Unit-I

Review of semi-conductor in physics:

Open-circuited p-n junction

Diode equation:

PN diode as Rectifier (Forward and reverse bias):

Voltage Characteristics:

BJT as an amplifier and as switch:

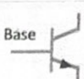
Brief idea of dc analysis:

Biasing circuits:

Small signal operation and models:

Single stage BJT amplifier:

Difference between diode and transistor:

Basis For Comparison	Diode	Transistor
Definition	A semiconductor device in which current flows only in one direction.	A semiconductor device which transfers the weak signal from low resistance circuit to high resistance circuit.
Symbol	Cathode (+)  Anode (-)	Base  Collector Emitter
Uses	Rectification	Regulator, Amplification and Rectification
Terminal	Two (Anode and Cathode)	Three (Emitter, Base and Collector)
Switch	Uncontrolled	Controlled
Types	Junction diode, Light emitting diode, Photodiodes, Schottky diodes, Tunnel, Veractor and Zener diode.	Bipolar transistor and Field Effect Transistor.
Region	P-region and N-region	Emitter, Collector and Base
Depletion Region	One	Two

Transistor:

- It was developed in the year 1947 by the three American physicists, John Bardeen, Walter Brattain and William Shockley.
- A Transistor is a three terminal semiconductor device that can be used to conduct and insulate electrical current or voltage. Generally, it is used to regulate or control the flow of electronic signals.It acts as an amplifier (e.g. radio receiver) and a switch (e.g. digital circuits).
- Transistor are inferred due to small size, light weight, no heating requirements, higher efficiency, easy to use, no warm-up period is required, lower operating voltages.

Types of transistor

- Bipolar Junction Transistor (BJT)
  - n-p-n
  - p-n-p
- Field Effect Transistor (FET) (uses EF to control the flow of current in Semiconductor)
  - JFET (Junction-FETs)
  - MOSFET
    - Depletion MOSFET
    - Enhancement MOSFET

(MOSFET: Metal-oxide-Semi conductor field effect transistor)

BJT (BipolarJunction Transistor): (What is BJT + What are the function or Uses of BJT)

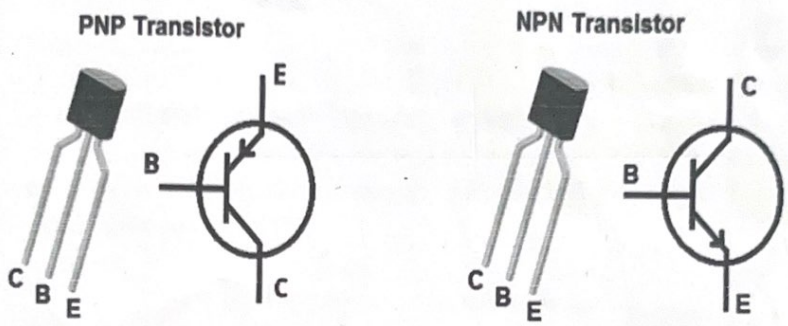
It is a three-terminal semiconductor device consisting of two p-n junctions. It is used as a switching device and for amplification of signals.It is an active device (current controlled device).

Weak signal $\boxed{\text{BJT}}$ Strong signal

It consist of two PN junction formed by sandwiching either P-type or N-type semiconductor between a pair of opposite types **(i) n-p-n (ii) p-n-p**

Basics parts and symbol of a Transistor:

A transistor is composed of three layers of the semiconductor materials.

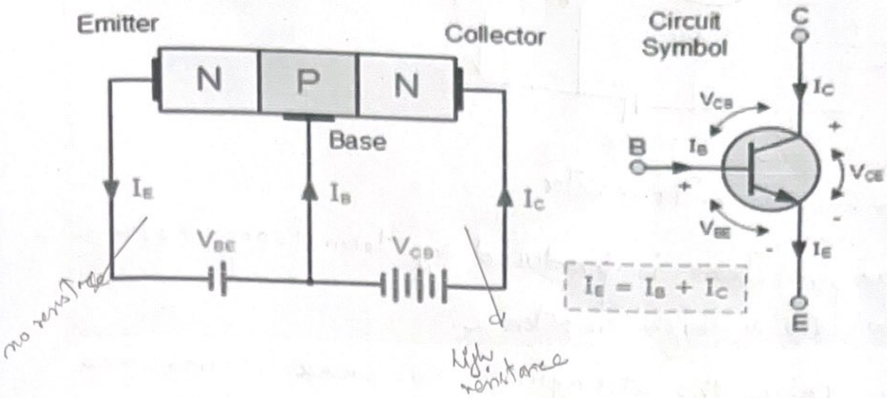


The three terminals are (Features of the terminal)

(i) **Emitter (E):** Heavily doped, Moderate size
(ii) **Base (B):** Lightly doped, Thin
(iii) **Collector (C):** Moderately doped, lager/wider

(i) **n-p-n type**

Working:



Forward bias causes the electron ejection to flow towards the base and constitutes emitter current I_E, base electron tends to combine with the holes since base is lightly doped and very thin very few electron combines with the holes i.e., less than 5% to constituents I_B having small value in μA. Rest of the electron i.e., more than 95% cross over the collector region to constituents collector current through diffusion and minority carriers across the junction which is the ~~because of~~ reverse bias.

