UNIT-II

Special Perpose Diode

Zener Diode:-

*Zener diodes are semiconductor devices that allow current to flowing both directions (specifically in reverse direction)

*Zener diodes are also known as "Breakdown diodes".

* It is a heavly dopped semi-conductor device designed to function in reverse direction.

* In forward biase zener diode works similarly to a regular diode.

* In Reverse biase mode a small ~~ritage~~ leakage current flows through the diode, as the reverse voltage increases & reaches zener voltage the current begins to flow through the diode.

There are two types breakdowns in zener diode. They are.

→ Avalanche breakdown

→ Zener breakdown

Avalanche breakdown :-

* This type of breakdown occurs in normal diodes and also in zenor diode.
* when the reverse voltage is applied to P-n function the free electron gains the energy to accelarate at high velocities.
* These high velocity electrons collide with others and produce large number of free electrons which results in increase of current through the diode (normal diode gets damage). however zenor diode is designed specifically and can handle sudden current spy.

Zenar Breakdown :-

When the reverse biase voltage applied to zenar diode approaches its zenar voltage, the electric field in the depletion region becomes strong and free electrons move faster. ~~The faster~~

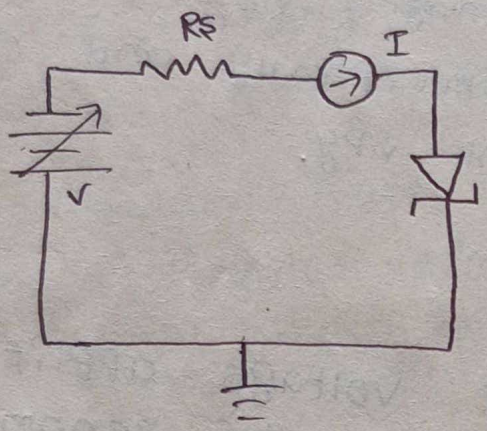
→ The faster movement of electrons due to application of reverse voltage causes sudden increasin current.

→ This type of breakdown is consider as zenor breakdown.

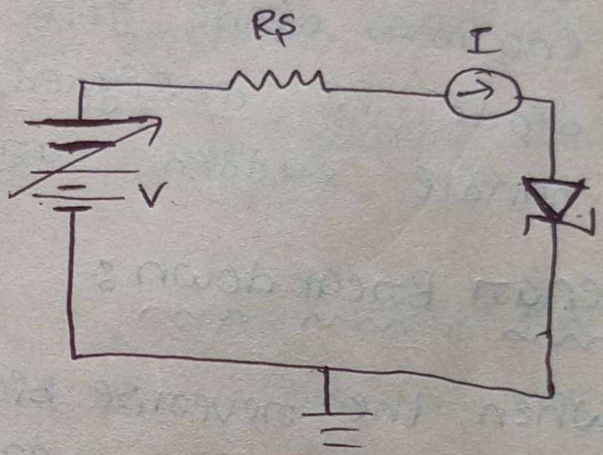
fig:- zenardiode symbol

VI- characteristics of zenar Diode :-

The circuit diagram for finding the VI characteristics of zenar diode under forward biase & Reverse biase are as shown below.



