLICATIONS OF UJT

Due to above reasons, this device is being used in a variety of applications. A few include oscillators, trigger circuits, saw-tooth generators, bistable network etc.

The UJT is very popular today mainly due to its high switching speed.

A few select applications of the UJT are as follows:

- (i) It is used to trigger SCRs and TRIACs
- (ii) It is used in non-sinusoidal oscillators
- (iii) It is used in phase control and timing circuits
- (iv) It is used in saw tooth generators
- (v) It is used in oscillator circuit design

SCHOTTKY BARRIER DIODE

Schottky Diode:

It is also called Schottky barrier diode or hot-carrier diode.

A Schottky barrier diode is a metal semiconductor junction formed by bringing metal in contact with a moderately doped n type semiconductor material. A Schottky barrier diode is also called as known as Schottky or hot carrier diode. It is named after its inventor Walter H. Schottky, barrier stands for the potential energy barrier for electrons at the junction. It is a unilateral device conducting currents in one direction (Conventional current flow from metal to semiconductor) and restricting in the other.

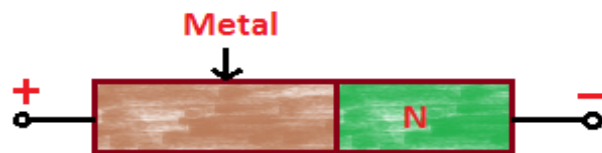


Fig.16

- The charge storage problem of P-N junction can be minimize or limited in schottky diodes.
- The potential barrier is set with a contact between a metal & semiconductor.
- The rectifying action is depends on majority carrier only.
- As the result there are is o excess minority carrier to recombination hence low level of reverse recovery time.
- These diodes are used as rectifier at a single frequency exceeding 300 MHz to 20 GHz.

CONSTRUCTION SCHOTTKY BARRIER DIODE:

A Schottky barrier diode is shown in the figure 17

A metal–semiconductor junction is formed between a metal and a semiconductor, creating a Schottky barrier (instead of a semiconductor–semiconductor junction as in conventional diodes). Typical metals used are molybdenum, platinum, chromium or

tungsten, and certain silicides, e.g. palladium silicide and platinum silicide; and the semiconductor would typically be n-type silicon.

The metal side acts as the anode and n-type semiconductor acts as the cathode of the diode. This Schottky barrier results in both very fast switching and low forward voltage drop.

The choice of the combination of the metal and semiconductor determines the forward voltage of the diode. Both n- and p-type semiconductors can develop Schottky barriers; the p-type typically has a much lower forward voltage.

As the reverse leakage current increases dramatically with lowering the forward voltage, it can not be too low; the usually employed range is about 0.5–0.7 V and p-type semiconductors are employed only rarely.

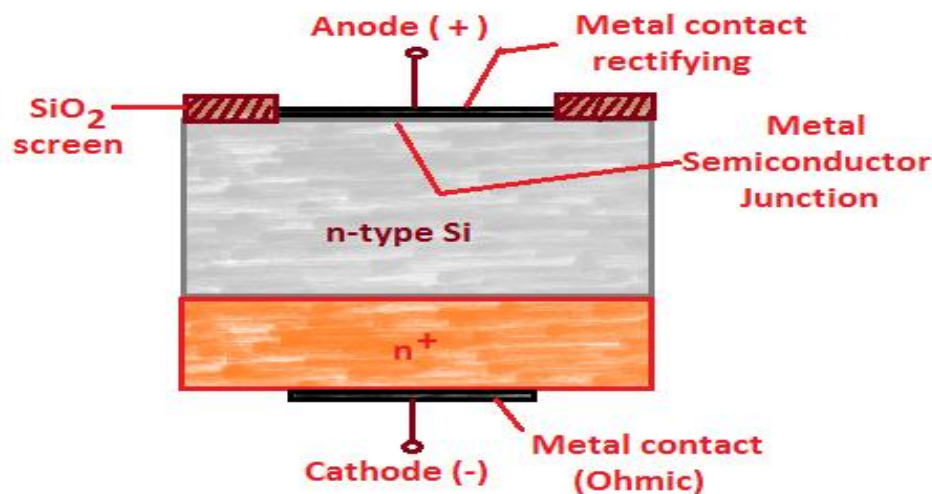


Fig 17

Schottky barrier diode is an extension of the oldest semiconductor device that is the point contact diode. Here, the metal-semiconductor interface is a surface, Schottky barrier rather than a point contact. The Schottky diode is formed when a metal, such as Aluminium, is brought into contact with a moderately doped N-type semiconductor as shown on fig. It is a unipolar device because it has electrons as majority carriers on both sides of the junction. Hence, there is no depletion layer formed near the junction. It shares the advantage of point contact diode in that there is no significant current from the metal to the semiconductor with reverse bias. Thus, the delay present in the junction diodes due to hole-electron recombination time is absent here. Hence, because of the large contact area between the metal and semiconductor than in the point contact diode, the forward resistance is lower and so is noise.

Below certain width the charge carriers can tunnel through the depletion region. At very high doping levels the junction does not behave as a rectifier anymore and becomes an ohmic contact. This can be used for simultaneous formation of ohmic.

The forward current is dominated by electron flow from semiconductor to metal and the reverse is mainly due to electron from metal to semiconductor. As there is very little minority carrier injection from semiconductor into metal, Schottky diodes are also said to be majority carrier devices. The diode is also referred to as hot carrier diode because when it is forward biased, conduction of electrons on the N-side gains sufficient energy to cross the junction and enter the metal. Since these electrons plunge into the metal with large energy, they are commonly called as hot carriers.

- Operation is due to the fact that the electrons in different material have different potential energy.
- N type semiconductors have higher potential energy as compare to electrons of metals.
- When these two are brought together in contact, there a flow of electron in both direction across the metal-semiconductor interface when contact is first made.
- A voltage is applied to the schottky diode such that the metal is positive with respect to semiconductor.
- The voltage will oppose the built in potential and makes it easier to current flow.

