MID-2 IMPORTANT QUESTIONS

1. Explain the working of L-Section filter and derive the expression for ripple factor?
2. Explain the working of C filter and derive the expression for ripple factor?
3. Explain the working of L filter and derive the expression for ripple factor?
4. Explain the working of CLC filter and derive the expression for ripple factor?
5. Explain the input and output characteristics of CB configured transistor circuit with a neat circuit diagram.
6. Determine the value of emitter current and Collector current of a transistor having $\alpha$=0.98 and $I_{CBO}$=4μA. the base current is 50μA.
7. Derive the relation between $\alpha$, $\beta$ & $\gamma$.
8. Explain the input and output characteristics of CE configured transistor circuit with a neat circuit diagram.
9. Derive the expression for stability factor of Self Bias Method?
10. A) Compare BJT and FET.
    b) Write about FET Parameters.
11. Demonstrate the construction and operation of a Depletion MOSFET and draw its Characteristics.
12. Demonstrate the construction and operation of Enhancement MOSFET and draw its Characteristics.

## RECTIFIER WITH FILTERS :-

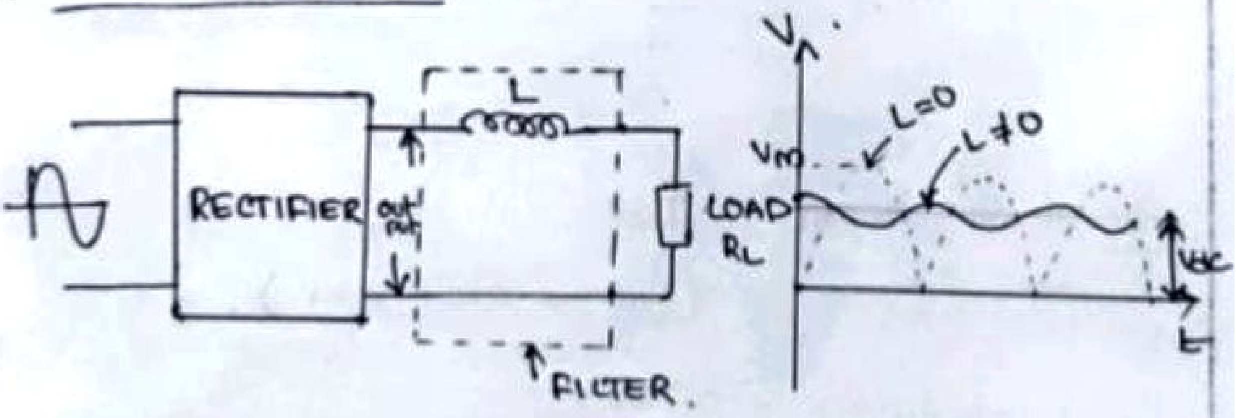
The output of a Rectifier contains ripple components in addition to a DC term. Hence it is necessary to include a FILTER between the rectifier and the load in order to attenuate these ripple components.

TYPES :- Depending upon the components used and the way they are connected, the filter circuits may be classified as :-

(1) INDUCTOR [L] Filter.
(2) Capacitor [C] Filter.
3) L-SECTION or LC Filter
4) π - SECTION Filter.

FILTER CIRCUIT :- An electronic circuit or device which blocks the AC component but allows the DC component of the rectifier to pass to the load is called FILTER CIRCUIT.

① INDUCTOR FILTER :-



The operation of the inductor filter depends on the fundamentals property of an inductor to oppose any change of current.

Any sudden changes occur in a circuit without an inductor are smoothed out by the presence of an inductor in the circuit.

→ The o/p voltage at the load is slightly reduced because of the drop in the resistance of the inductor.

→ It requires the current to flow through it for all times of operation. so that it cannot be used with HWR.

To analyse this filter for a FULL WAVE RECTIFIER,

$$V_0 = \frac{2V_m}{\pi} - \frac{4V_m}{\pi} \sum_{K=2,4,6} \frac{\cos K\omega t}{(K^2-1)} \quad — ①.$$

$$= \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t - \frac{4V_m}{15\pi}\cos 4\omega t - \frac{4V_m}{35\pi}\cos 6\omega t \cdots$$

Assuming the third and higher terms contribute little o/p The o/p voltage is $V_0 = \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t$ — ②.

Diode, choke and Transformer resistances are very small when compared to $R_L$.

Then the max current $i_m = \left(\frac{V_m}{R_L}\right)$ — ③.

$$\text{Impedance} = \sqrt{R_L^2 + (2\omega L)^2}$$

Therefore resulting current is,

$$i = \underbrace{\frac{2V_m}{\pi R_L}}_{DC} - \underbrace{\frac{4V_m}{3\pi} \cdot \frac{\cos(2\omega t - \phi)}{\sqrt{R_L^2 + 4\omega^2 L^2}}}_{\text{ripple}} \quad — ④$$

where, $\phi = \tan^{-1}\left(\frac{2\omega L}{R_L}\right)$.

