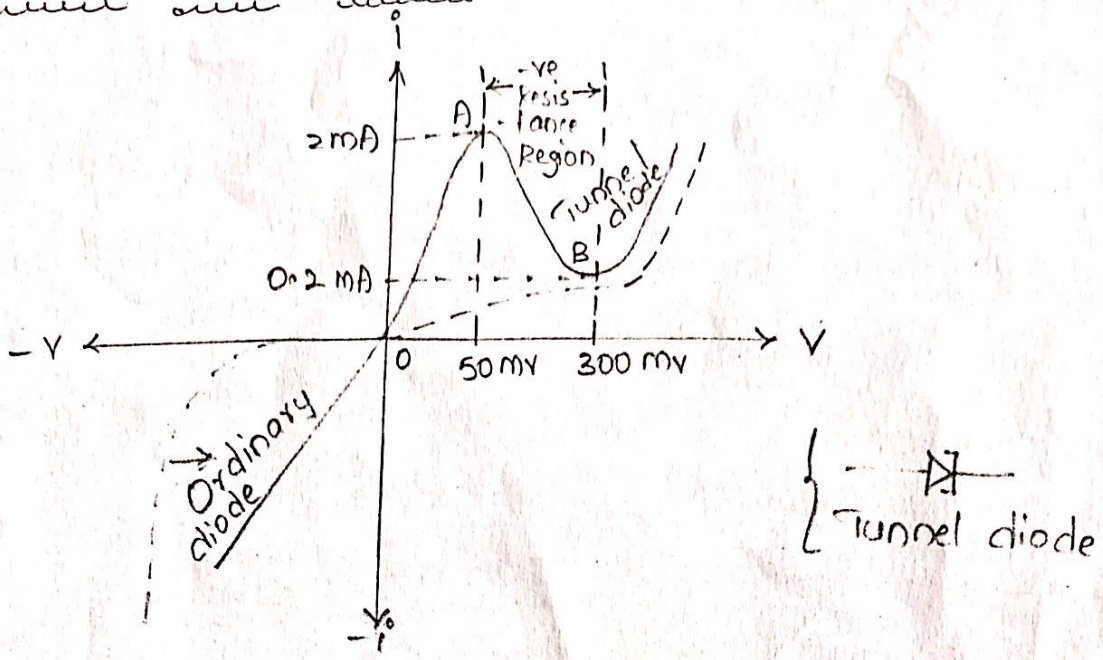
Special Purpose Electronic Devices.

Tunnel Diode (Esaki):



V-I characteristics of Tunnel diode

* The tunnel or Esaki diode is a thin junction diode which exhibits negative resistance under low forward biased conditions.
* An ordinary p-n junction diode has an impurity concentration of about 1 part in 10^8.

  With this amount of doping the width of the depletion layer is of the order of 5 microns.
* The potential barrier restrains the flow of carriers from the majority carrier side to the minority carrier side.
* If the concentration of impurity atoms is greatly increased to the level of 1 part in 10^3.

* The resulting diode equivalent ckt is thus reduced to parallel combination of junction capacitance C_j & -ve resistance $-R_D$.

* Typical values of circuit components are $R_s = 6\Omega$, $L_s = 0.1$ nanohenry, $C_j = 0.6$ Pecofarads & $R_D = 75\Omega$.

Applications:

1. Tunnel diode is used as an ultra high speed switch with switching speed of the order of nanoseconds or pecoseconds.
2. As logic memory storage device.
3. As microwave oscillator.
4. In relaxation oscillator circuit
5. As an amplifier.

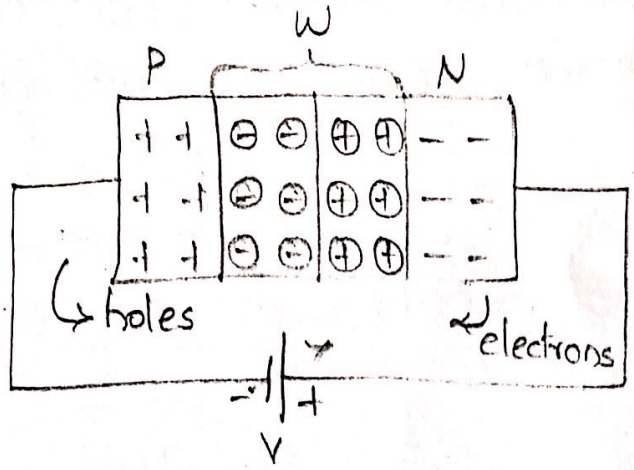
Advantages:

