Chapter 05

Semiconductor:

A semiconductor is a substance which has resistivity (10^{-4} to $0.5\ \Omega m$) inbetween conductors and insulators. (Ge, Si, C)

properties of semiconductor:

1. resistitvity inbeetween conductors and insulators.
2. resistance $\propto \frac{1}{\text{temperature}}$
3. can be converted into conductors by adding impurity.

Crystals

A substance in which molecules are orderly arrange

All semiconductors have crystaline structure.

Energy required to break co-valent bonds:

Ge $\rightarrow$ 0.7 ev

Si $\rightarrow$ 1.1 ev

Effects of temperature in semiconductor

① At absolute zero:

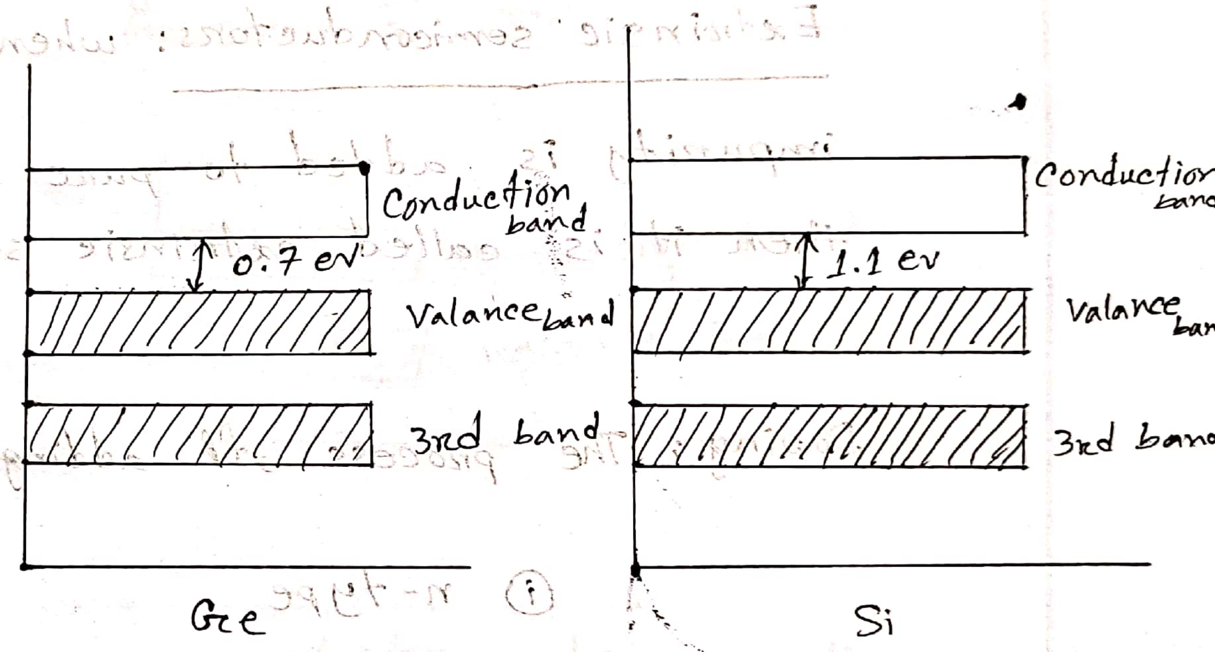
At zero degree temp. co-valant bonds are so strong and there are no free electrons.

② Avobe absolute zero:

when the temperature is raised then the co-valent bonds become weak and there are some free electrons which can flow current throug the semiconducto

Ⅲ Energy Band description of semiconductors :

A semiconductor is a substance which has resistivity inbetween conductor and insulators.



Forbidden bands are very small in semiconductors.

Types of semiconductors :

Intrinsic semiconductor: Pure semiconductors are known as intrinsic semiconductors.

Extrinsic semiconductors: when a little bit impurity is added to pure semiconductor then it is called extrinsic semiconductor.

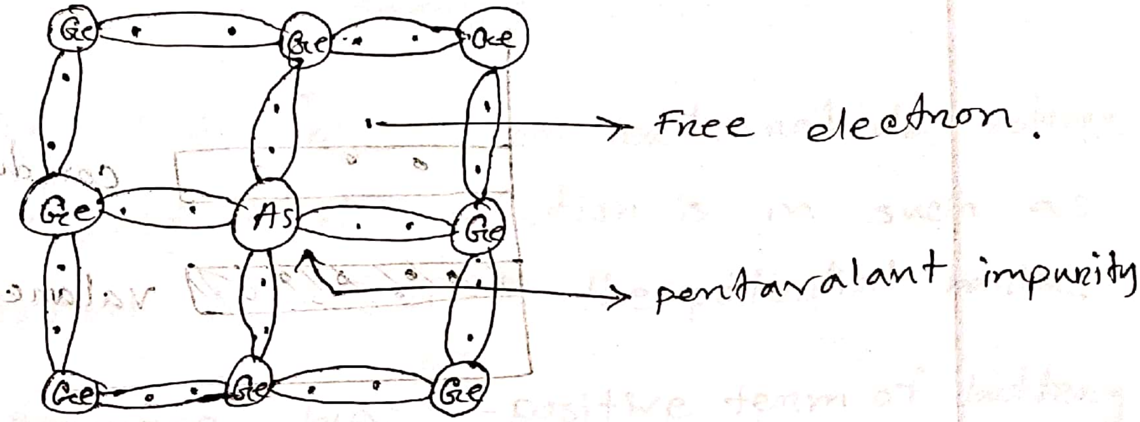
Doping: The process off adding impurity:

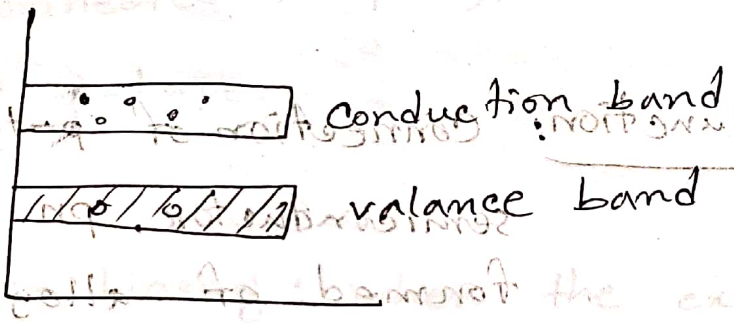
(i) n-type

(ii) p-type

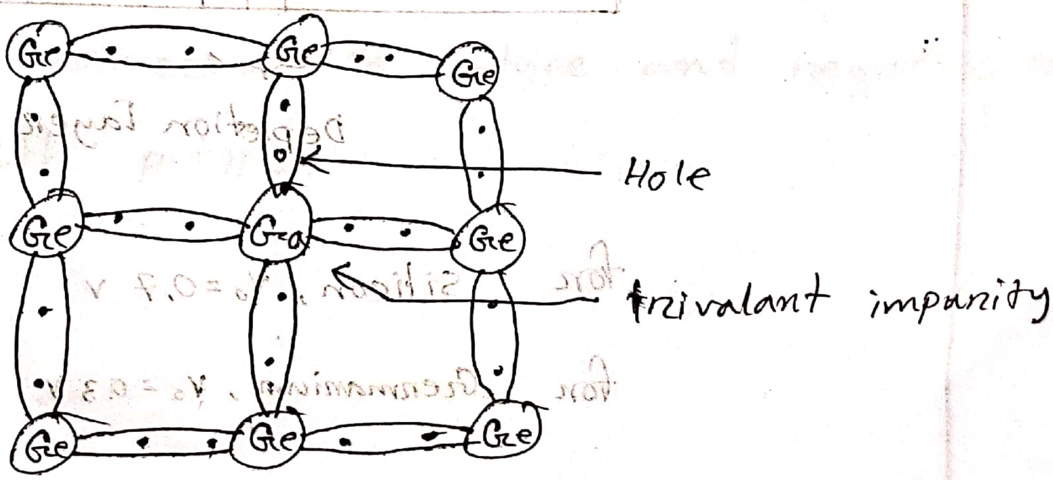
n-type semiconductor: when small amount of pentravalant is added to semiconductor.

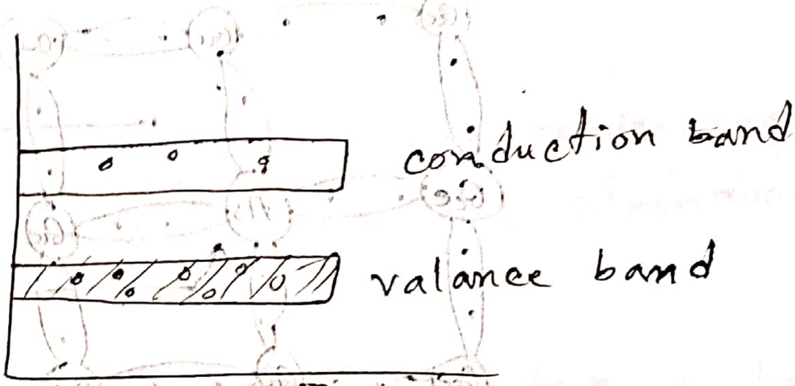
pentavalant impurity: arsenic, antimony, phosphorus



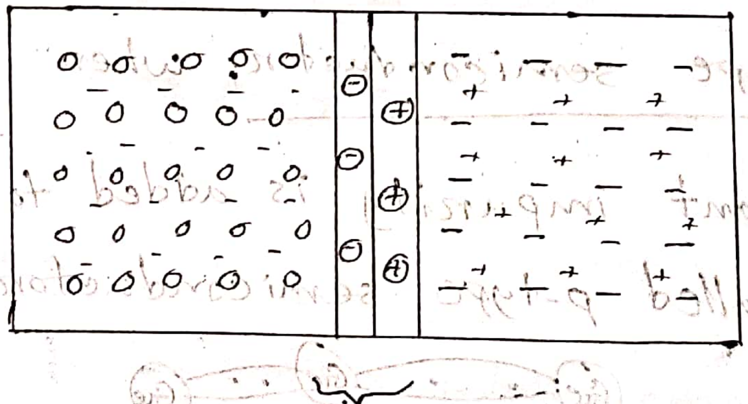


P-type semiconductor: when small amount of trivalant impurity is added to semiconductor then its called p-type semiconductor.





