Zener Diode:

→ When the reverse voltage reaches V_{BD} in normal PN-junction diode, the current through the junction & power dissipated at the junc will be high.

→ Such an operation is destructive & diode gets damaged.

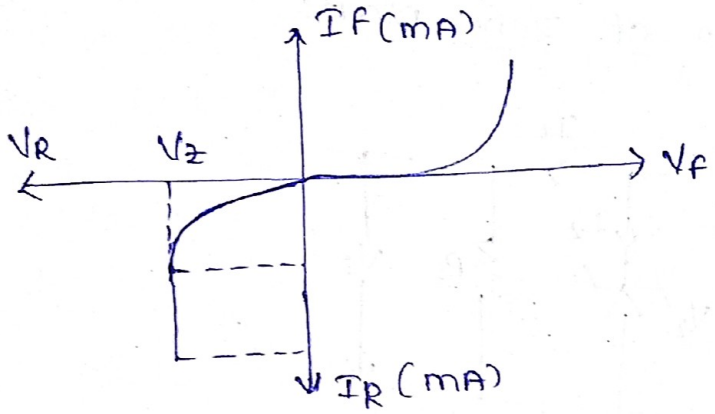
→ One such a diode is known as zener diode.

→ Zener diode is heavily doped than ordinary diode.

→ Zener diode is same as that of ordinary PN junction diode under f.B.

→ Under RB, the breakdown of the junction occurs.

fig: V-I characteristics of Zener Diode



→ If the diode is heavily doped, depletion layer will be thin and breakdown occurs.

→ If the diode is lightly doped, it has a higher breakdown voltage.

Two Mechanisms :-

(i) Avalanche Breakdown:

→ As applied R.B ↑es, field across the junction also ↑es, as a result velocity of carriers also ↑es.

→ This process is cummulative (↑ng by successive additions) in nature & results in generation of avala-

nche carriers within a short time.

→ This mechanism of carrier generation is known as avalanche breakdown (or) avalanche multiplication.

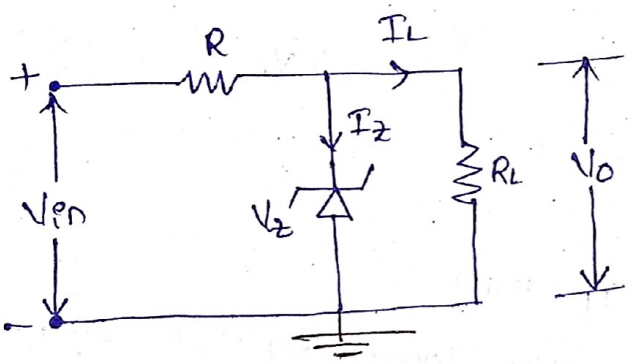
(ii) Zener Breakdown:

→ for lightly doped diodes, zener breakdown voltage (V_{ZBD}) becomes high.

→ Though $V_{BD,Z}$ occurs for lower breakdown voltage & Avalanche breakdown occurs for higher breakdown voltage, such diodes are called as zener diodes.

Symbol for Zener diode:

CKt diagram of Zener Diode:



→ multiplication effect of free carriers is given by the equ

$$M = \frac{1}{1-\left(\frac{V}{V_{BD}}\right)^n}$$

→ where M = Carrier multiplication factor.

V = applied reverse voltage.

V_{BD} = Reverse Break-down

n = Empirical constant

→ for N-type Si, $n \approx 4$ & for P-type Si, $n \approx 2$

→ M is very small for $V = 0.9 V_{BD}$

→ But when $V > 0.9 V_{BD}$, M is very large

→ Reverse current is given by $I_R = M I_O$

→ True zener diode displays a -ve temp coeff, i.e breakdown voltage ↓es with ↑ing temp.

→ True avalanche diode displays a +ve temp coeff, i.e breakdown voltage ↑es with ↑ing temp.

→ Breakdown voltage for Si diodes occurs at a voltage as low as 5V with 10^{17} impurity atoms/cm^3 or as high as 1000V with 10^{14} impurity atoms/cm^3.

Varactor Diode:

→ Varactor diode is also called as a varicap(or) tuning (or) voltage variable capacitor diode.

→ When any diode is R.B, a depletion region is formed as shown in the fig-(a)

fig (a): Depletion Region in a R.B PN-junction

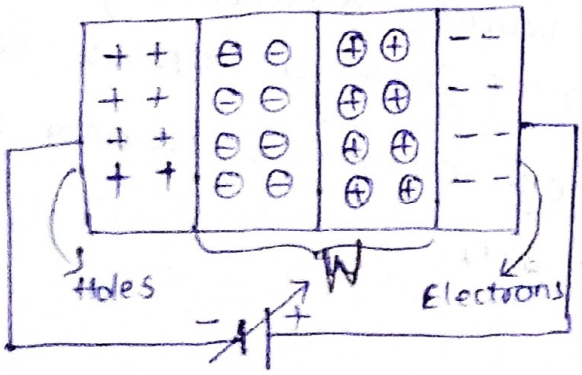
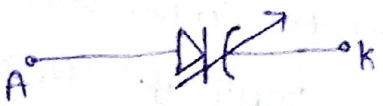


fig-b: Circuit Symbol of varactor Diode



→ The larger the reverse bias applied across the diode, the width of the depletion layer "W" becomes wider.