Forward biase



Reverse biase

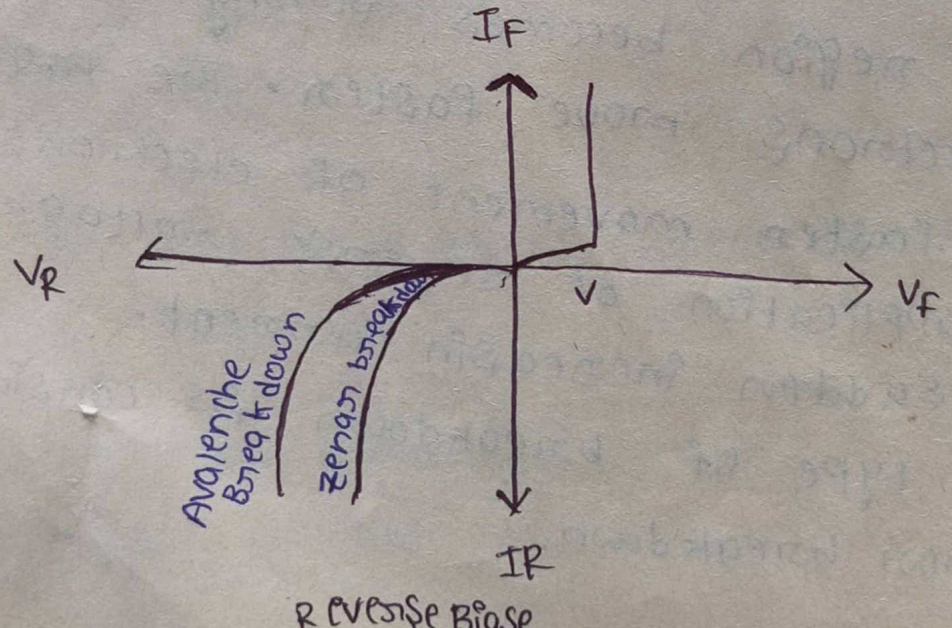


fig:- VI characteristics of zenar Diode

Zenar diode specifications:-

* Zenar/break down voltage = 0.4 v to 200 v
* Maximum zenar current IZ = 200 micro A to 200 A
* Minimum zenar current IZ = 5 milli A to 10 mA
* Power Rating = Typical values such as 200 mW, 400 mW, 1W, 4W
* Temperature stability diodes around 5 volts have maximum value
* voltage Tollarence ± 5%
* Zenar Resistance: It is the resistance to the zenar diode to control the operation

Differences b/w Avalanche breakdown and zenar breakdown.

Avalenche Breakdown	Zenar breakdown.
1. It occurs when high voltage increase the free electrons in semi-conductor & sudden increase in current is observed.	1. It happens when the electron gains energy & jumps from valence band to conduction band and causes current flow.
2. Avalenche breakdown is seen in the diodes which have breakdown voltage greater than 8 volts.	2. This type of break down is seen in the diodes having a break down voltage b/w 5 volts & 8 volts.

3. This break down is observed in lightly broked diodes.	3. Heavily dopped Diodes.
4. If the temperature is increase the break down voltage is also increases.	4. If the temperature is increases the breakdown voltage is decreases.
5. The VI characteristics are not sharpe.	5. The VI characteristics curve is very sharpe

Zenar diode APPLICATIONS:-

The applications of zenar diode are:→Voltage regulation.

→over voltage protection
→switching applications
→In clipping circuits
→As a voltage shifter

→Voltage Regulation:

* Zener diode is a voltage Regulator
* The main application of zener diode is voltage Regulator
* when the break down voltage is equal to the load voltage then the resistance connected in series limits the current through the diode when there is excess

amount of voltage while the diode is conduct -ing.

* The circuit diagram for zener diode as a voltage regulator is as shown below.

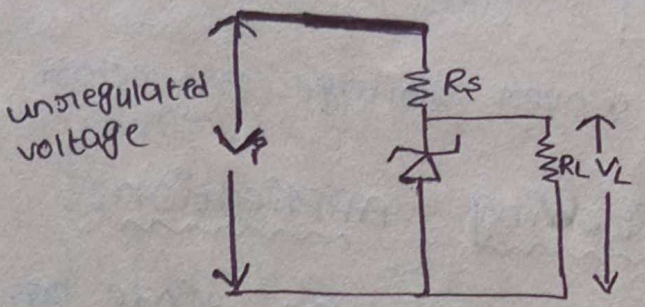


Fig:- Zener diode as voltage Regulator

→ Zener Diode As a over voltage Protection:

* When the input voltage increases ~~voltage~~ and reaches the zener breakdown voltage the current through the diode will create a voltage drop across the resistor.
* Hence the access voltage is short circuited to the ground.
∴ zener diode allows only the require voltage & blocks the access voltage
* The circuit diagram for over voltage protection using zenar diode also known as such protection is as shown below.