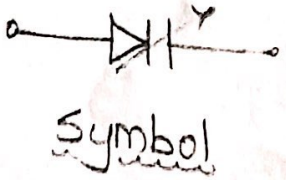
1. Low noise
2. Ease of operation
3. High speed
4. Low power

Disadvantages:

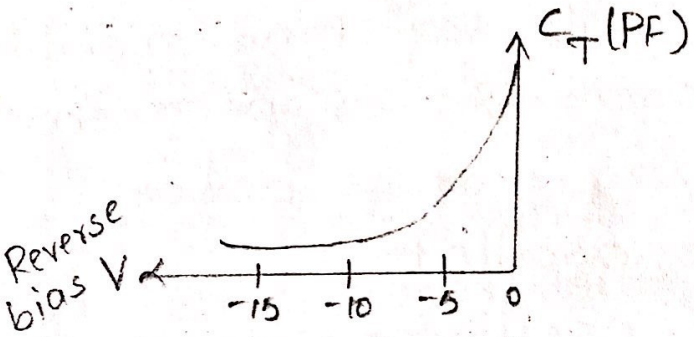
1. Voltage range over which it can be operated is 1 volt (or) less.
2. Being a two terminal device there is no isolation b/w the input & output circuit.

Varactor Diode:





Depletion Region in Varactor diode.



Characteristics of Varactor diode

The varactor diode is also called as varicap, tuning (or) voltage variable voltage capacitor diode, is also a junction diode with a small impurity does it at junction. which has the useful property that its junction or transition capacitance is easily varied electronically.

When any diode is reverse bias, a depletion region is formed. The larger the reverse bias applied across the diode, the width of the depletion region 'w' becomes wider. conversely by decreasing

decrease - bias voltage, the depletion region 'w' becomes narrower.

* This depletion region is devoid of majority carriers & acts like an insulator preventing conduction between the N & P- regions of the diode just like a dielectric which separates the two plates of a capacitor.

* The varactor diode as the capacitance is inversely proportional to the distance b/w the two plates.

* The transition capacitance (C_T) varies inversely with the reverse voltage. Consequently an increase in reverse bias voltage will result in an increase in the depletion region width & a subsequent decrease in transition capacitance (C_T).

* At 0 volt the varactor depletion region 'w' is small & the capacitance is large approximately 600 PF.

When the reverse bias voltage across the varactor is 15V the capacitor is 30 PF.

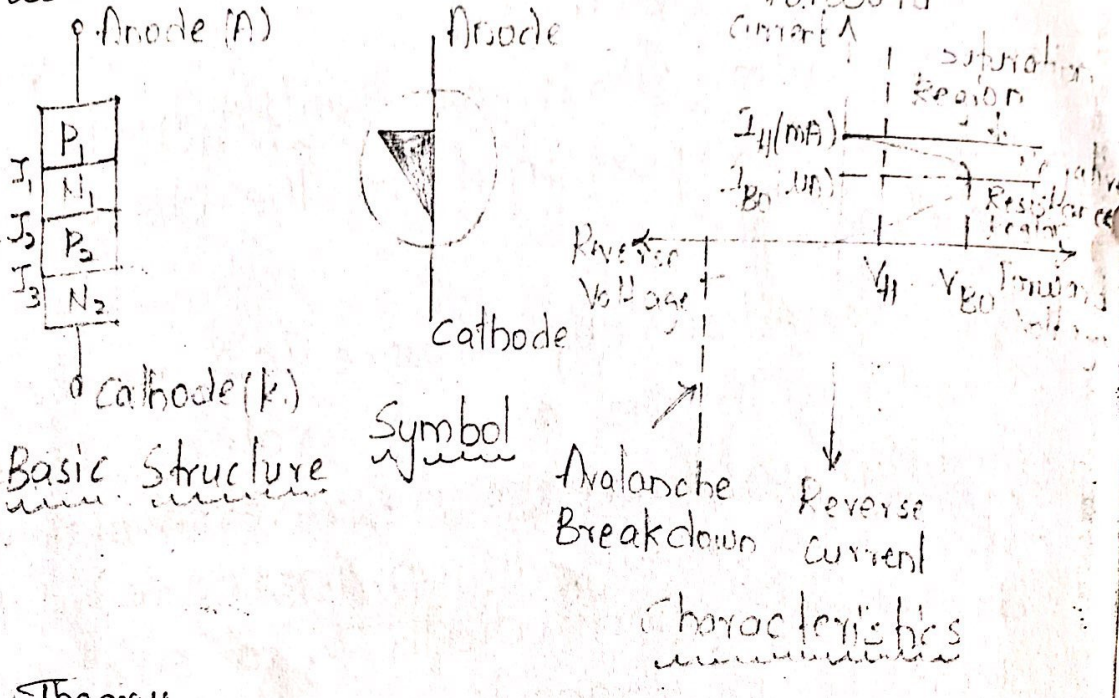
Applications:

The varactor diodes are used in FM radio & TV receivers, self-adjusting bridge circuits & adjustable band-pass filters with improvement in the tune of

used & construction.