→ Similarly by ↓ing the reverse bias voltage the depletion region width "W" becomes narrower.

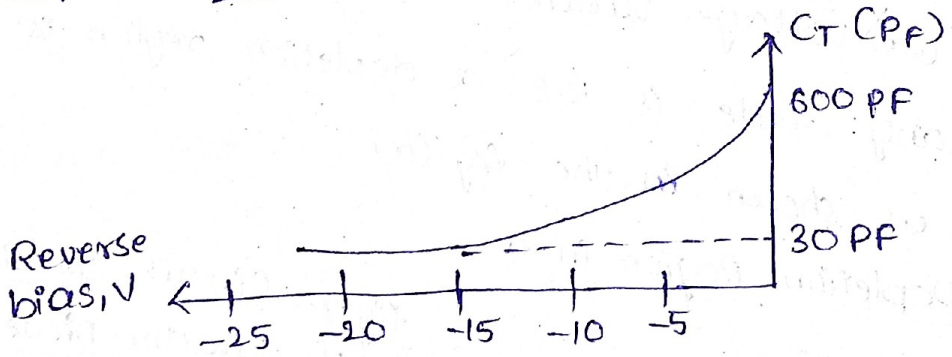
→ "W" acts like a insulator preventing conduction blw N & P regions of diode, just like a dielectric which separates the two plates of a capacitor.

→ As the capacitance is inversity proportional to the distance blw the plates ($C_T \propto 1/W$) reverse bias voltage decreases. ↓ Transition Capacitance.

→ As ↑ in RB voltage will ↑ in depletion region width & a ↓ in C_T.

→ Characteristic of a varactor diode are as shown in the fig - ©.

fig-c : Characteristic of a varactor diode :



→ At zener volt, the varactor depletion region 'w' is small & capacitance is large at approx 600 pf.

→ When the R.B voltage across the varactor is -15V, the capacitance is 30 Pf.

Applications:

(1) Used in FM Radio & TV receivers, Automatic frequency circuits (AFC).

(2) Used in self adjusting bridge ckts & adjustable band pass filters (BPF's)

(3) Varactor diode also find applications in tuning of LC resonant ckt in microwave (μw) frequency multipliers.

(4) Very Low Noise (VLN) Amplifier in microwave (μw) parametric amplifiers.

Light Emitting Diode (LED):

→ LED is a PN-junction diode which emits light when f.B, by a phenomenon, called as Electroluminescence.

→ In all sc PN-Junc's, some of the energy is radiated as heat & some in the form of photons.

→ In Si & Ge, greater % of energy is given out in the form of heat.

→ Charge recombination takes place when e^{-}'s from N-side cross the junction & recombine with holes on P-side.

→ When an LED is f.B, e^{-}'s & holes moves towards the junction & recombination takes place.

→ Difference of energy blw C.B & V.B is radiated in the form of light energy.

→ The brightness of emitted light is directly

proportional to the f.B current (I_f).

fig-a LED under fB

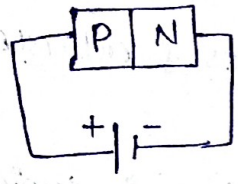
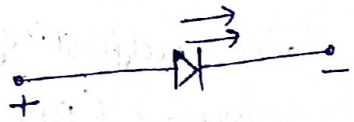
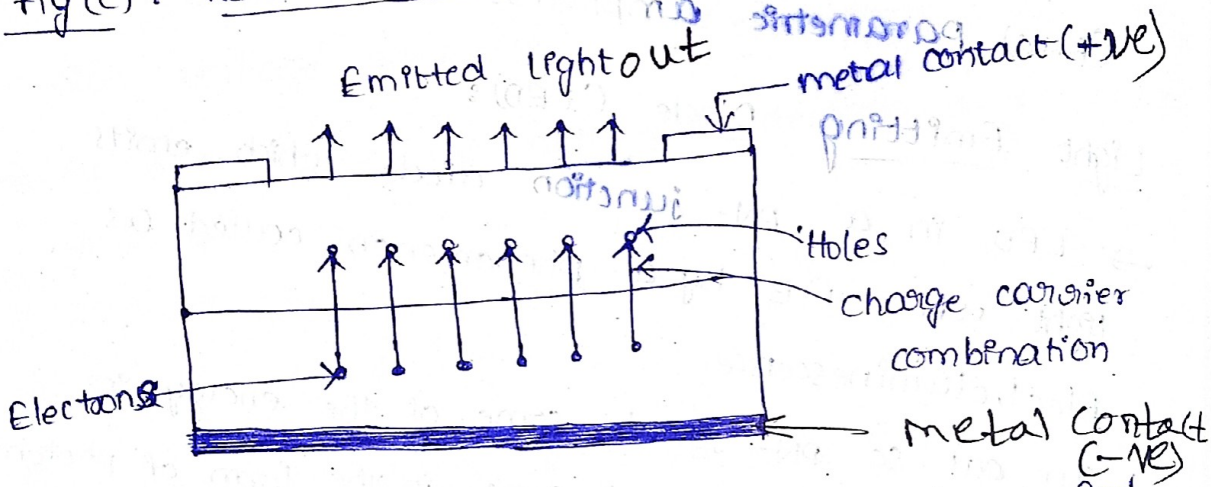


fig-b: Symbol of LED



→ When emitted light is coherent, ie essentially monochromatic, then such a diode is called as Injection Laser Diode (ILD).

fig (c): Recombination of Emission of light



→ LED's radiate different colours such as Red, green, yellow, orange & white.