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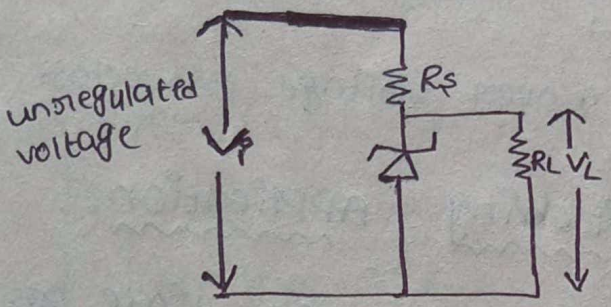

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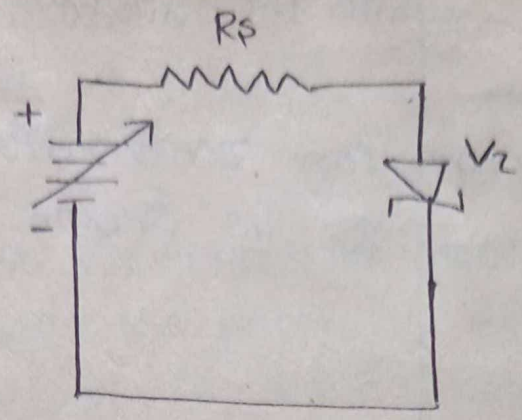


fig:- zener diode as a over voltage protector.

Zener Diode as a switching Application:-

* Like the p-n junction diode zener diode ~~can also~~ cannot be used a switch but it conducts in both the direction. i.e forward direction & reverse direction.

zener diode as a clipping circuits:-

* The clipper circuits are used to prevent the output signal from going beyond a determined value without changing anything of the input signal.

* These kind of circuits are generally used in TV and FM transmitors for eliminating interference.

* The Example of zener diode as a clipping circuit is as shown below.

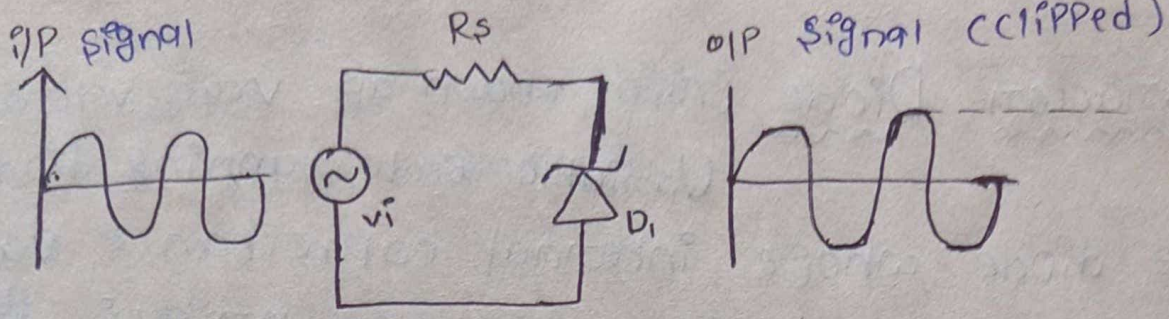


fig:- single zener diode

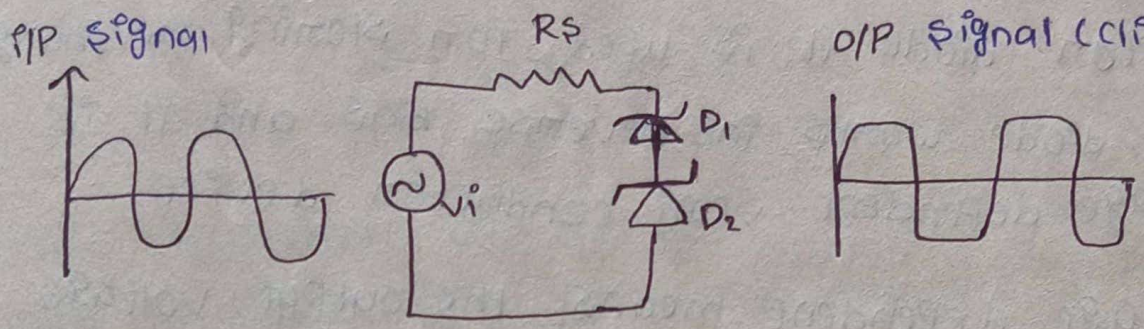


fig:- double zener diode

Zener Diode as a voltage shifter:-

* A zener diode can be applied to a circuit with a resister to act as a voltage shifter.
* The circuit learns output voltage by a quantity which is equal to zener breakdown voltage.
* The circuit diagram & voltage shifting operation is as given below.