Varactor diodes find application in tuning of LC resonance ckt in microwave frequency multipliers & in very low noise microwave parametric amplifiers.

Shocklay Diode (PNPN diode):



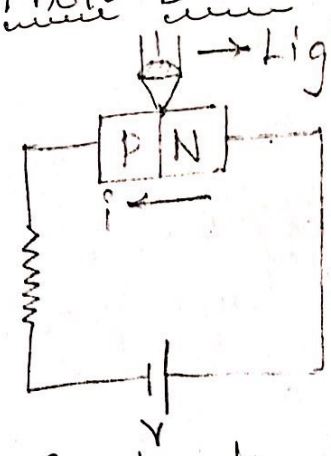
- Theory:

* Thyristor in general is a semiconductor device having three or more junctions. such a device acts as a switch without any bias & can be fabricated to have voltage ratings of several hundred volts & current ratings from a few amperes to almost 1000 amperes.
* The family of thyristor consists of PNPN diode, SCR, LASCR, UJT etc....
* The figure is a four layer PNPN silicon device with two terminals.

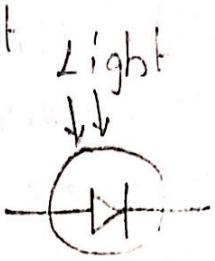
device in such a way that anode is positive with respect to cathode. Junctions J_1 & J_3 are forward biased & J_2 is reverse biased, then the applied voltage appears across the reverse bias junction J_2.

* Now the current flowing through the device is only Reverse saturation current.
* As this applied voltage is increased, the current increases slowly until firing or breakdown voltage V_{BO} is reached.
* Once firing takes place, the current increases abruptly & the voltage drop across the device decreases sharply.
* At this point the diode switches over from off to on stage.
* Once the device is fired into conduction a minimum amount of current known as I_H is required to flow to keep the device in on stage.
* To turn the device off from on stage, the current has to be reduced below I_H by reducing the applied voltage close to zero i.e., below holding voltage V_H.
* Thus the diode acts as a switch during forward-bias condition.

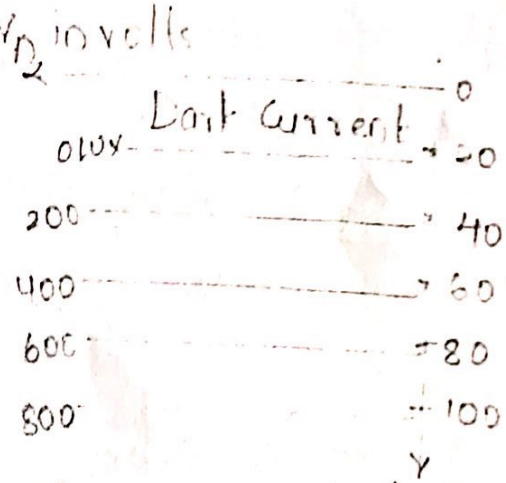
Photo Diode:



Construction



Symbol



Characteristics

Theory:

* Silicon photo diode is a light sensitive device also called photo-detector which converts light signal into electrical signal.
* The diode is made of a semi-conductor pn-junction kept in a sealed plastic or glass-casing.
* The cover is so designed that the light rays are allowed to fall on one sur-face across the junction.

  The remaining sides of the casing are painted to restrict the penetration of light-rays.
* A lens permits light to fall on the junc-tion. When light falls on the reverse biased pn photo diode junction, hole-electron pairs are created.
* The movement of these hole-electron pairs in a properly connected circuit results in current flow.
* The magnitude of the photo-current

depends on the number of charge carriers generated.

* This current is also effected by the frequency of light falling on the junction of the photo-diode.

* The magnitude of the current under large reverse bias is given by

$$I = I_S + I_0(1 - e^{V/\eta V_T}).$$

where, I_0 = Reverse saturation current

I_S = Short Circuit current which is proportional to the light intensity.

V = voltage across the diode.

V_T = Volt equivalent of temperature.

η is the parameter

$\eta = 1$ for Ge & $\eta = 2$ for Si.

Characteristics of a photo-diode:

* The reverse-current increases in direct proportion to the level of illumination.

* Even when no light is applied there is a minimum reverse leakage current called dark current flowing through the device.

Ge has higher dark current than Si.