Pn-junction: connection of p-type and n-type semiconductor. pn junction are formed of alloying.



for silicon, $V_0 = 0.7$ v

for Germanium, $V_0 = 0.3$ v.

Biasing :

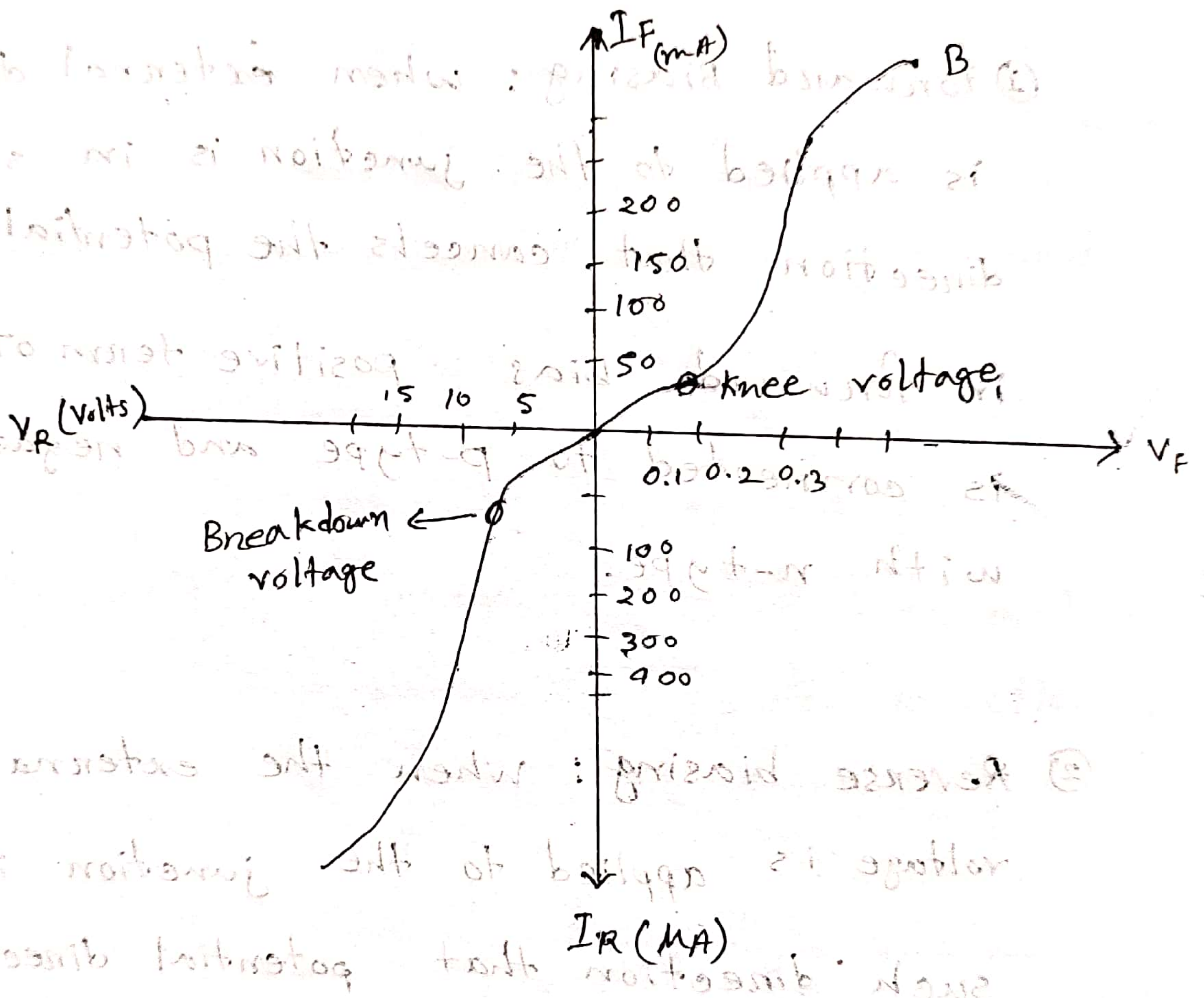
① Forward Biasing : when external dc voltage is applied to the junction is in such as direction that cancels the potential barrier.

in forward bias positive term of battery is connected to p-type and negative term with n-type.

② Reverse biasing : When the external d.c voltage is applied to the junction is in such direction that potential direction barrier is increased.

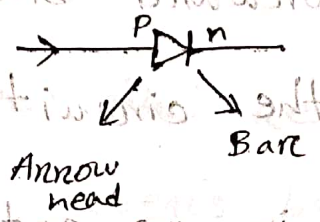
in reverse biase positive term of battery is connected to n-type and negative term with p-type.

V-I characteristics :

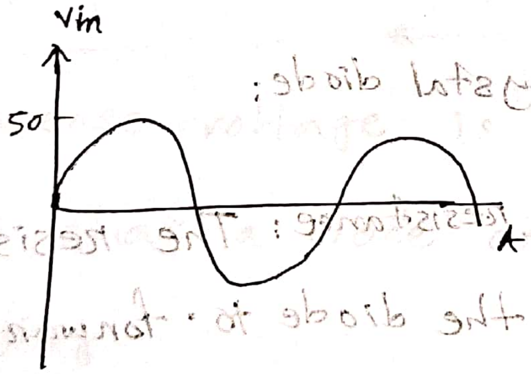


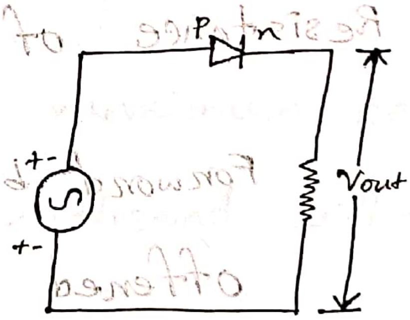
Chapter 06

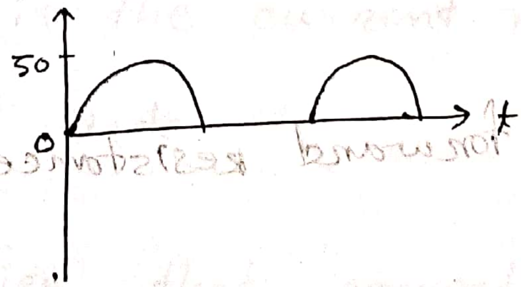
Diode: Combination of p-type and n-type semiconductor.



Crystal Diode as a rectifier: AC → DC







During the positive half cycle of a.c input voltage the arrowhead become positive and diode is in forward biased. And it conducts current in the circuit.

This is how ~~in~~ we get dc output from an ac input. Crystal diode works as a rectifier.

Resistance of crystal diode:

Forword biase resistance: The resistance offered by the diode to forward bias is known as forward resistance.

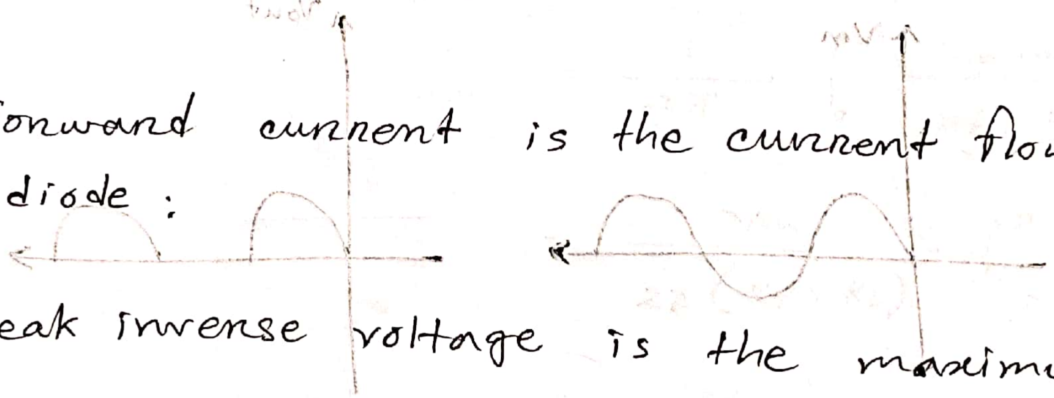
- dc forward resistance: $\dfrac{\text{forward voltage}}{\text{forward current}}$

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

• Ac forward resistance, $Rf = \dfrac{\text{changes in forward vol-}}{\text{Changes in forward current}}$

reverse resistance: the resistance offered by the diode to the revers bias is known as reverse resistance.

• Forward current is the current flow from farward diode :



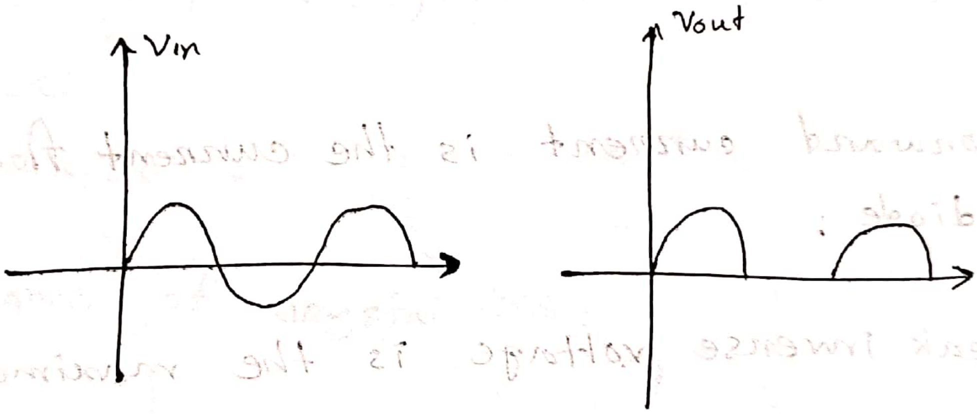
• peak inverse voltage is the maximum reverse voltage that a diode can withsand without destroying.