CHARACTERISTICS OF SCHOTTKY DIODE

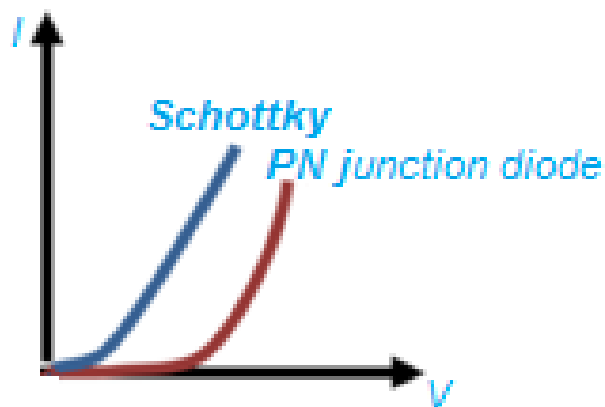


FIG .18

Above figure shows the V-I characteristics of a Schottky and a PN junction diode. The current in a PN junction diode is controlled by the diffusion of minority carriers whereas the current in the schottky diode results from the flow of majority carriers over the potential barrier at the metal-semiconductor junction. The reverse saturation current for a Schottky diode is larger than that of a PN junction diode. The storage time for a Schottky diode is theoretically zero. The schottky diode has a smaller turn-on voltage and shorter switching time than the PN junction diode.

ADVANTAGES :

- Schottky diode turns on and off faster than ordinary P-N junction diode the basic reason behind this is that schottky diodes are based on majority carrier.
- As there is no minority carrier there is no worry about depletion layer.

It has much less voltage overshoot

APPLICATIONS SCHOTTKY BARRIER DIODE:

- Schottky diode can be used for rectification of signals of frequencies even exceeding 300 MHz.
- It is commonly used in switching power supplies at frequencies of 20 GHz
- Its low noise figure finds application in sensitive communication receivers likeradars.
- It is also used in clipping and clamping circuits and in computer gating.
- Schottky barrier diodes are used in bipolar transistor TTL based **74LS (low power Schottky)** and **74S (Schottky)** families of logic circuits . The Schottky diode by preventing the BJT going into hard saturation reduces the switching time of BJT from saturation to cut off.
- Schottky diodes are often used as ant saturation clamps on transistors.
- They play an important role in GaAs circuits.
- They are used as rectifiers in high power applications circuits.
- Schottky Barrier Diodes are used in voltage clamping applications.
- Schottky Barrier Diodes are used in stand-alone photo voltaic systems
- They are used in radio frequency applications as mixer (or) detector diode

VARACTOR DIODE

The varactor diode was named because of the variable reactor or variable reactance or variable capacitor or variable capacitance property of these diodes. A varactor diode is considered as a special type of diode that is widely used in the electronics industry and is used in various electronics applications. Varactor diode is also a semiconductor microwave solid-state device, it is frequently used in applications where variable capacitance is desired which can be achieved by controlling voltage.

Varactor diodes are also termed as varicap diodes, in fact, these days they are usually termed as varactor diodes. Even though the variable capacitance effect can be exhibited by the normal diodes (P-N junction diodes), but, varactor diodes are preferred for giving the desired capacitance changes as they are special types of diodes. These diodes are specially manufactured and optimized such that they enables a very high range of changes in capacitance. Varactor diodes are again classified into various types based on the varactor diode junction properties. And, these are termed as abrupt varactor diodes, gallium-arsenide varactor diodes, and hyperabrupt varactor diodes.

The symbol of varactor diode is shown in the Fig 19

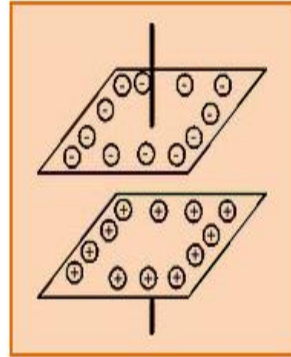


Fig 19

The varactor diode symbol consists of the capacitor symbol at one end of the diode that represents the variable capacitor characteristics of the varactor diodes. In general, it looks like a normal PN-junction diode in which one terminal is termed as the cathode and the other terminal is termed as anode. Here, varactor diode consists of two lines at one end (cathode end of normal diode) that indicates the capacitor symbol.

VARACTOR DIODE WORKING

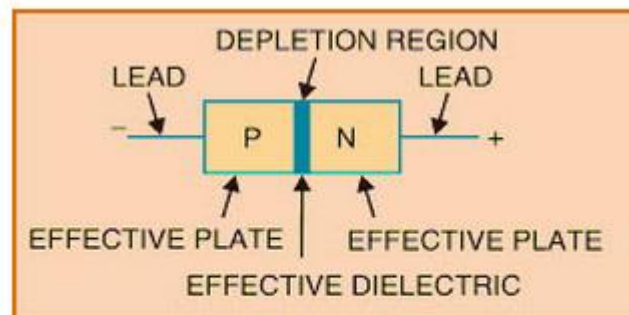
To understand the working principle of the varactor diode, we must know what is a capacitor and how can we change the capacitance. Let us consider the capacitor that consists of two plates separated by an insulating dielectric as shown in the figure 20.



Capacitor

Fig 20

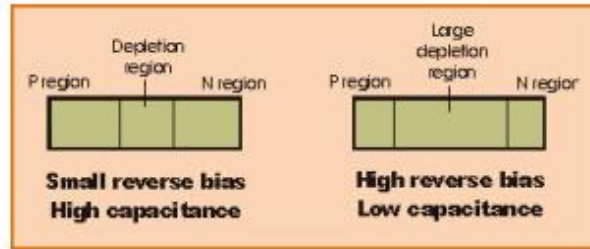
We know that the capacitance of an electrical capacitor is directly proportional to the area of the plates, as the area of the plates increases the capacitance of the capacitor increases. Consider the reverse biased mode of the diode, in which P-type region and N-type region are able to conduct and thus can be treated as two plates. The depletion region between the P-type and N-type regions can be considered as insulating dielectric. Thus, it is exactly similar to the capacitor shown above.



