* What is crystal? What its is important in electronics

A crystal is a solid material whose atoms or molecules are arranged in a regular repeating pattern called a crystal lattice

This orderly structure gives crystals unique physical and electrical properties.

Example:

Table salt (NaCl), Quartz (SiO_2)

pure Si, Ge (used in electronics)

Importance:

i) Used in Semiconductor Devices: Crystals like Silicon, Ge are used to make diodes, transistors and integrated circuits (ICs)

ii) Crystal Diodes are used for Rectification. to convert AC to DC

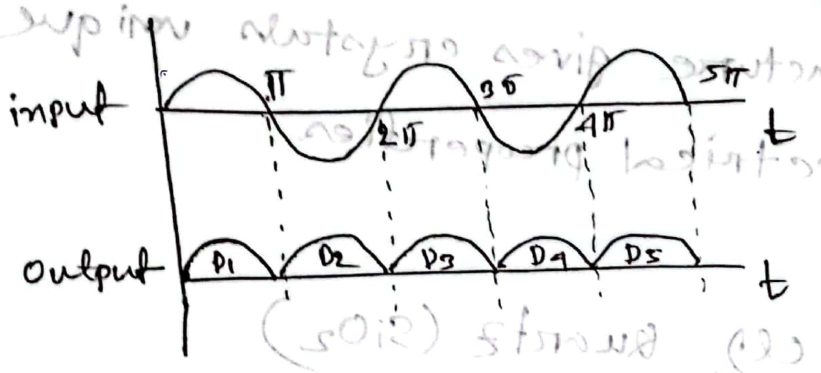
iii) Oscillators and Timing Circuits,

iv) provide Stable Electrical properties.

v. Quartz crystals help in accurate frequency generation in clocks and computers.

* Derive an expression for the efficiency of a full-wave rectifier.

Here, input & output waves forms are→



Here,
Input a.c voltage, $V = V_m \sin\theta$
r_f = Forward resistance of diode
R_L = Load Resistance
Instantaneous current,
$$i = \frac{V}{r_f + R_L} = \frac{V_m \sin\theta}{r_f + R_L}$$

For full wave rectifier, the efficiency is defined as ration of d.c output power P_{dc} to input power $P_{a.c}$

$$\therefore \text{Efficiency, } \eta = \frac{P_{dc}}{P_{ac}} \longrightarrow (1)$$

We know,

$$\text{Average (DC) current, } I_{dc} = \frac{2I_m}{\pi}$$

$$\text{where, } I_m = \frac{V_m}{r_f + R_L}$$

$$\therefore \text{d.c. Power output, } P_{dc} = I_{dc}^2 R_L$$

$$P_{dc} = \left(\frac{2I_m}{\pi}\right)^2 \times R_L \quad \text{--- (11)}$$

Again, r.m.s value of current,

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$\therefore$ a.c input power, $P_{ac} = I_{rms}^2 \times (r_f + R_L)$

$$P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L) \quad \text{--- (14)}$$

$\therefore$ For, full wave rectification is,

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{\left(\frac{2I_m}{\pi}\right)^2 R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)}$$

$$= \frac{4\cancel{I_m^2} R_L \times 2}{\pi^2 \cancel{I_m^2} (r_f + R_L)}$$

$$= \frac{8R_L}{\pi^2 (r_f + R_L)} = \frac{0.812 R_L}{(r_f + R_L)}$$

$$= \frac{0.812}{\left(1 + \frac{r_f}{R_L}\right)} \quad \boxed{R_L \text{ divide by both side}}$$

When, $r_f << R_L$

The efficiency will be maximum if r_f is negligible as compared to R_L

$\therefore$ Maximum efficiency = 81.2%

Thus, the maximum efficiency of a full-wave rectifier is 81.2%.

Note: Full-wave rectifier efficiency is twice that of half-wave rectifier.

* Ripple Factor:

The ratio of r.m.s. value of a.c component to the d.c. component in the rectifier output is known as ripple factor.

$$\text{Ripple factor} = \frac{\text{r.m.s value of a.c component}}{\text{Value of d.c. component}} = \frac{I_{ac}}{I_{dc}}$$

- Smaller ripple factor $\Rightarrow$ more effective rectification.
- Large r.f. $\rightarrow$ more pulsations $\Rightarrow$ poor rectification.

Now, ~~I_{ac}~~ the output current is composed of a.c current as well as d.c component present in the outputs.

Let, I_{ac} = R.M.S. value of a.c component present in output.

I_{dc} = d.c. " "

I_{RMS} = R.M.S. value of total load current.

$\therefore I_{rms} = \sqrt{I_{dc}^2 + I_{ac}^2}$

or, $I_{rms}^2 = I_{dc}^2 + I_{ac}^2$

or $I_{ac}^2 = I_{rms}^2 - I_{dc}^2$

or $I_{ac} = \sqrt{I_{rms}^2 - I_{dc}^2}$

dividing both side by I_{dc}

or, $\frac{I_{ac}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}$

$\boxed{\therefore R.F. = \frac{I_{ac}}{I_{dc}}}$

$\boxed{\text{or } R.F. = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}}$

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i) For Half-wave:

We know, $I_{rms} = \frac{I_m}{2}$, $I_{dc} = \frac{I_m}{\pi}$

$\therefore R.F. = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

$= \sqrt{\frac{\left(\frac{I_m}{2}\right)^2}{\left(\frac{I_m}{\pi}\right)^2} - 1} = \sqrt{\frac{\cancel{I_m^2} \times (3.1416)^2}{4 \times \cancel{(I_m)^2}} - 1}$

$= 1.21$

* Half এ AC বেশি থাকে DC কম থাকে।

In half-wave rectifier, AC component > DC

* তাই output current অনেকটাই উঠা-নামা করে (pulsating)

So, resulting in high pulsations

* তাই ভাল না AC to DC তে রূপান্তর

Therefore, it is inefficient for converting a.c. into d.c.

---

ii) Full-wave:

We know, $I_{rms} = \frac{I_m}{\sqrt{2}}$, $I_{dc} = \frac{2 I_m}{\pi}$

$\therefore R.F. = \sqrt{\frac{\cancel{I_m^2} \times \pi^2}{2 \times 4 \cancel{I_m^2}} - 1}$

$= 0.48$

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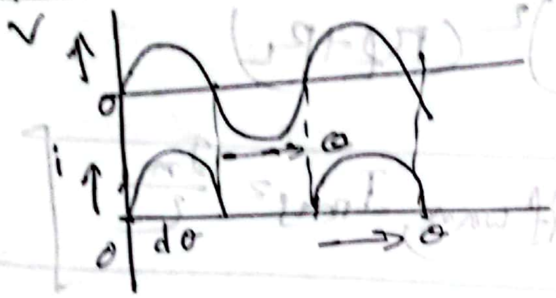
In full-wave, $\boxed{DC > AC}$ component

∴ pulsation is less than half wave rectifier.

∴ It is more used for conversion of a.c. to dc.