The rms value of ac or ripple component is,

$$i = I_m/\sqrt{2} . = \frac{4V_m}{3\sqrt{2}\pi} \cdot \frac{1}{\sqrt{R_L^2 + 4\omega^2 L^2}}$$

$$\text{Ripple Factor} = \frac{I_{rms}}{I_{dc}} = \frac{\frac{4V_m}{3\sqrt{2}\pi} \cdot \frac{1}{\sqrt{R_L^2 + 4\omega^2 L^2}}}{\frac{2V_m}{\pi \cdot R_L}}$$

$$= \frac{2R_L}{3\sqrt{2}\sqrt{R_L^2 + 4\omega^2 L^2}}$$

$$= \frac{2 R_L}{3\sqrt{2} \cdot R_L \sqrt{1 + \left(\frac{4\omega^2 L^2}{R_L^2}\right)}}$$

$$= \frac{\sqrt{2}}{3\sqrt{1 + \left(\frac{4\omega^2 L^2}{R_L^2}\right)}}$$

$\left(\frac{4\omega^2 L^2}{R_L^2}\right) \gg 1$ then,

$$\text{Ripple factor } r = \frac{\sqrt{2}}{3\sqrt{\frac{4\omega^2 L^2}{R_L^2}}}$$

$$= \frac{\sqrt{2} R_L}{3 \times 2\omega L}$$

$$r = \frac{R_L}{3\sqrt{2}\omega L}$$

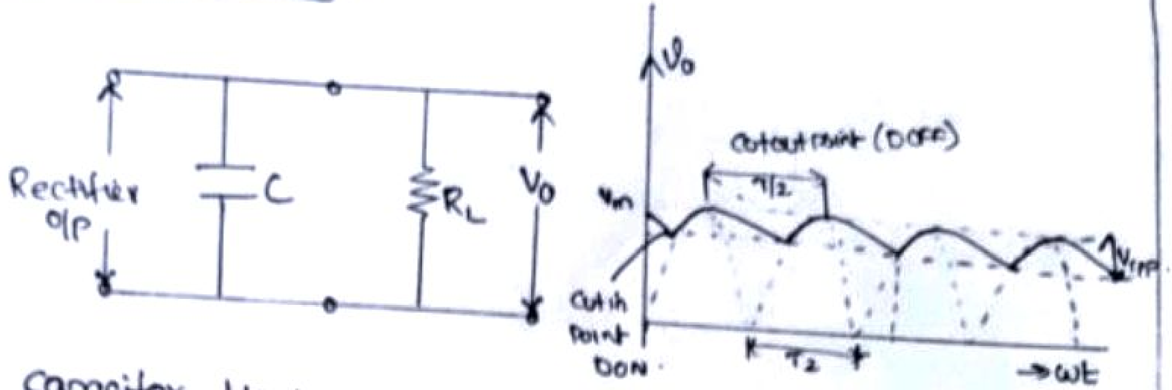
$r$ is small when $R_L$ is small, so this filter is used when $R_L$ is SMALL.

If $R_L = \infty$, $r = \frac{\sqrt{2}}{3\sqrt{1 + \left(\frac{2\omega L}{R_L}\right)^2}} \to 0$

$\boxed{r = \frac{\sqrt{2}}{3} = 0.471}$ which is slightly less than 0.483

* The inductor filter is used when $R_L$ is very small.

## CAPACITOR FILTER :-




Capacitor blocks DC component and allows AC component. The operation of a 'C'-filter is to short the ripple to gnd but leave the DC to the o/p when it is connected across a pulsating DC voltage.

During the positive half cycle capacitor charges to a peak value Vm and will try to maintain this value as full wave rectifier o/p drops to zero. While the full wave rectifier o/p decays towards zero the capacitor will discharge through $R_L$ slowly untill the transformer voltage again increases to a value greater than the capacitor voltage and is shown in the fig.

The ripple voltage waveform can be assumed to be TRIANGULAR.

The charge acquired $= V_{r\text{-}p\text{-}p} \times C$

The charge lost $= I_{dc} \times T_2$ $\quad (T_2 = T/2$ assume$)$

$\therefore$ Charge lost = charge acquired $\quad T = 1/f$

$$I_{dc} T_2 = V_{r\text{-}p\text{-}p}\, C$$

$$\therefore V_{rpp} = \frac{I_{dc}}{C}(T/2)$$

$$\boxed{V_{r\text{-}p\text{-}p} = \frac{I_{dc}}{2fC}}$$

Ripple waveform is triangular and the rms value of ripple is given by,

$$\boxed{V_{rms} = \frac{V_{rpp}}{2\sqrt{3}}}$$

$$V_{rms} = \frac{I_{dc}}{\cancel{2}4\sqrt{3}fc}$$

But $\boxed{I_{dc} = \frac{V_{dc}}{R_L}}$ $\Rightarrow$ $V_{rms} = \frac{V_{dc}}{4\sqrt{3}fc\,R_L}$

$$\left(\frac{V_{rms}}{V_{dc}}\right) = \boxed{\Gamma = \frac{1}{4\sqrt{3}R_L fc}}$$

Ripple may be decreased by increasing $R_L$ or C or both

$\Rightarrow$ $\Gamma$ is small when $R_L$ or C in very large.

→ The magnitude of o/p DC is improved because of charging and discharging the capacitor.

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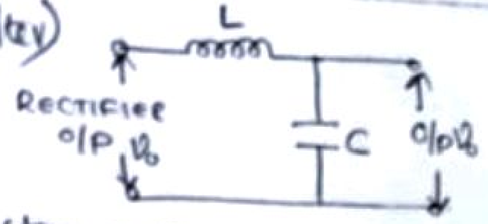
## L-SECTION FILTER (LC filter)




* The Ripple factor is proportional to $R_L$ in inductor filter.
* The Ripple factor is inversely proportional to $R_L$, in capacitive filter.

→ If these sections are combined forms a L-SECTION FILTER and is independent of $R_L$.

