Sol T

Problems

(21) In a common base connection, the emitter current is 1mA. If the emitter ~~current~~ circuit is open, the collector current is 50 μA. Find the total collector current. Given that $\alpha = 0.92$

Sol CB ; $\alpha = 0.92$ ✓

$I_E = 1mA$; $I_{CBO} = 50\mu A$; $I_C = ?$

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

$$I_C = 0.92\,(1 \times 10^{-3}) + (50 \times 10^{-6})$$

$$\boxed{I_C = 0.97\,mA}$$

(22) Find the value of β (i) $\alpha = 0.9$

(ii) $\alpha = 0.98$

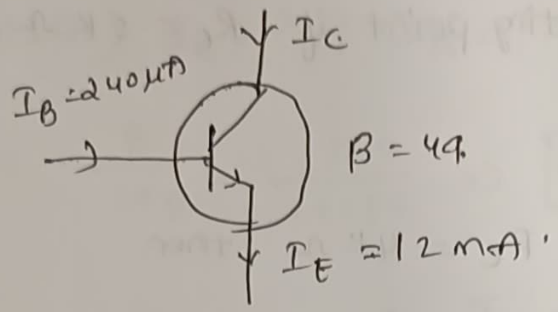
(iii) $\alpha = 0.99$

Sol (i) $\alpha = 0.9$; $\beta = \dfrac{\alpha}{1-\alpha} = \dfrac{0.9}{1-0.9} = 9$

(ii) $\alpha = 0.98$; $\beta = \dfrac{\alpha}{1-\alpha} = \dfrac{0.98}{1-0.98} = 49$

(iii) $\alpha = 0.99$; $\beta = \dfrac{\alpha}{1-\alpha} = \dfrac{0.99}{1-0.99} = 99$

...nd the 'α' rating of the transistor shown in figure and hence determine the value of I_C using both α and β rating of the transistor.



Sol

$$\alpha = \frac{\beta}{1+\beta} = \frac{49}{1+49} = 0.98$$

$$I_C = \alpha I_E = 0.98\,(12mA) = 11.76mA$$

$$I_C = \beta I_B = 49\,(240\mu A) = 11.76mA$$

(24) For a certain transistor; $I_B = 20\mu A$, $I_C = 2mA$ & $\beta = 80$. Calculate I_{CBO}.

Sol

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

$$2 = 80(20) + I_{CEO} \Rightarrow \boxed{I_{CEO} = 0.4mA}$$

$$\alpha = \frac{\beta}{\beta+1} = \frac{80}{80+1} = 0.988$$

$$I_{CBO} = (1-\alpha)\, I_{CEO} = (1-0.988) \times 0.4$$

$$\boxed{I_{CBO} = 0.0048mA}$$

(25) In a transistor circuit, collector load is 4 kΩ ... quiescent current (Zero signal Collector current) is 1 ...

(i) What is the operating point if $V_{CC} = 10V$?

(ii) What will be the operating point if $R_C = 5k\Omega$?

Sol $V_{CC} = 10V$; $I_C = 1mA$

(i) when collector load $R_C = 4k\Omega$, then

$$V_{CE} = V_{CC} - I_C R_C = 10 - 1(4) = 6V$$

$\therefore$ operating point is 6V, 1mA.

(ii) when collector load is $R_C = 5k\Omega$, then

$$V_{CE} = V_{CC} - I_C R_C = 10 - 1(5) = 5V$$

$\therefore$ operating point is 5V, 1mA.

---

(26) a) Transistor has $\alpha = 0.975$. What is the value of β and γ?

b) If $\beta = 200$, What is the value of α and γ.

Sol a) $\alpha = 0.975$; $\beta = \frac{\alpha}{1-\alpha} = \frac{0.975}{1-0.975} = 39$

$\gamma = 1+\beta \Rightarrow \gamma = 1+39 \Rightarrow$ $\boxed{\gamma = 40}$ $\boxed{\alpha = 39}$

b) $\beta = 200$; $\alpha = \frac{\beta}{1+\beta} = \frac{200}{1+200} = 0.995$

$\gamma = 1+\beta \Rightarrow \gamma = 1+200 \Rightarrow$ $\boxed{\gamma = 201}$ $\boxed{B = 0.995}$

transistor has $\beta = 150$. Calculate the approximate collector and base currents if the emitter current is 10 mA.

Sol $\beta = 150$; $I_C = ?$; $I_B = ?$; $I_E = 10\,mA$.

$$\alpha = \frac{\beta}{1+\beta} = \frac{150}{1+150} \Rightarrow \boxed{\alpha = 0.993}$$

$I_C = \alpha I_E$ (or) $I_C = \beta I_B$

$I_C = 0.993 \times 10$ $\qquad 9.93 = 150 \times I_B$

$\boxed{I_C = 9.93\,mA}$ $\qquad I_B = 0.0662\,mA$

$$\boxed{I_B = 66.2\,\mu A}$$

---

(28) A transistor has $I_B = 105\,\mu A$ and $I_E = 2.05\,mA$. Find a) 'β' of the transistor b) 'α' of the transistor. c) Emitter current 'I_E' d) If 'I_B' changes by $27\,\mu A$ and I_C changes by 0.65 mA, Find the new value of β.

Sol Given; $\beta = ?$ $\quad I_B = 105\,\mu A$; $I_C = 2.05\,mA$.

a) $I_C = \beta I_B \Rightarrow \beta = \dfrac{I_C}{I_B} = \dfrac{105 \times 10^{-6}}{2.05 \times 10^{-3}}$

$$\boxed{\beta = 19.523}$$

b) $\alpha = ?$; $\alpha = \dfrac{\beta}{1+\beta} = \dfrac{19.523}{1+19.523}$

$$\boxed{\alpha = 0.951}$$

c) $I_t = ?$; $I_E = I_C + I_B$

$$I_t = (2.05 \times 10^{-3}) + (105 \times 10^{-6})$$

$$\boxed{I_E = 2.155\ mA}$$

d) $I_B = 27\ \mu A$; $I_C = 0.65\ mA$; $\beta = ?$

$$I_C = \beta I_B \Rightarrow \beta = \frac{I_C}{I_B} = \frac{0.65 \times 10^{-3}}{27 \times 10^{-6}}$$

$$\boxed{\beta = 24.07}$$

---

(4) The common base dc current gain of transistor is 0.967. If the emitter current is 10mA, what is the value of the base current.

CB

Sol: $\alpha = 0.967$; $I_E = 10mA$; $I_B = ?$, $I_C = ?$

$$I_C = \alpha I_E \Rightarrow I_C = 0.967 \times 10$$

$$\boxed{I_C = 9.67\ mA}$$

$$I_E = I_C + I_B$$

$$I_B = I_E - I_C$$

$$I_B = 10 - 9.67$$

$$\boxed{I_B = 0.33\ mA}$$

$$\boxed{I_B = 330\ \mu A}$$

In a common base connection, current amplification factor is 0.9, If the emitter current is 1mA, determine the value of base current.

Sol CB ; $\alpha = 0.9$; $I_E = 1mA$; $I_B = ?$

$$I_C = \alpha I_E = 0.9 \times 1$$

$$\boxed{I_C = 0.9mA}$$

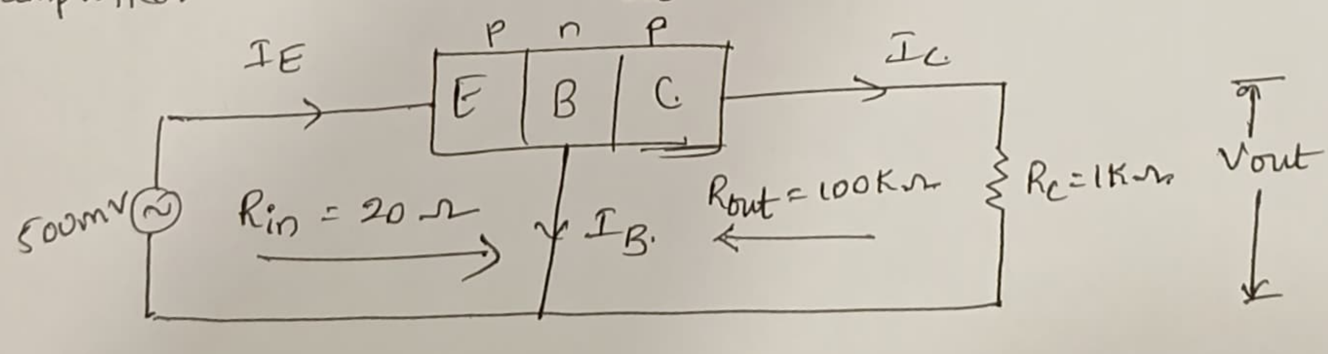
$$I_E = I_C + I_B$$

$$I_B = I_E - I_C$$

$$I_B = 1 - 0.9$$

$$\boxed{I_B = 0.1mA = 100\mu A}$$

(31) A common base transistor amplifier has an input resistance of 20Ω and output resistance of $100K\Omega$. The collector load is $1K\Omega$. If a signal of 500mV is applied between emitter and base, find the voltage amplification. Assume α_{ac} to be nearly one.



Sol Input current ; $I_E = \frac{\text{Signal}}{R_{in}} = \frac{500 mV}{20 \Omega}$

$I_E = 25 mA$.