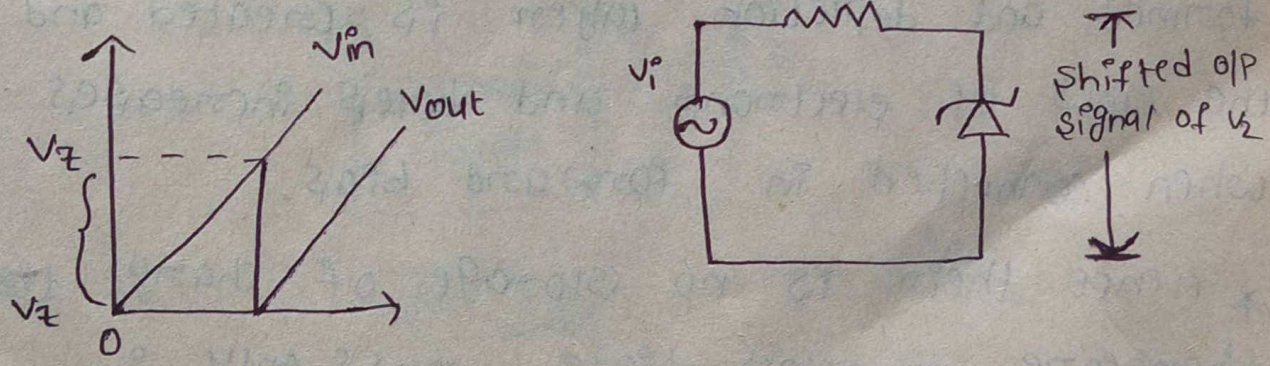


fig:- zener diode as a voltage shifter.

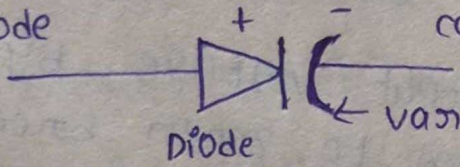
Varactor Diode (Also known as vcap, volt cap, Variable diode, Tunning diode)

The diode whose internal capacitance ~~varies~~ ~~with~~ ~~the~~ where is with the various ~~of~~ of ~~voltage~~ reverse voltage is known as Varactor diode it is used for storing the charge.

* This diode works in reverse bias and it is voltage dependent semi conductor device.

* voltage dependent means the output voltage is depending up on input voltage

* It is used in a place where the variable capacitor is required.



← variable capacitor (or) Parallel plate capacitor.

Working :-

*When a P-type semi-conductor end and n-type semi-conductor are joined then P-n junction is formed and depletion layer is created and the flow of electrons and holes increases when connected in forward bias.

* Hence their is no storage of charge ~~there~~ therefore varactor diode works only in

reverse bias by storing the charge in the depletion region.

* The value of capacitence can be calculated by the given formula

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

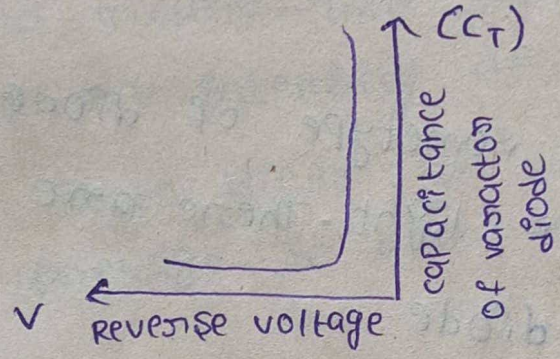
where ε = Permitivity of di-electric

A = Area of junction

W = width of depletion region.

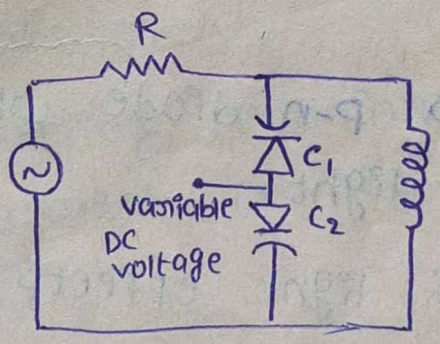
* The capacitence of the varactor diode increases with increase in N-type region. and the P-type region decrease with increase in depletion region.

characteristics of varactor diode :-



characteristics of varactor diode.