Varactor Diode with P-N Junction and Depletion Region

Fig 21

The size of the depletion region of diode changes with change in reverse bias. If the varactor diode reverse voltage is increased, then the depletion region size increases. Similarly, if the varactor diode reverse voltage is decreased, then the depletion region size decreases or narrows. Hence, by varying the reverse bias of the varactor diode the capacitance can be varied



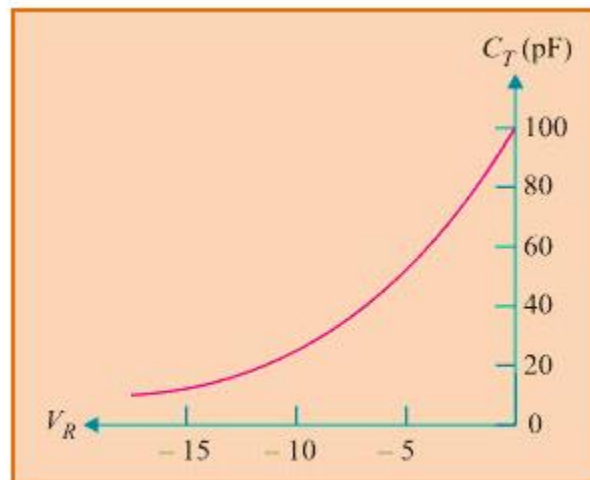
Variation of Capacitance with Variation in Depletion Region of Varactor Diode

Fig 22

VARACTOR DIODE CHARACTERISTICS

The varactor diodes have the following significant characteristics:

- Varactor diodes produce considerably less noise compared to other conventional diodes.
- These diodes are available at low costs.
- Varactor diodes are more reliable.
- The varactor diodes are small in size and hence, they are very light weight.
- There is no useful purpose of varactor diode operated when it is operated in forward bias.
- Increase in reverse bias of varactor diode increases the capacitance as shown in the figure below.



Characteristics of Varactor Diode

Fig 23

APPLICATIONS

Few important applications of varactor diodes can be listed as follows:

- **RF Filters**
- Voltage Controlled Oscillators (VCOs)
- Varactor diodes can be used as frequency modulators.
- In microwave receiver LO, varactor diodes can be used as frequency multipliers.
- Varactor diodes can be used as RF phase shifters.
- Varactor diodes are used to vary the capacitance in variable resonant tank LC circuits. Since the junction capacitance of a varactor is in the pF range, it is suitable for use in highfrequency circuits.
- automatic frequency control device,
- FM modulator,
- adjustable band-pass filter
- Parametric amplifier

TUNNEL DIODE

This diode was first introduced by Dr. Leo Esaki in 1958.

A tunnel diode is a pn junction that exhibits negative resistance between two values of forward voltage (i.e., between peak-point voltage and valley-point voltage).

A conventional diode exhibits *positive resistance when it is forward biased or reverse biased. However, if a semiconductor junction diode is heavily doped with impurities, it exhibits negative resistance (i.e. current decreases as the voltage is increased) in certain regions in the forward direction. Such a diode is called tunnel diode

CONSTRUCTION

It is a high-conductivity two-terminal P-N junction diode having doping density about 1000 times higher as compared to an ordinary junction diode. This heavy doping produces following three unusual effects :

Firstly, it reduces the width of the depletion layer to an extremely small value (about 0.00001 mm).

Secondly, it reduces the reverse breakdown voltage to a very small value (approaching zero) with the result that the diode appears to be broken down for any reverse voltage.

Thirdly, it produces a negative resistance section on the V/I characteristic of the diode. It is called a tunnel diode because due to its extremely thin depletion layer, electrons are able to tunnel through the potential barrier at relatively low forward bias voltage (less than 0.05 V).

Such diodes are usually fabricated from germanium, gallium-arsenide (GaAs) and gallium antimonide (GaSb). The commonly-used schematic symbols for the diode are shown in fig 23. It should be handled with caution because being a low-power device, it can be easily damaged by heat and static electricity.

THEORY.

The tunnel diode is basically a pn junction with heavy doping of p-type and n-type semiconductor materials. In fact, a tunnel diode is doped approximately 1000 times as heavily as a conventional diode. This heavy doping results in a large number of majority carriers. Because of the large number of carriers, most are not used during the initial recombination that produces the depletion layer. As a result, the depletion layer is very narrow. In comparison with conventional diode, the depletion layer of a tunnel diode is 100 times narrower. The operation of a tunnel diode depends upon the tunneling effect and hence the name.

Tunneling effect. The heavy doping provides a large number of majority carriers. Because of the large number of carriers, there is much drift activity in p and n sections. This causes many valence electrons to have their energy levels raised closer to the conduction region. Therefore, it takes only a very small applied forward voltage to cause conduction.

The movement of valence electrons from the valence energy band to the conduction band with little or no applied forward voltage is called tunneling. Valence electrons seem to tunnel through the forbidden energy band.

As the forward voltage is first increased, the diode current rises rapidly due to tunneling effect. Soon the tunneling effect is reduced and current flow starts to decrease as the forward voltage across the diode is increased. The tunnel diode is said to have entered the negative resistance region. As the voltage is further increased, the tunneling effect plays less and less part until a valley-point is reached. From now onwards, the tunnel diode behaves as ordinary diode i.e., diode current increases with the increase in forward voltage.

V-I CHARACTERISTIC.

shows the V-I characteristic of a typical tunnel diode.

As the forward voltage across the tunnel diode is increased from zero, electrons from the n-region “tunnel” through the potential barrier to the p-region. As the forward voltage increases, the diode current also increases until the peak-point P is reached. The diode current has now reached peak current I_P (= 2.2 mA) at about peak-point voltage V_P (= 0.07 V). Until now the diode has exhibited positive resistance. (ii) As the voltage is

increased beyond V_P , the tunneling action starts decreasing and the diode current decreases as the forward voltage is increased until valley-point V is reached at valley-point voltage $V_V (= 0.7V)$. In the region between peak-point and valley-point (i.e., between points P and V), the diode exhibits negative resistance i.e., as the forward bias is increased, the current decreases. This suggests that tunnel diode, when operated in the negative resistance region, can be used as an oscillator or a switch.