Now, according to Kirchhoff law,

$$I_E = I_B + I_C$$

Thecollector current is composed of the two components (i) Minority (ii) Majority

$$I_C = I_C\,(mA) + I_{CO}\,(\mu A)$$

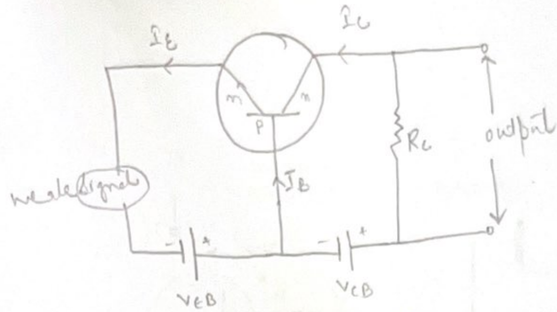
I_C (mA), is of majority current components. The minority current components is called the leakage current and represented by I_{CO}.

(ii) **p-n-p type**

Working:

(Do your self).

Transistor as an Amplifier :- (overview).



transfer + Resistance = Transistor.

- The basic amplification is produced by transfering current I from a low to a high resistance.
- A transistor raises the strength of a weak signal and thus act as an Amplifier. The week signal is applied b/w E-B junction and output is taken across R_C connected in collector circuit.
- In order to acheive faithfull amplification the input circuit should always remain in forward bias. to do so a DC voltage is applied along with a varying signal the DC voltage is known as DC biased voltage and its magnitude is such that it always keep the input circuit forward biased regardless of the polarity of the signal.

→ Why n-p-n configuration is preferred over p-n-p configuration.

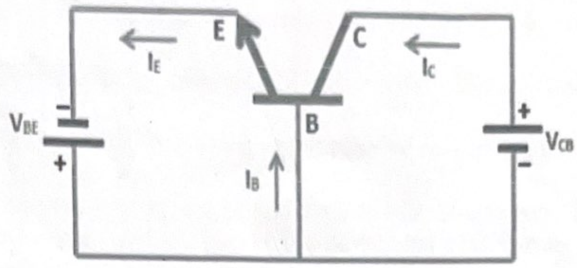
∵ The mobility of electron is much higher than that of hole. as n-p-n is electron dominated configuration and p-n-p is hole dominated configuration.

Configuration of transistor :

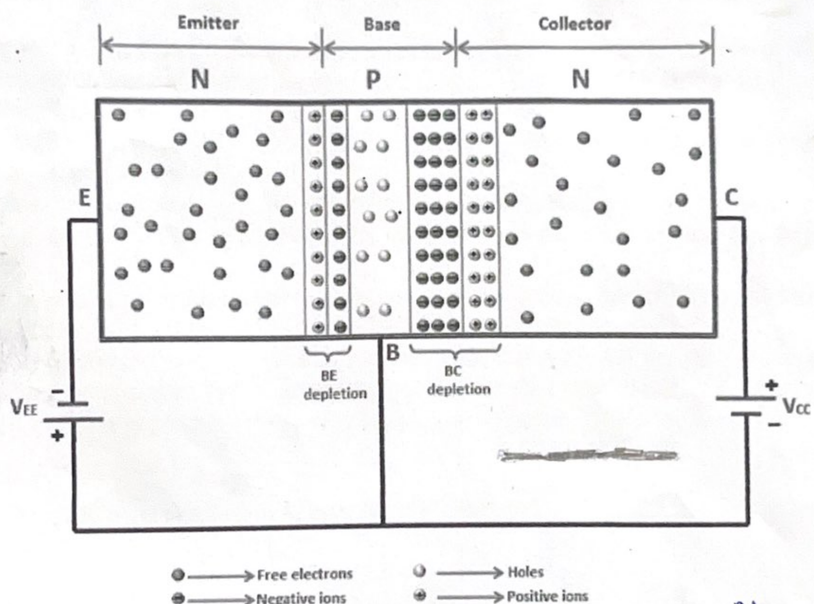
(i) **Common base (CB) configuration**

Common baseconfiguration is derived from the fact that the base is common to both the input and output sides of the configuration.

(a) Construction:



(b) Working:



How I_E, I_B and I_C are generated in the transistor circuit ?

- In the figure you can see that base-emitter junction is in forward biased condition through applied voltage V_{BE} and collector-base junction is in the reverse-biased state through the voltage source V_{CB}.