From the Fourier series $v_o = \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t$

$$V_{dc} = \frac{2V_m}{\pi}$$

$$I_{rms} = \frac{\frac{4V_m}{3\pi}}{\sqrt{2}} \cdot \frac{1}{X_L}$$

If the voltage flowing through the capacitor creates the ripples in the o/p voltage.

$$V_{rms} = I_{rms} \times X_c$$

$$= \frac{4V_m}{3\sqrt{2}\pi} \cdot \frac{1}{X_L} \cdot X_c$$

$$= \left(\frac{2V_m}{\pi}\right)\left(\frac{2}{3\sqrt{2}}\right) \cdot \frac{X_C}{X_L}$$

$$= V_{dc}\left(\frac{2}{3\sqrt{2}}\right)\left(\frac{X_C}{X_L}\right)$$

$$\boxed{\gamma = \frac{V_{rms}}{V_{dc}} = \frac{2}{3\sqrt{2}}\left(\frac{X_C}{X_L}\right)} \quad \text{—①.}$$

where, $X_C = \frac{1}{2\omega C}$, $X_L = 2\omega L$

$$\gamma = \frac{2}{3\sqrt{2}}\left(\frac{1}{4\omega^2 LC}\right), \quad \boxed{\gamma = \frac{1}{6\sqrt{2}}\left(\frac{1}{\omega^2 LC}\right)} \text{—②}$$

at $f = 50Hz$,

$$r = \left(\frac{0.8365}{LC}\right)$$ where C in μF and L in Henry

r IS INDEPENDENT OF $R_L$ load and depends upon L and C.

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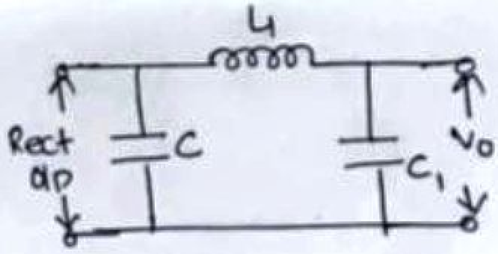
**π - SECTION FILTER** :- A very smooth output may be obtained by using a filter that consists of two capacitors C and $C_1$ separated by an inductor such filter is in the form of π, so that named as π filter.

The filter action of three components C, $L_1$ and $C_1$ is as follows:-




1) Action of C: It provides easy path to ac component and journey through the inductor. It also increases the Vdc value because of its charging and discharging action.

2) Action of $L_1$: It provides easy path to DC component and blocks the ac component which was not filtered by C because of its high reactance.

3) Action of $C_1$:- Any C component which the inductor has failed to block is bypassed by this capacitor. and only pure DC across the load.

From fourier series analysis, of the waveform,

$$\vartheta = V_{dc} - \frac{V_m}{\pi}\left[\sin 2\omega t - \frac{\sin 4\omega t}{2} + \frac{\sin 6\omega t}{3} + \cdots\right]$$

But $V_{rms} = \frac{I_{dc}}{2fc}$

The second harmonic RMS value is,

$$V_2' = \frac{V_{rms}}{\pi\sqrt{2}} = \frac{I_{dc}}{2\sqrt{2}\pi fc}$$

$$V_2' = \frac{I_{dc}}{\sqrt{2}(2\pi fc)} \times \frac{2}{2}$$

$$= \frac{\sqrt{2} I_{dc}}{(4\pi fc)} = \sqrt{2} I_{dc} X_C$$

$\because$ where $I_{dc} = \frac{V_{dc}}{R_L}$

$$V_2' = \sqrt{2}\left(\frac{V_{dc}}{R_L}\right) X_C$$

$V_2'$ is applied to the L-section $(L_1 C_1)$ by using the Same logic the o/p ripple is,

$$V_2'\left(\frac{X_{C1}}{X_{L1}}\right)$$

$$V_{rms} = V_2'\left(\frac{X_{C1}}{X_{L1}}\right)$$

$$V_{rms} = \sqrt{2} V_{dc}\left(\frac{X_C}{R_L}\right)\left(\frac{X_{C1}}{X_{L1}}\right)$$

$$\boxed{r = \frac{V_{rms}}{V_{dc}} = \sqrt{2}\left(\frac{X_C}{R_L}\right)\left(\frac{X_{C1}}{X_{L1}}\right)}$$

where all reactances calculated at the Second harmonic frequency. This expression gives the second harmonic ripple.

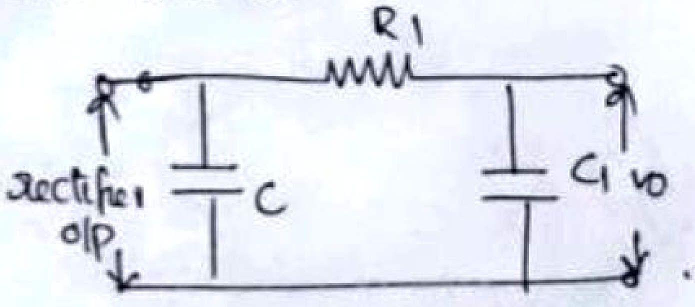
## Advantages

1) It can be used with HWR as well as FWR
2) output obtained is MORE
3) o/p obtained is almost DC.

## Disadvantages:-

1) Cost is more
2) Size is large
3) weight is more because of inductor applied in the circuit.

To overcome this disadvantage an Inductor is replaced by a resistor (100 to 200Ω). Then it is called capacitor - input RC filter. But this reduces the o/p voltage because of voltage drop in the resistor.