→ Some of LED's emit Infrared (invisible) light also.

→ wavelength of the emitted light depends on the energy gap of the material.

(i) Gallium Arsenide (GaAs) – Infrared radiation (Invisible)

(ii) Gallium Phosphide (GaP) – Red or Green.

(iii) Gallium Arsenide phosphide (GaAsP) – Red or yellow.

→ In order to protect LED's, resistance of 1KΩ or 1.5 KΩ must be connected in series with another LED.

→ LED's emits no light when R.B.

→ LED's operate at voltage levels from 1.5 to 3.5 V. with current in milliamperes.

→ Power requirement is typically from 10 to 150 mwatt with a lifetime of 100,000 + hours.

→ LED's can be switched ON & OFF at a very fast speed of 1 ns.

Photo Diode:

→ Silicon photodiode is a light sensitive device, also called photodetector which converts light signals into electrical signals.

fig-a: Photo diode construction:

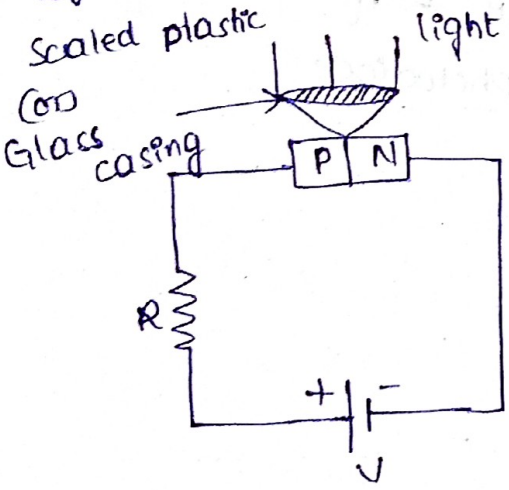
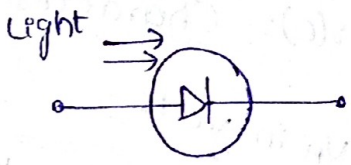


fig-b: Symbol:



→ As shown in fig-b diode is made of a semi-conductor PN junction kept in a sealed plastic or glass casing.

→ The cover is so designed ~~mainly~~ mainly to allow light rays fall on one surface across the

junction.

→ Remaining sides are painted to restrict penetration of light rays.

→ When light falls on R.B PN photo diode junction hole - electron pairs are created.

→ The magnitude of photo current depends on no. of charge carriers generated on the illumination of diode element.

→ Magnitude of current under large reverse bias is given by $\boxed{I = I_s + I_o\left(1 - e^{V/\eta V_T}\right)}$

Where I_o = Reverse saturation Current.

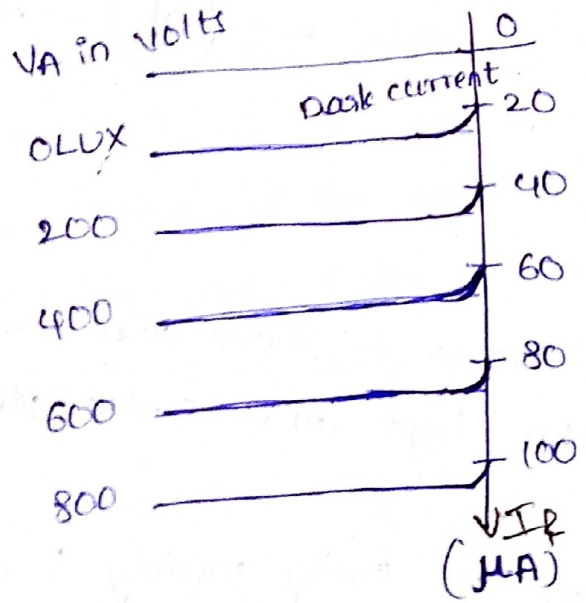
I_s = Short - CKt current proportional to light intensity.

V = Voltage across dicde,

V_T = Volt equivalent of temp,

η = constant $\Rightarrow \eta = 1$ for Ge & $\eta = 2$ for Si

fig:(c): Characteristics of photodiode



→ Characteristics of a photodiode are shown in fig-(c)

→ When no light is applied, there is a min reverse leakage current called dark current flowing through the device.

→ Ge has higher dark current than Si, but it also has higher level of reverse current.

Applications:

→ Photodiodes are used as light detector demodulators & encoders.

→ Also used in optical communication system, high speed counting & switching circuits.

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