varactor diode as a Turning circuit (Ckt) :-



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

where $C = \frac{C_1 C_2}{C_1 + C_2}$

Advantages:-

* It produces less noise compared to other diodes.
* Small in size and less weight
* Low cost and realiable

Optical Diode

* Opto means light optical diodes are operated based on the light.
* There are types of optical diode that conducts based on the intensity of light They are:

→ Photo diode
→ Solar cell

* There are also sometype of diode whose conduction delivers light. There are

→ Light Emitting diode
→ LASER diode

Photo diode:-

* Photo diode is a p-n diode which works on intensity of light.
* The intensity of light effects the conduction in this diode.
* This diode operates in reverse bias condition.

* The symbol & construction of photo diode is as shown below:-

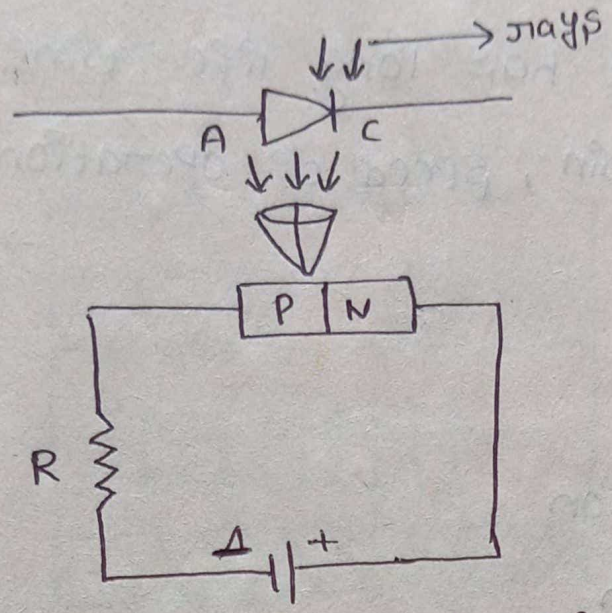


fig:- construction of photo diode

* The light when focused on depletion region electron hole pairs are formed & flow of electrons occurs. This conduction of electrons depends on intensity of light

* The photo diode is encapsulated in glass package to allow light to fall on to it.

* Even when there is no light a small amount of current flows which is known as Dark current.

* By changing illumination level the reverse current can be changed.

Advantages of Photo diode :-

* Low noise & low cost.
* Small size and it has long life time.
* It has high gain, speed of operation, sensitivity.

Applications :-

* character detection
* object detection
* Switching circuits
* Encoders
* optical communication

Solar cell :-

* It is a normal p-n junction diode but it has its conduction due to rush of photons converted into flow of electrons.
* The working of solar cell is similar to photo diode but has another objective of converting maximum incident light into energy, and stores it.
* The symbol of solar cell & construction of solar cell is as shown below.