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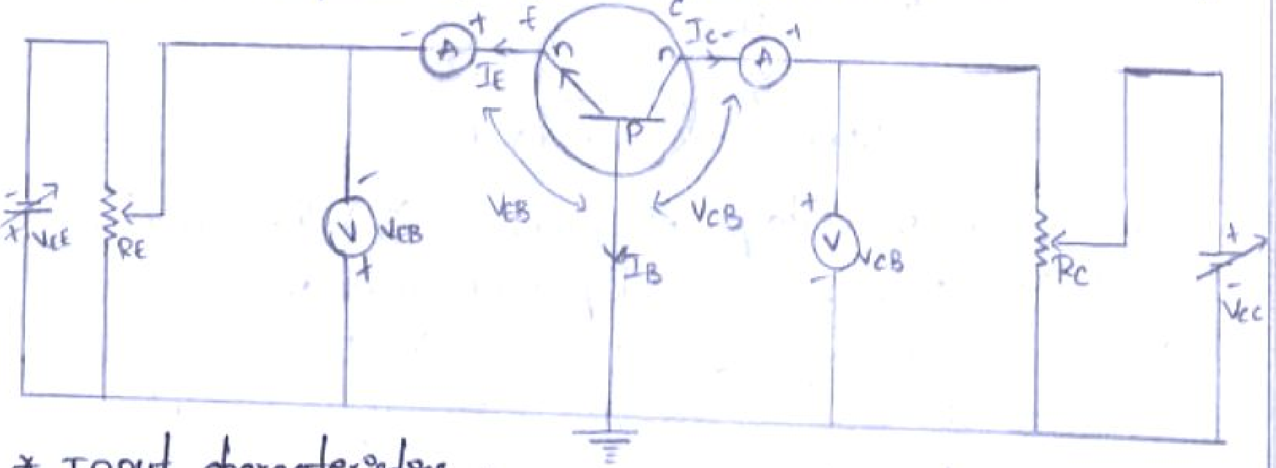
## common Base configuration ($C_B$)

If the Base of the pnp or npn transistor is connected to ground is called common base configuration.

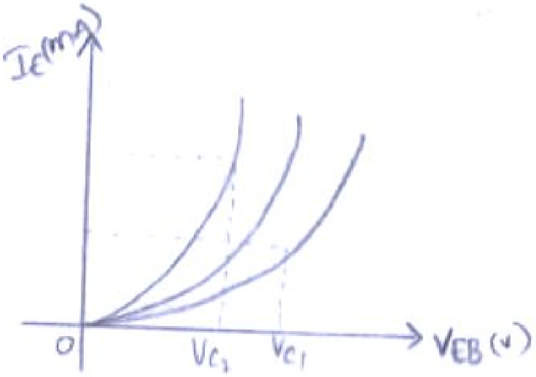
The circuit diagram of $C_B$ configuration is shown in below figure




* Input characteristics

It is the curve between input voltage ($V_{EB}$) and input current ($I_E$) at constant collector Base voltage ($V_{CB}$) the emitter current ($I_E$) is taken along y-axis & emitter Base voltage ($V_{EB}$) along x-axis. The junction between emitter and Base is in forward bias and collector and Base junction is in reverse Bias.

The two terminals of BJT emitter & Base Now acts as an pn junction diode. Then the input characteristics of $C_B$ configuration similar to forward Bias of PN junction diode.



→ The input resistance is the ratio of change in emitter-base voltage ($\Delta V_{EB}$) and the resulting change in emitter current ($\Delta I_E$) at constant collector base voltage.

$$\boxed{r_i = \frac{\Delta V_{EB}}{\Delta I_E}}$$

Where $V_{CB}$ = constant.

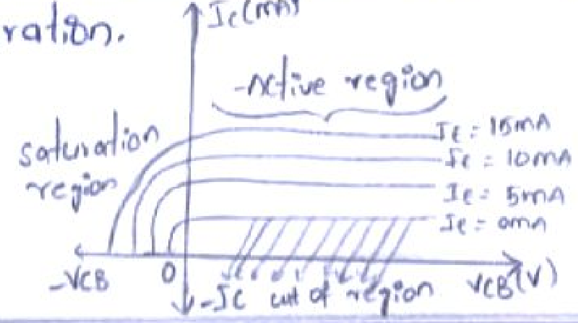
- For the cut in voltage of junction (ie) the emitter current ($I_E$) increases rapidly with small increases in emitter base voltage ($V_{EB}$) therefore the input resistance of CB (common Base configuration) is very small. It can be observed that there is a slight increase in emitter current ($I_E$) with increase in ($V_{CB}$). This is due to change in the width of depletion region where Base collector region is in reverse

→ $V_{CB}$ is positive for npn transistor and it is negative for pnp transistor similarly $V_{EB}$ is negative of npn transistor and +ve for pnp transistor.

* <u>output</u> <u>characteristics</u> of <u>CB</u> <u>configuration</u>.

→ It is the curve between collector current ($I_C$) and collector-Base voltage ($V_{CB}$) at constant emitter ($I_E$)

→ The collector current ($I_C$) is taken along y-axis & $V_{CB}$ is taken along x-axis. The below figure shows the output characteristics of CB configuration.



The output characteristics of CB configuration has '3' Base regions.

1) Active region 2) cut-off region 3) saturation region.

Active region

→ For the operation in the Active region the emitter Base junction is forward bias while collector Base junction is in reverse bias.

→ In this region collector current ($I_C$) is approximatly eqaual to ($I_E$) emitter current & Transistor works as an Amplifier.

→ In the Active region the collector current is almost constant.

→ The $I_C$ is almost independent on $V_{CB}$ (collector base voltage). Therefore, the output resistance which is the ratio of change in collector Base voltage ($V_{CB}$) and resulting change in current ($I_C$) at constant $I_E$

$$\boxed{R_o = \frac{\Delta V_{CB}}{\Delta I_C}}$$ Where $I_E$ is constant.

→ output resistance is independent of $V_{CB}$ therefore it provides high dynamic output resistance.

cut-off region

The region below the curve $I_E=0$ is known as cut-off region where $I_C$ is nearly '0' and the collector base junction, emitter base junction are in reverse bias.

Saturation region

In this region emitter base junction ($J_E$) & collector base junction ($J_C$) Both are in forward bias. Here, the $I_C$ is Independent of $I_E$. $I_C$ decreases rapidly as $V_{CB}$ become more negative.