• Reverse current is the current flow from a revers biased diode.

• Crystal diode rectifier that converts ac supply to dc supply.

• Half wave rectifier:

The rectifier conduct current only during the positive half cycle of input ac supply. during negative half cycles no ~~curned~~ current is conducted.



Disadvantages:

(1) the pulsating current in the load contains alternating component whose basic frequency is equal to the supply.

(ii) output is low.

Efficiency of half wave rectifier:

$$\eta = \frac{\text{dc power output}}{\text{Input ac power}}$$

$V = V_m \sin\theta$

R_f = diode resistance

R_L = Load resistance

d.c power:

$$I_{av} = I_{dc} = \frac{1}{2\pi}\int_0^{\pi} i \, d\theta$$

$$= \frac{1}{2\pi}\int_0^{\pi} \frac{V_m \sin\theta}{R_f + R_L} \, d\theta$$

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

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

$$= \frac{V_m}{2\pi(R_f + R_L)} \times (2)$$

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

$$\therefore \text{dc power, } P_{dc} = I_{dc}^2 \times R_L$$

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

Input ac power :

The ac power input = $P_{ac} = I_{rms}^2 \times (r_f + R_L)$

for a half wave rectifier, $I_{rms} = \frac{I_m}{2}$

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

$$\therefore \text{efficiency} = \frac{\text{dc power output}}{\text{ac input power}}$$

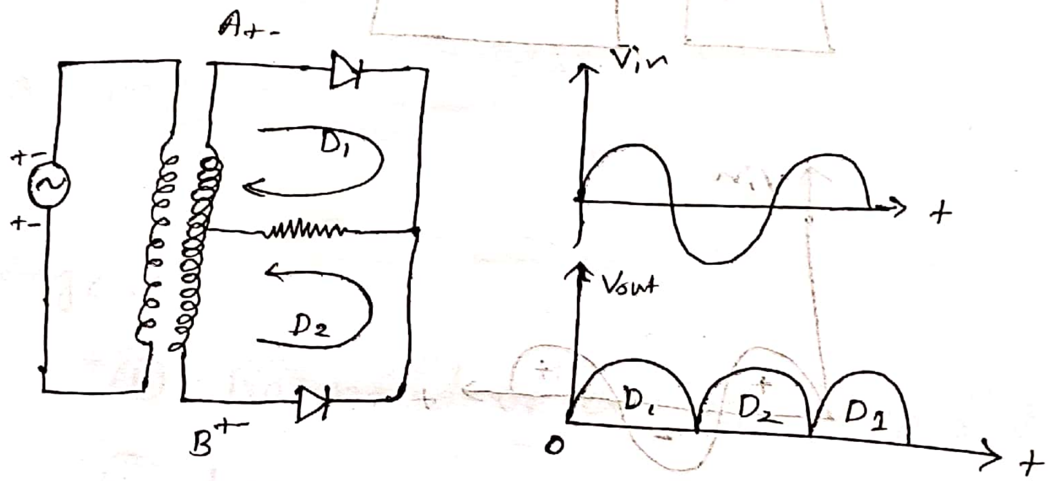
$$= \frac{\left(I_m/\pi\right)^2 \times R_L}{\left(I_m/2\right) \times (r_f + R_L)}$$

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

The efficiency is maximum if r_f is negligib.

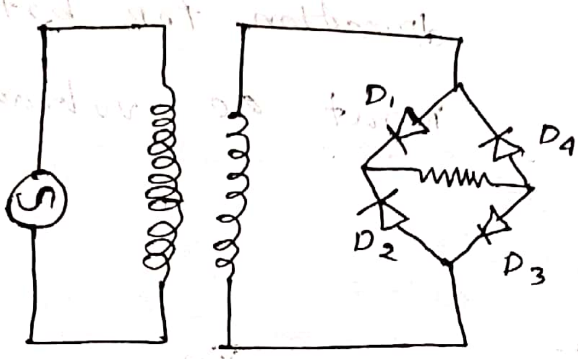
$\therefore$ Maximum efficiency = 90.6 %

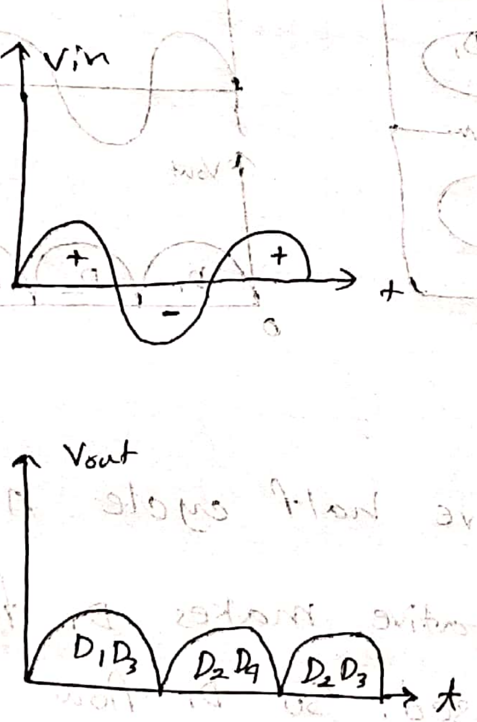
Ful wave rectifier: In full wave rectification, current flows through the load in the same direction for both half cycle of input ac voltage.



During the positive half cycle A is positive and this B is negative, makes D_1 forward biased and D_2 reversed biased. So D_1 flow current but D_2 does not. During the negative half cycle B is positive and A is negative. D_1 is reverse and D_2 is forword. This is how in full wave rectifier the both ac input gives dc output.

Full wave bridge rectifier:





the need for a centre tapped power transformer is elimated in the bridge rectifier. During the positive half cycle. D_1 an D_3 becomes ~~positive~~ forward biased and current flows and ~~ee~~ during the negative half cycles D_2 and D_4 becomes forward biased and current flows.

with this way from a full wave bridge rectifier we get dc output for both cycle of ac input.

Advantages:

(i) No need of centre tapped transformer

(ii) Less PIV

Disadvantages:

(i) Requires 4 diodes

(ii) voltage drop is twice.

CamScanner

Efficiency of full wave rectifier.

$$v = V_m \sin\theta$$

$$i = \frac{v}{R_f + R_L} = \frac{V_m \sin\theta}{R_f + R_L}$$

dc power output:

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

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

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

ac power input:

$$P_{ac} = I_{Rms}^2 (R_f + R_L)$$

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

$$\therefore P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 (R_f + R_L)$$

$$\therefore \text{efficiency}; \eta = \frac{P_{dc}}{P_{ac}}$$

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

$$= \frac{0.812\,R_L}{R_f + R_L}$$

$$= \frac{0.812\,R_L}{1 + \frac{R_f}{R_L}}$$

the efficiency will be maximum if R_f is negligible.

$$\therefore \text{Max } \eta = 81.2\%$$

Ripple factor: The output of a rectifier consist of a dc component and an ac component is known as Ripple.

The ratio of rms value and dc component is called ripple factor.

$$\text{Ripple factor} = \frac{\text{rms value of ac component}}{\text{value of dc component}}$$

$$\text{half wave ripple factor} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$$= 1.21$$

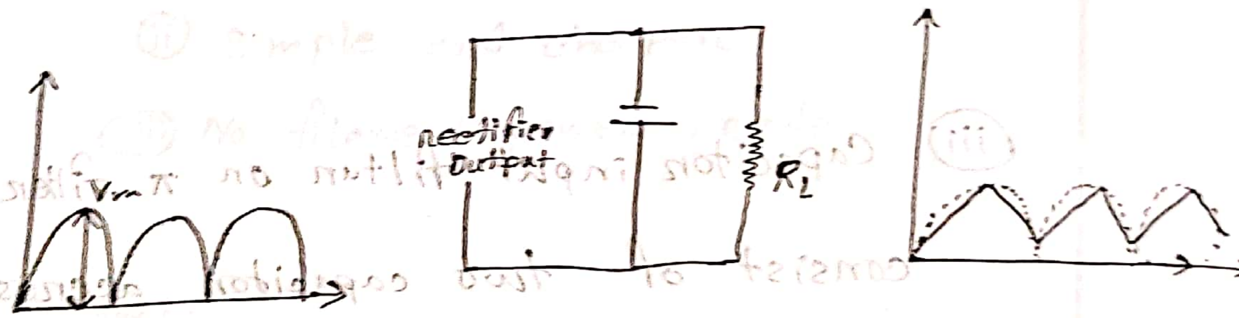
$$\text{full wave ~~re~~ ripple factor} = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1}$$

$$= 0.48$$

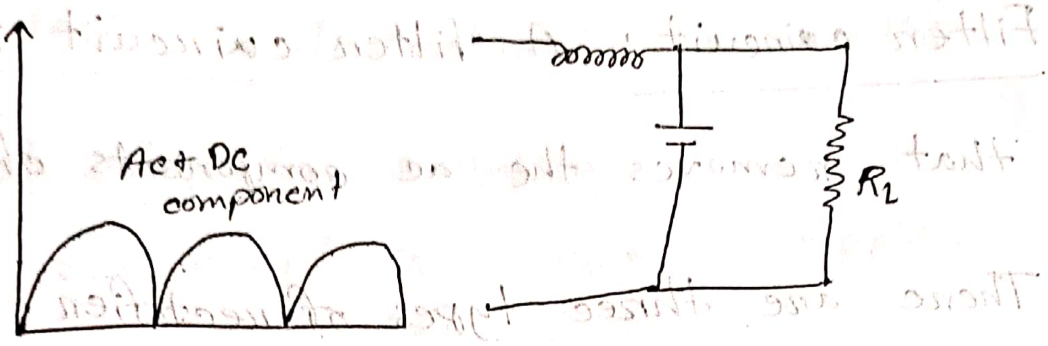
Filter circuit : A filter circuit is a device that removes the ac components of rectifier.