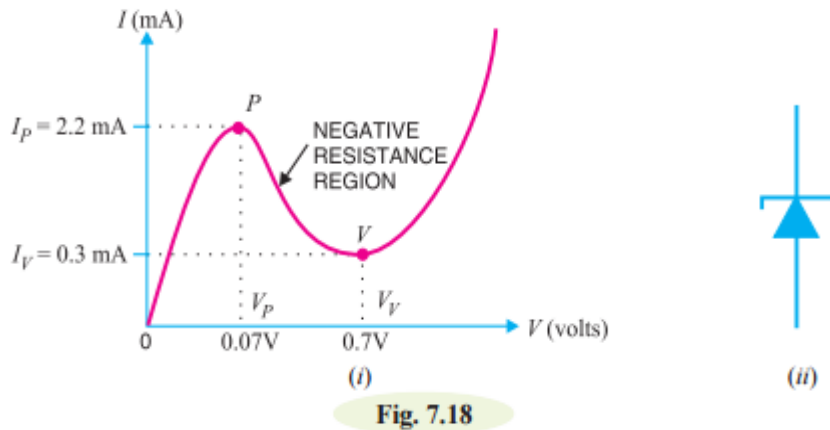


Fig 24

(iii) When forward bias is increased beyond valley-point voltage $V_V (= 0.7 V)$, the tunnel diode behaves as a normal diode. In other words, from point V onwards, the diode current increases with the increase in forward voltage i.e., the diode exhibits positive resistance once again. It may be noted that a tunnel diode has a high reverse current but operation under this condition is not generally used.

Tunneling Effect

In a normally-doped P-N junction, the depletion layer is relatively wide and a potential barrier exists across the junction. The charge carriers on either side of the junction cannot cross over unless they possess sufficient energy to overcome this barrier (0.3 V for Ge and 0.7 V for Si). As is well-known, width of the depletion region depends directly on the doping density of the semiconductor. If a P-N junction is doped very heavily (1000 times or more)*, its depletion layer becomes extremely thin (about 0.00001 mm). It is found that under such conditions, many carriers can 'punch through' the junction with the speed of light even when they do not possess enough energy to overcome the potential barrier. Consequently, large forward current is produced even when the applied bias is much less than 0.3 V. This conduction mechanism in which charge carriers (possessing very little energy) bore through a barrier directly instead of climbing over it is called tunneling

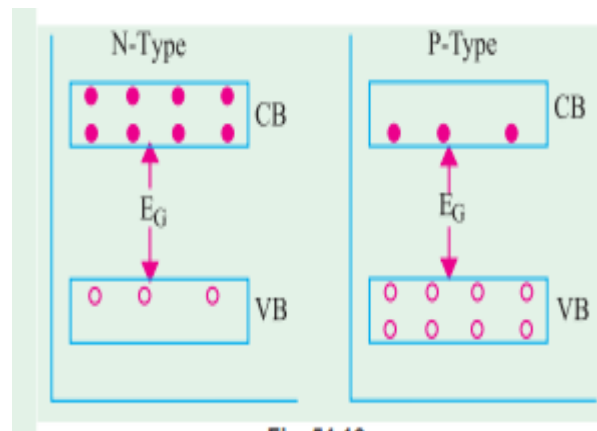
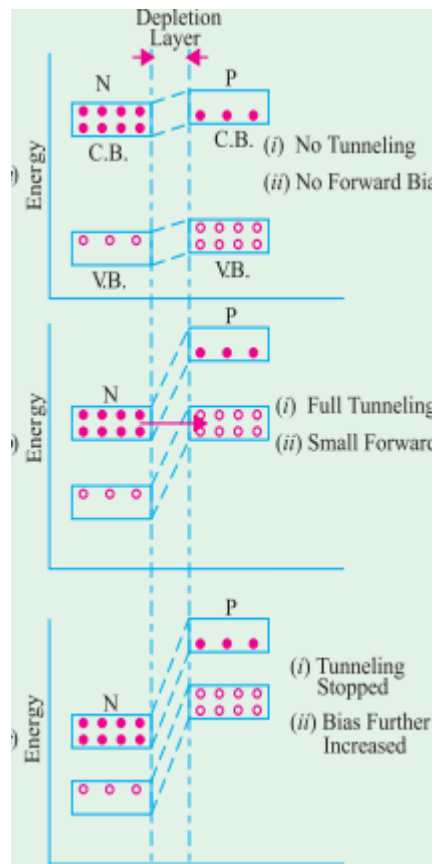


Fig 25

EXPLANATION

Energy band diagrams (EBD) of N-type and P-type semiconductor materials can be used to explain this tunneling phenomenon. Fig. 54.16 shows the energy band diagram of the two types of silicon separately. As explained earlier (Art. 51.21), in the N-type semiconductor, there is increased concentration of electrons in the conduction band. It would be further increased under heavy doping. Similarly, in a P-type material, there is increased concentration of holes in the valence band for similar reasons. (a) No Forward Bias When the N-type and P-type materials are joined, the EBD under no-bias condition becomes as shown in Fig. 24(a).

The junction barrier produces only a rough alignment of the two materials and their respective valence and conduction bands. As seen, the depletion region between the two is extremely narrow due to very heavy doping on both sides of the junction. The potential hill is also increased as shown.

(b) Small Forward Bias When a very small forward voltage ($\cong 0.1$ V) is applied, the EBDs become as shown in Fig. 54.17 (b). Due to the downward movement of the N-region, the P-region valence band becomes exactly aligned with the N-region

conduction band. At this stage, electrons tunnel through the thin depletion layer with the velocity of light thereby giving rise to a large current called peak current I_p .

(c) Large Forward Bias When the forward bias is increased further, the two bands get out of alignment as shown in Fig. 24(c). Hence, tunneling of electrons stops thereby decreasing the current. Since current decreases with increase in applied voltage (i.e. dV/dI is negative), the junction is said to possess negative resistance at this stage. This resistance increases throughout the negative region. However, it is found that when applied forward voltage is increased still further, the current starts increasing once again as in a normal junction diode.