Relationship between [$\alpha$, $\beta$, $\gamma$]

We know that from 3 configurations of BJT - Amplification factors can be represented as follows

$$\alpha = \frac{I_C}{I_E}, \quad \beta = \frac{I_C}{I_B}, \quad \gamma = \frac{I_E}{I_B}$$

(8)

$$I_C = \alpha I_E, \quad I_C = \beta I_B, \quad I_C = \gamma I_B$$

Relationship between $\alpha$, $\beta$

$$I_E = I_B + I_C$$

$$\alpha = \frac{I_C}{I_E} = \frac{I_C}{I_B + I_C}$$

$$\alpha = \frac{\beta I_B}{I_B + \beta I_B}$$

$$\alpha = \frac{\beta \cancel{I_B}}{(1+\beta)\cancel{I_B}}$$

$$\boxed{\alpha = \frac{\beta}{1+\beta}}$$

Relationship between $\beta$, $\alpha$

$$I_E = I_B + I_C$$

$$I_E = I_B + \beta I_B$$

$$I_B = I_B(1+\beta)$$

$$\beta = \frac{I_C}{I_B} = \frac{\alpha I_C}{I_B}$$

$$\beta = \frac{\alpha \cancel{I_B}(1+\beta)}{\cancel{I_B}}$$

$$\beta = \alpha(1+\beta)$$

$$\beta = \alpha + \alpha\beta$$

$$\beta - \alpha\beta = \alpha$$

$$\beta(1-\alpha) = \alpha$$

$$\boxed{\beta = \frac{\alpha}{1-\alpha}}$$

## Relationship between $\gamma$ & $\beta$

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

$$\gamma = \frac{\cancel{I_B}(1+\beta)}{\cancel{I_B}}$$

$$\boxed{\gamma = 1+\beta} \quad \text{—— (1)}$$

## Relationship b/w $\gamma$ & $\alpha$

$$\gamma = 1+\beta$$

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

$$= \frac{1-\cancel{\alpha}+\cancel{\alpha}}{1-\alpha}$$

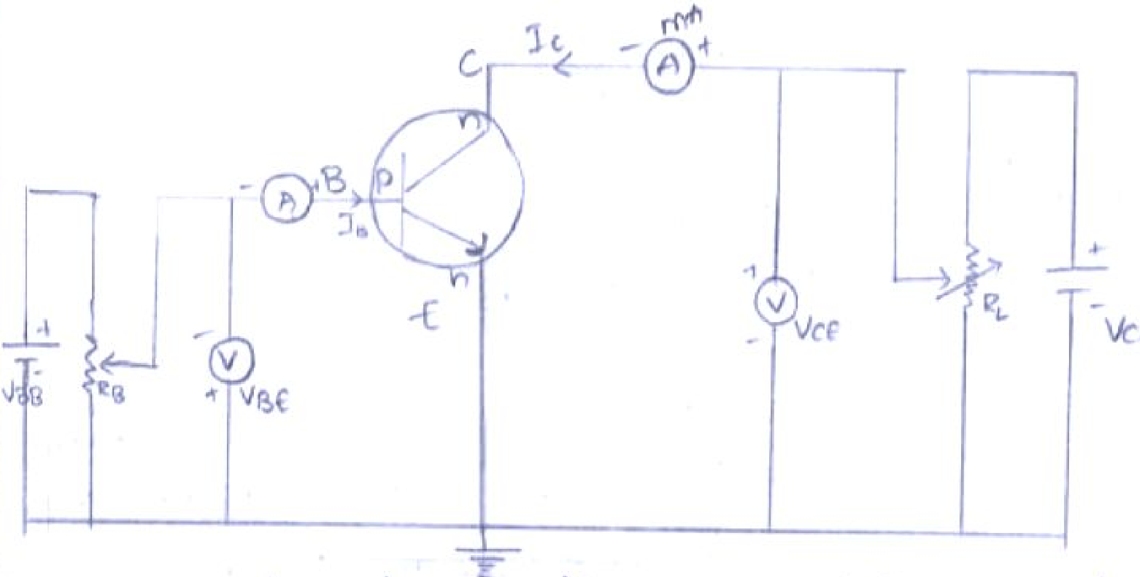
$$\boxed{\gamma = \frac{1}{1-\alpha}} \quad \text{—— (2)}$$

## Relationship b/w $\alpha, \beta, \gamma$

From (1) & (2)

we get $\boxed{\gamma = 1+\beta = \frac{1}{1-\alpha}}$

## common emitter configuration (CE)




. In CE configuration emitter is connected to ground, input is applied to base terminal and output is taken across the collector terminal

### Input characteristics

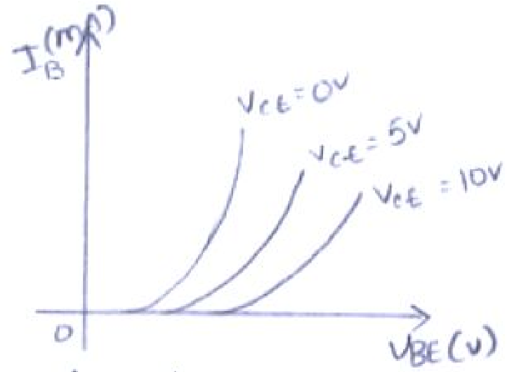
To determine the input characteristics the collector to emitter voltage is kept constant and Base current is increased from '0' with equal steps by increase $V_{CE}$ the circuit diagram of CE configuration is shown in above fig.

The value of $V_{BE}$ and $I_B$ are noted for fixed values of $V_{CE}$. When $V_{CE}$ = 0V the Base emitter junction is forward Biased and junction behave as a forward biased diode. Hence the input characteristics for $V_{CC}$ = 0 is similar to that of forward Biased diode when $V_{CE}$ is increased the width of the depletion region at the reverse biased collector base junction will increase.