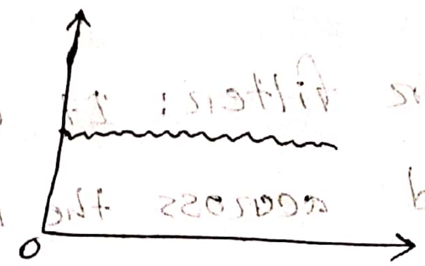
There are three types of rectifier :

(i) Capacitor filter: It consist of a capacitor C placed accross the rectifier.

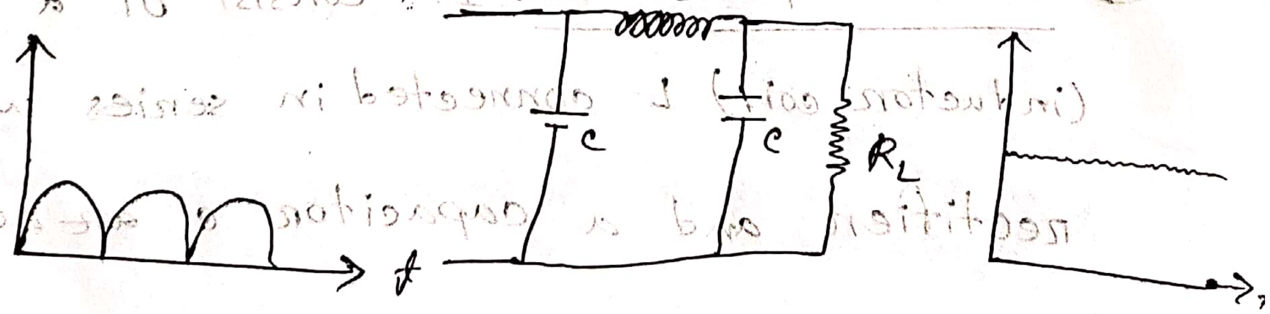


(ii) Choke input filter: It consist of a choke (inductor coil) L connected in series with the rectifier and a capacitor C ~~ar~~ accross the load.





(iii) Capacitor input filter or π filter: it consist of two capacitor accross the load and a choke in series.



• Crystal Diodes vs vaccum Diodes:

Semiconductor diodes have a number of advantages as compared to their electron tube counterparts (vaccum diodes)

Advantages:

(i) smaller, rugged and longer life.
(ii) Simple and cheaper
(iii) No filament power needed.

Disadvantages:

(i) heat sensitive
(ii) handle small currents
(iii) can not stand on overload

Chapter 7

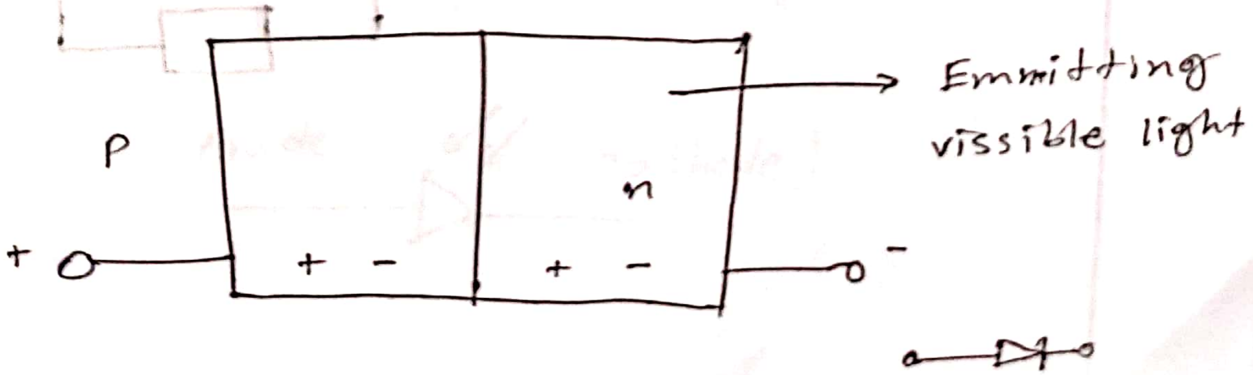
Special purpose of Diodes

Zener Diode:

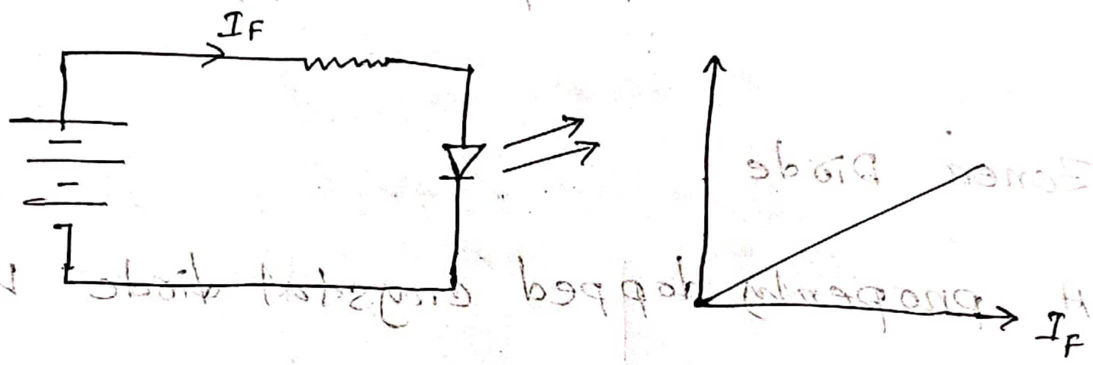
A properly dopped crystal diode has a sharp breakdown voltage known as zener diode.

Led:

A light emmiting diode is a diode that gives off vissible light ~~gives of~~ when forward biased.



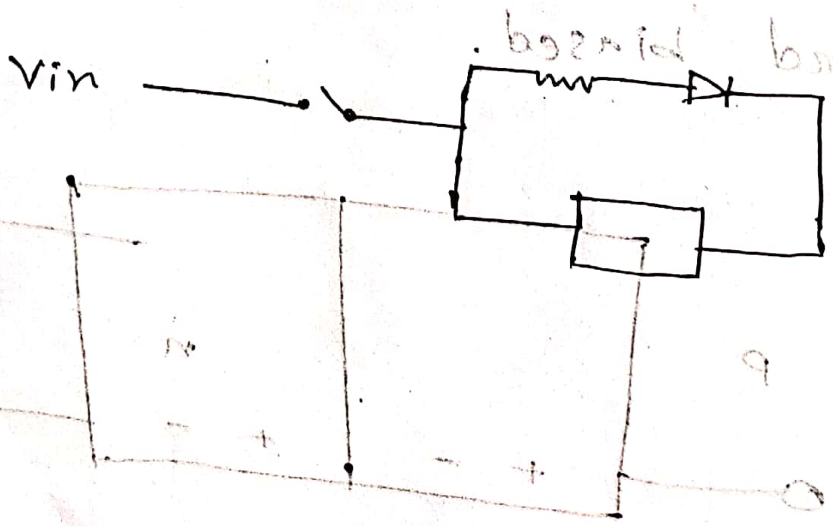
Led voltage and current :



Application of Led :

Led is useful as an indicator but not good for illumination.

① As a power indicator :



(ii) Seven- segment display:

led are often grapped to form seven segment display.

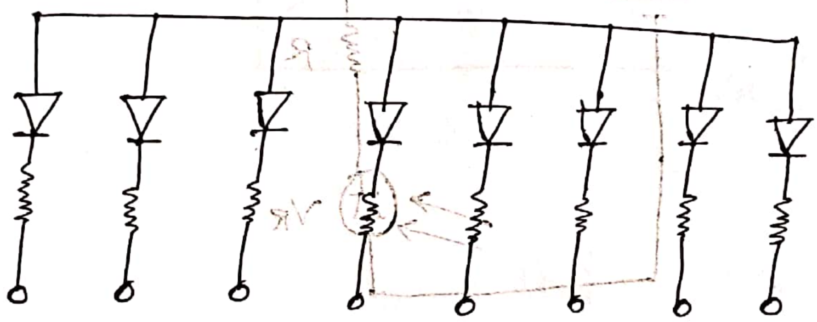
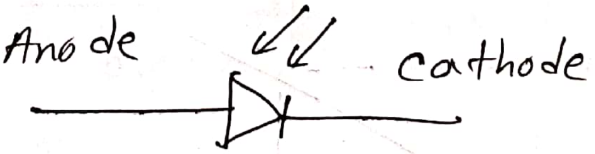


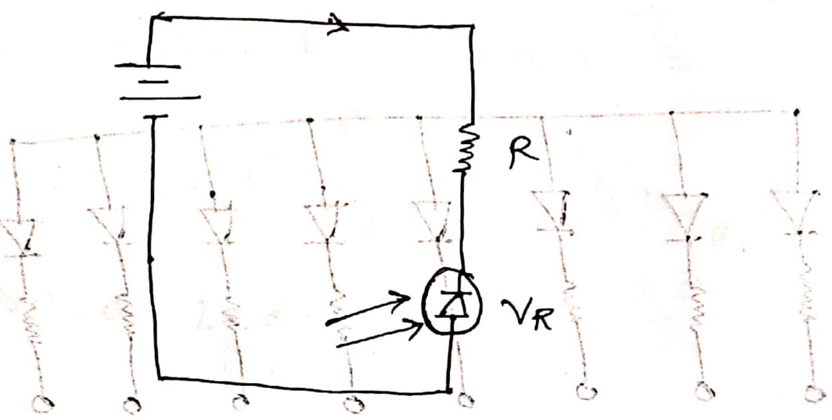
photo diode:

a special purpose pn junction diode fabricated with a transparent window to allow light to full on the diode:



* Transform energy incident to atoms

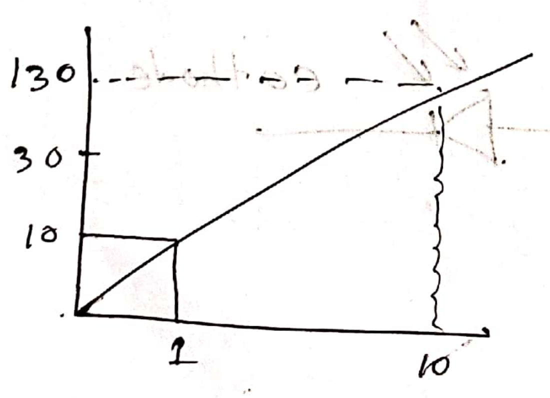
photo diode operation:



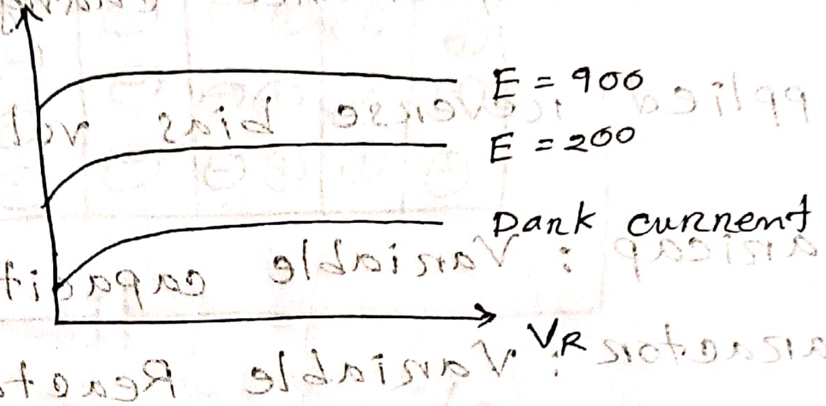
$$R_p = \frac{V_R}{\text{Dark current}}$$

Characteristics of photo diode:

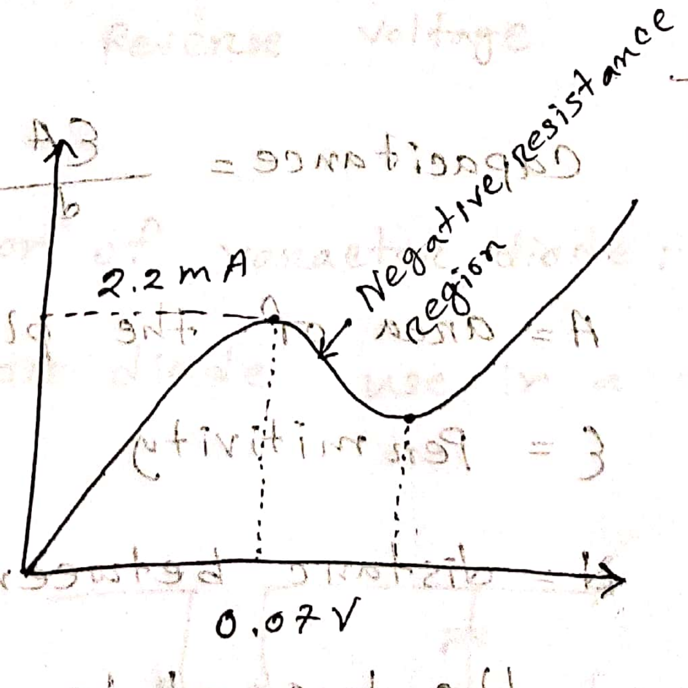
(i) Reverse current - Illumination curve



(ii) Reverse voltage-current curve:



V–I characteristics :

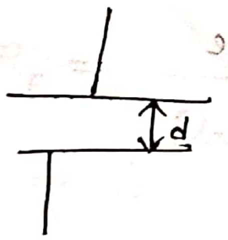


Varactor Diode:

Internal capacitance changes with the applied reverse bias voltage.

varicap : Variable capacitor

varactor : Variable Reactance.

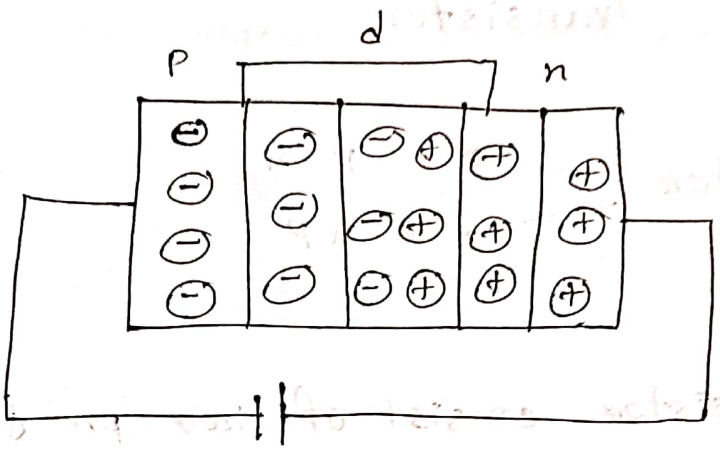


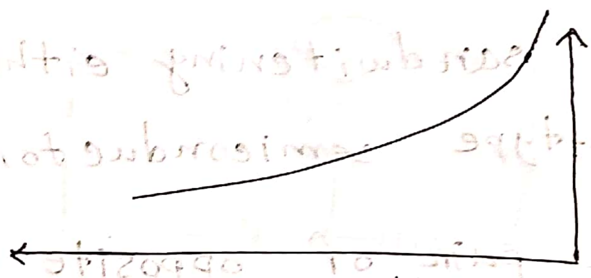
$$\text{Capacitance} = \frac{\varepsilon A}{d}$$

A = area of the plates

ε = Permitivity

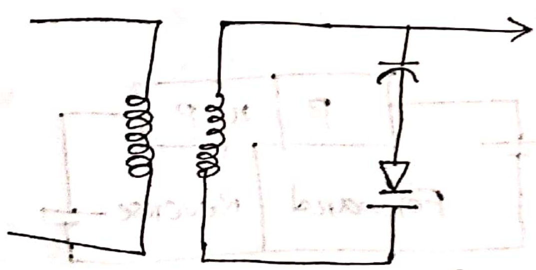
d = distanc between the two plates





Application of varactor diode :

varactor diode use in a turned circuit.

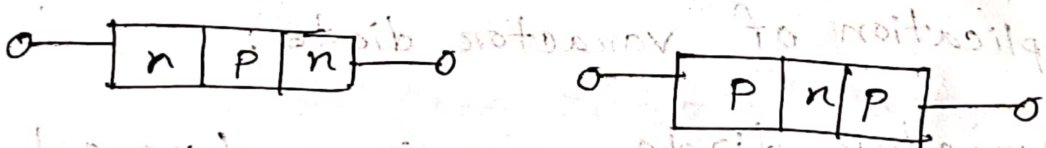


$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

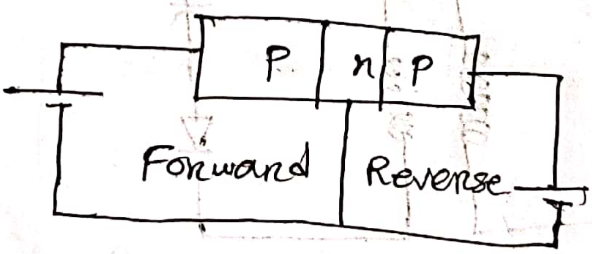
Transistor

Transistor → n-p-n
Transistor → p-n-p

A transistor consist of two pn junction formed by sandwitening either p-type or n-type semiconductor between a pair of opposite type.

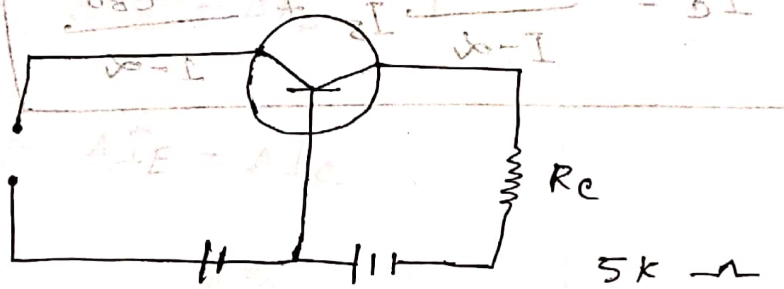


Transistor Terminals :



Transistor circuit as an amplifier:

Transistor ~~pat~~ (raises the strength of a weak signal and than acts an amplifiers.



~~two~~ current amplification factor (α)

$I_E \rightarrow$ Input current

$I_c \rightarrow$ Collector current

$$\alpha = \frac{\Delta I_c}{\Delta I_E}$$

$$I_c = \alpha I_E$$

Total collector current, $I_C = \alpha I_E$

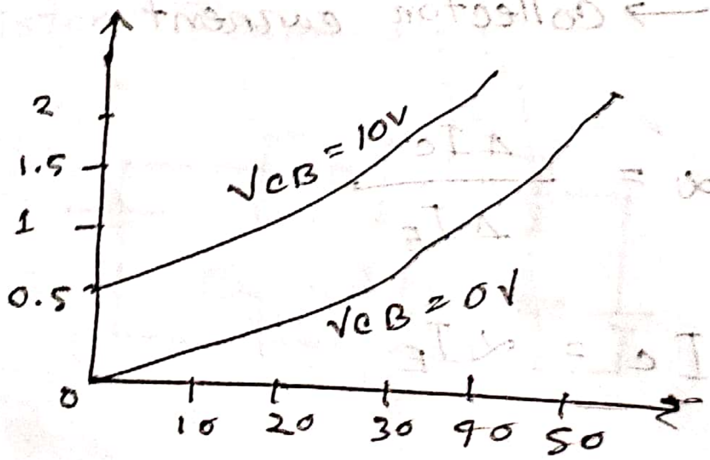
$$I_C = \alpha(I_C + I_B) + I_{CBO}$$

$$= \alpha I_C + \alpha I_B + I_{CBO}$$

$$\boxed{I_C = \frac{\alpha}{1-\alpha} I_B + \frac{I_{CBO}}{1-\alpha}}$$

Input characteristics :

graph between current I_E and emitter-base voltage V_{EB}. where collector - Base voltage V_{CB} is constant



Relation between β and α :