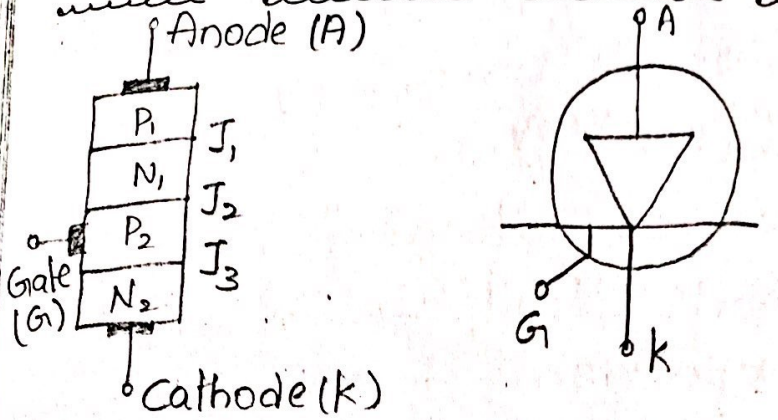
* Photo-diodes are used as light detectors, demodulators & encoders.

* They are also used in optical communication system, high speed counting and

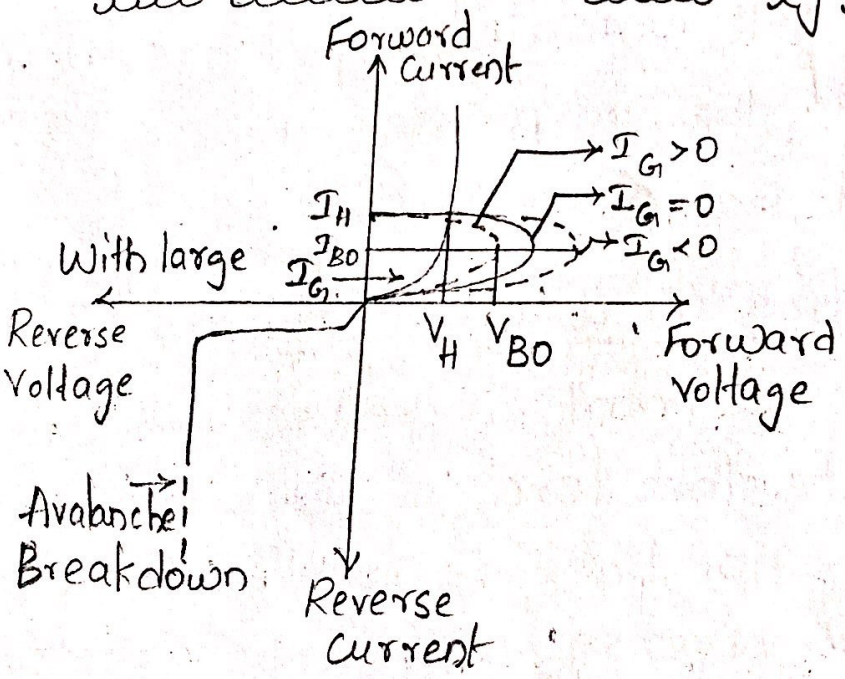
switching circuits.

* They are used in computer card punching & tapes; light operated switches, sound track films and electronic control circuits.

Silicon Controlled Rectifier (SCR):



(a) Basic structure (b) Circuit Symbol



(c) Characteristics of SCR.

* It is a four layer three terminal device for for which the end p layer acts as anode & the end N layer acts as cathode & p-layer nearer to cathode acts as gate.

- As leakage current

small compared to Germanium, SCR's are made of silicon & not Germanium.

Characteristics of SCR:

* The characteristics of SCR acts as a switch when it is forward-biased when the gate is kept open i.e, gate current $I_G = 0$. operation of SCR is similar to PNPN diode.
* When $I_G < 0$, the amount of reverse bias applied to J_2 is increased so the break-over voltage V_{BO} is increased.
* When $I_G > 0$, the amount of reverse bias applied to J_2 is decreased thereby decreasing the breakover voltage.
* With very large positive gate current, breakover may occur at a very low voltage such that the characteristics of SCR is similar to that of ordinary PN diode.
* ~~As~~ The voltage at which SCR is rea switched on can be controlled by varying the gate current I_G.
* It is commonly called as controlled switch.
* Once SCR is turned on, the gate losses control i.e., the gate cannot be used to switch the device off.

* One way to turn the device off is by lowering the anode current below the holding current I_H by reducing the supply voltage below holding voltage V_H keeping the gate open.

Applications:

* SCR is used in relay control, motor-control, phase control, heater control, battery chargers, inverters, regulated power supplies & as static switches.