Hence the effective width of Base will decrease this effect causes decrease in the Base current $I_B$ therefore

(b)

for $V_{CE} > 0V$ the curve shifts to the right as $V_{CE}$ increases




## output characteristics

To determine the output characteristics the Base current $I_B$ is kept constant at suitable value by adjusting emitter voltage $V_{BE}$.

→ The magnitude of collector emitter voltage $V_{CE}$ is increased in suitable eaual steps from '0' and the collector current ($I_C$) is noted for each settings of $V_{CE}$

The output characteristics of CE configuration consist of 3 regions
1) Active region 2) saturation region 3) cut-off region

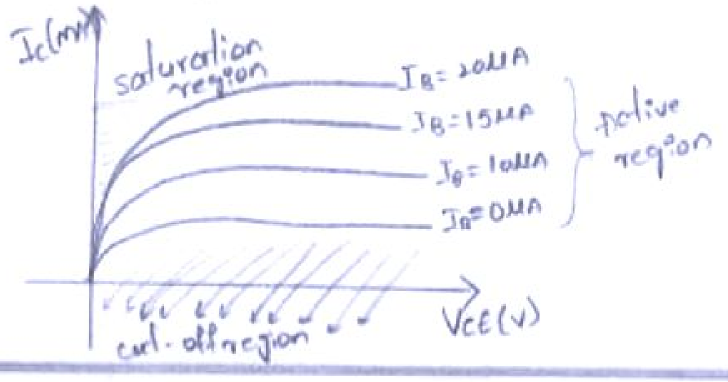
→ under active region the collector current is almost constant with $I_B$ but the current in milli ampier.

→ Under saturation regions means Both junctions are in forward bias that current $I_C$ linearly increases with $V_{CE}$

→ When $V_{CE}=0$ small reverse saturation current flows between collector to emitter terminal even if $I_B=0$ micro ampier

→ At different values of $I_B$ the $I_C$ current shifts its level in milli-Ampier.

→



Stability factor (S) for self Bias :-

- Apply KVL to the Base emitter loop

$$V_{th} - I_B R_B - V_{BE} - I_E R_E = 0$$

$$V_{th} = I_B R_B + V_{BE} + I_E R_E = 0$$

$$V_{th} = I_B R_B + V_{BE} + (I_B + I_C) R_E = 0$$

$$V_{th} = I_B R_B + V_{BE} + I_B R_E + I_C R_E = 0$$

Diff w.r.to $I_C$

$$\frac{\partial}{\partial I_C} V_{th} - \frac{\partial}{\partial I_C} I_B R_B + \frac{\partial}{\partial I_C} V_{BE} + \frac{\partial}{\partial I_C} I_B R_E + \frac{\partial}{\partial I_C} I_C R_E = 0$$

$$0 = \frac{\partial I_B}{\partial I_C} R_B + 0 + \frac{\partial I_B}{\partial I_C} R_E + R_E$$

$$0 = \frac{\partial I_B}{\partial I_C} (R_B + R_E) + R_E$$

$$-R_E = \frac{\partial I_B}{\partial I_C} (R_B + R_E)$$

$$\frac{\partial I_B}{\partial I_C} = \frac{-R_E}{R_B + R_E}$$

$$\Rightarrow \quad S = \frac{1+\beta}{1-\beta\left(\frac{\partial I_B}{\partial I_C}\right)} = \frac{1+\beta}{1-\beta\left(\frac{-R_E}{R_B+R_E}\right)}$$

$$= \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_B+R_E}\right)}$$

$$S = \frac{1+\beta}{1+\beta\left(\frac{\cancel{R_E}}{\cancel{R_E}\left(1+R_B/R_E\right)}\right)}$$

$$S = \frac{1+\cancel{\beta}}{1+\cancel{\beta}(1)} \qquad R_B/R_E <<< 1$$

$$\boxed{S \simeq 1}$$

From above stability factor expression $R_B/R_E$ controls the stabilization of transistor

Therefore if $R_B/R_E <<< 1$ then stability factor becomes '1' but practically $R_B/R_E \neq 0$

MOSFET:-

→ Metaloxide semiConductor field effective transistor. It is a second category of field effect transistor. In MOSFET the gate of the transistor is insulated from the channel by $SiO_2$ layer. Due to this the input resistance of MOSFET is very high. Because of this insulated gates MOSFET is also called IGFET (insulated gate field effective transistor).

- The two types of MOSFET's are Depletion MOSFET and Enhancement MOSFET:

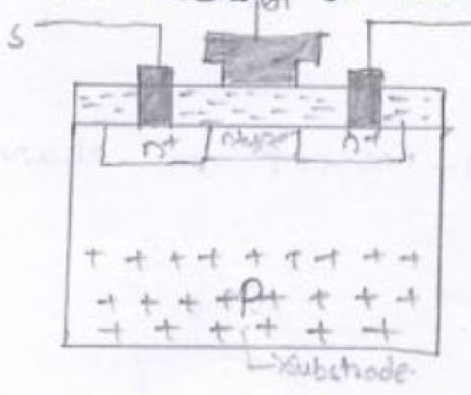
Depletion MOSFET:- It is further divide into two types:-

i) N-channel D-MOSFET
ii) P- channel D-MOSFET

i) N- channel D-MOSFET:-

- Two highly doped N-regions are diffused into a lightly doped P-type substrade is challed depletion N-DMOSFET.