IE IB

- Due to forward biasing voltage V_{BE} electrons that are major carriers in emitter will bear a force of repulsion due to negative terminal of battery also holes in the base of the transistor will bear the force of repulsion from the positive side of the voltage source.
- Due to this electron move towards the base from emitter and holes moves from base to emitter.
- Due to the movement of electrons and holes current flows. The real current is due to the flow of electrons which flows from emitter to base.
- But we follow conventional current that is from base to emitter. Hence current is generated at base and emitter (I_B, I_E).
- The electrons that move from emitter toward base will combine with a hole which is majority carriers and holes moving toward the base to emitter combine with the emitter.
- In the above diagram, you can note that the area of the base is very less. So, less number of electrons coming from emitter will combine with holes in base remaining will enter to the collector.
- The electrons enter into the collector will bear the force of attraction from the positive side of the battery.
- So free electrons in collectors move to the positive side of the battery due to that current is generated at the collector region. (I_C)
- The current produced at collectors and base is due to electrons coming from the emitter. hence, emitter current is large than the collector and base current and equal to the sum of these two currents.

$$IE = IB + IC$$

- ~~As we discuss above emitter is input and collector is output~~.
- As output or collector current is less than the emitter current hence gain of current is less than the one. (gain = output/input)
- In simple words, a common base amplifier attenuates current ~~that~~ rather than amplification of it.
- As the base-emitter junctions at input operate as a forward-biased diode. So the impedance of a common base amplifier at the input is less.
- The collector-base junction behaves like a reverse-biased diode due to this impedance for a common base at the output is high.
- So we can conclude that input impedance for the common base is less and high at the output.
- Such a transistor that has less input impedance and large output impedance give large voltage gain.
- As the gain is large but the current is less so the power gain of this amplifier is less than other amplifiers.
- These amplifiers are used in such an application where less input is needed.
- Base amplifier configuration is mostly used in the current buffer circuit.
- This amplifier is not commonly used as a common emitter and collector is used.

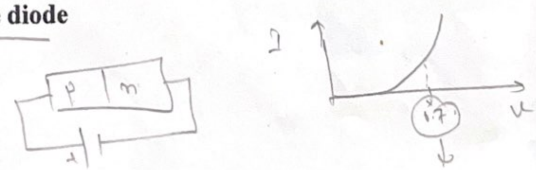
gain

impedance

Input Characteristics: (variation of current with voltage)

Current: I_E
Voltage: V_{BE}
For various output voltage (V_{CB})

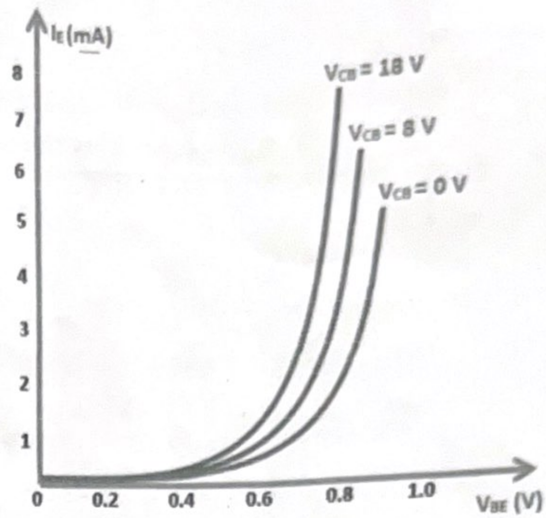
In case of simple diode



breakdown voltage → 0.7V for silicon

V_{CB} ↑es → KB ↑es → depletion region ↑es → recombination ↓es
↓
hdes less
more & more e moves toward collector
↓
hence I_E ↑es.

Why I_E increases with increasing V_{CB} ?



As, the V_{CB} is in the reversed bias on increasing the VCB values the reverse bias increases which results in thicker BC depletion regions and the base becomes much thinner. Thus, less recombination takes at the base and more electron moves toward the collector, resulting in higher IE.

Input resistance:

$$r_i = \left.\frac{\Delta V_{BE}}{\Delta I_E}\right|_{\text{at const. } V_{CB}}$$

Output characteristics:

Current: I_C

Voltage: V_{CB}

For various input current (I_E)