* Efficiency of half-wave:



Here, $I_{av} = I_{dc} = \frac{1}{2\pi}\int_0^{\pi} i\,d\theta = \frac{1}{2\pi}\int_0^{\pi} \frac{V_m \sin\theta}{r_f + R_L}\,d\theta$

$= \frac{V_m}{2\pi(r_f+R_L)}\int_0^{\pi} \sin\theta\,d\theta$

$= \frac{V_m}{2\pi(r_f+R_L)}\left[-\cos\theta\right]_0^{\pi} = \frac{-V_m}{2\pi(r_f+R_L)}(-1-1)$

$= \frac{V_m}{\cancel{2}\pi(r_f+R_L)} \times \cancel{2} = \frac{V_m}{(r_f+R_L)} \times \frac{1}{\pi}$

$\boxed{I_{dc} = \frac{I_m}{\pi}}$ $\left[I_m = \frac{V_m}{r_f+R_L}\right]$

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$\therefore$ D.C. Power, $P_{dc} = I_{dc}^2 \times R_L$

$$= \left(\frac{I_m}{\pi}\right)^2 \times R_L$$

A.C. Power input, $P_{AC} = I_{RMS}^2 (r_f + R_L)$

$$= \left(\frac{I_m}{2}\right)^2 (r_f + R_L)$$

$$\boxed{\text{for half wave, } I_{RMS} = \frac{I_m}{2}}$$

$\therefore$ Rectifier efficiency $= \dfrac{P_{dc}}{P_{AC}}$

$$= \frac{\left(\frac{I_m}{\pi}\right)^2 \times R_L}{\left(\frac{I_m}{2}\right)^2 (r_f + R_L)} = \frac{\cancel{I_m^2} R_L \times 4}{\pi^2 \times \cancel{I_m^2} (r_f + R_L)}$$

$$= \frac{0.406 R_L}{r_f + R_L} = \frac{0.406}{1 + \frac{r_f}{R_L}}$$

When, $r_f << R_L$

The efficent will be maximum

--- is 40.6%

Half

$$I_{rms} = \frac{I_m}{2}$$

$$I_{dc} = \frac{I_m}{\pi}$$

$$P_{dc} = I_{dc}^2 R_L$$

Full

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$I_{dc} = \frac{2 I_m}{\pi}$$

$$P_{dc} = I_{dc}^2 R_L$$

$$P_{AC} = I_{rms}^2 (r_f + R_L)$$

$$I_m = \frac{V_m}{r_f + R_L} = \frac{V_m \sin\theta}{r_f + R_L}$$

$V_m \rightarrow V_{ac,max}$

* Discuss on resistance of crystal Diode with figure and graphs.

A crystal diode shows different resistance behavior under forward and reverse bias condition. This resistance is not constant and varies based on type of voltage applied (DC or AC)

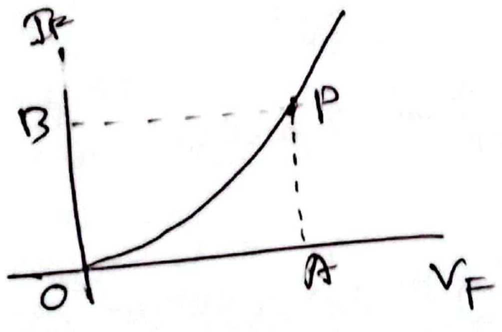
Two types:

Forward Resistance:

When the diode is forward biased, it conducts current easily and offers small resistance

There are two types:

i) DC (R_f):



- It is the ratio of DC voltage across the diode to the resulting DC current.
- From the forward characteristic curve,

$$R_f = \frac{OA}{OB}$$

where, OA is forward voltage
OB " " current.

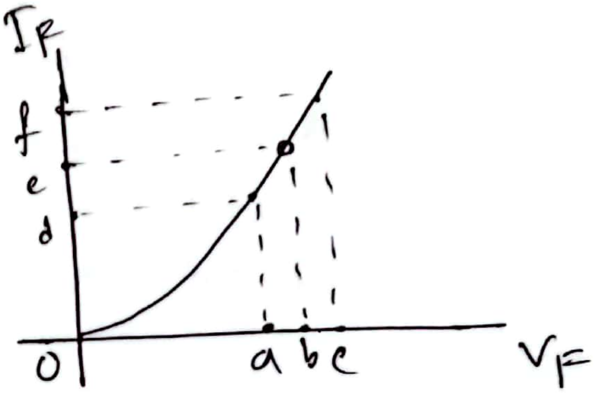
ii) AC F.R (r_f):

- It is the opposition to a changing forward current.

From figure,

$$r_f = \frac{\text{Change in forward voltage}}{\text{Change in forward current}} = \frac{oc - oa}{of - od} = \frac{ac}{df}$$

Typical value: Forward resistance ranges from 1Ω to 25Ω



Reverse Resistance:

When reverse biased the diode offers very high resistance, ideally infinite but practically very >

Practically, due to small leakage current, it is very high but not infinite.

Ge, reverse-to forward resistance ratio = 40000 : 1

Si " " 1000000 : 1

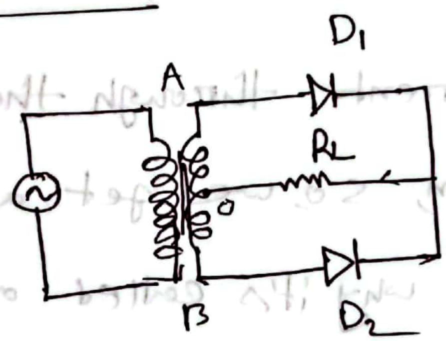
* What are the different types of full wave rectifiers? Explain their operations with appropriate figures and graphs.

Two types:

i) Centre-Tap Full-wave Rectifier

ii) Full-Wave Bridge Rectifier.

i) Centre-tap:



A centre tap rectifier is a type of full-wave rectifier that uses a centre-tapped transformer and two diodes to convert AC int DC.

A centre-tap full-wave rectifier uses a transformer with a centre-tapped secondary winding and two diodes to convert AC into DC.

operation:

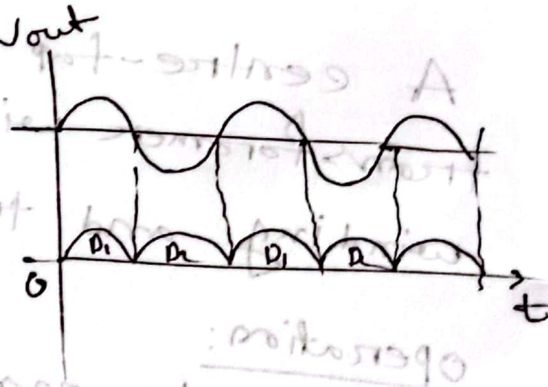
During the positive half cycle of the input AC signal, point A of the transformer becomes positive and point B becomes negative. In this case diode D_1 is forward-biased and conducts current, while diode D_2 is reverse-biased and does not conduct current.

So, current flows from $A \rightarrow D_1 \rightarrow R_L \rightarrow$ Center tap O

During the negative half-cycle, point B becomes positive and A becomes negative. Now, D_2 is forward and conducts; D_1 is reverse, and stays off.

The current flows from $B \rightarrow D_2 \rightarrow R_L \rightarrow$ center tap O.

In both half cycles, current through the load flows in the same direction, so we get a DC output across the load. This is why it's called a full-wave rectifier.