APPLICATIONS

Tunnel diode is commonly used for the following purposes :

1. as an ultrahigh-speed switch-due to tunneling mechanism which essentially takes place at the speed of light. It has a switching time of the order of nanoseconds or even picoseconds;

2. as logic memory storage device – due to triple-valued feature of its curve for current.

3. as microwave oscillator at a frequency of about 10 GHz – due to its extremely small capacitance and inductance and negative resistance.

4. in relaxation oscillator circuits – due to its negative resistance. In this respect, it is very similar to the unijunction transistor.

ADVANTAGES AND DISADVANTAGES

The advantages of a tunnel diode are :

1. low noise,
2. ease of operation,
3. high speed,
4. low power,
5. Insensitivity to nuclear radiations T

The disadvantages are

- : 1. the voltage range over which it can be operated properly is 1 V or less;
2. being a two-terminal device, it provides no isolation between the input and output circuits

PIN diode

A **PIN diode** is a diode with a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.

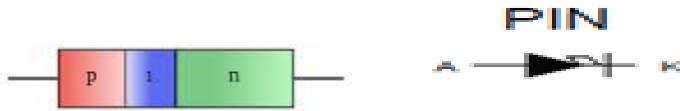


Fig 26

the PIN diode consists of a semiconductor diode with three layers. The usual P and N regions are present, but between them is a layer of intrinsic material a very low level of doping. This may be either N-type or P-type,

The thickness of the intrinsic layer is normally very narrow, typically ranging from 10 to 200 microns. The outer P and N-type regions are then heavily doped

here is very lightly doped wide region between P and N regions. Wide I – region makes them inefficient rectifiers. Under zero or Reverse Bias PIN diode has low capacitance so high resistance to RF signal. Under FB a typical PIN diode will have very low resistance (typical 1 Ω) an RF conductor. It makes a good RF switch

The PIN diode has heavily doped p-type and n-type regions separated by an intrinsic region. When reverse biased, it acts like an almost constant capacitance and when forward biased it behaves as a variable resistor.

The built in field stretches over the intrinsic region, causing minority carriers to be swept out by the field over a larger volume. It is often used for light detectors, and some high efficiency solar cells.

The capacitance between the P and N region decreases because of the increased separation between P and N region. This advantage allows the PIN diode to have fast response time. Hence these diodes are useful at very high frequencies (above 300MHz)

There is a greater electron hole pair generation because of the increased electric field between the P and N region. This advantage allows the PIN diode to process even the weak signal

OPERATION

When P n region is unbiased (no voltage is applied across the diode) there is a diffusion of electron and holes across the junction due to the different concentration of atoms in the P I N region

The diffusion of electrons and holes produce a depletion layer across the P I and N I junction as shown in Fig.7-21(b). The depletion layer penetrates to a little distance in the P -type and N -type semiconductor regions but to a larger distance in the I-region. Under such condition, the device has a high value of resistance.

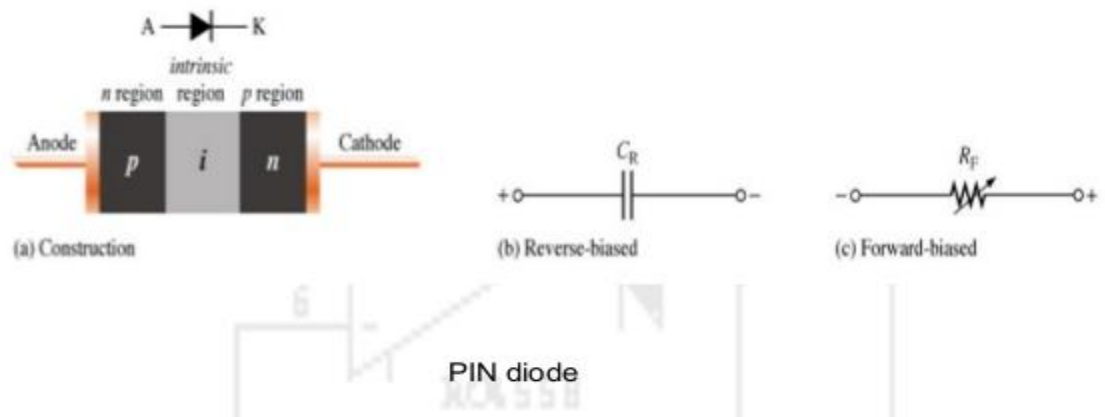


Fig 27

When the PIN diode is forward biased, the width of the depletion layer decreases. As a result of this, more carriers are injected into the I-region. This reduces the resistance of the I-region. If the depletion layer is not thick, then the I-region becomes flooded with the carriers at a suitable bias. Thus, when a PIN diode is forward biased, it acts like a variable resistance as shown in Fig 27. The forward resistance of an intrinsic region decreases with the increasing current.

On the other, when the PIN diode is reverse biased, the depletion layers become thicker. As the reverse bias is increased, the thickness of the depletion layer increases till the I-region becomes free of mobile carriers. The reverse bias, at which this happens, is called swept out voltage. At this stage the PIN diode acts like an almost constant capacitance as shown in Fig. 27

APPLICATION

The PIN diode is used in a number of areas as a result of its structure providing some properties which are of particular use.

- **High voltage rectifier:** The PIN diode can be used as a high voltage rectifier. The intrinsic region provides a greater separation between the P and N regions, allowing higher reverse voltages to be tolerated.
- **RF switch:** The PIN diode makes an ideal RF switch. The intrinsic layer between the P and N regions increases the distance between them. This also decreases the capacitance between them, thereby increasing the level of isolation when the diode is reverse biased.
- **Photodetector:** As the conversion of light into current takes place within the depletion region of a photodiode, increasing the depletion region by adding the intrinsic layer improves the performance by increasing the volume in which light conversion occurs.

These are three of the main applications for PIN diodes, although they can also be used in some other areas as well

GUNN DIODE

Gunn diode basics

The Gunn diode is a unique component - even though it is called a diode, it does not contain a PN diode junction. The Gunn diode or transferred electron device can be termed a diode because it does have two electrodes. It depends upon the bulk material properties rather than that of a PN junction. The Gunn diode operation depends on the fact that it has a voltage controlled negative resistance.