Before the characteristics let us understand

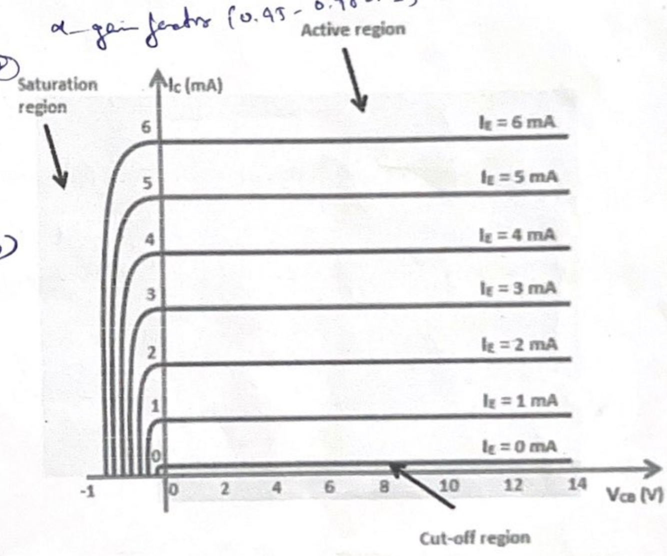
$$I_E = I_B + I_C \rightarrow (1)$$

and

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

$I_C = \alpha I_E$ α – gain factor (0.95 – 0.98 ~ 1)

$\boxed{I_C \simeq I_E} \rightarrow (2)$



Saturation region: (Both diode FB)

Both the diodes are in forward bias. So, to make the reverse bias to forward bias we change the polarity by decreasing the voltage. So, with decrease in the V_{CB} voltage the $I_C$current decreases. Because the electron from the emitter are now restricted because of the forward bias or the positive polarity.So, I_C current decreases.

Active region: (1 FB · 1 RB)
E-B junction (Forward biased)
B-C junction (Reverse biased)
Through V_{CB} we get the current I_C, But further increasing the V_{CB}, I_C is not changing because I_C doesn't depend on V_{CB}, instead it depends on IE current. As I_C= alpha(I_E) or I_C ~ I_E

Cut-off region: (R.B) (RB)
E-B junction (open means no supply i.e., I_E=0)
B-C junction (Reverse biased)

So, ifI_E=0 then I_C is 0 (there is some leakage current which is negligible)

In the active region transistor work as an amplifier, whereas, in cut-off region it works as a switch.

- IC varies with the VCB only for few voltages less than 1V transistor is never operated in this region.
- When VCB is increased to 1 or 2 V, IC becomes constant and depends on IE only. Here almost all emitter current flows through the collector and the transistor is operated in this region.
- A very large change in VCB produces very small change in IC, this indicates that the output resistance is very high.
- Beyond the particular value of VCB, the reversed bias collector junction breaks down and the current increases rapidly. A transistor is not designed to operate in this region.

Output resistance :

$$r_o = \left.\frac{\Delta V_{CB}}{\Delta I_C}\right|_{I_E}$$

Thus, the r_o of common base circuit is very high approx. several tens K ohms..

(C) Current amplifi~~cation~~er factor (Alpha) α (gain)

Ratio of the change in output Current to change in input current at constant V_{CB} is called Current amplifier factor.

$$\alpha = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB}}$$

$$I_E > I_C \Rightarrow \alpha < 1$$

α can be ↑ed by ↓ing I_B, but it can't be made 1. This is achieved by making the base thin and doping it light. Practically value of α in commercial transistors range from 0.9 to 0.99.

B) Expression for Collector Current :-

1. Part of emitter current that reaches collector (αI_E)
2. Leakage current ($I_{breakage}$). This current is due to the movement of minority carriers. BC junction on account of it being reverse biased.

$$I_C = \alpha I_E + \underbrace{I_{breakage}}_{\rightarrow I_{CBO}} \Big] \text{ total collector current.}$$

$$I_C = \alpha I_E + I_{CBO} \rightarrow (1)$$

We know

$$I_E = I_C + I_B$$

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

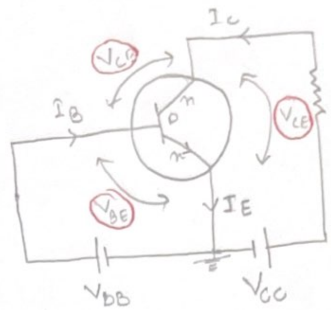
$$I_C(1-\alpha) = \alpha I_B + I_{CBO}$$

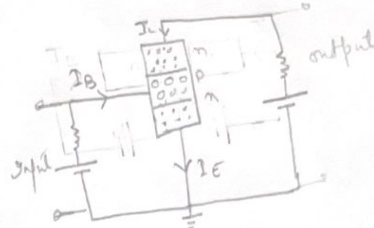
$$\boxed{I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{(1-\alpha)} I_{CBO}}$$

Date 21.09.2023

2. Common Emitter Configuration:-

The common Emitter amplifier is a three basic single-stage BJT and is used as a voltage Amplifier. The input of this amplifier is taken from the base terminal, the output is collected from the collector terminal and the emitter terminal is common for both the terminal.