Disadvantage:

i) Difficult to find the centre tap on the secondary winding

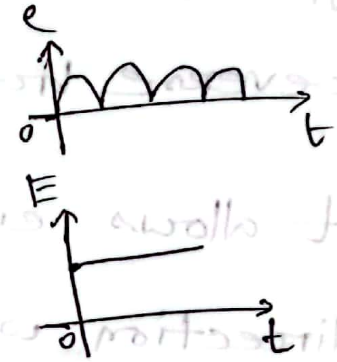
ii) The diodes used must have high peak inverse voltage

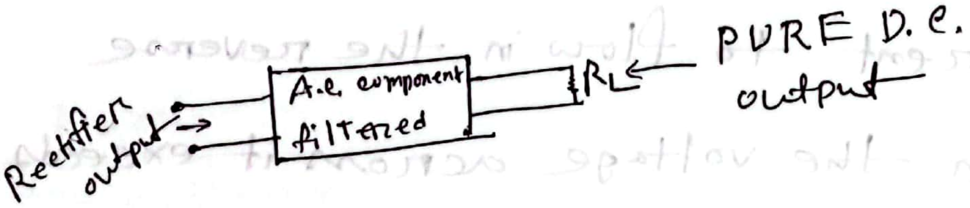
iii) Only half of the secondary voltage is used by each diode - results in lower output voltage.

iv) Transformer cost is high

A Filter circuit: is a device which removes the a.c. component of rectifier output but allows the d.c. component to reach the load.

obviously, a filter circuit should be installed between the rectifier and the load





Type:

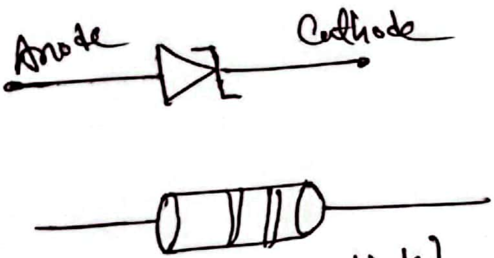
i) Capacitor filter:

ii) Choke input filter:

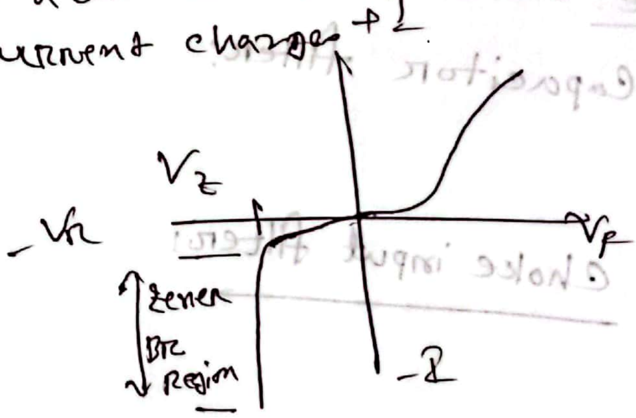
iii) Capacitor input filter or π-filter:

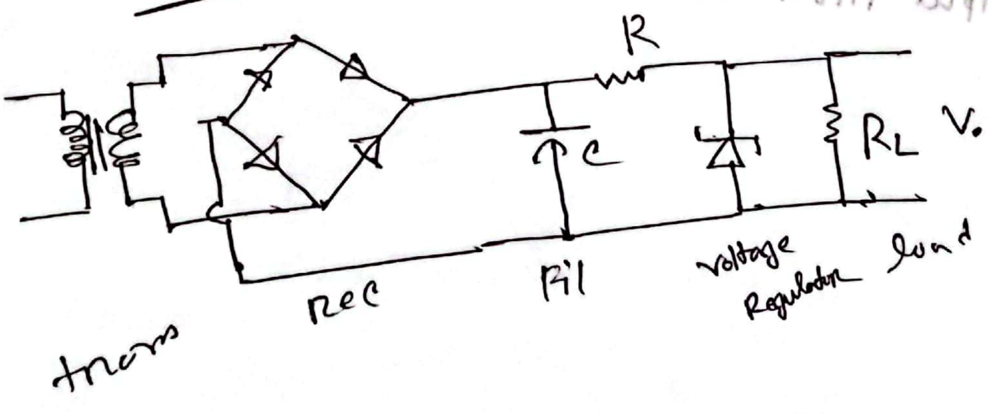
Zener Diode: A zener diode is a special type of diode designed to operate in the reverse breakdown region without damage.

It allows current to flow in the reverse direction when the voltage across it exceeds a certain value called Zener Breakdown Voltage. It can maintain a constant output voltage even if the input voltage or load current changes.

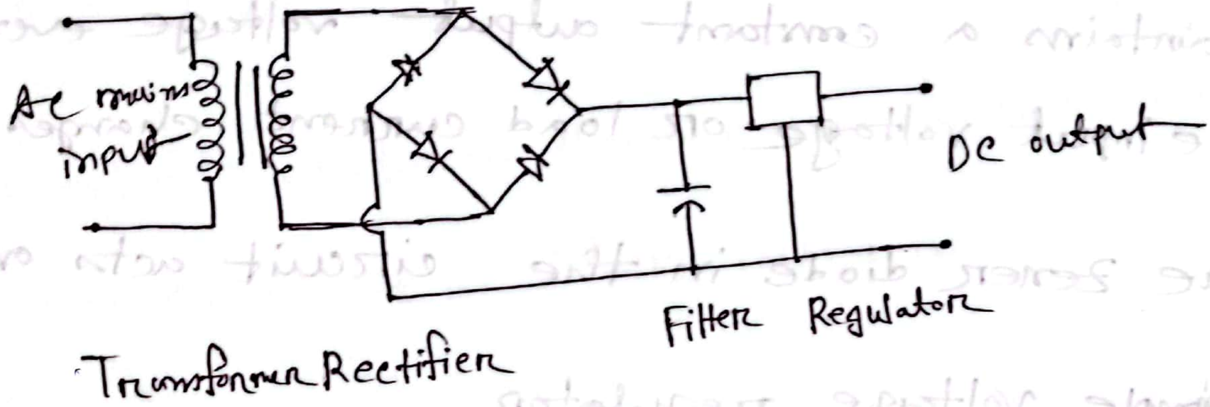


(Zener diode)





Power Supply:



Principle:

Transformer:

- Steps down the high-voltage AC mains to a lower AC voltage

ii) Rectifier: Converts the low voltage AC into pulsating DC using a bridge rectifier

iii) Filter: Smooths the pulsating DC and makes it a steady DC using capacitor

A voltage regulator is a device or circuit that maintains a constant output voltage even if the input voltage or load current changes.

The zener diode in the circuit acts as a simple voltage regulator.

Principal of power supply:

Step-1: The AC supply is stepped down by the transformer to a lower AC voltage.

Step-2: The rectifier converts AC to DC.

Step-3: The filter (capacitor) removes ripples and smoothens the DC output

Step-4: The zener diode is connected across the load in reverse bias.

Step-5: If the voltage across the load becomes higher than the zener voltage, the zener diode turns on and controls the extra voltage, the zener diode starts conducting and keeps the voltage constant at the desired level.

* Mention faults in Center-Tap full wave rectifier.

We can divide the rectifier faults into two classes viz.

1) Faults in Transformer.

i) A shorted primary or secondary winding

ii) An open " " " "

iii) A short between the primary or secondary winding and the transformer frame.

2) Faults in Rectifier Diodes:

i) ~~If one~~ Shorted diode: primary fuse below due to secondary short.

ii) open diode: output becomes like a half-wave rectifier

* V-I characteristics of Zener Diode:

i) F.B. Region:

· When zener diode is forward biased (anode positive, cathode negative), it behaves like a normal diode.

· After a small threshold voltage (about 0.7 Si) the current increases rapidly.