Since ; α_{ac} is nearly ; output current ; $I_C = I_E = 25 mA$

Output voltage ; $V_{out} = I_C R_C$

$V_{out} = 25 mA \times 1 K\Omega$

$V_{out} = 25 V$

$\therefore$ voltage amplification ; $A_V = \frac{V_{out}}{\text{Signal}} = \frac{25 V}{500 mV}$

$\boxed{A_V = 50}$

THE END.

समझे !!

EEE ASSIGNMENT

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CONTENT : MODULE - IV.

(BIPOALAR JUNCTION TRANSISTOR AND APPLICATIONS).

① Define Bipolar junction transistor and briefly explain bipolar junction transistor.

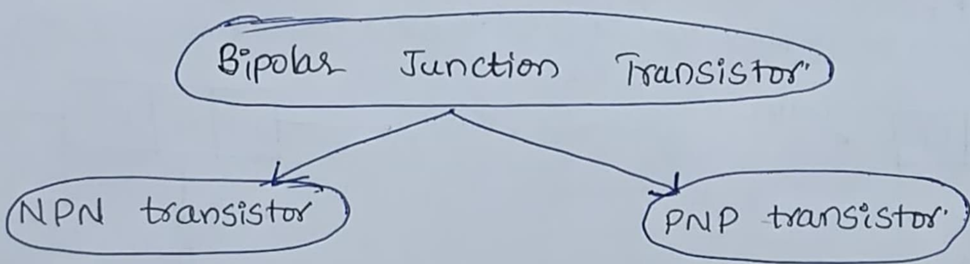
⑬ Illustrate The types of bipolar junction transistor.

Ans Bipolar junction transistor is a three terminal Semiconductor device that regulates current or voltage flow and acts as a switch or gate for signals.

→ Bipolar junction transistor shortly called as BJT. is famous and commonly used device. It is used as amplifier and logic switches.

→ BJT Consists of three terminals : Collector → C
Emitter → E.
Base → B.

→ BJT is generally of two types.



① NPN transistor:

Emitter → N - type → This region is heavily doped with electrons (-vely charged carriers).

Base → P - type → This region is slightly doped with holes (+vely charged Carriers).

Collector → N - type → This region is moderately doped with electrons.

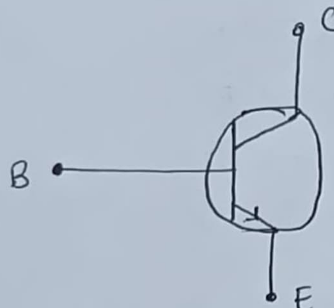
② PNP transistor :

Emitter → P-type → This region is heavily doped with holes.

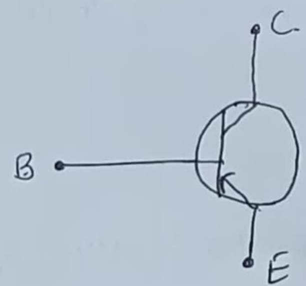
Base → N-type → This region is lightly doped with electrons.

Collector → P-type → This region is moderately doped with holes.

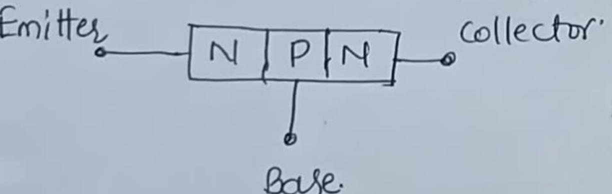
Symbol of NPN transistor



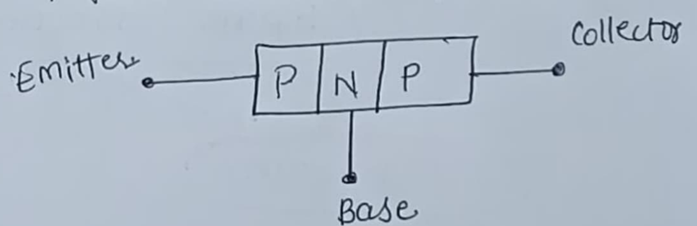
Symbol of PNP transistor:



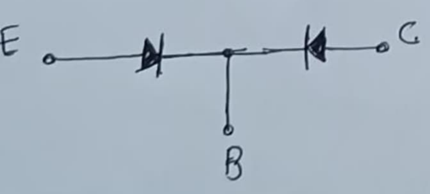
Physical construction of NPN transistor



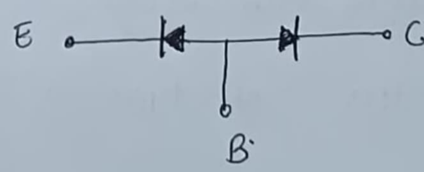
physical construction of PNP transistor



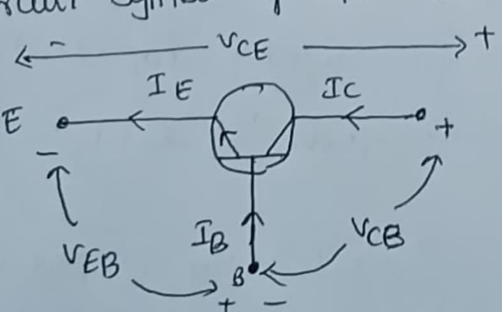
Two diode Analogy of PNP transistor



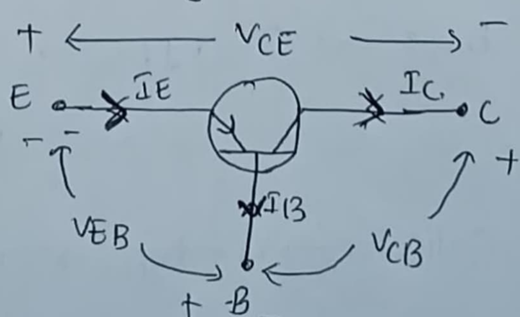
Two diode Analogy NPN transistor



Circuit symbol of NPN transistor



Circuit symbol of PNP transistor.



* The PNP and NPN transistors can be differentiated using a multimeter.

---

② Define current gain parameters of a CE, CB and CG transistor and relate parameters.

Ans **Current gain (α):** The current gain of a transistor in common Base configuration is defined as the ratio of output current or collector current (I_C) to the input current or emitter current (I_E).

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

* The current gain of a transistor in common Base configuration is less than unity. The typical current gain of a common base amplifier is 0.98.

Current gain (β): The current gain of a transistor in Common Emitter configuration is defined as the ratio of output current or collector current (I_C) to the input current or base current (I_B).

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

* The current gain of a transistor in CE configuration is high. Therefore, the transistor in CE configuration is used for amplyfying the current.

Current gain (γ) : It is defined as the ratio of change in output current or emitter current I_E to the change in ~~output~~ input current or base current I_B.

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

* The current gain of a common collector amplifier is high.

Relation between the parameters α, β and γ:

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

* $\alpha = \frac{\beta}{\gamma} \Rightarrow \boxed{\alpha \times \gamma = \beta}$

---

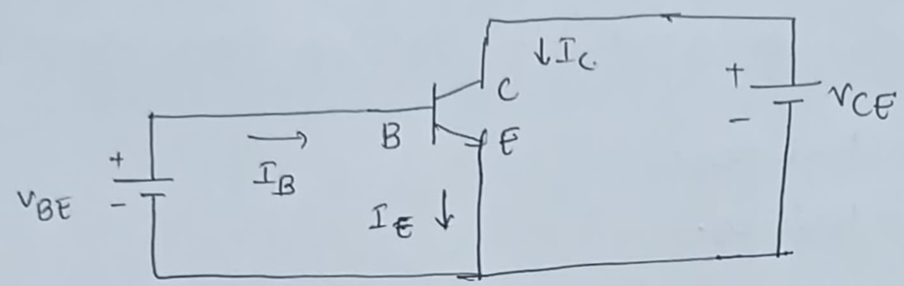
(3) Demonstrate the working of transistor in common emitter configurations and draw its input and output characteristics.

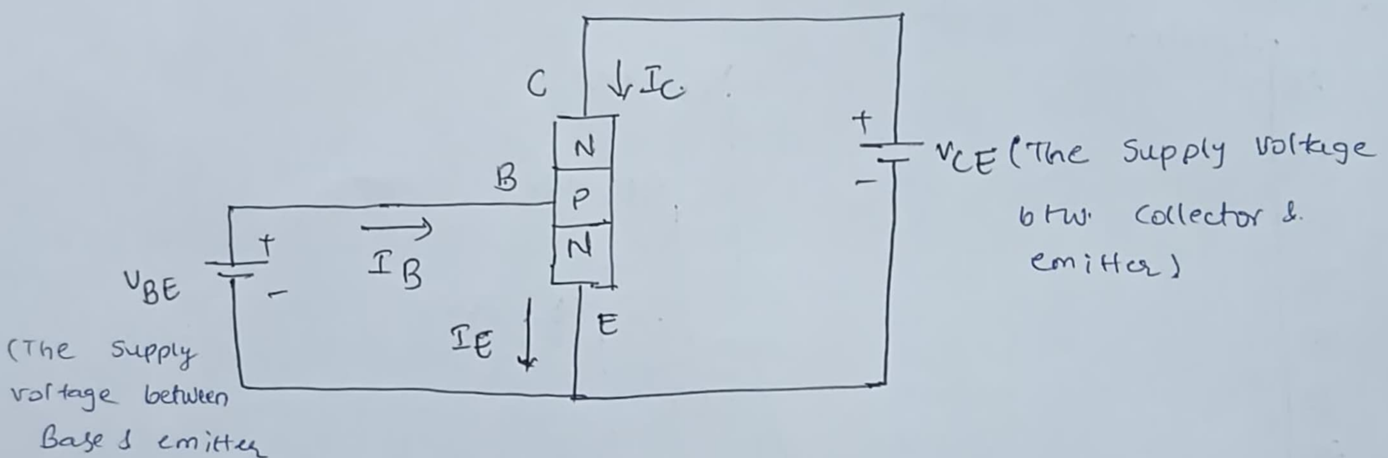
Ans * In common emitter configuration, base is the input terminal, collector is the output terminal and emitter is the common terminal for both input and output.