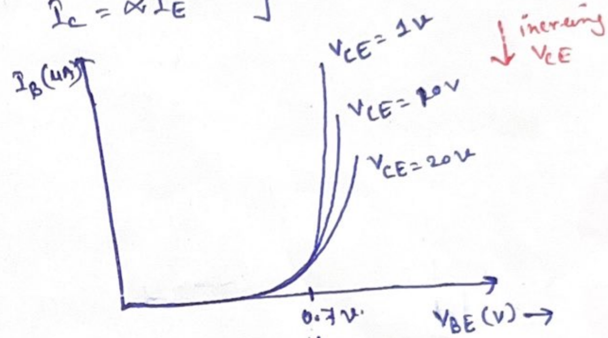


Working Principle:

Input characteristics: (the characteristic is same as p-n diode)

Input current = I_B ; $I_E = I_B + I_C$

output current = I_C ; $I_C = \alpha I_E$



We have the Eqn:-

$$V_{CE} = V_{CB} + V_{BE} \rightarrow \text{fix}$$

Let fixed V_{BE}, and vary V_{CE}

(Why I_B decreases with increase in V_{CE})

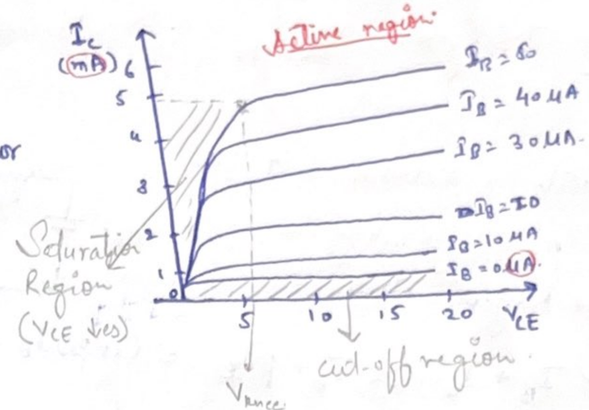
V_{CE} ↑es → V_{CB} ↑es → Reverse Bias ↑es
↓
Depletion region thick
↓
no. of holes ↓es
↓
recombination ↓es, So lesser number of valance electron moves toward base.
So, I_B ↓es

i.e. V_{CE} ↑es → I_B ↓es.

* **Input resistance:-** $r_i = \left.\dfrac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE}}$

Input resistance of CE configuration is higher than the input resistance of CB configuration.

Output characteristics:- (I_C, V_{CE}) at I_B.



• **Base Current Amplification factor (β):-**

The ratio of change in collector current to the change in base current is base current amplification.

i.e $\beta = \frac{\Delta I_C}{\Delta I_B}$

β changes from 20 to 500

$\mu A \rightarrow mA$ { Amplification of Current }

relation b/w α and β:-

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{(CE Configuration)}$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{(CB Configuration)}$$

We know,

$$I_E = I_B + I_C$$

and $I_C = \alpha I_E$

$$\beta = \frac{\alpha I_E}{\Delta I_B} = \frac{\alpha \Delta I_E}{(\Delta I_E - \Delta I_C)}$$

$$= \frac{\alpha \cancel{\Delta I_E}}{\cancel{\Delta I_E}\left(1 - \frac{\Delta I_C}{\Delta I_E}\right)}$$

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

Expression for Collector Current: (in CE).

$$I_E = I_B + I_C \rightarrow (1)$$

$$I_C = \alpha I_E + I_{CBO} \rightarrow (2)$$

$$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO} \rightarrow (3)$$

If $I_B = 0$ (Base is open circuit), Collector Current will flow to the emitter (i.e. I_{CEO} → collector cut off current with base open.)

$$I_{CEO} = \frac{I_{CBO}}{1-\alpha} \rightarrow (4)$$

Substituting value of $\frac{I_{CBO}}{1-\alpha}$ in Eqn (3)

$$I_C = \frac{\alpha}{1-\alpha} I_B + I_{CEO} \rightarrow (5)$$

$$\boxed{I_C = \beta I_B + I_{CEO}}$$ ($\because I_{CEO} = \frac{I_{CBO}}{1-\alpha}$)

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

$$\left(\begin{aligned} \beta &= \frac{\alpha}{1-\alpha} \\ (1-\alpha)\beta &= \alpha \\ 1+\beta &= \frac{1}{1-\alpha} \end{aligned} \right)$$

$\frac{\alpha}{1-\alpha}$ → large value.
0.99

Current Amplification

now explain graph → as we ↑es I_B, I_C becomes βI_B (i.e. Amplication of current is there)

Leakage in transistor is due to minority carrier and is independent of temperature.

I_E in term of β:

$$I_C = \beta I_B$$

$$I_E = I_C + I_B$$

$$= \beta I_B + I_B$$

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

Common Emitter Configuration is mostly used Configuration Why?

Because it does amplification of voltage, Current and power. Mostly it is used for Current and power amplification.

1. High current gain

$$I_C = \beta I_B + I_{CEO}$$

β is high $\therefore I_C >> I_B$. $\left(\text{gain} = \frac{I_C}{I_B}\right)$ (α)

2. High voltage and Power Gain

3. Moderate output to input impedance ratio.

In CE configuration ratio of output impedence to input impedence is small i.e about 50, this makes CE circuit arrangement an Ideal one for Coupling b/w various transistor stages.