2) R.B. Region:

i) When R.B (anode negative, cathode (+)), only a very small leakage current flows initially.

ii) As the reverse voltage reaches a certain value called zener voltage (V_Z), the diode start conducting heavily.

iii) After V_Z, even if the current increases, the voltage remains nearly constant.

* Choke input filter: A choke input filter is a filter circuit that uses an inductor (called a choke) in series with the rectifier output and a capacitor across the load.

* A crystal diode is a semiconductor device made of a p-n junction that allows current to flow only in one direction
It is widely used for Rectification, switching, and signal detection.

A vaccum diode: is an electron tube with two electrodes (cathode and anode) placed inside a vacuum.
It allows electrons to ~~flo~~ flow from the heated cathode to the anode, permitting current flow in one direction only.

Capacitor filter: A filter that uses a capacitor to reduce ripple and smooth the DC output.

Capacitor input Filter: A filter where a capacitor is connected first after the rectifier to remove AC ripples.

* How zener diode can be used as voltage stabilizer.

A zener diode can maintain a constant output voltage even if the input voltage or load current changes.

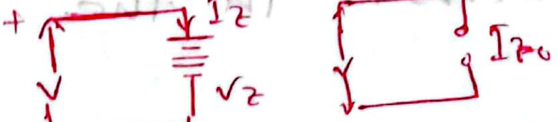
In the circuit, the zener diode is connected in reverse bias across the load. A series resistor (R_s) is used to absorb extra voltage changes.

i) When input voltage increases, the zener diode conducts more current to keep the output voltage constant.

ii) When input voltage decreases, the zener diode conducts less or stops conducting again maintaining the same output voltage.

iii) As long as input voltage is greater than the zener voltage, the zener diode keeps the output fixed at zener voltage (V_Z).

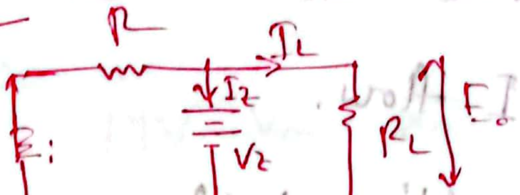
Thus the zener diode acts as a voltage stabilizer by maintaining a steady voltage across the load.



* What do you mean by break down voltage?

Breakdown voltage is a parameter of a diode that defines the largest reverse voltage that can be applied without causing an exponential increase in the leakage current in the diode.

on



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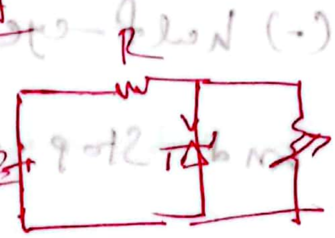

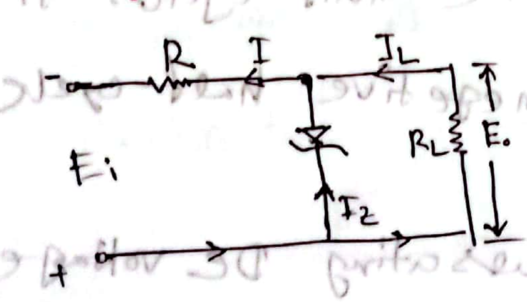

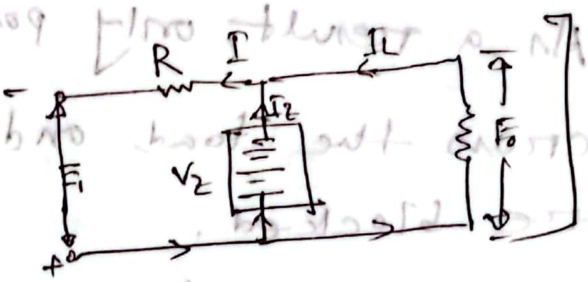

Zener voltage stabilizer

* What is rectifier? How crystal diode can be used as a rectifier.

A rectifier is a device that converts alternating current (AC) to direct current (DC)

It allows current to flow in only one direction and blocks it in the opposite direction.

A crystal diode can work as a rectifier because it conducts current only in one direction

i) During the positive half-cycle of AC input, the diode becomes for. b. and allows I to pass through the load (R_L).

ii) (-) half-cycle, the diode becomes R.b. and stop the I flow.

iii) As a result, only positive half-cycles appear across the load and negative half-cycle are blocked.

This process produces a pulsating DC voltage across the load.

Thus a crystal diode converts AC into DC and acts as a rectifier

* Why we use Filter in an Electrical Network?

We use filter in an electrical network to remove unwanted AC components (ripples), ~~from the~~ and allow only DC voltage to reach the load. Filters smooth the pulsating DC and provide a steady and pure DC supply for proper.

PIV: Peak inverse voltage is the maximum voltage that appears across a diod when it is in the reverse-biased condition (non conducting state)

Half: $PIV = V_m$ = max input value

Full Bridge: $PIV = V_m$ "

Center tap-Full → PIV $2V_m$

* Mention different type of energy band to the properties.

i)

ternal

i) Valence Band: The energy band that contain the outermost electrons (valence electrons) of an atom is called the valence band.

Properties:

i) It is the highest fully occupied band at 0K.

ii) Electrons here are bound to atoms and can not move freely.

iii) Does not contribute directly to electrical conduction.

iv) When electrons gain enough energy, they may jump to the conduction band.

v) In inert gases, the valence band is completely filled whereas in other substances the valence band is partially filled.

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* Mention different type of energy band and their properties.

i)

i) Valence Band: The energy band that contain the outermost electrons (valence electrons) of an atom is called the valence band.

Properties:

i) It is the highest fully occupied band at 0K.

ii) Electrons here are band to atoms and cannot move freely.

iii) Does not contribute directly to electrical conduction.

iv) When electrons gain enough energy, they may jump to the conduction band.

v) In inert gases, the valence band is completely filled whereas in other substances the valence band is partially filled.

2) Conduction Band: is the band of electron orbitals that electrons can jump up into from the valence band when excited.

Properties:

i) Electrons in this band are not bound to atoms and can move freely, thus enabling electrical conduction.

ii) In metals, some valence electrons become free even at room temperature and move to this band.

iii) If the conduction band is:

- Partially filled, the material conducts electricity
- Empty, the material can't conduct (insulators)

3) Forbidden Energy Gap: The forbidden energy gap is the energy difference between the valence band and the conduction band.

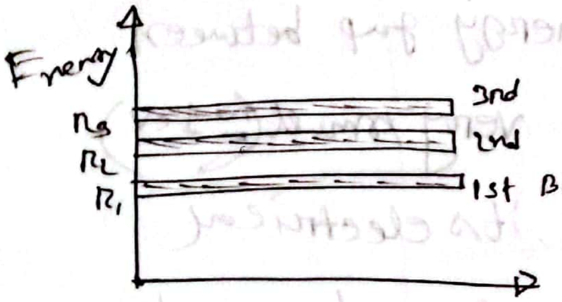
Properties:

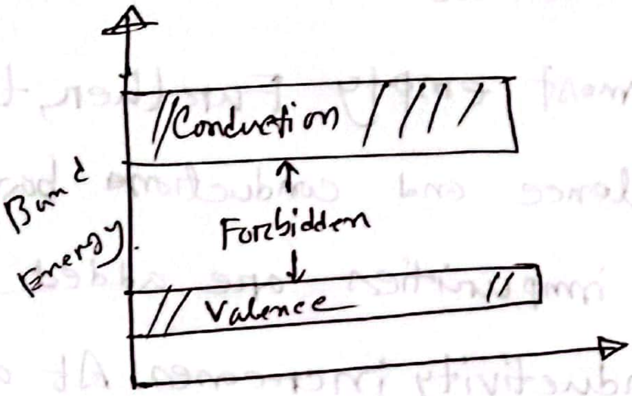
i) No electrons can exist in this region.

ii) The width of the forbidden energy gap is a measure of the bondage of valence electrons to the atom.

iii) The greater the energy gap, more tightly the valence electrons are bound to the nucleus.

iv) In order to push an electron from valence band to the conduction band (make the valence electron free) external energy equal to the forbidden energy gap must be supplied.