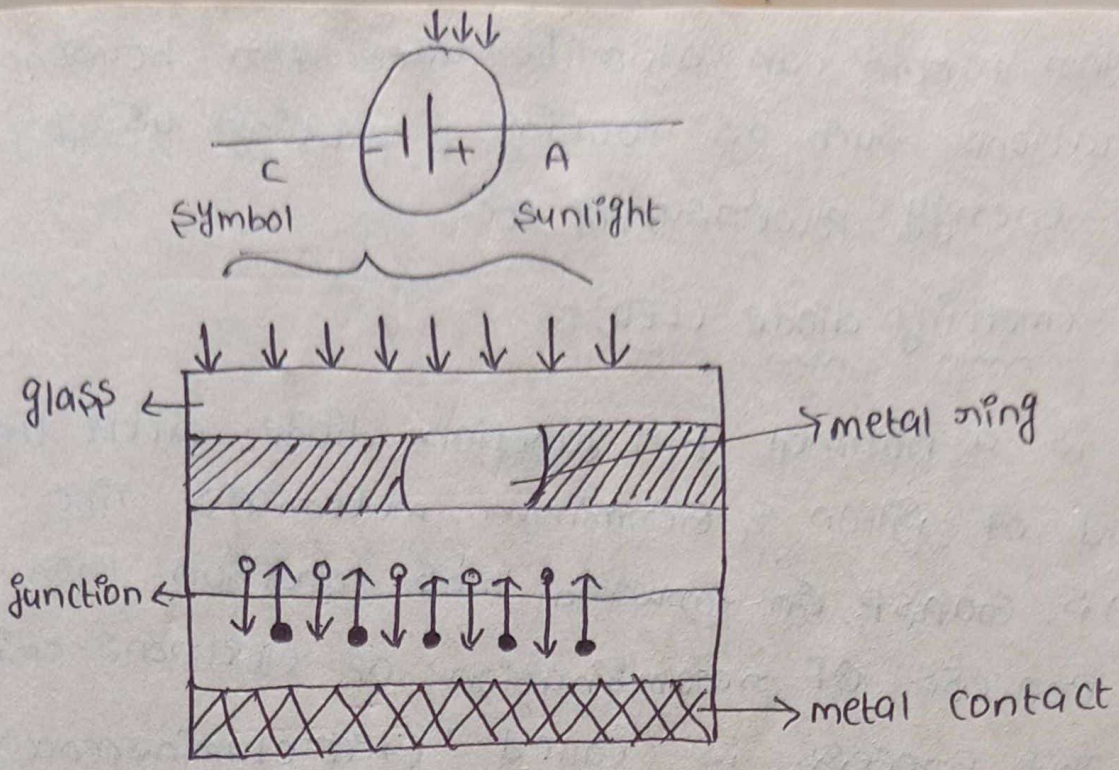


fig:- construction of solar cell

* a P-n junction diode with an intentric material in depletion region is made to encapsulate in glass.

* when the light is incident on solar cell the photons in the light collide with valence electrons & get energined thus a flow of electrons is generated & current is directly proportional to the light intensity this is called photo voltaic effect.

Applicant:-

1. The solar pannels for agriculture, Power supplies, Sattellites etc.

2. Solar cells are also used in telemetry
   → Electronic watches
   → Remote lighting systems etc.

3. Solar panals can also be used for household applications such as cooking & heating using solar energy, power supply etc.

Light Emetting diode (LED) :-

* It is a normal P-N function diode except that instead of Silcon & Germinum, materials like Ga, As, GaAsP, Ga forward bias condition then the process of recombination of electrons emits light. This process is called "Electroluminiscence" GaP etc are used

* This diode is connected in forward bias condition then the process of recombination of electrons emitts light. This process is called "Electroluminiscence".

* The color of the light depends on energy band gap and also the type of material used for example GaAsP, Red / yellow

GaP → Red / Green

GaN → Blue

GaAs → Infrared light

IR light.

* The symbol & construction of LED is as shown below.

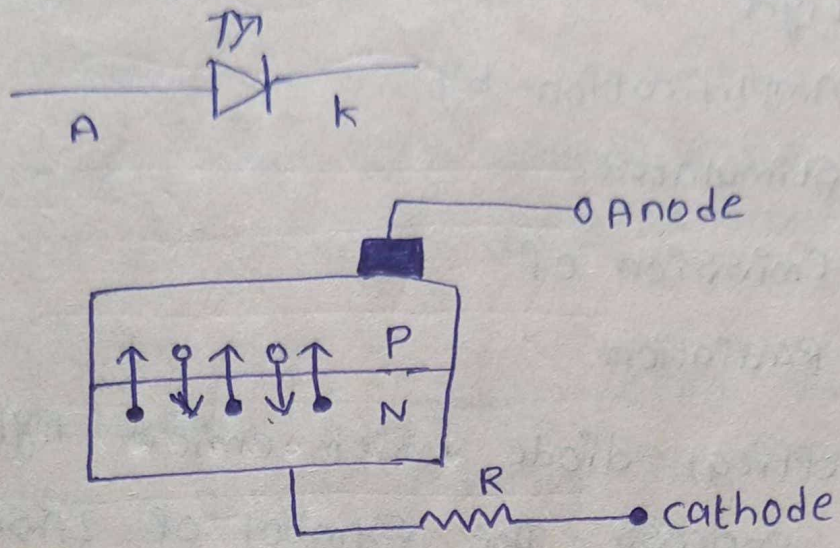


fig:- construction of LED

Applications:-

1. LED's are used as display devices in '7' segment display, digital clocks, traffic signals, display boards in railway stations, etc.
2. In commerical applications like barcode readers IR (infraRed) machines, video displays.
3. In optical communication like Information transfer through fibre optic cable, door and security control systems, Railway signaling etc.