Q. The constant α of a transistor is 0.95. What would be the change in the collector current corresponding to a change of 0.4mA in the base current in the Common emitter configuration.

Given $\alpha = 0.95$ | as $\beta = \frac{\alpha}{1-\alpha}$

$\Delta I_B = 0.4mA$

$\Delta I_C = ?$

$$\because \beta = \frac{\alpha}{1-\alpha} = \frac{0.95}{1-0.95} = 19$$

Also $\beta = \frac{\Delta I_C}{\Delta I_B}$

$$\Delta I_C = \beta \times \Delta I_B$$

$$= 19 \times 0.4mA$$

$$\therefore \boxed{\Delta I_C = 7.6mA}$$

H/W: In the CE configuration, the voltage drop across a resistance of 6kΩ connected in the collector circuit is 6 volts. If the current gain in the CB configuration of a transistor is 0.995, then find the base current I_B.

Given $R_L = 6k\Omega$, $V_o = 6V$, $\alpha = 0.995$

$$\because \beta = \frac{\alpha}{1-\alpha} \Rightarrow \frac{0.995}{1-0.995} = 199$$

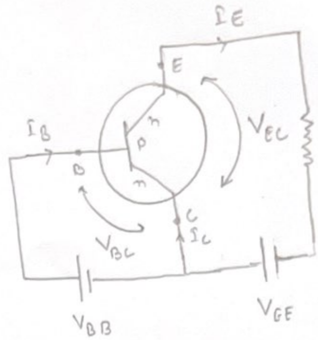
Also $\beta = I_C/I_B$

$$= (V_o/R_L)/I_B$$

$$199 = (6V/6k\Omega)/I_B \Rightarrow I_B = 5.02\,\mu A$$

3. Common Collector (CC):-

In this configuration, the base terminal of the transistor serves as the input, the emitter terminal is the output and the collector terminal is common for both input and output.



The input is applied between the base and collector while the output is taken from the emitter and collector.

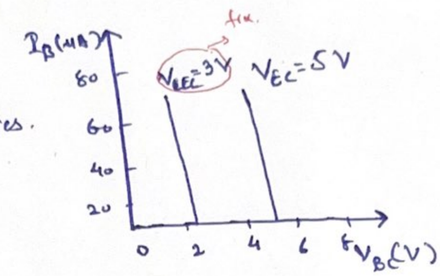
Working Principle:

Input characteristics:-

(I_B, V_{BC})

i.e. I_B decreases $\rightarrow$ V_{BC} increases.

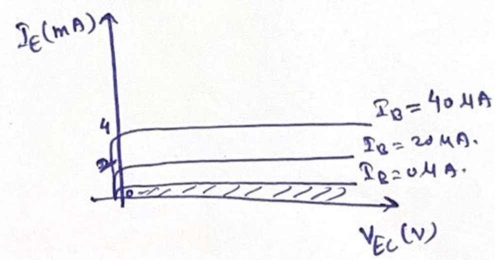
at constant V_{EC}.



Output characteristics:-

i) Saturation (Both diode F-B)

ii Active region.



Dynamic Input resistance:

$$r_i = \frac{\Delta V_{BC}}{\Delta I_B}\Bigg|_{\text{at } V_{EC}=\text{Const.}}$$

Dynamic output resistance:

$$r_o = \frac{\Delta V_{EC}}{\Delta I_E}, \quad I_B = \text{Const.}$$

i) Current Amplifier factor (γ): (in CC)

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

as $\Delta I_E \simeq \Delta I_C$.

This configuration also provides the same current gain as in Common Emitter.

Relation b/w γ and α:

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

$$\alpha = \frac{\Delta I_C}{\Delta I_B}$$ (Current Amplifier gain in CB)

$$I_E = I_B + I_C$$

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

$$\gamma = \frac{1}{1 - \frac{\Delta I_C}{\Delta I_E}}$$

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

ii) Expression for ~~Collector~~ Emitter Current:

$$I_C = \alpha I_E + I_{CBO} \longrightarrow ①$$

$$I_E = I_C + I_B \longrightarrow ②$$

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

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

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

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

$$\left(\begin{aligned} \because \beta &= \frac{\alpha}{1-\alpha} \\ (1-\alpha)\beta &= \alpha \\ 1+\beta &= \frac{1}{1-\alpha} \end{aligned} \right)$$

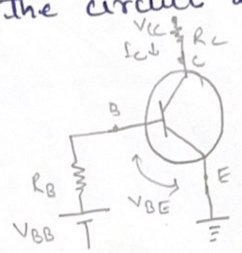
Why C-C Configuration is not used for Amplification?