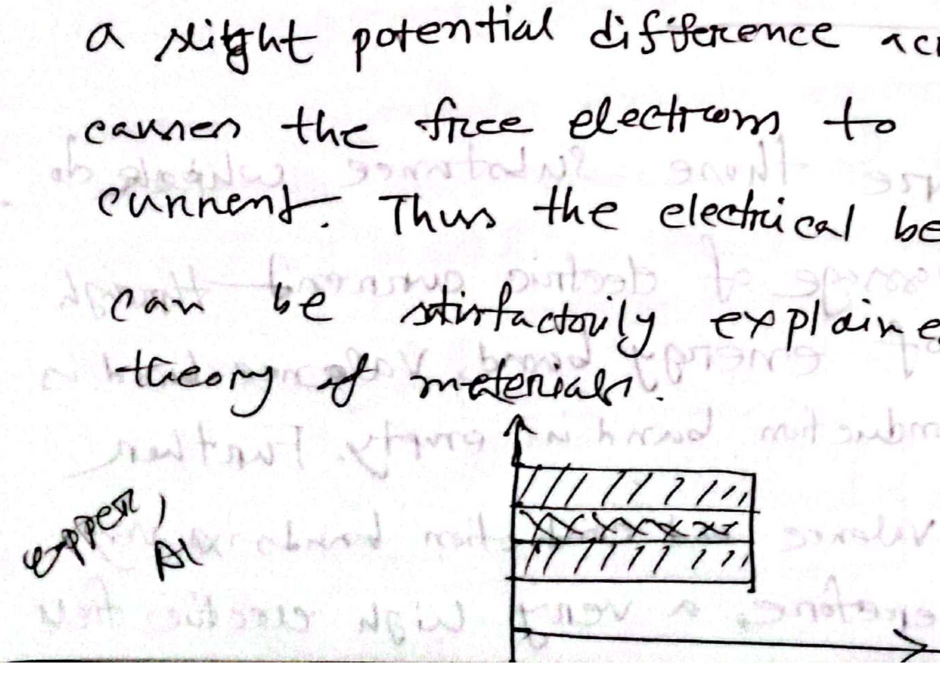




* Classify solids considering energy bands and gap!

1) **Conductors:** is a substance or material that allows electricity to flow through it.

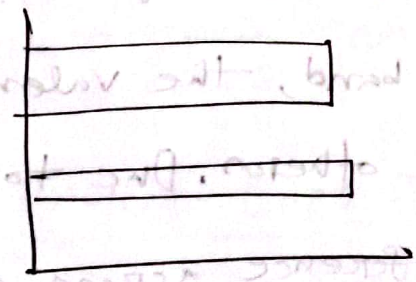
i) In terms of energy band, the valence and conduction bands overlap each others. Due to this overlapping a slight potential difference across a conductor causes the free electrons to constitute electric current. Thus the electrical behaviour of conductors can be satisfactorily explained by the band energy theory of materials.



(ii) Semiconductors: are those substances whose electrical conductivity lies inbetween conductors and insulators. In terms of energy band, the valence band is almost filled and conduction band is almost empty. Further, the energy gap between valence and conductions bands is very small ($\simeq 1 ev$) If impurities are added to it, its electrical conductivity increases. At absolute zero temperature it behaves as an insulator

Its electrical conductivity increases with the rise in temperature.

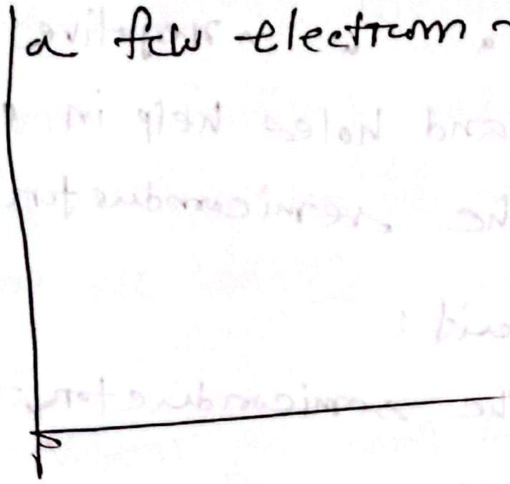
- Silicon, Germanium



3) Insulators: are those substance which do not allow the passage of electric current ~~through~~ them. In term of energy band, valence band is full while the conduction band is empty. Further the energy gap between valence and conduction bands is very large ($\simeq 15 eV$). Therefore, a very high electric field

is required to push the valence electrons to the conduction band. At room temperature, electrons can't gain enough energy to jump the gap. At very high temperature a few electrons may jump, slightly reducing resistance.

Fuller, wad etc



* Different type of semiconductor:

1) Intrinsic semiconductor: is a pure semiconductor material like Si, Ge, that has not been intentionally doped with impurities. Here the number of free electrons (negatively charged carriers) is equal to the number of holes (positively charged "empty" space where electrons could be).

These materials exhibit electrical conductivity solely based on the properties of the semiconductor material itself, without any added dopants.

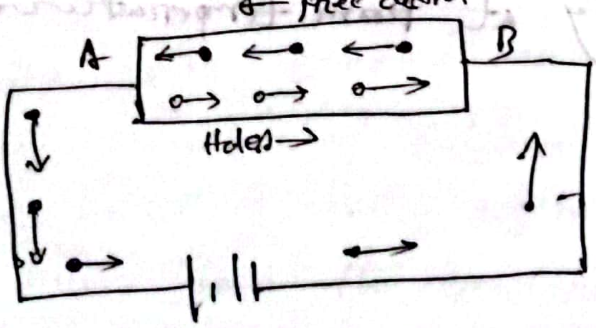


Figure: Inside the semiconductor:

- Free electron (negative charge) move towards the positive terminal (A).
- Holes (positive) " " " " negative " (B)
- Both free electrons and holes help in current conduction inside the semiconductor.

In the external circuit:

- In the wires outside the semiconductor, the current is only due to electrons.
- Electrons flow from the negative terminal → through the wire → to terminal B of the semiconductor.
- At terminal B, electrons enter the semiconductor and fill holes, cancelling them.
- " " A, new holes are created as electrons are pulled away from atoms into the positive terminal.

continuous process

The intrinsic semiconductor has little current conduction capability at room temperature.

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Extrinsic: is ~~defined as that~~ formed by doping a small amount of impurity into a pure (intrinsic) semiconductor to increase its conductivity.

Doping means intentionally adding impurity atoms to increase the number of charge carriers (either electrons or holes).

two types:

i) p-type: When a small amount of trivalent impurity is added to a pure semiconductor, it is called p-type.

formed:

Let's take a pure germanium (Ge) crystal.