* That means the base terminal and common emitter terminal are known as input terminals whereas collector terminal and common emitter terminal are known as output terminals.

* sometimes common emitter configuration is also referred to as CE configuration, common emitter amplifier, or CE amplifier and is most widely used transistor configuration.

* In CE configuration, the emitter terminal is grounded so the CE configuration is also known as grounded emitter configuration.





* The input signal is applied between the base and emitter terminals while the output signal is taken between the collector and emitter terminals. Thus, the emitter terminal of a transistor is common for both input and output and hence it is named as common emitter configuration.

* The CE amplifiers are generally used when large current gain is needed.

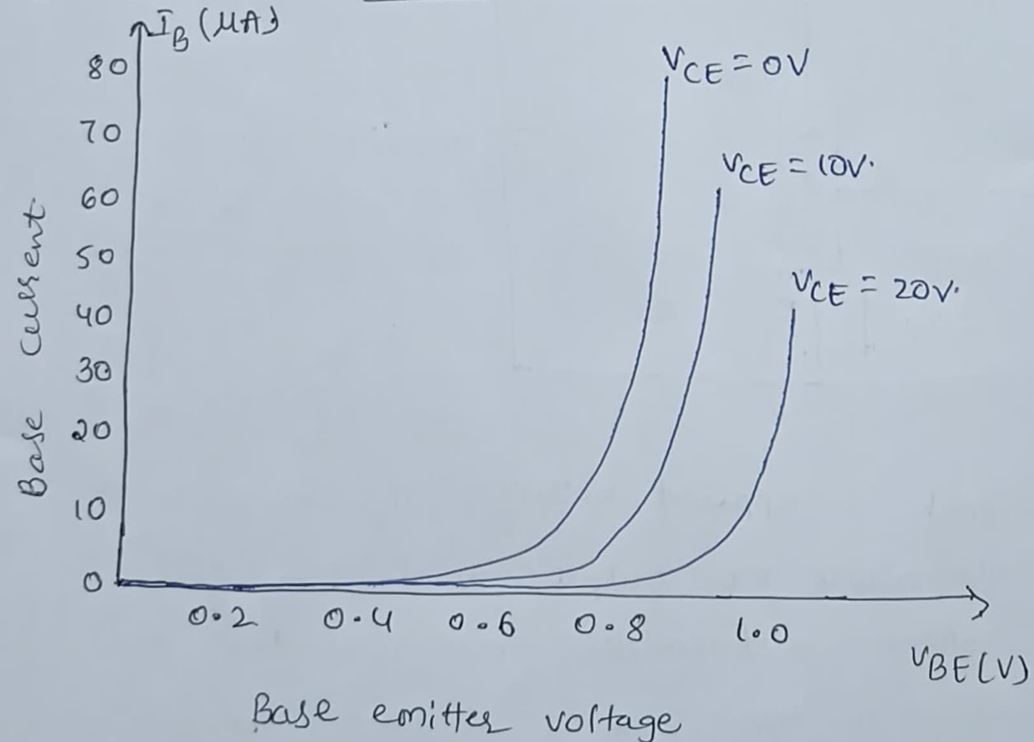
* The CB amplifier has to medium input and output impedance levels.

* The current gain & voltage gain in CB amplifier is medium. However, the power gain is high.

To fully describe the behaviour of a transistor with CE configuration, we need two set of characteristics.

a) Input Characteristics.
b) Output Characteristics.

A) Input characteristics:

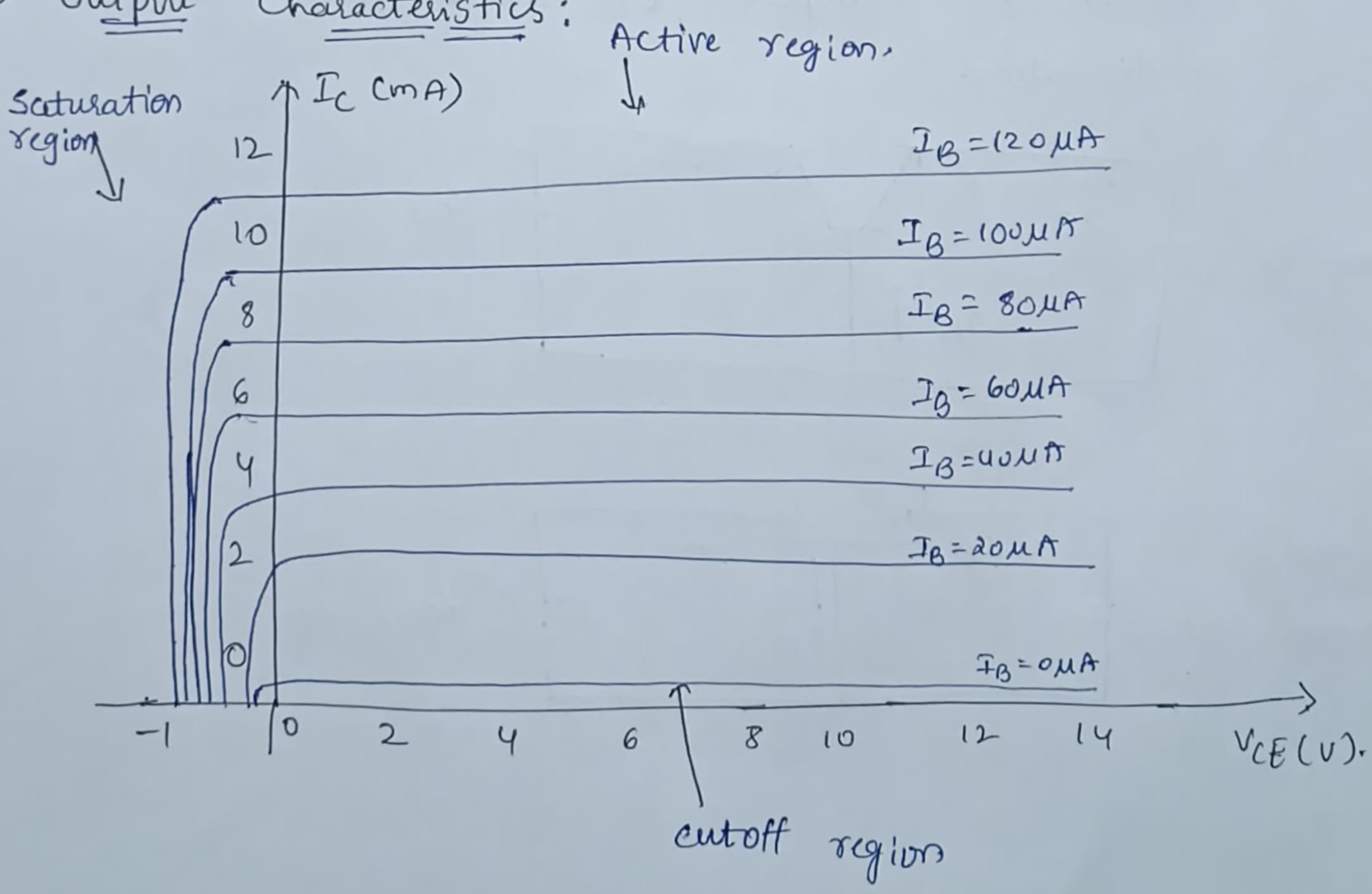


* To determine the input characteristics, the output voltage V_{CE} is kept constant at 0 volts and the input voltage V_{BE} is increased from 0 volts to different voltage levels.

* The cut in voltage of a silicon transistor is 0.7 volts and germanium transistor is 0.3 volts. In our case, it is a silicon transistor. So from the above graph, we can see that after 0.7 volts, a small increase in input voltage (V_{BE}) will rapidly increases the input current (I_B).

* From above characteristics, we can see that for higher fixed values of output voltage V_{CE}, the curve shifts to the right side. This is because for higher fixed values of output voltage, the cut in voltage is increased above 0.7 volts. Therefore, to overcome this cut in voltage, more input voltage V_{BE} is needed than previous case.

B) Output Characteristics:



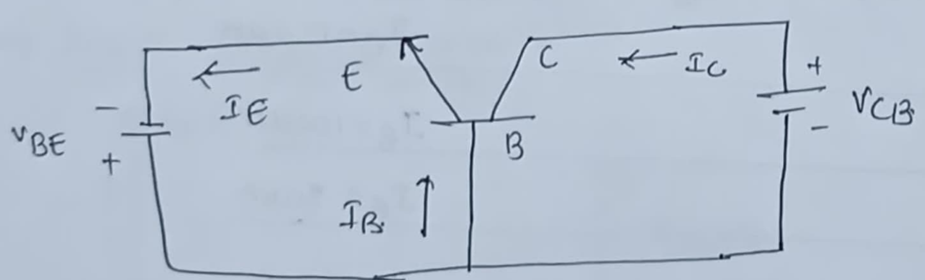
* A curve is drawn between output current I_C and output voltage V_{CE} at constant input current I_B (0 μA).