This configuration has high input resistance & low output resistance hence voltage gain < 1, so, ~~hence~~ CC Configuration is not used for Amplification. ~~This~~ It is generally used for impedence matching i.e for deriving low impedence load and high impedence Source.

Q. Why CE is mostly used Configuration?

* DC Analysis & DC Load Line :-

In case of amplifier, it has two input AC & DC input. If we analyse the circuit as DC input it is called DC analysis.



What is DC Load Line?

In a graph which has all possible values of output current I_c and output voltage V_{CE}. So applying KVL to the output of CE confi. we get.

$$V_{CC} = I_c R_c + V_{CE}$$

$$V_{CC} - I_c R_c - V_{CE} = 0$$

$$I_c R_c = -V_{CE} + V_{CC}$$

$$\boxed{I_c = -\frac{1}{R_c} V_{CE} + \frac{V_{CC}}{R_c}} \rightarrow A$$

n Order to get a line, we required minimum two points. So, to get the points. put

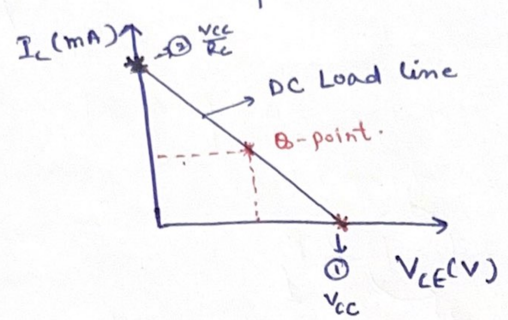
i) $I_C = 0$ in Eqⁿ (A)

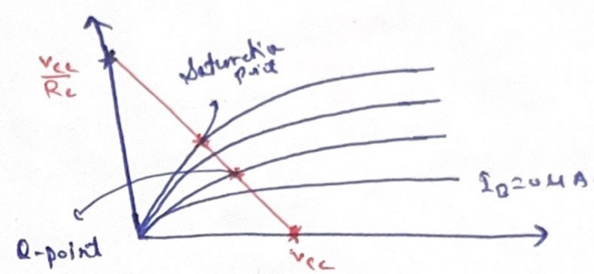
then $\boxed{V_{CE} = V_{CC}} \rightarrow (1)$

ii) $V_{CE} = 0$ in Eqⁿ (A)

So, $\boxed{I_C = \frac{V_{CC}}{R_C}} \rightarrow (2)$

DC Load Line in output characteristics.





Now, comes. Q-point / operating point:

- Zero Signal value of I_C and V_{CE} are known as the operating point. When a signal is applied variation of I_C + V_{CE} takes place about the line.
- For a faithful amplification we select Q-point at exactly middle of the plot.

Transistor Biasing :- BJT $\xrightarrow{ON}$ Saturation. $\xrightarrow{OFF}$ cut-off. $\xrightarrow{amplifier}$ Active region.

The proper flow of zero signal collector current, and the maintenance of proper collector-emitter voltage during the passage of signal is known as Transistor Biasing.

To obtain the faithful amplification in a transistor. It is required the transistor in active region.

Biasing circuit:- (Basic purpose of transistor)

In transistor biasing we want to keep BE junction FB and CB junction properly RB during the application of signal. which can be done by adjusting a bias battery in the circuit. The circuit that provide the transistor biasing is called the Biasing Circuit.

What is Stabilization:- (Means to make the operating point independent of T)

Semi-conductor show temperature dependent characteristics and hence the operating point also changes with temperature. Which is Undesirable.

→ The process of making operating point independent of Temperature changes or variation in transistor parameter is known as Stabilization.

The unstable Q-point causes the thermal runaway.

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

I_{CBO} is the collector leakage current which is highly influenced by the temperature & ↑es of 10°C temp. doubles the I_{CBO} which is an experimentally varified fact. So, from Eqn. (1) I_C ↑es by $(1+\beta) I_{CBO}$ times, Hence ↑es in I_C.

1. Shift the operating point.
2. This high I_C current when flows produces heat within the transistor. This ↑es the transistor temp. & hence I_{CBO} further ↑es. ↑es in I_{CBO}, I_C ↑es by $(1+\beta) I_{CBO}$ & This ↑es. I_C will further raised the temperature.

This effect is cummutative and in second I_C becomes too large & hence burn the transistor.

s self destruction of an unstablized transistor is known as thermal runaway.

Hence for stability of operating point I_c should kept constant irrespective of change in I_{CBO}. This implies that I_c can be constt. by using I_B.

Stability factor: (S)

The extend to which biasing circuit is capable of keeping I_c constant with variation in I_{CBO} is defined in term of stability factor

$$S = \left.\frac{dI_c}{dI_{CBO}}\right|_{\text{at const. } \beta \text{ or } I_B}$$

→ Ideal value of $S = 1$, (not possible to attian this value).
→ performance is satisfactory for $S < 25$.