GUNN DIODE SYMBOL

The Gunn diode symbol used in circuit diagrams varies. Often a standard diode is seen in the diagram, however this form of Gunn diode symbol does not indicate the fact that the Gunn diode is not a PN junction. Instead another symbol showing two filled in triangles with points touching is used as shown below.



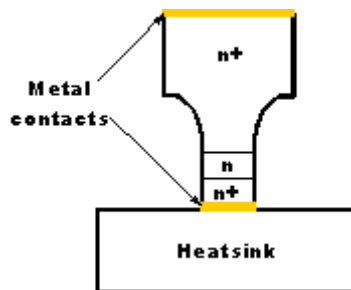
Fig 28

GUNN DIODE CONSTRUCTION

Gunn diodes are fabricated from a single piece of n-type semiconductor. The most common materials are gallium Arsenide, GaAs and Indium Phosphide, InP. However other materials including Ge, CdTe, InAs, InSb, ZnSe and others have been used. The device is simply an n-type bar with n+ contacts. It is necessary to use n-type material because the transferred electron effect is only applicable to electrons and not holes found in a p-type material.

Within the device there are three main areas, which can be roughly termed the top, middle and bottom areas.

The most common method of manufacturing a Gunn diode is to grow and epitaxial layer on a degenerate n+ substrate. The active region is between a few microns and a few hundred micron thick. This active layer has a doping level between 10^{14}cm^{-3} and 10^{16}cm^{-3} - this is considerably less than that used for the top and bottom areas of the device. The thickness will vary according to the frequency required



A discrete Gunn diode with the active layer mounted onto a heatsink for efficient heat transfer

. Fig 29

The top n+ layer can be deposited epitaxially or doped using ion implantation. Both top and bottom areas of the device are heavily doped to give n+ material. This provides the required high conductivity areas that are needed for the connections to the device.

Devices are normally mounted on a conducting base to which a wire connection is made. The base also acts as a heat sink which is critical for the removal of heat. The connection to the other terminal of the diode is made via a gold connection deposited onto the top surface. Gold is required because of its relative stability and high conductivity.

During manufacture there are a number of mandatory requirements for the devices to be successful - the material must be defect free and it must also have a very uniform level of doping.

For the construction of these diodes, only N-type material is used, which is due to the transferred electron effect applicable only to N-type materials and is not applicable to the P-type materials. The frequency can be varied by varying the thickness of the active layer while doping

GUNN DIODE'S WORKING

This diode is made of a single piece of N-type semiconductor such as Gallium Arsenide and InP (Indium Phosphide). GaAs and some other semiconductor materials have one extra-energy band in their electronic band structure instead of having only two energy bands, viz. valence band and conduction band like normal semiconductor materials. These GaAs and some other semiconductor materials consist of three energy bands, and this extra third band is empty at initial stage.

If a voltage is applied to this device, then most of the applied voltage appears across the active region. The electrons from the conduction band having negligible electrical resistivity are transferred into the third band because these electrons are scattered by the applied voltage. The third band of GaAs has mobility which is less than that of the conduction band.

Because of this, an increase in the forward voltage increases the field strength (for field strengths where applied voltage is greater than the threshold voltage value), then the number of electrons reaching the state at which the effective mass increases by decreasing their velocity, and thus, the current will decrease.

Thus, if the field strength is increased, then the drift velocity will decrease; this creates a negative incremental resistance region in V-I relationship. Thus, increase in the voltage will increase the resistance by creating a slice at the cathode and reaches the anode. But, to maintain a constant voltage, a new slice is created at the cathode. Similarly, if the voltage decreases, then the resistance will decrease by extinguishing any existing slice.

GUNN DIODE'S CHARACTERISTICS

The current-voltage relationship characteristics of a Gunn diode are shown in the above graph with its negative resistance region. These characteristics are similar to the characteristics of the tunnel diode.

As shown in the above graph, initially the current starts increasing in this diode, but after reaching a certain voltage level (at a specified voltage value called as threshold voltage

value), the current decreases before increasing again. The region where the current falls is termed as a negative resistance region, and due to this it oscillates. In this negative resistance region, this diode acts as both oscillator and amplifier, as in this region, the diode is enabled to amplify signals.

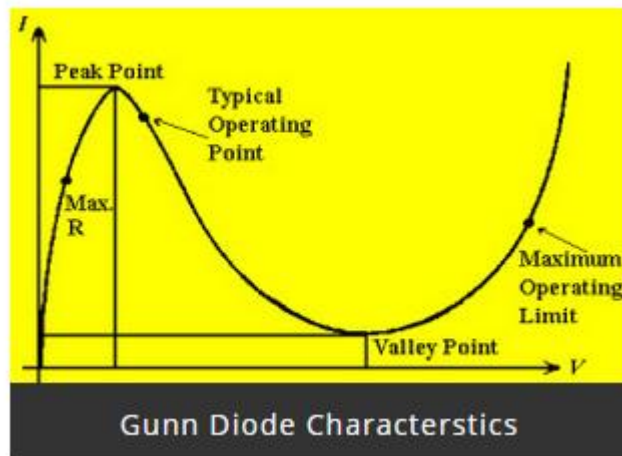


Fig 30

GUNN DIODE'S APPLICATIONS

- Used as Gunn oscillators to generate frequencies ranging from 100mW 5GHz to 1W 35GHz outputs. These Gunn oscillators are used for radio communications, military and commercial radar sources.
- Used as sensors for detecting trespassers, to avoid derailment of trains.
- Used as efficient microwave generators with a frequency range of up to hundreds of GHz.
- Used for remote vibration detectors and rotational speed measuring tachometers.
- Used as a microwave current generator (Pulsed Gunn diode generator).
- Used in microwave transmitters to generate microwave radio waves at very low powers.
- Used as fast controlling components in microelectronics such as for the modulation of semiconductor injection lasers.
- Used as sub-millimeter wave applications by multiplying Gunn oscillator frequency with diode frequency.
- Some other applications include door opening sensors, process control devices, barrier operation, perimeter protection, pedestrian safety systems, linear distance indicators, level sensors, moisture content measurement and intruder alarms.