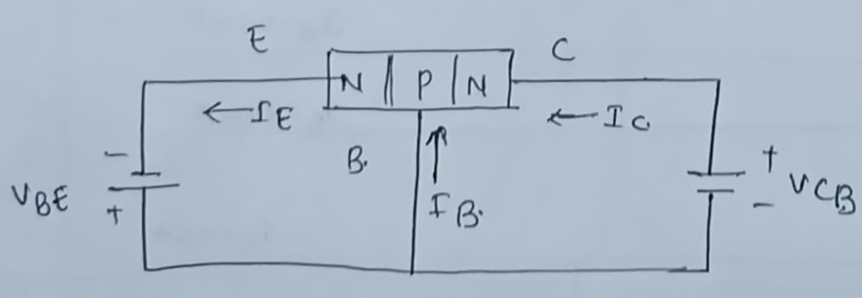
* In the above graph, we can see the three regions Active region, ~~cot~~ cutoff region and Saturation region.

④ Explain the working of a transistor in Common base configurations and draw its input and output characteristics.

Ans * In common base configuration, the base terminal is grounded so the common base configuration is also known as grounded base configuration.

* Sometimes common base configuration is referred to as common base amplifier, CB amplifier or CB configuration,



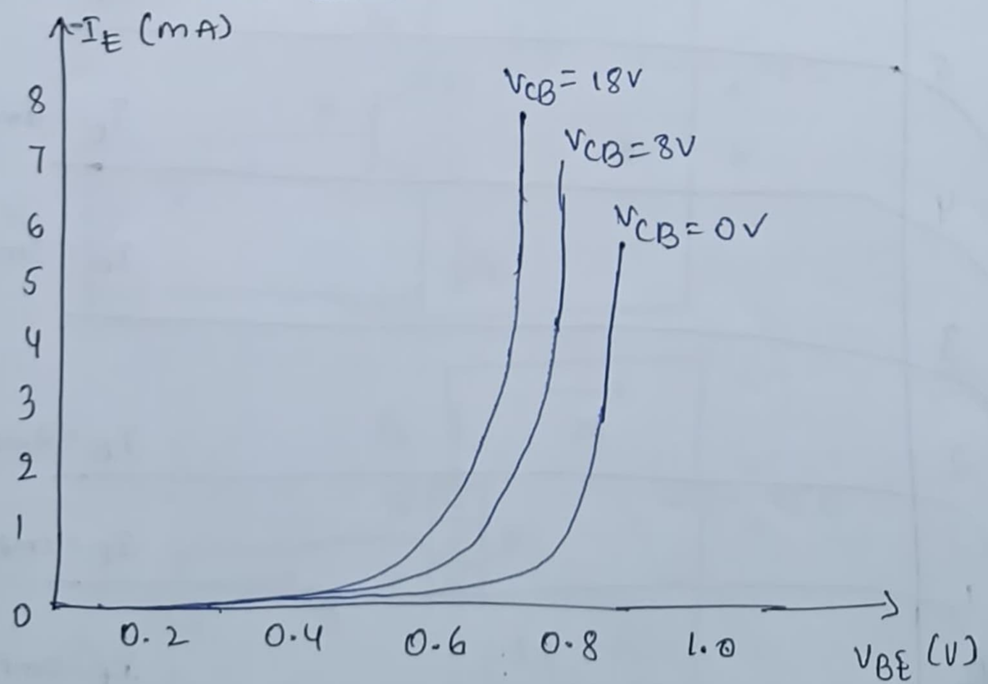


* This type of transistor arrangement is not very common and is not as widely used as the other two transistor configurations. The common base amplifier is mainly used as a voltage amplifier or current buffer.

* The working principle of pnp transistor with CB configuration is same as the npn transistor with CB configuration. The only difference is in npn transistor free electrons conduct most of the current whereas in pnp transistor the holes conduct most of the current.

* To fully describe the behaviour of a transistor with CB configuration, we need two set of characteristics:
  a) Input Characteristics.
  b) Output Characteristics.

A) Input Characteristics ;

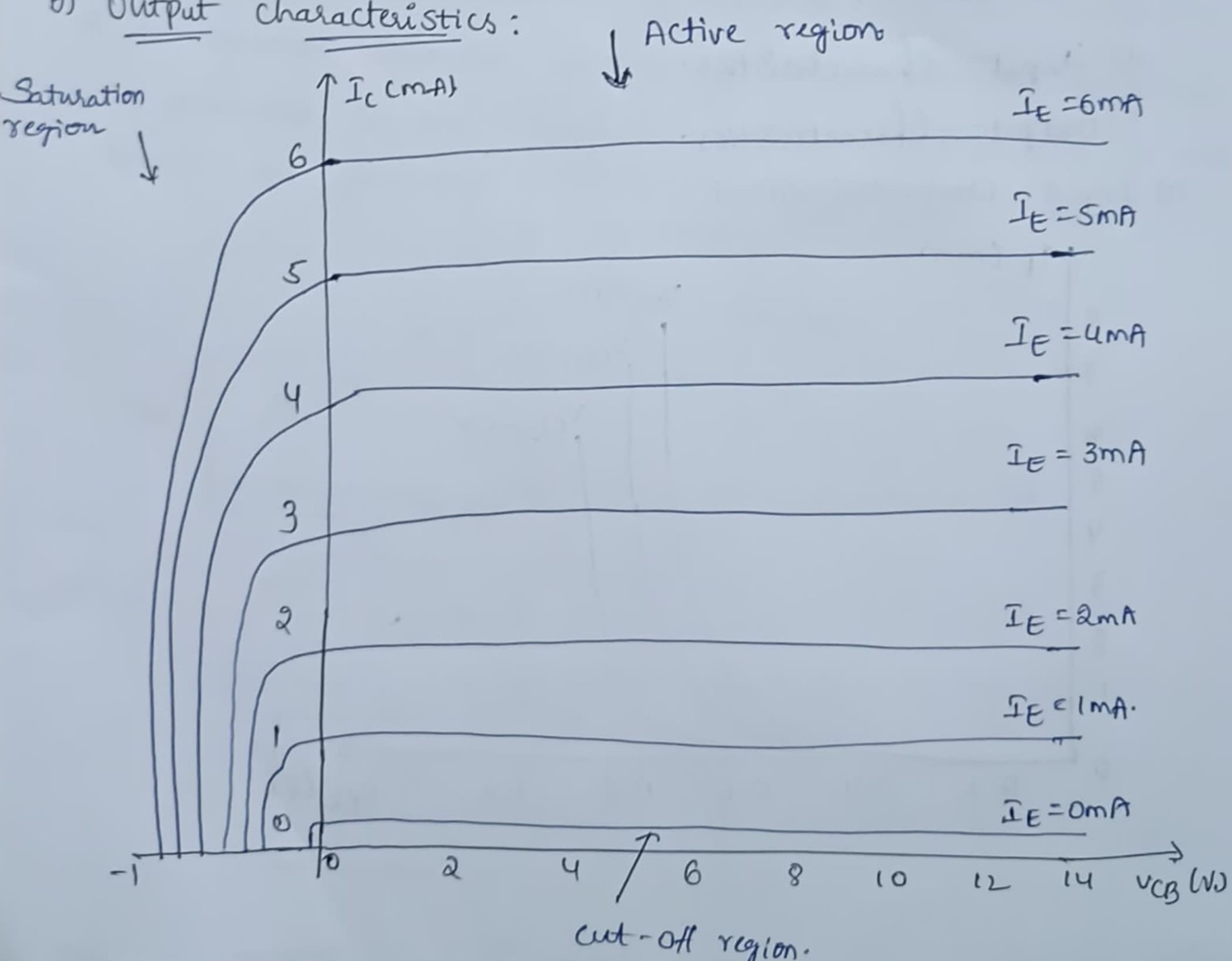


* To determine the input characteristics, the output voltage V_{CB} (collector - base voltage) is kept constant at zero volts and the input voltage V_{BE} is increased from 0 volts to different voltage levels.

* A curve is drawn between input current I_E and input voltage V_{BE} at constant output voltage V_{CB} (0 volts).

* The cut in voltage of a silicon transistor is 0.7 V and Germanium transistor is 0.3 V. In our case, it is a silicon transistor. So from the above graph, we can see that after 0.7 volts, a small increase in input voltage (V_{BE}) will rapidly increase the input current (I_E).