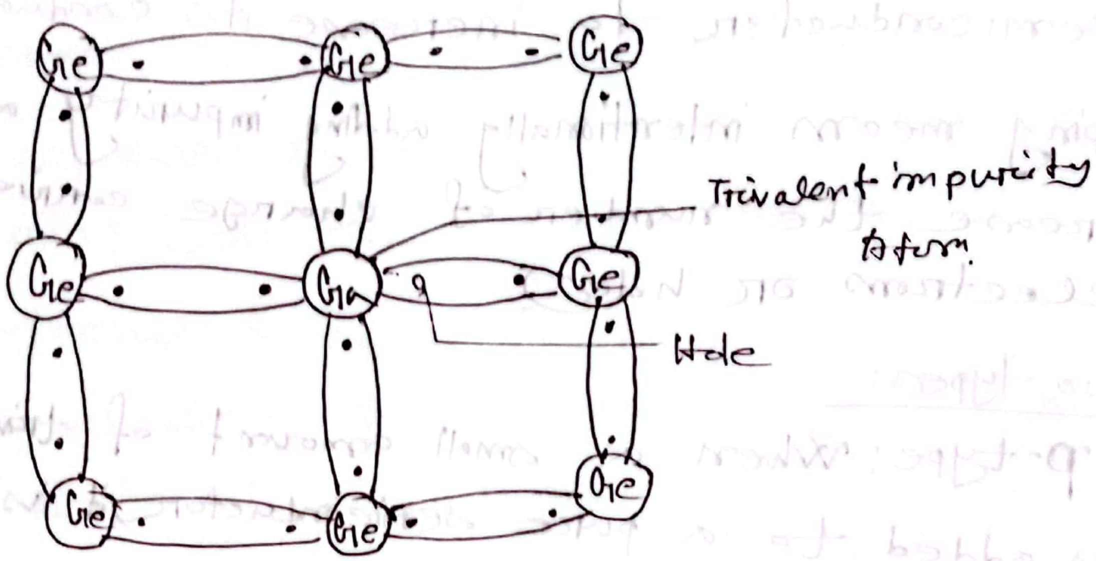
- When gallium is added to it, the (Ga) gallium atom replaces one germanium atom
- Ga has only 3 valence electrons, so it can form only 3 covalent bonds with neighboring Ge atoms.
- But a Ge atom needs 4 bonds, so, the fourth bond remains incomplete - it lacks one electron.
- This missing electron is called a hole.

So, a Ga atom creates one hole.

A small amount of galium can create millions of the holes in the crystal

Here, holes are the majority charge carrier.

These holes help conduct current, and that's why it's called an acceptor-type semiconductor.



n-types:

When a small amount of pentavalent impurity is added to a pure semiconductor it is known as n-type semiconductor.

Let's take a pure germanium crystal.

i) when a small amount of As is added to the crystal, each As atom replaces one Ge atom

ii) The As atom uses 4 of its electrons to form 4 covalent bonds with neighboring Ge atom.

iii) But As has 5 electrons, so 1 electron remain free.

This creates extra free e⁻, which are the majority charge carriers. so most of the current flows due to electrons. Hence, it is known as a donor-type semiconductor

* What do you know regarding the biasing of a p-n junction?

Biasing means applying an external voltage to a PN junction to control its behavior. It helps in controlling the flow of current through the junction.

two type:

Forward Bias:

When the p-type region of a p-n junction is connected to the positive terminal of a battery and the n-type region is connected to the negative terminal this is called forward bias.

In this condition,

- Free electrons in the n-type move toward the junction.
- Holes in the p-type also move toward the junction
- The depletion layer becomes thinner, and the potential barrier decreases, it is very small (0.1 to 0.3)
- Electrons and holes recombine at the junction.
- If the external voltage increase, the current increase too.

It allows easy flow of electric current

figure.

R.B.

=

In this condition:

· Free electrons in the n-type and holes in the p-t[illegible] move away from the junction

· the Dipletion layer becomes wider, and the potential barrier increases.

· Very little or almost no current flows through the junction.

· The flow of charge carriers is stopped.

· - and it prevents the flow of current in the PN junction,

* Explain How pn Junction is formed?

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* What are the different types of rectifiers? discuses principle of opperations of all the rectifiers also compare among them.

3 types:

i) Half wave – output: is pulsating DC, with large gaps between the pulses.

ii) Full-wave (center-tap transformer):
output is more continuous than half-wave

iii) Full-wave bridge –
output ; It provides full-wave rectification like the center-tap type, but more efficient

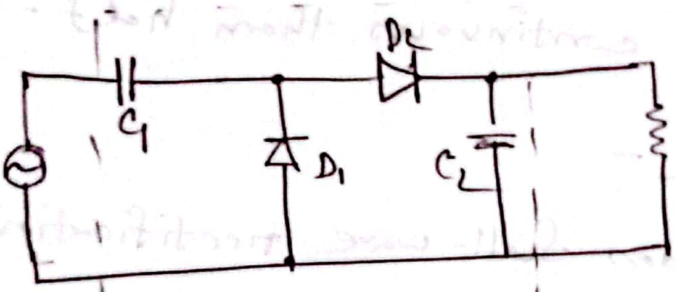
Compare:

Feature	Half	full	Bridge
No of diod	1	2	4
Transformer Requirment	No	Yes (center-tap)	No
Efficiency	Low 40.6%	Medium (81.2%	High 81.2%
Ripple factor	High 1.21	Lower than half-wave 0.48	Same as full-wave 0.48
Complexity	simple	M	slightly complex
D.V	Low	H	H

O.f.	f_{in}	$2f_{in}$	$2f_{in}$
P.I.V	V_{in}	$2V_{in}$	V_m

* Half-wave voltage doubler.

A half-wave voltage doubler uses two diodes (D_1, D_2) and two capacitors (C_1, C_2) to produce a DC voltage approximately twice the peak of the input AC voltage.



double the PIV of the output

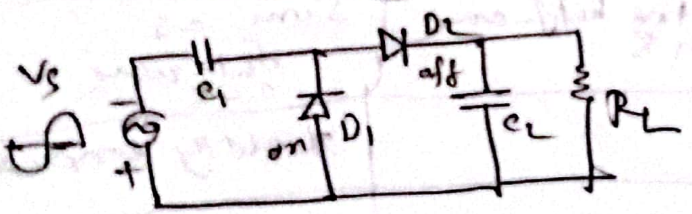
Half wave voltage doubler.

C_2 is still uncharged.

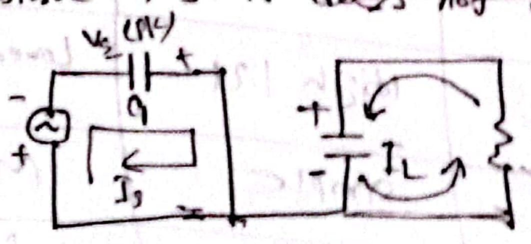
Step by step operation:

i) During the ~~positive~~ negative Half cycle:

- Diode D_1 is forward biased, and conducts.
- Capacitor C_1 charges up to the peak voltage (V_m) of the AC supply. ↳ to the peak value of input AC voltage (V_{spk}) through D_1
- Diode D_2 is reverse biased, so it does not conduct



negative figure



During the positive Half-cycle of the AC ~~output~~ input:

i) D_1 is reverse biased (OFF), D_2 is SB (ON)

ii) Now the source voltage (VS) and the charged voltage of C_1 (V_{spk}) add in series.

iii) So, C_2 is charged to $2 \times V_{spk}$ (from both VS and C_1)

iv) This doubled voltage appears across the load resistor (RL)

The output DC voltage becomes $2 \times V_{spk}$, hence the name "voltage doubler".

main	D_1	D_2	Action
N	ON	OFF	C_1 charges to V_{spk}
P	OFF	ON	C_2 " " $2 \times V_{spk}$

The circuit works as a voltage multiplier - It does not increase power, only voltage

Ideal diodes uses.

usefull for low-C, h-V

* Choke - input - Filter:

A choke input filter is used to remove AC ripple from the output of a rectifier and deliver smooth DC voltage

It has two main parts:

- A choke (L) connected is series with the rectifier output.
- A capacitor (C) connected in parallel across the load

Principle:

i) The rectifier output contains both AC and DC components, is applied across terminals 1,2 of the F.C.

ii) When the output goes through the choke (L) which is connected between terminal 2,3.