LASERDIODE

A laser diode is nothing but the p-n junction combined with an optical resonator. This p-n junction constitutes a diode and it is operated in forward bias. The applied current generates the photons at the junction and further collision results the emission of more photons. If the carrier density within the p-n junction surpasses a certain value the light generated will be amplified and will finally yield the laser emission.

One of the peculiarity of the laser light is given as, it is monochromatic in nature, which means that it consists of a single color. So it is referred to as coherent light which means that a light with a single wavelength. In the case of incoherent light, it has a wide band of wavelengths.

Laser Diode Symbol

The given figures show the symbol and basic construction of a laser diode. A laser diode consists of p-n junction which is made up of two doped gallium arsenide layers. The two ends are flat as well as parallel to each other. One end is highly reflective (mirror) and the other one is partially reflective in nature. The depletion layer length depends on the wavelength of the emitted light.



Fig 31

CONSTRUCTION

Fig shows the structure of an edge emitting laser diode. this type of structures' called febry-perot laser. As seen from the fig , a PN junction is formed by two layer of doped gallium arsenide(GaAs). The length of the PN junction bears a precise relation ship with the wave length of the light to be emitted. As seen there is a highly reflective surface at one endof the junction and a partially reflective surface at the other end .external leads provide the anode and cathode connections

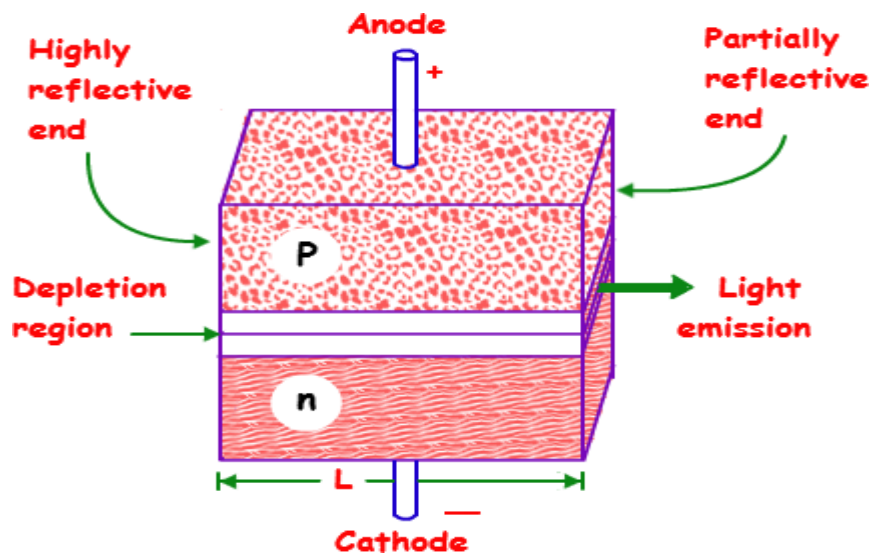


Fig 32

LASER DIODE THEORY BASICS

There are three main processes in semiconductors that are associated with light:

- *Light absorption:* Absorption occurs when light enters a semiconductor and its energy is transferred to the semiconductor to generate additional free electrons and holes. This effect is widely used and enables devices like photo-detectors and solar cells to operate.
- *Spontaneous emission:* The second effect known as spontaneous emission occurs in LEDs. The light produced in this manner is what is termed incoherent. In other words the frequency and phase are random, although the light is situated in a given part of the spectrum.
- *Stimulated emission:* Stimulated emission is different. A light photon entering the semiconductor lattice will strike an electron and release energy in the form of another light photon. The way in which this occurs releases this new photon of identical wavelength and phase. In this way the light that is generated is said to be coherent.

LASER DIODE WORKING

The working principle of laser diode is given below. If the diode is set to be in forward bias using an external source, the electrons cross the junction and combine with the hole as in normal diodes. During this process, photons were released. These newly released photons collide with other atoms which causes further production of photons. If we increase the forward bias current more photons are produced due to the collision of each other. Some of the photons reflected back from the depletion region, during the reflection again collide with other atoms and produce the photons. These reflections and generation of new photons results the intense laser beam and this beam pass through the partially reflected area of the p-n junction.

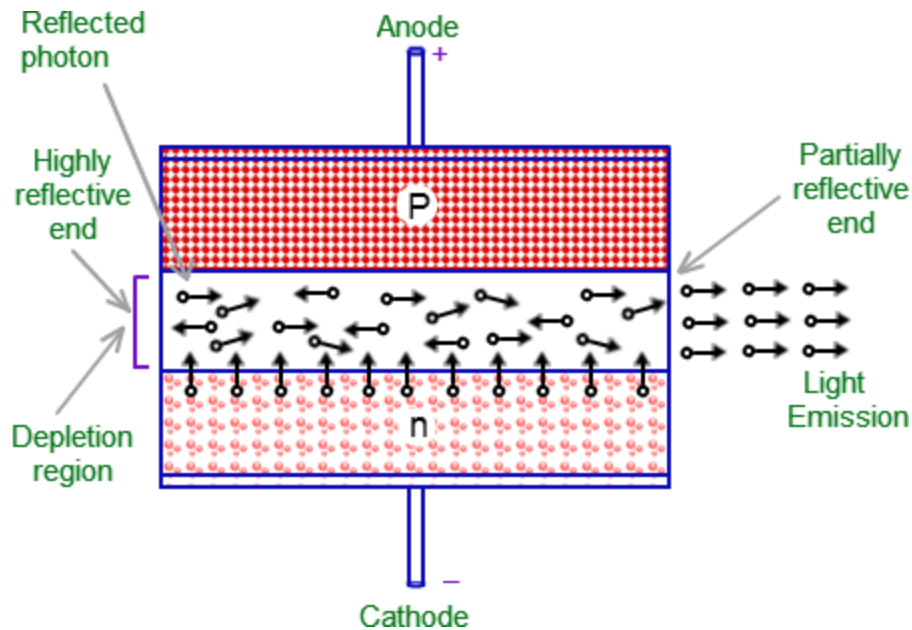


Fig 33

CHARACTERISTICS OF LASER DIODE

Threshold condition:

Threshold current is the most important and basic parameter for laser diodes. Incident spontaneous emission light propagating to the reflection mirror is amplified by stimulated emission and comes back to initial position after a round trip inside the laser cavity.