B) Output characteristics:



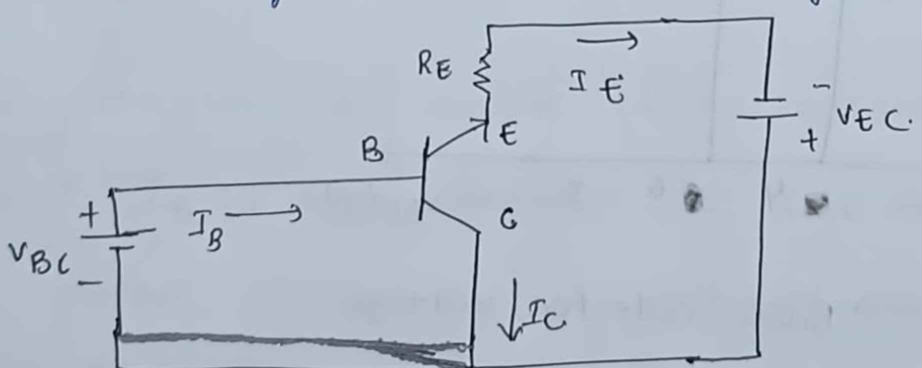
* A curve is drawn between output current I_C and output voltage V_{CB} at constant input current I_E (omA)

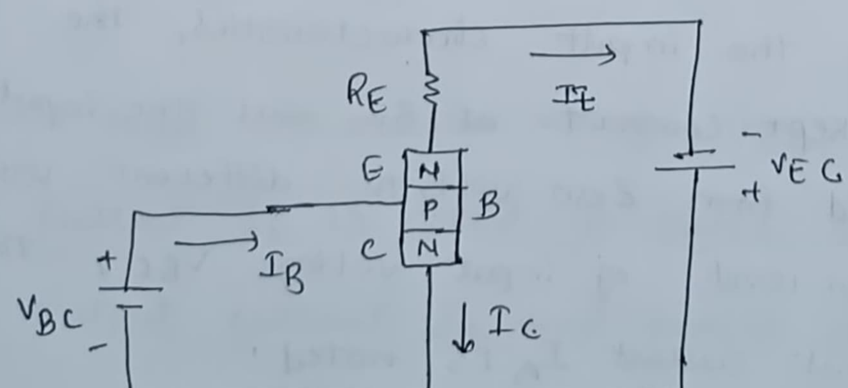
* From above characteristics, we can see that for a constant input current I_E, when the output voltage V_{CB} is increased, the output current I_C remains constant.

5) Explain working of transistor in Common Collector configurations and draw its input and output characteristics.

Ans * 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 & output. Hence, it is named as common collector configuration.

* In common collector configuration, the collector terminal is grounded so the common collector configuation is also known as grounded collector configuration.





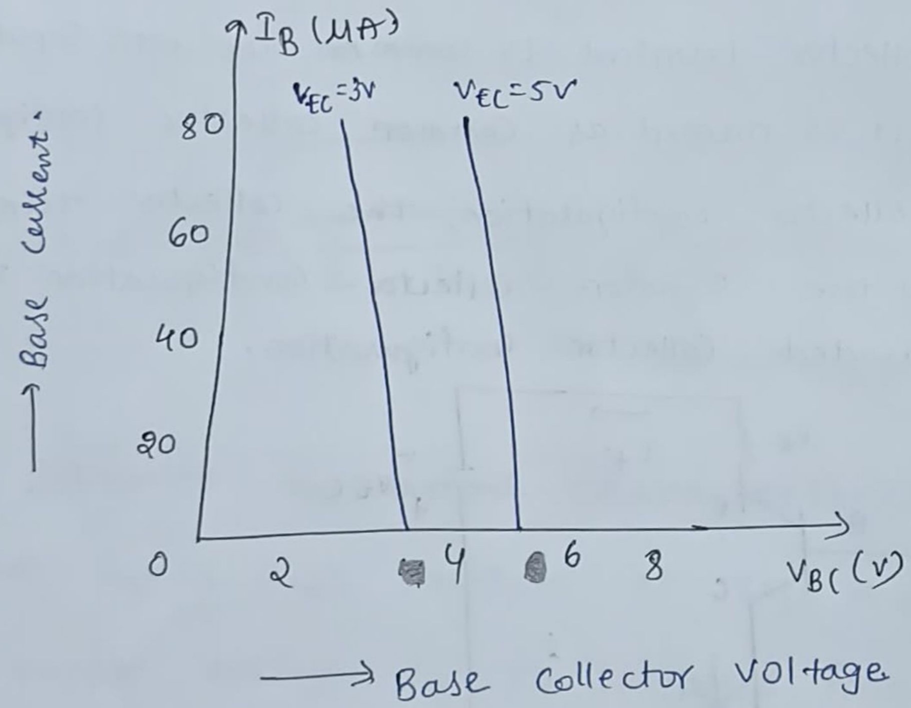
* The common collector amplifier has high input impedance and low output impedance. It has low voltage gain and high current gain.

* The power gain of the common collector amplifier is medium. To fully describe the behaviour of a transistor with CC configuration, we need two set of characteristics

A) Input characteristics.

B) Output characteristics.

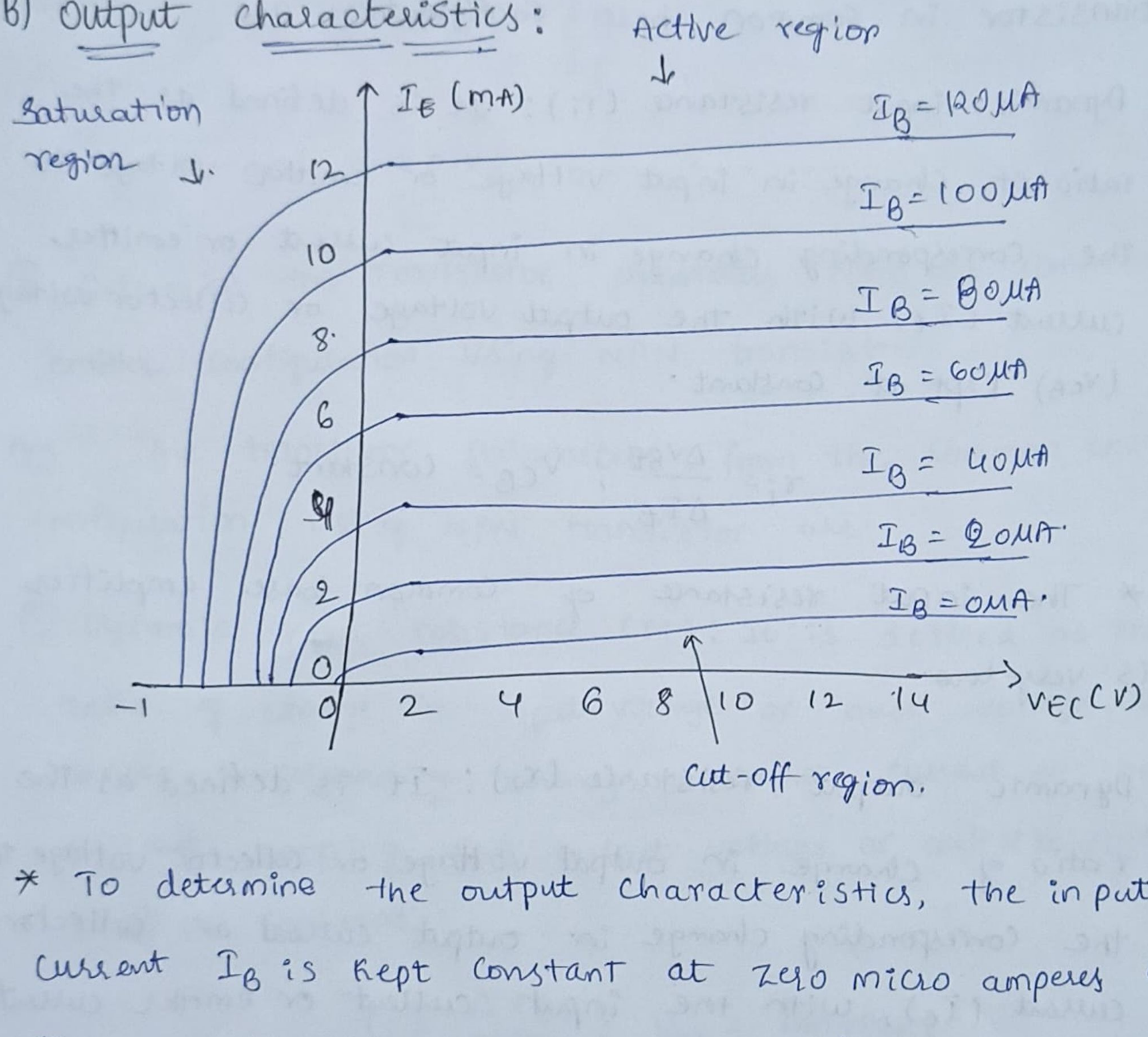
A) Input Characteristics:



* To determine the input characteristics, the output voltage V_{EC} is kept constant at 3V and the input voltage V_{BC} is increased from zero volts to different voltage levels. For each level of input voltage V_{BC}, the corresponding input current I_B is noted.

* A curve is then drawn between input current I_B and input voltage V_{BC} at constant output voltage V_{EC} (3V).

B) Output Characteristics:



* To determine the output characteristics, the input current I_B is kept constant at zero micro amperes and the output voltage V_{EC} is increased from zero volts to different voltage levels.

* For each level of output voltage V_{EC}, the corresponding output current I_E is noted. A curve is then drawn between output current I_E and output voltage V_{EC} at constant input current I_B (0μA).

⑥ Define transistor parameters of a bipolar junction transistor in common base configuration.

Ans The transistor parameters of a bipolar junction transistor in common base configuration are

① Dynamic input resistance (r_i): It is defined as the ratio of change in input voltage or emitter voltage to the corresponding change in input current or emitter current (I_E) with the output voltage or collector voltage (V_{CB}) kept at constant.

$$r_i = \frac{\Delta V_{BE}}{\Delta I_E} \; ; \; V_{CB} = \text{constant.}$$

* The input resistance of common base amplifier is very low.

② Dynamic output resistance (r_o): It is defined as the ratio of change in output voltage or collector voltage to the corresponding change in output current or collector current (I_C), with the input current or emitter current (I_E) kept at constant.

$$r_o = \frac{\Delta V_{CB}}{\Delta I_C} \; ; \; I_E = \text{constant.}$$

* The output resistance of common base amplifier is very high.