Expression for S for a transistor in CE Configuration:

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

Diff. w.r.t. I_C

$$1 = \beta \frac{dI_B}{dI_c} + (1+\beta) \underbrace{\frac{dI_{CBO}}{dI_c}}_{1/S}$$

$$1 = \beta \frac{dI_B}{dI_c} + \frac{(1+\beta)}{S}$$

$$\boxed{S = \frac{(1+\beta)}{1-\beta\left(\frac{dI_B}{dI_c}\right)}}$$

- General Eqn. for Setibility factor.

→ Lower The value of S, better is the thermal stability of the transistor.

→ How or by which changes change collector Current.
→ Why stabilization of operating point is necessary.
→ What is thermal runaway.
→ How thermal runaway is avoided.

y Biasing a transistor is needed or Essential?

Transistor biasing is done to get faithful amplification; So for that the following 3-points should be proper.

i) It should ensure proper Zero Signal Current.

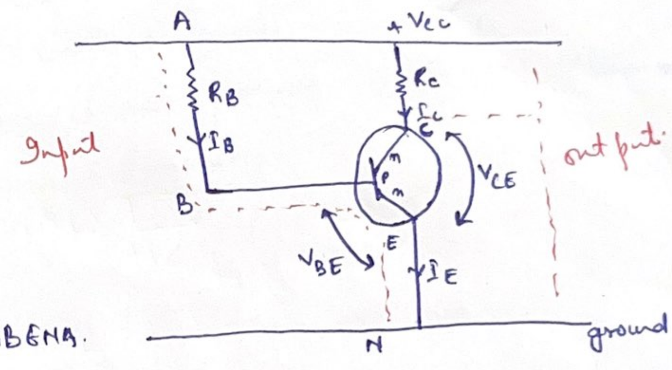
ii) It should ensure that V_{CE} does not fall below 0.5 V for Ge and 1 for Si transistor.

iii) It should ensure the stabilization of operating point.

Four Ways to Biase a Transistor
- Base resistor / Fixed Bias
- Emitter base Method
- Biasing with collector-feedback resistor
- Voltage-divider bias / Self biasing

① Fixed Bias:-

→ Input
→ output
→ stability factor
→ Load line
→



Applying KVL to input ABENA.

$$V_{CC} = I_B R_B + V_{BE}$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B}} \quad \text{or} \quad R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

↓ ①

as $V_{CC} > V_{BE}$

$$\boxed{R_B \simeq \frac{V_{CC}}{I_B}} \rightarrow ②$$

here, V_{CC} is fixed quantity and I_B is chosen at some suitable value, hence R_B can be found directly and for this reason. This method is called fixed Bias method.

Stability factor:

$$S = \frac{1+\beta}{1-\beta \frac{dI_B}{dI_C}}$$

Differentiate I_B in Eqⁿ ① i.e I_B

$$\frac{dI_B}{dI_C} = 0$$

Hence,
$$S = \frac{1+\beta}{1-\beta(0)}$$

$$\boxed{S = 1+\beta}$$

Comments:

$$S = 1+\beta$$

i.e
$$\frac{dI_C}{dI_{CBO}} = 1+\beta$$

or $dI_C = (1+\beta)dI_{CBO}$

i.e I_C changes $(1+\beta)$ times as much as I_{CBO} changes.
Hence, the fixed bias circuit provides poor thermal Stability.
hence, prone to thermal Runaway.

→ For output loop :-

$$V_{CC} = I_C R_C + V_{CE}$$

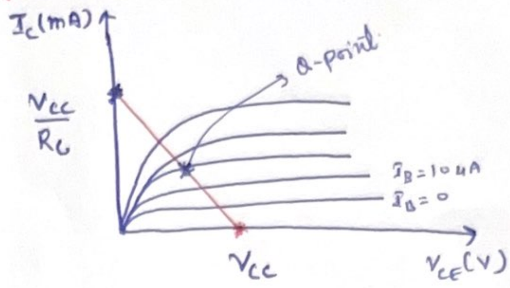
and $I_C = \beta I_B$.

So change in R_C will not affect I_B or I_C as long as we are in active region. However R_C will determine the magnitude of V_{CE}.

Load Line Analysis:

From Eq^n. (1)

$V_{CE} = V_{CC} - I_C R_C$



case i)

$V_{CE}\big|_{I_C=0} = V_{CC}$

case ii) $V_{CE} = 0$

$I_C\big|_{V_{CE}=0} = \frac{V_{CC}}{R_C}$

i.e Q-point changes by changing the following parameters.

i) I_C can change by varying I_B

ii) if V_{CC} is fixed & R_C changes

iii) if R_C is fixed and V_{CC} is changed.

Advantage:

- Simple.
- Calculations are simple.

Disadvantages:

i) High S and hence strong chances of thermal runaway.

ii) Poor Stability, there is no means of stopping ↑e in I_C due to I_{CBO}, as I_B is always fixed.