Advantages:-

1. High efficiency, speed & reliability.
2. NO UV radiations
3. Low cost & heat dissipation is less.
4. Easily controlable and programmable.

LASER DIODE :-

L = Light

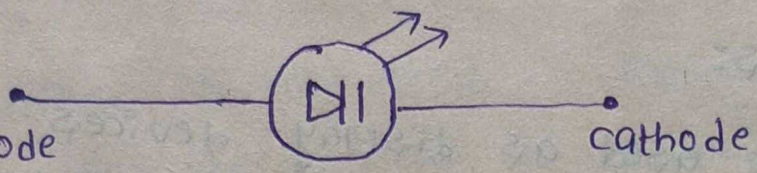
A = Amplification by

S = Stimulated

E = Emission of

R = Radiation

* It is a optical diode which emits light with stimulated process. The symbol of LASER diode is as shown in the figure.



* whenever a photon is incident on an atom that atom is excited from a low energy state to high energy state & two photons are released in the processed.

* Inorder to achieve amplification the atom is made to place in the metastable state for 10^{-3} sec.

* In general the atom can stay 10^{-8} sec in the higher energy state.

* while the atom gets to the lower state from metastable state two photons will be released & this process continuous. This effect is known as lasing effect.

* Having more no.of atoms in metastable state than lower energy state is called population inversion, which is the principle of LASER diode.

* The energy that lets atoms from the metastable state to the higher state is called optical pumping.

* The process of lasing effect, population inversion & optical pumping is as shown below.

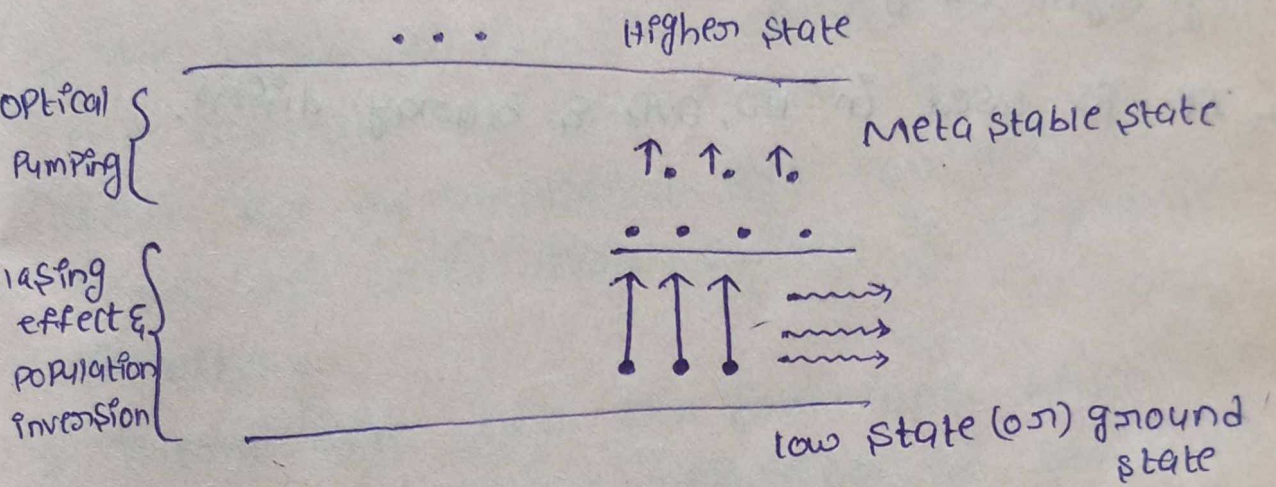


fig: Principle of LASER diode

Advantages:-

1. Low power consumption
2. Less cost
3. Less chance of electrical shock
4. High ON/OFF switching speed.

Disadvantages:-

1. Life time is less compared to LED
2. Quality is not so good.

3. It is prone to damage due to unstable power supplies.

Applications :-

1. LASER Guns, Electronic toys
2. In LASER Printers and LASER Fax machines
3. Used in medical applications, which involve LASER diodes like cataract surgery & Eye sight surgery.
4. It is used in HD, DVD & bluray disks.