③ current gain (α): It is defined as the ratio of output current or collector current (I_C) to the input current or emitter current (I_E).

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

* $\alpha < 1$ and $\alpha \approx 0.98$. (Expand it in words)

---

⑨ Determine the Transistor parameters from the common emitter configuration using NPN transistor.

Ans The transistor parameters from the common emitter configuration using NPN transistor are.

① Dynamic input resistance (r_i): It is defined as the ratio of change in input voltage or base voltage (V_{BE}) to the corresponding change in input current or base current keeping the output voltage or collector voltage (V_{CE}) at constant.

$$r_i = \frac{\Delta V_{BE}}{\Delta I_B}; \quad V_{CE} = \text{constant}.$$

* The input resistance in CE configuration is very low.

② Dynamic output resistance (r_o): It is defined as the ratio of change in output voltage or collector voltage (V_{CE}) to the corresponding change in output current or collector current keeping, the input current or base current (I_B) at constant.

$$r_o = \frac{\Delta V_{CE}}{\Delta I_C}, \quad I_B = \text{constant}$$

* The output resistance of CE configuration is high.

③ Current gain (β): It is defined as the ratio of output current or collector current (I_C) to the input current or base current (I_B).

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

* The value of 'β' is high in CE configuration.

---

⑩ Determine the Transistor parameters from the common collector configuration using NPN transistor.

Ans The transistor parameters from the common collector configuration using NPN transistor are:

① Dynamic Input resistance (r_i): It is defined as the ratio of change in input voltage or base voltage (V_{BC}) to the corresponding change in input current or base current (I_B), with the output voltage or emitter voltage (V_{EC}) kept at constant.

$$r_i = \frac{\Delta V_{BC}}{\Delta I_B}, \quad V_{EC} = \text{constant}.$$

* The input resistance in CC configuration is high.

② Dynamic output resistance (r_o): It is defined as the ratio of change in output voltage or emitter voltage (V_{EC}) to the corresponding change in output current or emitter current (I_E), with the input current or base current (I_B) kept at constant.

$$r_o = \frac{\Delta V_{EC}}{\Delta I_E} ; \ I_B = \text{constant.}$$

* The output resistance of CC configuration is low.

③ Current gain (γ): It is defined as the ratio of change in output current or emitter current (I_E) to the change in input current or base current (I_B).

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

* The current gain of a CC amplifier is high.

---

⑧ Explain Early effect in common base configuration of bipolar junction transistor.

Ans Early effect in common base configuration of bipolar junction transistor:

* Due to forward bias, the base-emitter junction (J_E) acts as a forward biased diode and due to reverse bias, the collector-base junction (J_C) acts as as a reverse biased diode.

* Therefore, the width of the depletion region at the base-emitter junction (J_E) is very small whereas the width of the depletion region at the collector-base junction (J_C) is very large.

* If the output voltage V_{CB} applied to the collector-base junction J_C is further increased, the depletion region width further increases.

* The base region is lightly doped as compared to the collector region. So the depletion region penetrates more into the base region and less into the collector region. As a result, the width of the base region decreases.

* This dependency of base width on the output voltage (V_{CB}) is known as an early effect.

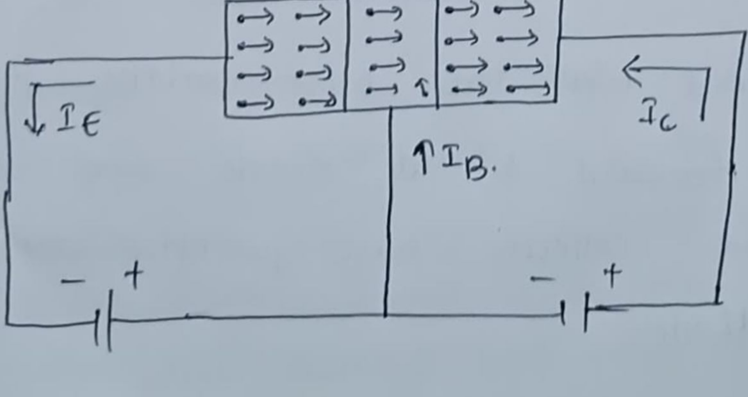
* If the output voltage V_{CB} applied to the collector-base junction J_C is highly increased, the base width may be reduced to zero and causes a voltage breakdown in the transistor. This phenomenon is known as punch through.

---

(20) Illustrate the working principle of NPN transistor (or)

(11) Define the operating modes of NPN transistor.

Ans



* The Base - emitter junction is connected in the forward bias condition by supply voltage V_{EE}. And the collector - base junction is connected in the reverse bias condition by supply voltage V_{CC}.

* In forward bias condition, the negative terminal of supply source (V_{EE}) is connected to the N- type semiconductor (Emitter). Similarly, in a reverse bias condition, the positive terminal of the supply source (V_{CC}) is connected to the N- type semiconductor (collector).

* The depletion region of the emitter - base region is thin compared to the depletion region of the collector - base junction (Note that the depletion region is a region where no mobile charge carriers are present and it behaves like a barrier that opposes the flow of the current).

* In N-type emitter, the majority charge carrier is electrons. Therefore, electrons start flowing from N-type emitter to a p-type base. And because of electrons, the current will start flowing the emitter - base junction. This current is known as Emitter current (I_E).

* These electrons move further to the base. The base is a p- type semiconductor. Therefore, it has holes.

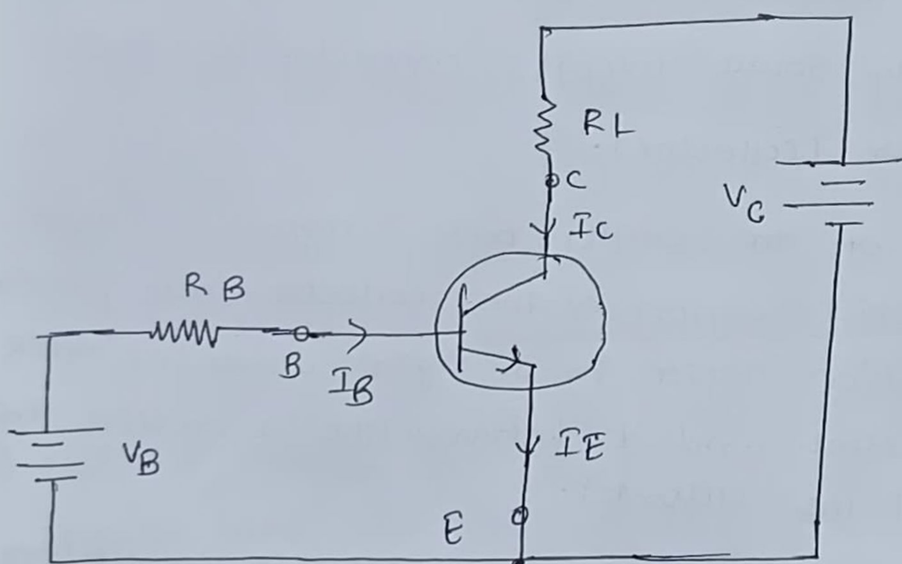
* But the base region is very thin and lightly doped. So, it has a few holes to recombine with the electrons.

* Hence, most of the electrons will pass the base region and few of them will recombine with the holes. Because of the recombination, the current will flow through the circuit and this current is known as base current I_B.

* The base current is very small compared to the emitter current. Typically, it is 2-5% of the total emitter current.

* Most of the electrons pass the depletion region of a collector-base junction and pass through the collector region.

* The current flowing by the remaining electrons is known as the collector current (I_C). The collector current is large compared to the base current.



* The voltage sources are connected to the NPN transistor as shown in the above figure.

* The collector is connected with the positive terminal of supply voltage V_{CC} with the load resistance R_L.

* The R_L also used to reduce the maximum current flowing through the device.

* The base terminal is connected to the positive terminal of supply voltage V_B with base resistance R_B. The base resistance is used to limit the maximum base current.

* When the transistor is switched ON, a large collector current flows through the device between the collector and the emitter terminals. But, for that small amount of base current must flowing into the base terminal of the transistor.

* By KCL, the emitter current is the addition of base current and collector current.

$$I_E = I_B + I_C.$$

* The transistor operates on different modes or regions depends on the biasing of junctions. It has three modes of operation. ① cut-off mode.
② Saturation mode
③ Active mode.