This process is subject to losses arising from light going through or diffracting at the reflection mirrors and scattering or absorption within an active light emitting medium. Light get attenuated if the total loss is greater than the gain. Injected current helps to strengthens the amplification light in the laser diode and when the gain and loss are balanced, initial light intensity becomes equal to the returned light intensity, this condition is referred to as a threshold.

A diode laser oscillates above the threshold when the gain is high enough. Output power is one of the important parameters to characterize a diode laser. The figure shows an experimental result, which depicts the output power of a typical continuous wave in a semiconductor diode laser as a function of injection current. When the forward bias current is low, the laser diode operates like a light emitting diodes (LEDs) where the carrier density in the active layer is not high enough for population inversion, spontaneous emission is dominated in this region. As the bias increases, population inversion occurs, stimulated emission becomes dominant at a certain bias current, the current at this point is called threshold current. The injection current above the threshold induces the abrupt onset of laser action and coherent light is emitted from the diode laser. The laser threshold current is evaluated by extrapolating the linear part of the characteristic to zero output power.

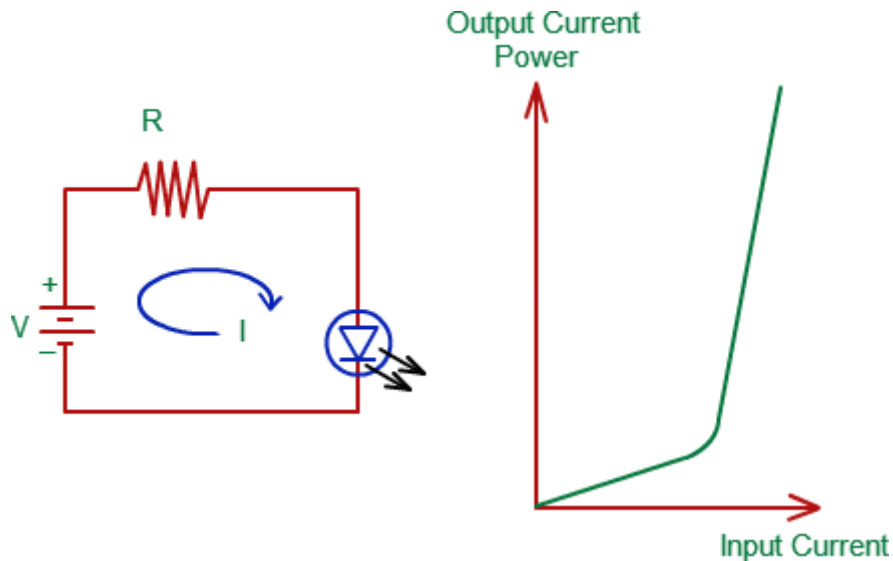


Fig 34

Laser diode technology has a number of advantages:

Power capability: Laser diodes are able to provide power levels from a few milliwatts right up to a few hundreds of watts.

Efficiency: Laser diode efficiency levels can exceed 30%, making laser diodes a particularly efficient method of generating coherent light.

Coherent light: The very nature of a laser is that it generates coherent light. This can be focussed to a diffraction limited spot for high density optical storage applications.

Rugged construction: Laser diodes are completely solid state and do not require fragile glass elements or critical set-up procedures. Accordingly they are able to operate under harsh conditions.

Compact: Laser diodes can be quite small allowing for laser diode technology to provide a very compact solution.

Variety of wavelengths: Using the latest technology and a variety of materials, laser diode technology is able to generate light over a wide spectrum. The use of blue light having a short wavelength allows for tighter focussing of the image for higher density storage.

Modulation: It is easy to modulate a laser diode, and this makes laser diode technology ideal for many high data rate communications applications. The modulation is achieved by directly modulating the drive current to the laser diode. This enables frequencies up to several GHz to be achieved for applications such as high-speed data communications.

APPLICATION

The use of LASER is in medical equipment used in surgery and in consumer product like compact disk(CD)Player, laser printers, hologram scanners etc

Some of the applications of laser diode is given below:

1. To make measuring equipments
2. Pumping of fibre and solid state lasers
3. Medical equipments
4. Printing technology
5. Lighting
6. Material processing
7. For scientific research.

QUESTIONS

1. What is a tunnel diode ?
2. Explain the V-I characteristics of a tunnel diode.
3. Explain the working of tunnel diode oscillator.
4. What is a varactor diode ?
5. Explain the working of varactor diode.
6. Give one application of varactor diode.
7. Explain the working of Shockley diode
8. Give the applications of schottky diode.
9. Define Negative resistance of tunnel diode.
10. Define Tunneling phenomenon. (or) How does tunnel diode works?
11. Explain the advantages & disadvantages of tunnel diode.
12. Explain the applications of tunnel diode.
13. Give the symbol and structure of schottky diode.
14. What is a Varactor diode?
15. What is Gallium Arsenide (GaAs) device?
16. What is Laser diode? And list the applications of Laser diode.
17. Draw the V-I characteristics curve for zener diode.
18. Draw equivalent circuit of tunnel diode.
19. Write short notes on varactor diode and Schottky barrier diode.
20. Explain the laser action for laser diode
21. With neat diagram explain about varactor diode.
22. What is a DIAC? Give the basic construction and symbol of DIAC.
23. List out the applications of DIAC.
24. What is a TRIAC? Give the symbol and structure of TRIAC.
25. Draw the V-I characteristics for TRIAC.
26. Give the application of TRIAC
27. Explain the construction, operation, V-I characteristics and application of SCR and explain its two transistor model.
28. Explain the construction operation, V-I characteristics and application of UJT.
29. Explain the construction operation, V-I characteristics and application of TRIAC.
30. Explain the construction, operation, V-I characteristics and application of DIAC.
31. Compare the characteristics and applications of UJT, SCR, DIAC and TRIAC.