- The choke offers high opposition to AC (blocks AC)
- It offers very low opposition to DC (allows DC to pass)
- So, most of the AC stays across the choke, and DC goes to the next stage.
  - DC flows to terminal 3.

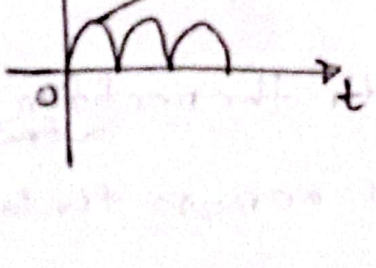
iii) Then the capacitor (C) removes any remaining AC by bypassing it to ground.

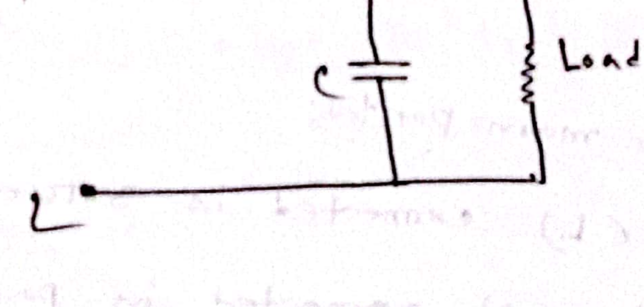
- The capacitor blocks DC from going through it.

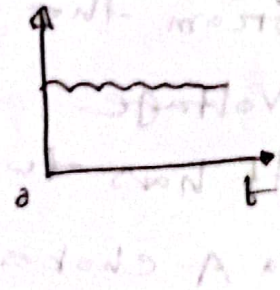
iv) As a result, only DC voltage reaches the load.

Final Result: The output becomes smooth DC with very little ripple.

This type of filter is very useful for large current.

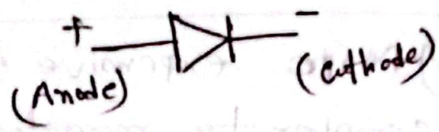






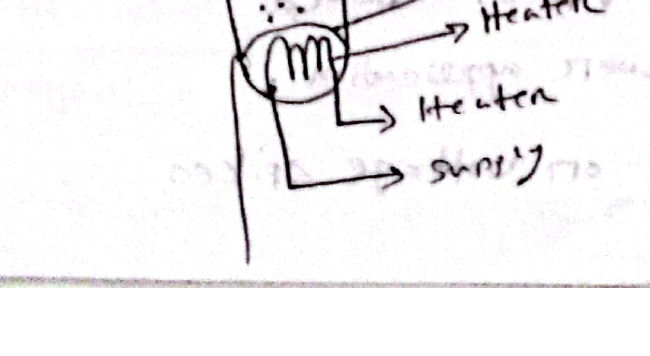
* Crystal Diode:

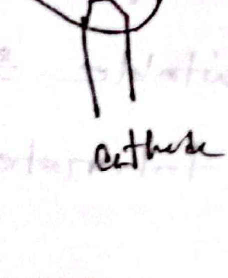
also know as a semiconductor diode, is a two-terminal electronic component that allows current to flow easily in one direction while significantly restricting it in the opposite direction. It constructed using a semiconductor material, typically Si, Ge, forming a p-n Junction. This junction is the heart of the diode, enabling its unidirectional current flow.



crystal diode

Vaccum diode: is the diode which allows the current flow from cathode to anode and blocks the current from anode to cathode is known as vaccum diode. The cathode of this diode generally emits free e⁻ so it is called an emitter whereas an anode gathers free electrons, so, it called a collector





Crystal	Vaccum
i) Made of semiconductor material like Si or GC	i) — of metallic electrodes (cathode and anode) enclosed a vacuum tube.
ii) Small in size, lightweight	ii) Bulky and larger in size
iii) No filament is required, so, no heating is needed	iii) Requires filament heating to emit e^-
iv) More efficient and consumes less power	iv) Less efficient due to power loss in the filament
v) Cheaper and easier to manufacture	v) More expensive and complex to manufacture

Advantage:

i) They are smaller, more rugged and have a longer life.

ii) They are simpler and inherently cheaper.

iii) They required no filament power. As a result they produce less heat than the equivalent vaccum diodes

Disadvantage:

i) Very sensitive to heat — excess temperature can damage it

2) They can handle small currents and low inverse voltages as compared to vaccum diodes.

3) Not suitable for high-power application.

4) can't tolerate overloads or voltage spikes

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* Working Principle of PNP transistor:

A pnp transistor consists of two p-type semiconductor layers separated by a thin n-type base. The three terminals are:

- Emitter (E) - p
- Base (B) - n
- Collector (C) = p

In operation:

both [
- The emitter-base (EB) Junction is forward biased.
- The collector - " (CB) " " RB.

When forward bias is applied:

i) Holes (majority carriers in the p-type emitter) are pushed towards the base region. This movement of holes constitutes emitter current (I_E)

Electron   n-

ii) The base is very thin and lightly doped, so only a small number of holes (about 5%) recombine with electrons in the base. This forms a small base current (I_B)

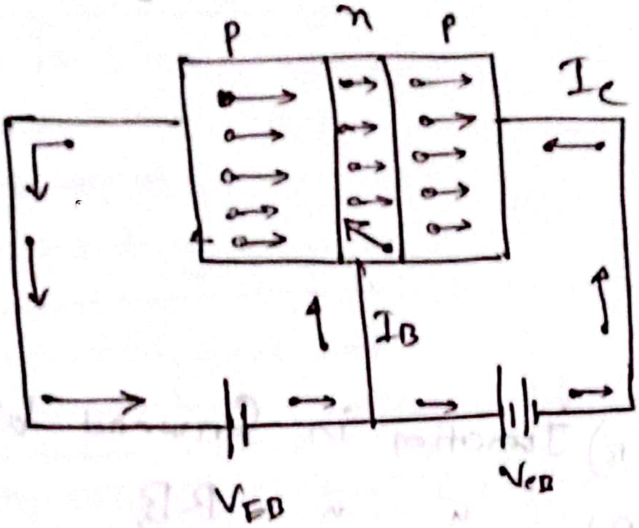
electron   holes

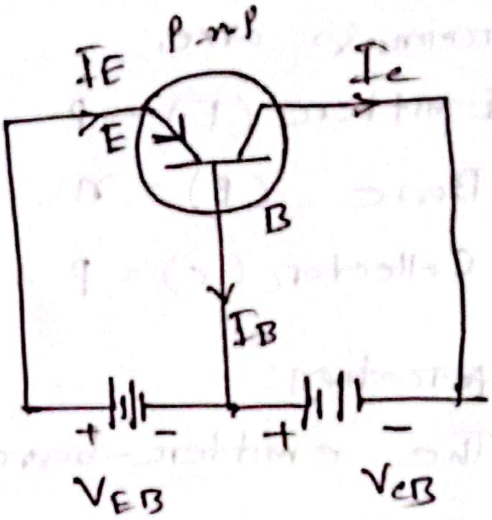
iii) The remaining majority (more than 95%) of holes cross over into the collector region and are attracted by the negative potential to constitute collector current (I_C).

electron

In this way, almost the entire emitter current flows in the

Collector circuit. It may be noted that current conduction within pnp transistor is by holes. However in the external connecting wires, the current is still by electrons.