- The basic construction of N-channel D-MOSFET is below;



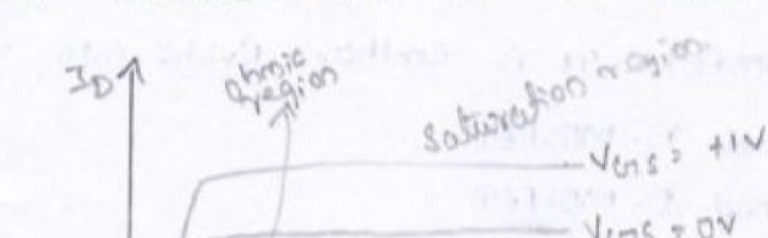

→ These two highly doped N-regions represent source and Drain. Usually substrade is connected to source terminal internally.

- The source and Drain terminals are connected to metallic contact.

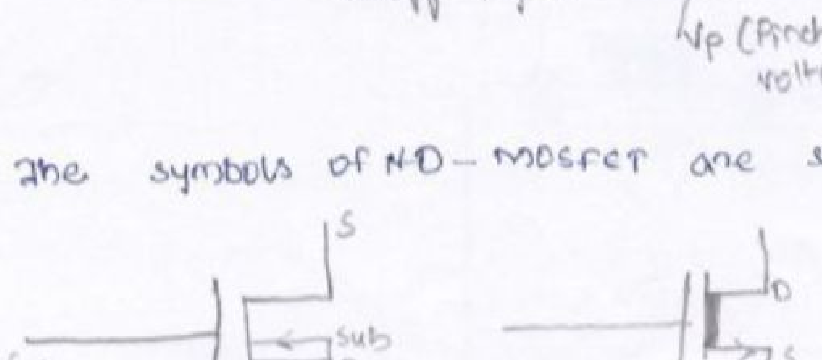
The gate is also connected to a metal contact by a very thin layer of dielectric material called $SiO_2$.

- The D-MOSFET always acts as an ON transistor. i.e., the channel is formed during manufacturing. If we apply -ve gate voltage, the -ve charges on the gate repel conduction electrons from the channel and attracts holes from the P-type substrade. In this process some of electrons are recombined with holes which depends on -ve voltage applied at the Gate.

- The drain characteristics of N-channel DMOSFET is;

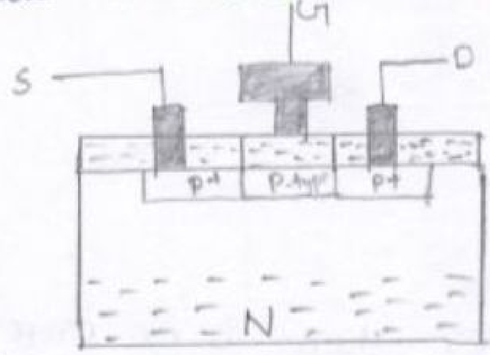



→ The symbols of ND-MOSFET are shown below;



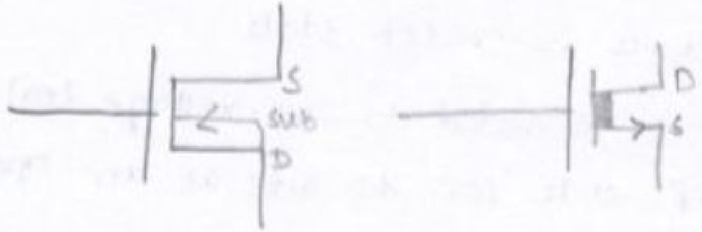
P-channel D-MOSFET:-

- Two highly doped P-regions are diffused into a lightly doped N-type substrade is known as P-channel D-MOSFET.
- The basic construction of P-chanel D-MOSFET is below;

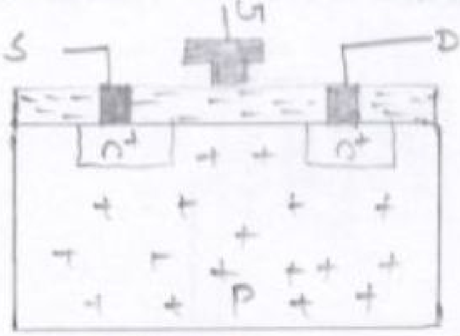



→ These two highly doped P-regions represent source and Drain. Usually substrade is connected to source terminal internally.

- The source and Drain terminals are connected to metallic. The gate is also connected to a metal contact surface but remains insulated from P-channel, by a very thin layer of dielectric material called $SiO_2$.
- The D-MOSFET always acts as an ON transistor. i.e., the chanel is formed during manufacturing. If we apply +ve gate voltage, the +ve charges on the gate repel conduction holes from the channel and attracts electrons from the N-type substrade. In this process, some of holes are recombined with electrons which depends on -ve voltage applied at gate.
- The symbols of P-MOSFET are below;



N-channel E-MOSFET:- Like depletion MOSFET 2 highly doped n-regions are diffused into a lightly doped P-type substrade. The source and drains are taken out, to metalic contacts. The construction of N-channel E-MOSFET is below;




- In N-channel E-MOSFET there is no proper channel b/w 2 n-regions. The $SiO_2$ layer is still present to isolate the gate metallic carriers b/w drain and source and it is seporated by channel.

Operation:-

Case (i):- when gate is open which is not connected to any source, then there is flow of carriers b/w source and drain since, different carriers are placed at channel. Even the drain and source terminals are connected to different voltages then also there is no flow of carriers in the channel.

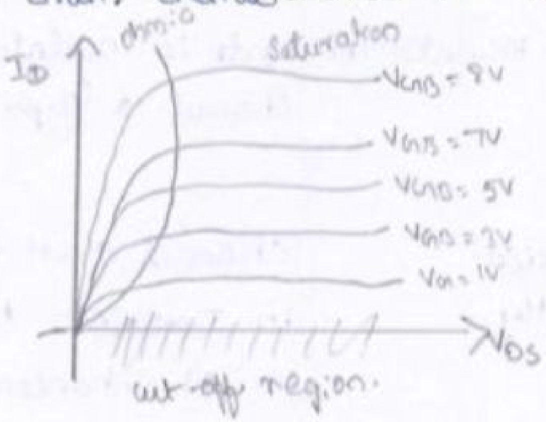
∴ The device is still in non-conducting mode.