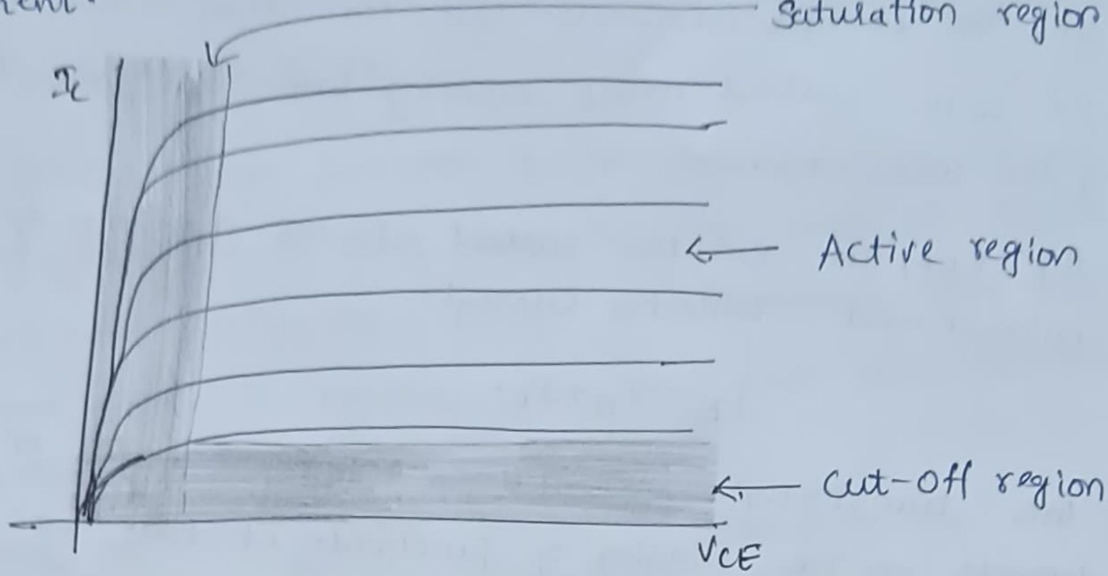
1) <u>Cut-off</u> <u>mode</u>: In cut-off mode, both junctions are in reverse bias. In this mode, the transistor behaves as an open circuit and it will not allow the current to flow through the device.

2) <u>Saturation</u> <u>Mode</u>: In saturation mode, both junctions are connected in forward bias. The transistor behaves as a close circuit and current flow from collector to emitter when the base - emitter voltage is high.

3) <u>Active</u> <u>mode</u>: In Active mode, the base-emitter junction is forward bias and collector - base junction is reverse biased. In this mode, the transistor operates as a current amplifier.

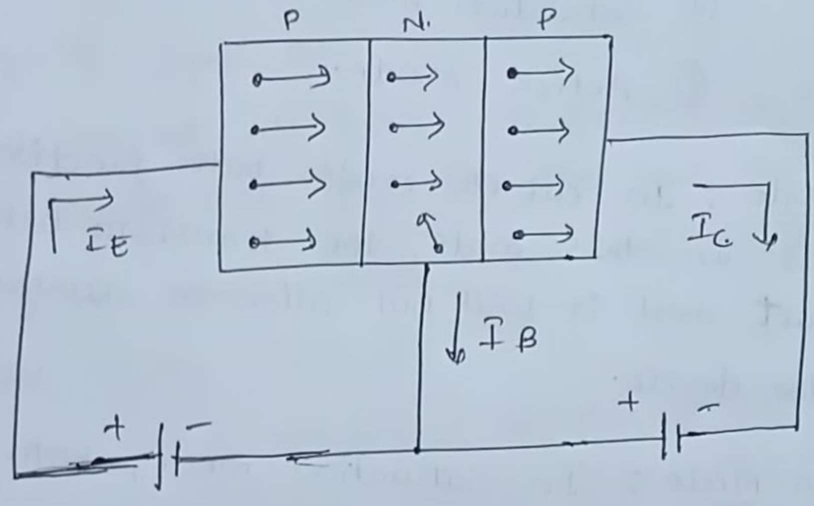
* n... to this type of principle bias, the depletion region

* The current flows between emitter and collector and the amount of current are proportional to the base current.



(18) & (19) Illustrate the working principle of PNP transistor.

Ans



* In a PNP transistor, one N-type semiconductor is sandwiched by two P-type semiconductor. In P-type semiconductors, the majority charge carriers are holes. Therefore, in the PNP transistor, the formation of the current is due to the movement of holes.

* Due to this type of ~~principle~~ bias, the depletion region at Emitter - Base junction is narrow, because it is connected in forward bias; while the collector - Base junction is in reverse bias and hence the depletion region at collector - Base junction is wide.

* The Emitter - base junction is in forward bias. Therefore, a very large no. of holes from emitter cross the depletion region and enter the base. Simultaneously, very few electrons enter in Emitter from the base and recombine with the holes.

* The loss of holes in the emitter is equal to the no. of electrons present in the base layer. But the no. of electrons in the base is very small because it is a very lightly doped and thin region.

* Therefore, almost all holes of Emitter will cross the depletion region and enter into the Base layer.

* Because of the movement of holes, the current will flow through the Emitter - Base junction.

* This current is known as Emitter current (I_E). The holes are majority charge carriers to flow the emitter current.

* The remaining holes which do not recombine with electrons in base, that holes will further travel to the collector. The collector current (I_C) flows through the Collector - Base region due to holes.

(15) Explain the ...

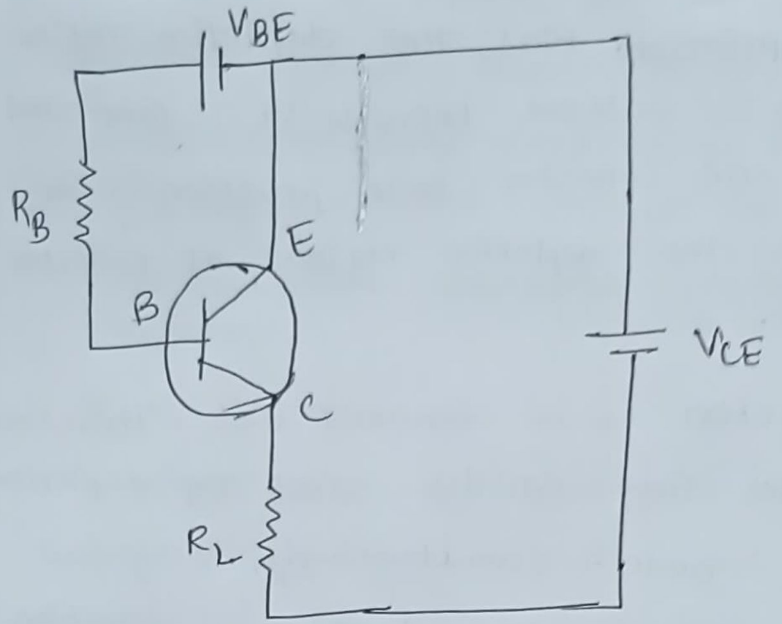


Fig: circuit of PNP transistor

* If we compare the circuit of PNP transistor with NPN transistor, then here the polarity and direction of current are reversed.
* If a PNP transistor is connected with voltage sources as shown in the above figure, the base current will flow through the transistor. The small amount of base current controls the flow of a large amount of current through emitter to collector provided that the base voltage is more negative than the Emitter voltage.
* If the Base voltage is not more negative than the emitter voltage, the current cannot flow through the device. so, it is necessary to give a voltage source in reverse bias more than 0.7V.
* Two resistors R_L and R_B connected in the circuit to limit the maximum amount of current through the transistor.
* If you apply KCL, the emitter current is a summation of the base current and collector current.

$$I_E = I_B + I_C$$

$$I_C = I_E - I_B$$

(12) Explain the bipolar junction Transistor as a switch.

Ans * A type of transistor known as bipolar junction transistor (BJT) employs both electrons and holes as charge carriers. A type of field-effect transistor called a unipolar transistor only employs one kind of charge carrier.

* A bipolar transistor can be used for switching or amplification by allowing a tiny current to be injected at one of its terminals and controlling a much greater current flowing between two other terminals.

* BJTS are regions in a single crystal of material that have two junctions between the n-type and p-type semiconductor types.

* we can create the junctions in a variety of ways, for as by doping the semiconductor differently as it grows or by depositing metal pelletes to create alloy junctions.

* The active region, cut-off region, and saturation region are the three modes of a transistor. The transistor functions as a switch in the cut-off and saturation modes. During the cut off zone, the transistor is off, and during the saturation period, it is on.

* last but not least, a transistor can function as a switch because a little electric current running through one part of it induces a greater current to flow through the other.

③ Another common application is in voltage amplification. Voltage amplifiers are used to amplify low-voltage signals, such as those from a sensor or thermo couple.

7, 14, 15, 16

⑭ Explain and draw Input and output characteristics of Common base configuration.

Ans To fully describe the behaviour of a transistor with CB configuration, we need two set of characteristics; They are: ① Input characteristics

② output characteristics

Input Characteristics :

* The input characteristics describe the relationship between input current (I_E) and the input voltage (V_{BE}).