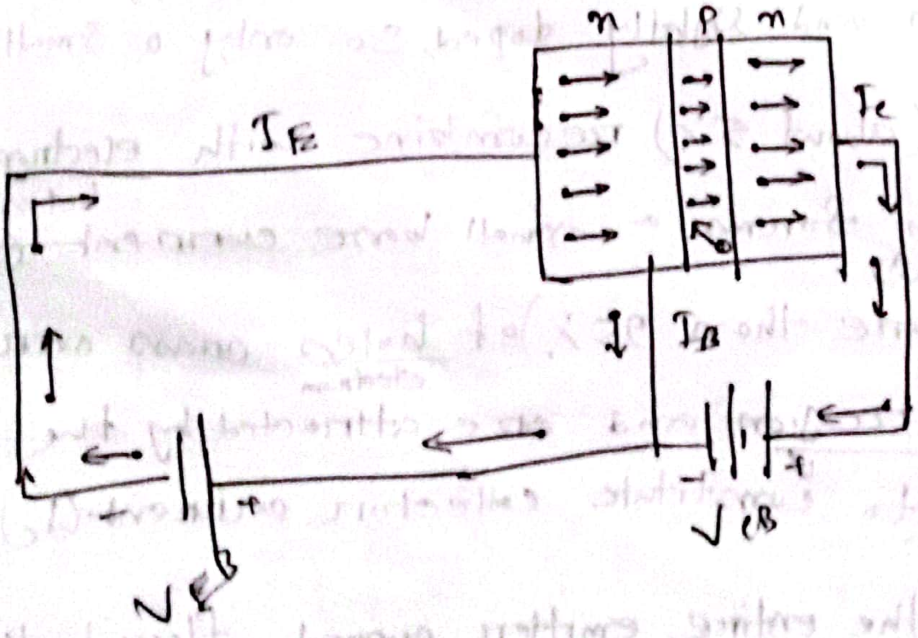


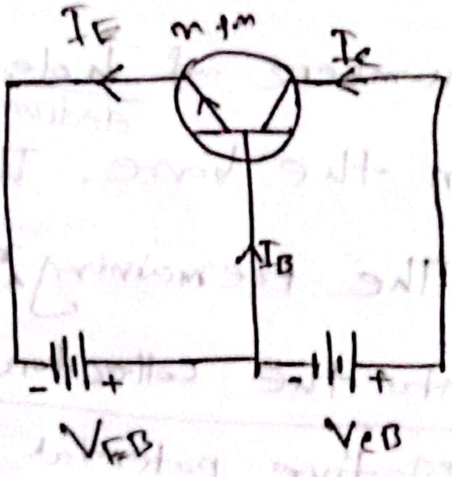


For n-pn last 6:

It is clear that emitter current is the sum of collector and base current i.e.,

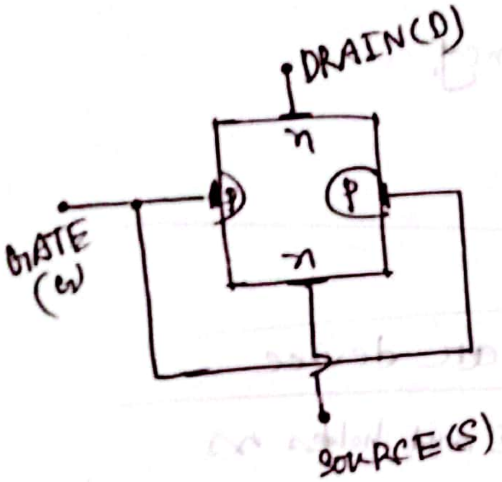
$$I_E = I_B + I_C$$



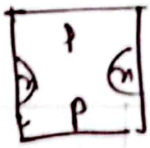


JFET

A Junction field-effect transistor is a type of field-effect transistor (FET) that uses a voltage applied to its gate to control the flow of current between its source and drain terminals. It has a three terminal semiconductor device in which current conduction is by one type of carrier i.e, electron or hole



n-channel JFET



P-

Advantages:

1) High input impedance: JFET has very high input resistance (about 100 MΩ),
So, the input and output are well isolated.

2) Low Noise: Since current flows through the whole material (not across junctions)
JFET Produces less noise compared to BJTs or Vacuum tubes.

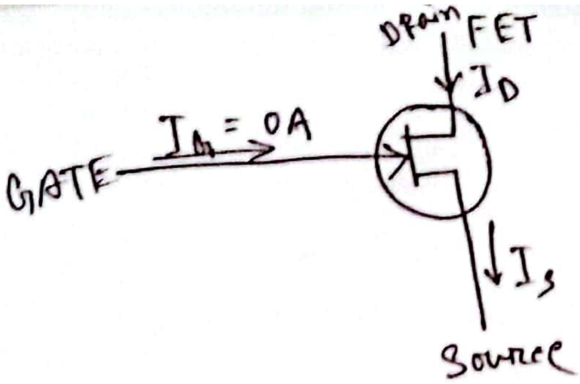
3) No thermal Runway: JFET has a negative temperature coefficient of resistance. This avoids the risk of thermal runway.

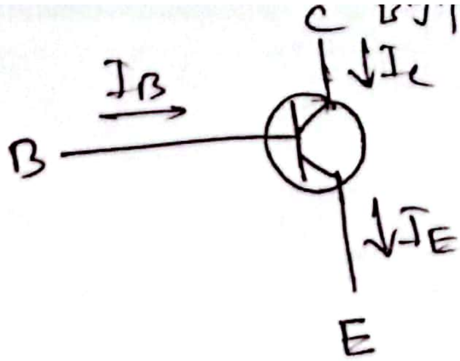
4) High power gain: A JFET has a very high power gain. This eliminates the necessity of using driver stages.

5) Small, Efficient & Long Life: A JFET has a smaller size, longer life, high efficiency.

* Difference

JFET	BJT
i) It is a unipolar device	i) It is a bipolar device
ii) Uses only one type of charge carrier (either e^- or holes)	ii) Uses both $\bar{e}$ and holes as charge carriers
iii) The gate-source junction is reverse biased. So it has high input impedance	iii) The base-emitter junction is F.B. so it has low input impedance
iv) Gate current is almost zero ($I_g \approx 0$)	iv) Base current is required (few microamperes)
v) Gain is measured by transconductance (g_m)	v) Gain is measured by current gain (β)
vi) Generates very low noise	vi) Generates more noise compared to JFET
vii) Terminals: Gate, Source, Drain (like grid, cathode anode in vacuum tube)	vii) Terminals: Base, Emitter, Collector (no direct vacuum tube analogy)





* How JFET amplifier works?