Case(ii):- when gate is connected to -ve voltage, all the electrons are placed on $SiO_2$ layer these electrons attracts holes from P-type substrade towards channel. In this case also there is no charge carriers across the channel. Again the device is in OFF state.

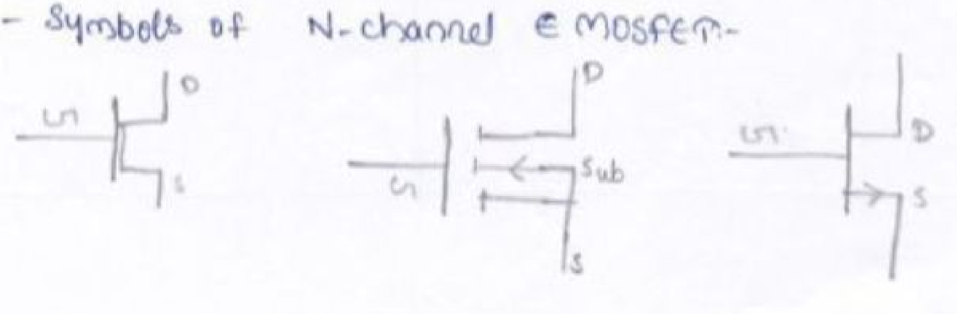
Note:- when N-MOSFET is connected to -ve voltage (or) logic 0 the device goes to OFF state (or) its acts as an open circuit.

Case iii):- When gate input is connected to +ve voltage of N-channel E-MOSFET, all the holes are placed $SiO_2$ layer. These holes attracts the minority carriers of P-substrade towards channel and repels majority carriers towards substrade. Now, the channel is replaced by opposite carriers, then a layer is formed which is called inversion layer. The minimum voltage which is applied to gate terminal to establish a proper channel b/w source and drain is called threshold voltage. When proper channel is placed based on applied voltage b/w chain and source the carriers moves from either source to drain (or) drain to source then we can say that the device is in ON state (or) the device acts as short circuit b/w source and drain.

- The drain characteristics of N-E MOSFET:-




- Symbols of N-channel E MOSFET:-



⑥

PARAMETERS OF FET :-

~~The~~ In a JFET, the drain current $I_D$ depends upon the drain voltage $V_{DS}$ and gate voltage $V_{GS}$.

$$\therefore I_D = f(V_{GS}, V_{DS}).$$

The main parameters of JFET are,

1) Drain Resistance.
2) Transconductance.
3) Amplification factor.

1) Drain Resistance($r_d$): It is the ratio of change in drain-Source voltage to the change in drain current at constant $V_{GS}$.

$$\therefore r_d = \left(\frac{\Delta V_{DS}}{\Delta I_D}\right)_{V_{GS} = \text{constant}}.$$

The drain resistance at $V_{GS} = 0$ ie when the depletion regions of the channel are absent is called as Drain source On Resistance $R_{DS}$.

② Transconductance $g_m$ ]. -- It is the ratio of change in drain current to the change in Gate source voltage at constant $V_{DS}$.

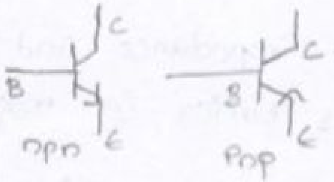
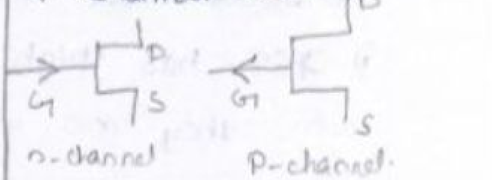
$$g_m = \left[\frac{\Delta I_D}{\Delta V_{GS}}\right]_{V_{DS} = \text{Constant}}.$$

③ Amplification FACTOR ($\mu$) : It is the ratio of change in drain source voltage to the change in Gate-Source voltage at constant $I_D$.

$$\mu = \left(\frac{\Delta V_{DS}}{\Delta V_{GS}}\right)_{I_D = \text{constant}}.$$

$$\boxed{\mu = g_m \cdot r_d}$$

Differences between BJT and FET:-

| S.No | Parameter | BJT | FET |
|---|---|---|---|
| 1) | Control element | Current controlled device - Input current $I_B$ controls $I_C$ | It is a voltage controlled device. - Input voltage $V_{GS}$ controls drain current $I_D$. |
| 2) | Device type | Current flows due to both majority and minority carriers. So, it is a bipolar device. | Current flows only due to majority carriers either electrons or holes. Hence, it is a unipolar device. |
| 3) | Types | npn, pnp | N-Channel JFET<br>P-Channel JFET |
| 4) | Symbol |  |  |
| 5) | Configuration | CE, CB, CC | CS, CD, CG |
| 6) | Input resistance | less, compare to JFET | high, compare to BJT |
| 7) | Size | bigger than JFET | Smaller than BJT |
| 8) | Sensitivity | higher sensitivity to change in the applied signals | less sensitivity to change in applied voltage. |
| 9) | Thermal stability | less | more |
| 10) | ratio of output to input | $\beta = \frac{\Delta I_C}{\Delta I_B}$ | $g_m = \frac{\Delta I_D}{\Delta V_{GS}}$ |
| 11) | Thermal noise | more in BJT because of more junctions | much lower in JFET bcoz, few charge carriers cross the junction. |