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad ; \quad \beta = \frac{\Delta I_C}{\Delta I_B}$$

$$I_E = I_C + I_B$$

$$\Delta I_E = \Delta I_C + \Delta I_B$$

$$\Delta I_B = \Delta I_E - \Delta I_C$$

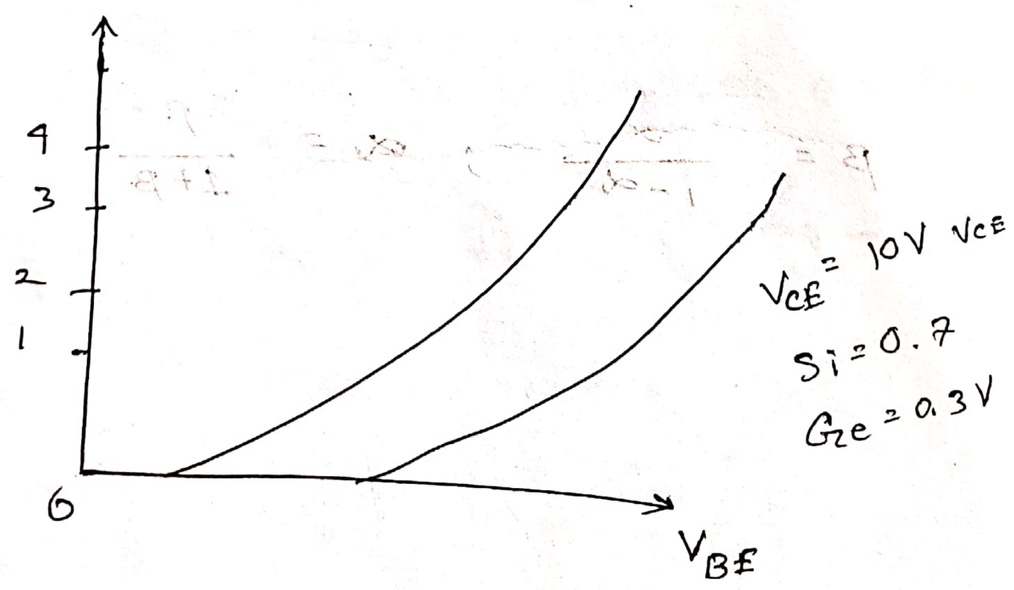
$$\frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

$$\beta = \frac{\alpha}{1-\alpha} \quad ; \quad \alpha = \frac{\beta}{1+\beta}$$

Characteristics of common Emmitter connection:

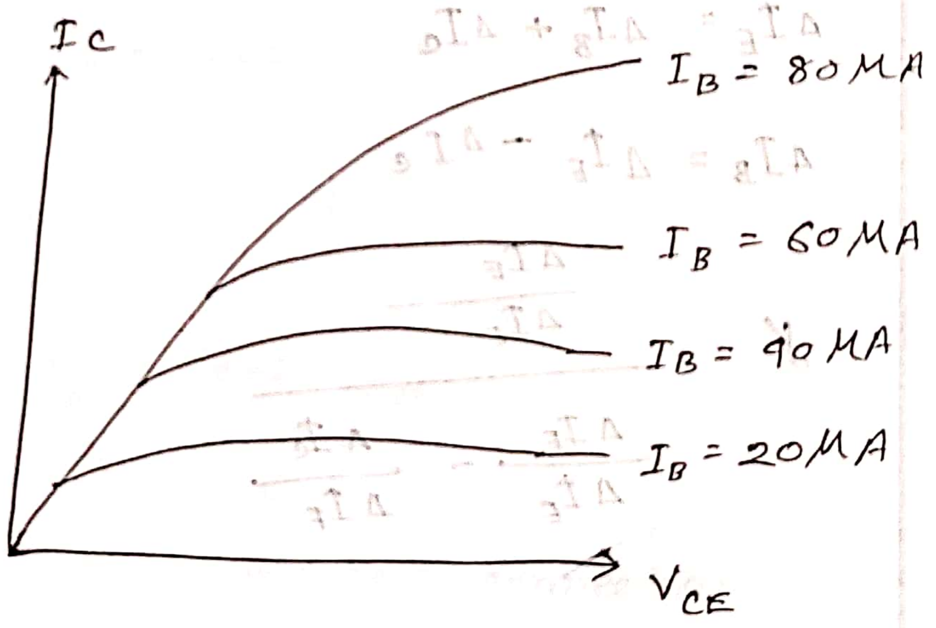
Input characteristics:

Curve between base current I_B and base-emitter voltage V_{BE} at constant at constant collector ~~et~~ emitter voltage V_{CE}



Output characteristics:

Curve between collector current I_c and collector-emitter voltage V_{CE} at constant base current I_B



output ressistanc $R_o = \frac{\Delta V_{CE}}{\Delta I_c}$

Relation between γ and α:

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$E = I_B + I_C$$

$$\Delta I_E = \Delta I_B + \Delta I_C$$

$$\Delta I_B = \Delta I_E - \Delta I_C$$

$$\gamma = \frac{\frac{\Delta I_E}{\Delta I_E}}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}}$$

$$\gamma = \frac{1}{1-\alpha}$$

Expression of collector current:

$$I_C = \alpha I_E + I_{CBO}$$

$$I_E = I_B + I_C$$

$$I_E = I_B + (\alpha I_E + I_{CBO})$$

$$I_E(1-\alpha) = I_B + I_{CBO}$$

$$I_E = \frac{I_B}{1-\alpha} + \frac{I_{CBO}}{1-\alpha}$$

$$I_E = (\beta+1) I_B + (\beta+1) I_{CBO}$$

Comparison of transistor connection :

Transistor vs vaccum tube :

(i) High voltage gain
(ii) lower supply voltage
(iii) No heating.

Sinusoidal Oscillator

An electric device that genarates sinasoidal oscillation of desired frequency is known as a sinusoidal oscillator.

Dc signal

↓

$\boxed{\text{Oscillator}}$

↓

Ac output

∿∿∿

frequency : Hz to GHz

Oscillator is non-rotating electronic device.

Advantage:

① No sound production.

② No rotating parts.

③ Low and High frequency output.

④ Frequency can be changed as desired.

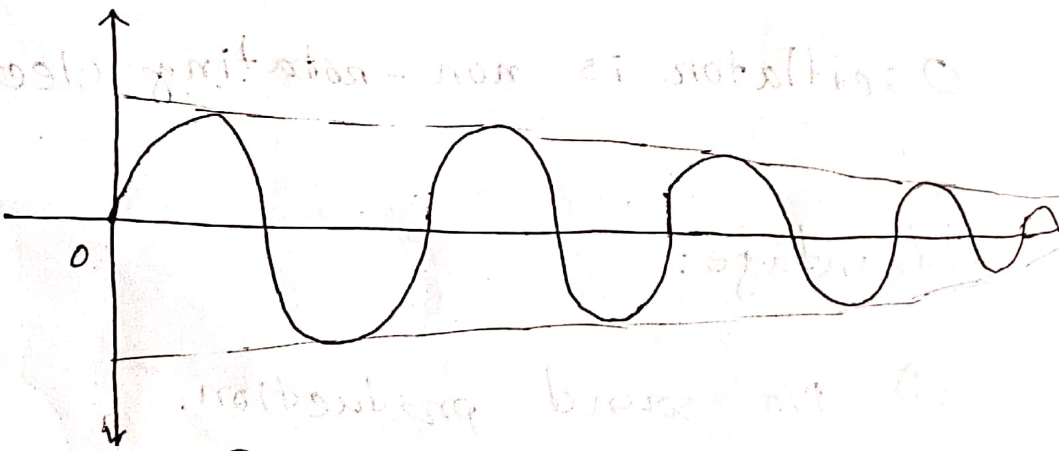
⑤ good frequency stability.

⑥ very high efficiency.

Types of sinusoidal oscillation:

(i) Damped oscillations:

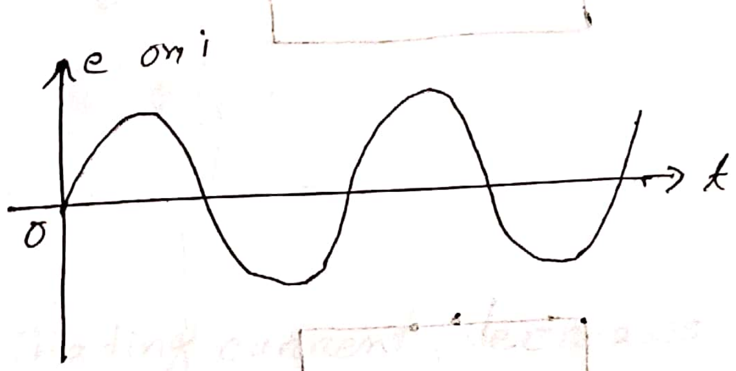
The electrical oscillators whose amplit goes on decreasing with time are called da oscillators.



frequency unchanged

(II) Undamped oscillations:

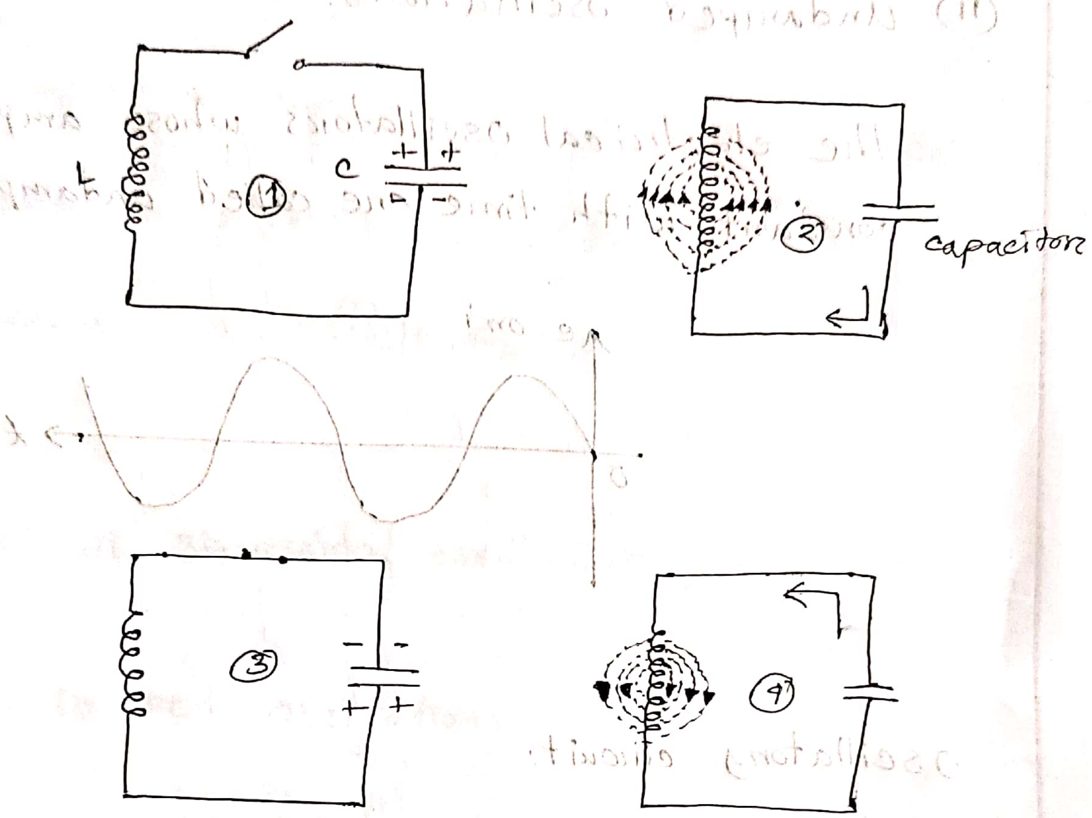
The electrical oscillators whose amplitude remains constant with time are called undamped oscillators.



Oscillatory circuit:

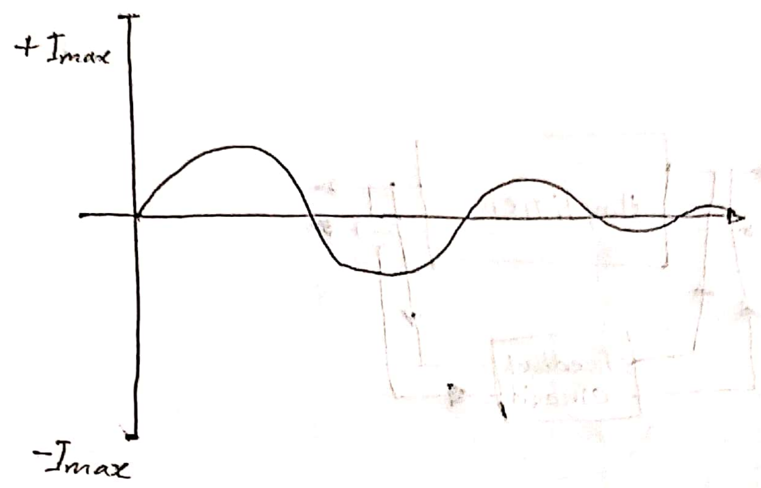
A circuit which produces electrical oscillators of any desired frequency is known as an oscillatory circuit or tank circuit.

→ Circuits consists of a capacitor (C) and inductance coil (L) in parallel.



The sequence of change and discharge results in alternating motion of electrons on an oscillating current.

Frequency: number of waves in a fixed time.

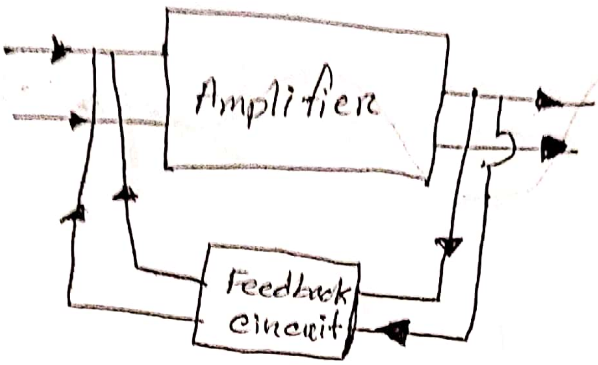


Amplitude of oscillating current decreases gradually and eventually it becomes zero when all the energy is consumed as losses. Therefore, the tank circuit by itself will produce damped oscillations.

Frequency of oscillations:

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

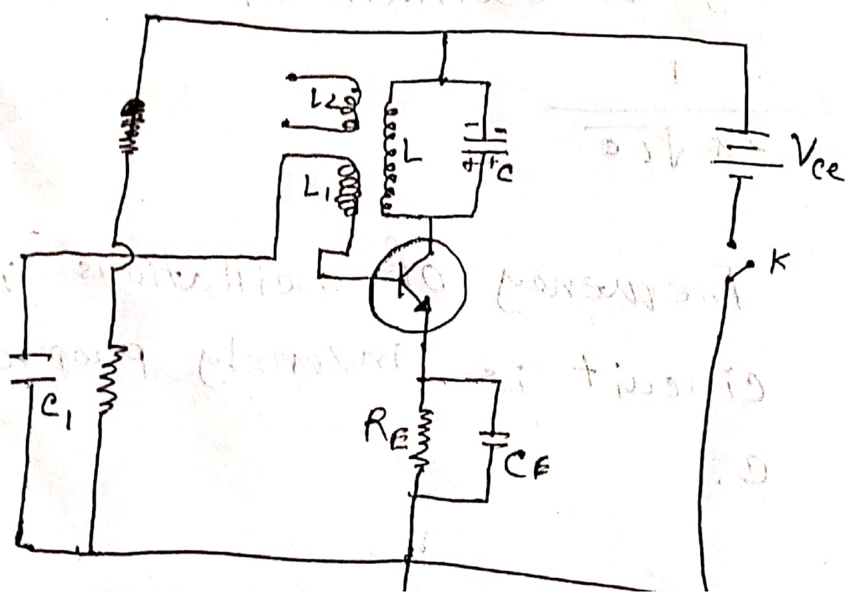
Frequency of oscillations in the tank circuit is inversly proportional to L and C.



Essential components of Transistor Oscillator:

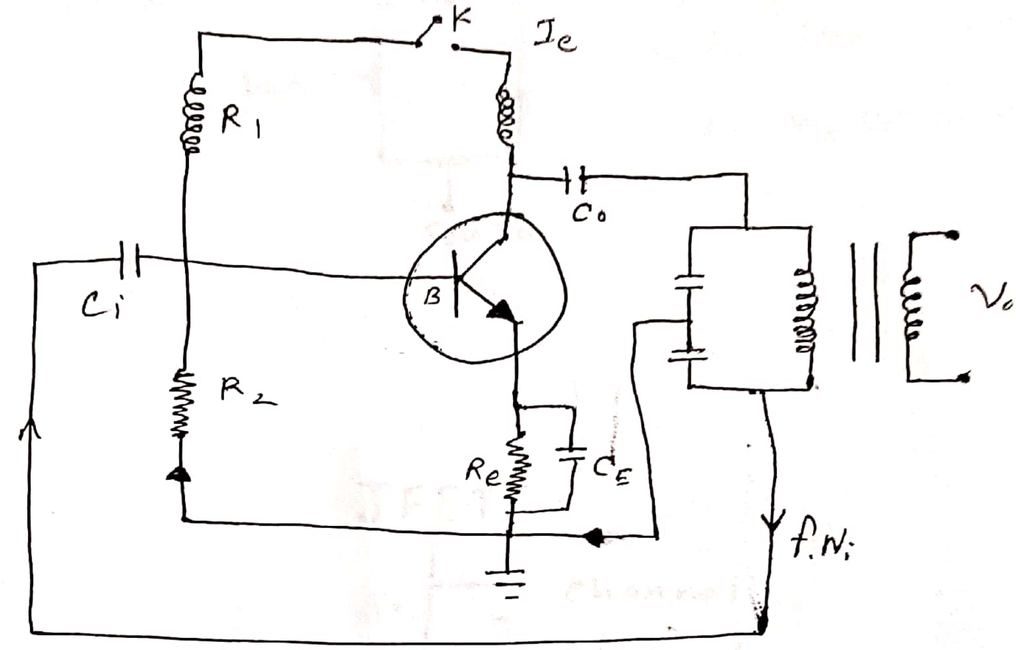
- Tank circuit
- Transistor Amplifier
- Feedback circuit

Tuned collector oscillator:

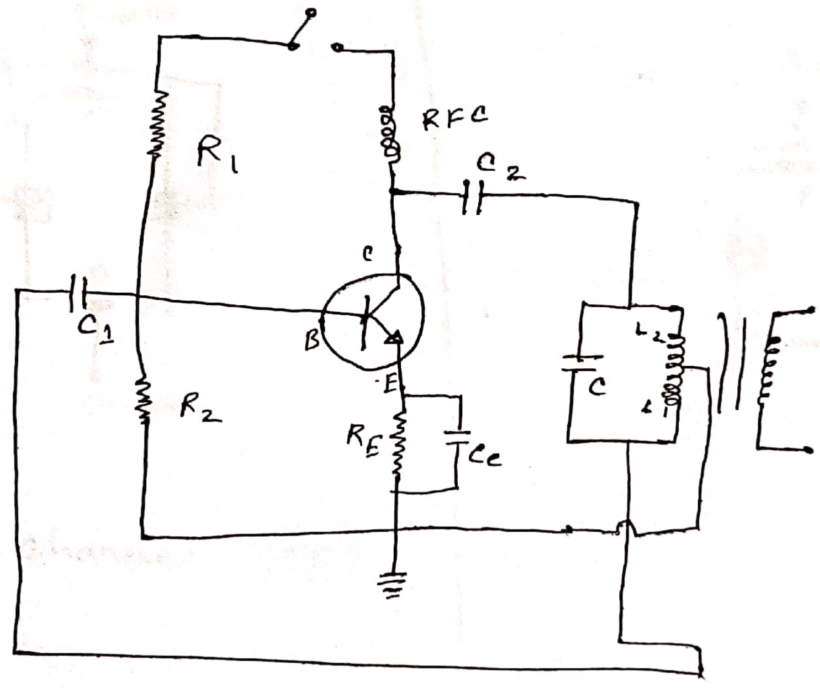


$$f = \frac{1}{2\pi\sqrt{LC}}$$

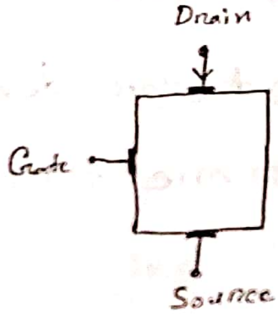
Colpitt's oscillator



Hartley oscillator:



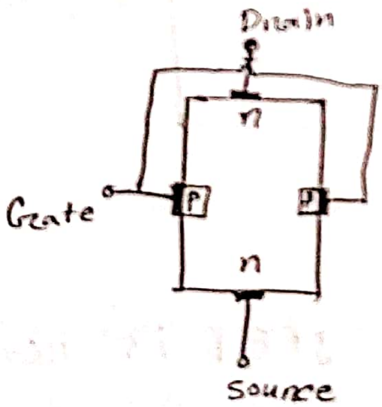
Junction Field effect Transistor (JFET)



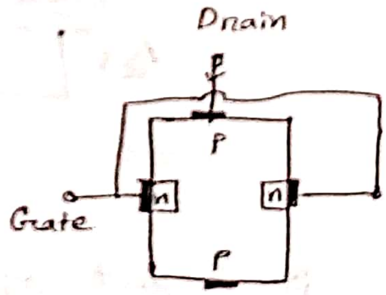
I_D = Drain current

I_D V_{GS} এর উপর নির্ভরশীল

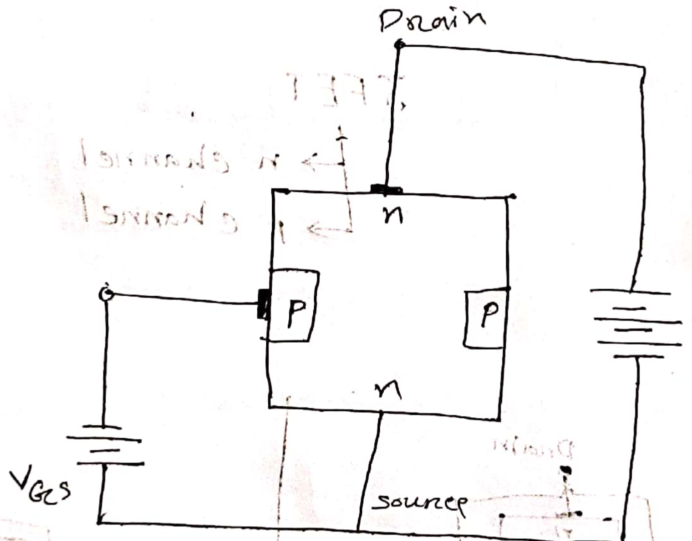
JFET
- → n channel
- → p channel



n-channel JFET



A junction field effect transistor is a three terminal semiconductor device in which current conduction is by one type of carrier.



(i) Input circuit of a JFET is reversed biased. high input impednce.

(ii) drain is so biased w.r.t source that I_D flows from the source to drain.

(iii) In all JFET, $I_S = I_D$

working procedure: Two pn junction from two deplation layer. current conduct through the channel between two depletion layer. width & resistance controlled by changing the input voltage V_{GS}. The greater the reverse voltage V_{GS}, the wider will be the depletion layer and narrower will be the conduction channel. So greater resistance and source to drain current decrease.

magnitude of drain current (I_D) can be changed by alternating V_{GS}.

BJT	JFET
① BJT has 3 terminals base, collector emitter	① JFET has 3 terminals. gate, source and drain
② It is a bipolar device	② It is a unipolar device
③ electron and holes carries current	③ either electron or holes carries current.

Metal oxide semiconductor FET (MOSFET)

MOSFET

- → D-MOSFET (depletion mode & enhanced mode)
- → E-MOSFET (enhanced mode)

D-MOSFET

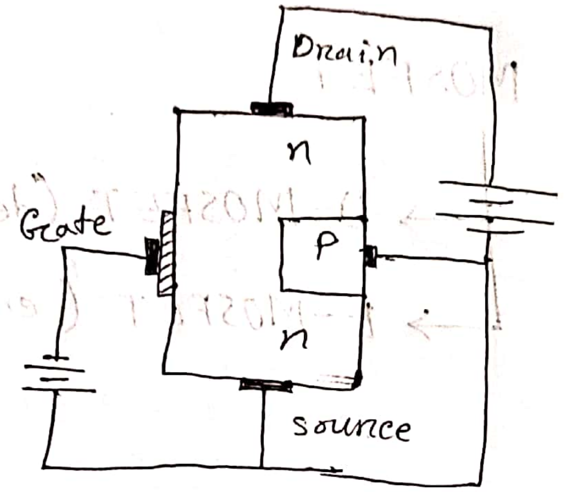
- → P channel D-MOSFET
- → N channel D-MOSFET

A Field effect Transistor (FET) that can be operated in the enhanced-ment mode is called a MOSFET.

Capacitor

- one plate is gate
- other plate is SiO_2

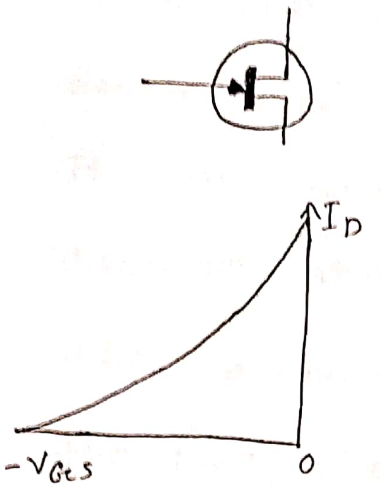
Circuit operation of D-MOSFET



gate forms small capacitor. One plate is gate & anther plate is metal oxide. When gate voltage is changed the electric field of the capacitor changes which in turn changes the resistance of the n-channel. The gate is insulated from the channel we can apply either negative or positive votage to the gate.

- Negative gate operation is called depletion mode
- Positive gate operation is known as enhancement mode.

JFET



- Depletion only
- extremely high input impedence.

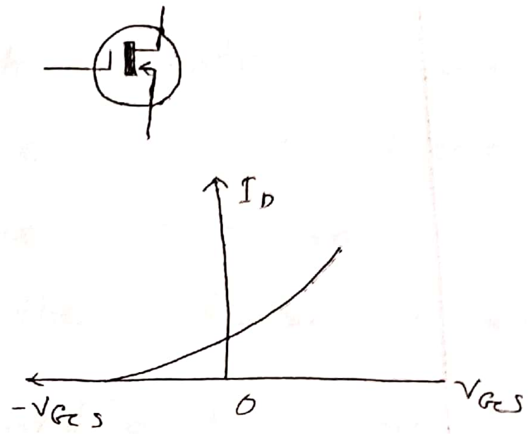
disadvantage.

→ Bias in stability

→ Can be operated in the diplation mode

→ Gate bias
self bias
voltage-Divider bias

DMOSFET



- Depletion and enhancement mode
- Higher input impedence than a comparable JFET

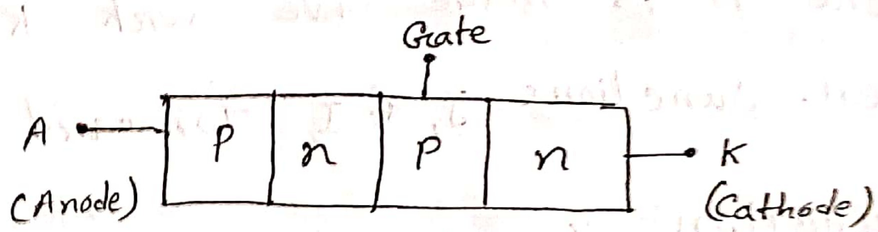
disadvantage

- Bias instability
- more sensitive to changes to changes in temperature than JFET

→ Gate bias,
self bias,
voltage divider bias, zero bias.

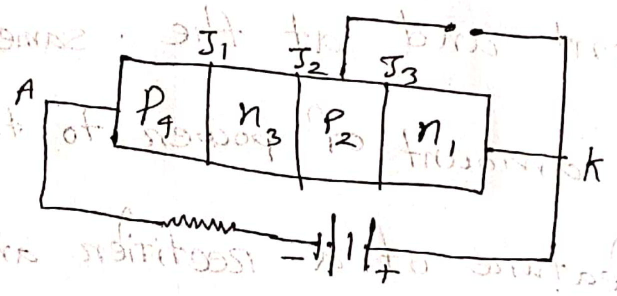
SCR

- 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 it can control the amount of power to the load. So SCR combines the feature of a rectifier and a transistor.



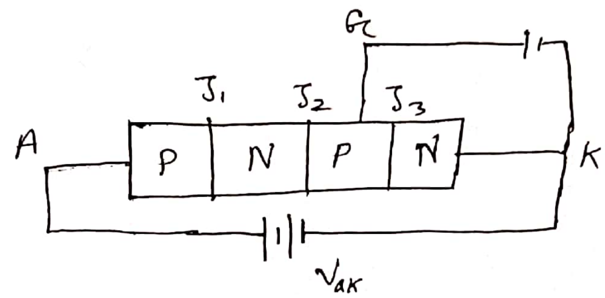
Working of SCR

(i) When gate is open : (Forward blocking model)



Here A is made +ve wrk K while G is kept open. Junctions J_1 & J_3 forward biased while the Junction J_2 is Reverse biased. Due to this small leakage current flows though the SCR. SCR offer high impedence to the current flow. therefore SCR acts as an open switch in this mode.

(ii) switch ON:



By applying (+)ve voltage to G terminal avalanche breakdown occurs at J_2. & current starts flowing through the SCR. So SCR act as a closed switch.

More is the gate current, the minimum will be the time to come in conduction mode.