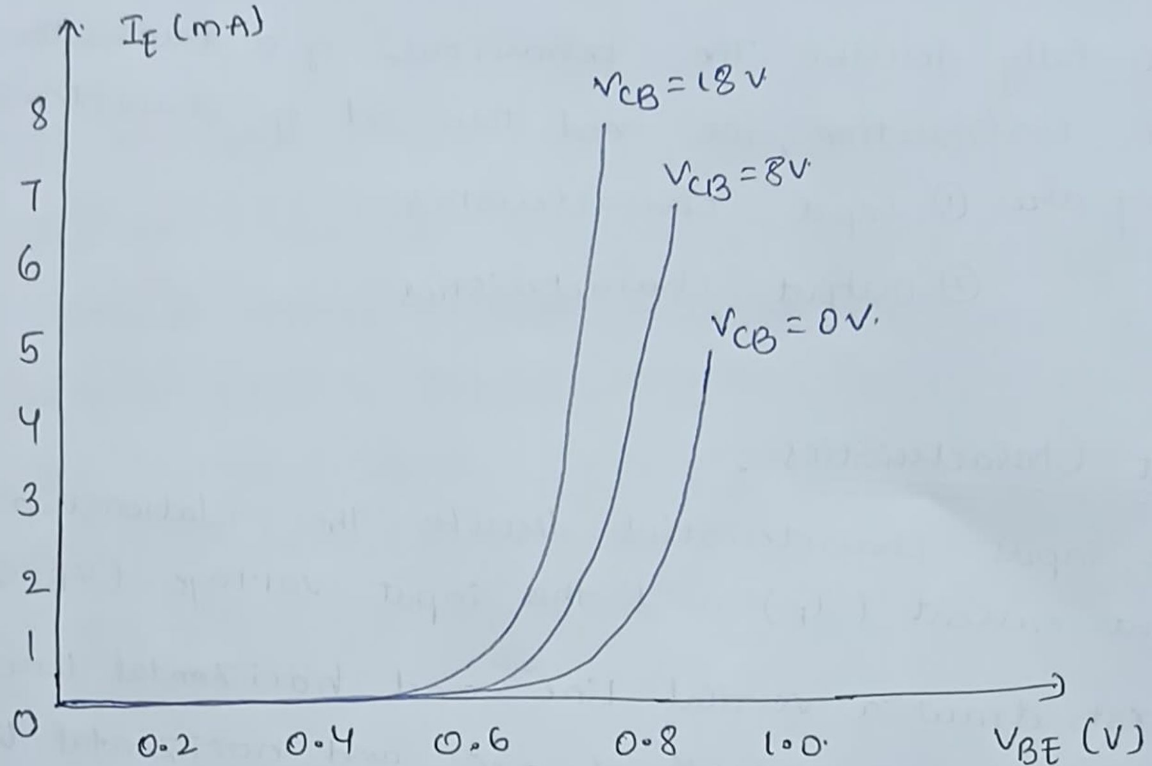
* First, draw a vertical line and horizontal line. The vertical line represents y-axis and horizontal line represents x-axis.

* The input current or emitter current (I_E) is taken along the y-axis (vertical line) and the input voltage (V_{BE}) is taken along the x-axis (horizontal line).

* To determine the input characteristics, the output voltage V_{CB} is kept constant at zero volts and the input voltage V_{BE} is increased from zero volts to different voltage levels.

* For each voltage level of the input voltage (V_{BE}), the input current (I_E) is recorded on a paper or in any other form.

* A curve is then drawn between input current (I_E) and input voltage (V_{BE}) at constant output voltage V_{CB} (0 volts).



I/P characteristics CB configuration.

* The output voltage (V_{CB}) is increased from zero volts to a certain voltage level (8 volts) and kept constant at 8 volts.

* While increasing the output voltage (V_{CB}), the input voltage (V_{BE}) is kept constant at zero volts.

* After we kept the output voltage (V_{CB}) constant at 8 volts, the input voltage V_{BE} is increased from zero volts to different voltage levels. For each voltage level of the input voltage (V_{BE}), the input current (I_E) is recorded on a paper or in any other form.

* A curve is then drawn between input current I_E and input voltage (V_{BE}) at constant output voltage V_{CB} (8 volts).

* This is repeated for higher fixed values of the output voltage (V_{CB}).

* When output voltage (V_{CB}) is at zero volts and emitter-base junction (J_E) is forward biased by the input voltage (V_{BE}), the emitter-base junction acts like a normal p-n junction diode. So, the input characteristics are same as the forward characteristics of a normal p-n junction diode.

* The cut in voltage of a silicon transistor is 0.7 volts and germanium transistor is 0.3 volts. In our case, it is a silicon transistor. So from the above graph, we can see that after 0.7 volts, a small increase in input voltage (V_{BE}) will rapidly increase the input current (I_E).

* When the output voltage (V_{CB}) is increased from zero volts to a certain voltage level (8 volts), the emitter current flow will be increased which in turn reduces the depletion region width at emitter-base junction. As a result, the cut in voltage will be reduced. Therefore, the curves shifted towards the left side for higher values of output voltage (V_{CB}).

Output Characteristics:

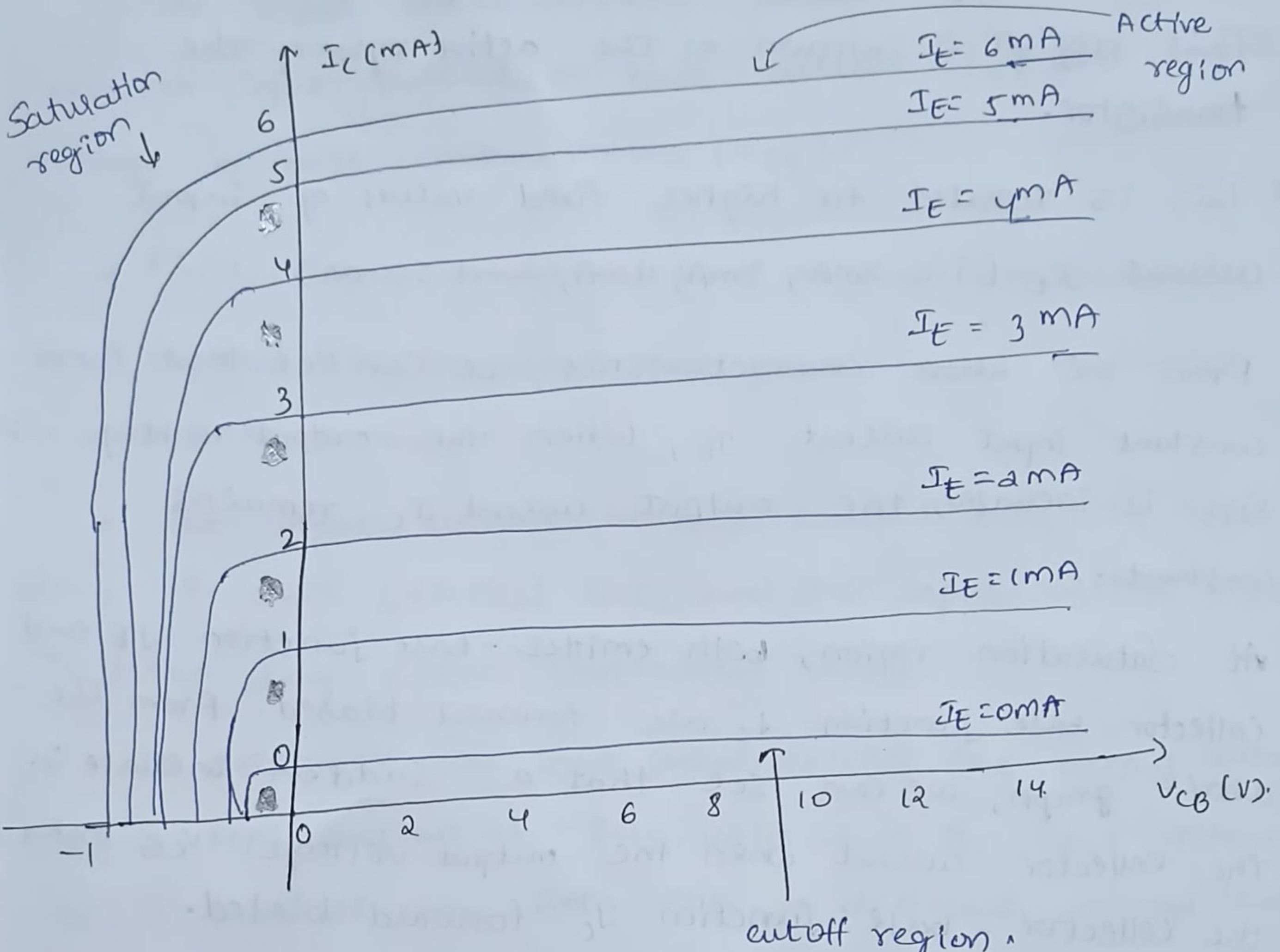
* The output characteristics describe the relationship between output current (I_C) and the output voltage (V_{CB}).

* First, draw a vertical line and a horizontal line. The vertical line represents Y-axis and horizontal line represents X-axis. The output current or collector current (I_C) is taken along the Y-axis (vertical line) and the output voltage (V_{CB}) is taken along the X-axis (horizontal line).

* To determine the output characteristics, the input current or emitter current I_E is kept constant at zero mA and the output voltage V_{CB} is increased from zero volts to different voltage levels. For each voltage level of the output voltage V_{CB}, the output current (I_C) is recorded.

* A curve is then drawn between output current I_C and output voltage V_{CB} at constant input current I_E (0 mA).

* When the emitter current or input current I_E is equal to 0 mA, the transistor operates in the cut-off region.



O/P characteristics of CB configuration.

* Next, the input current (I_E) is increased from 0 mA to 1 mA by adjusting the input voltage V_{BE} and the input current I_E is kept constant at 1 mA. While increasing the input current I_E, the output voltage V_{CB} is kept constant.

* After we kept the input current (I_E) constant at 1 mA, the output voltage (V_{CB}) is increased from zero volts to different voltage levels. For each voltage level of the output voltage (V_{CB}), the output current (I_C) is recorded.

* A curve is then drawn between output current I_C and output voltage V_{CB} at constant input current I_E (1mA). This region is known as the active region of the transistor.

* This is repeated for higher fixed values of input current I_E (i.e 2mA, 3mA, 4mA, and so on).

* From the above characteristics, we can see that for a constant input current I_E, when the output voltage V_{CB} is increased, the output current I_C remains constant.

* At saturation region, both emitter-base junction J_E and collector-base junction J_C are forward biased. From the above graph, we can see that a sudden increase in the collector current when the output voltage V_{CB} makes the collector-base junction J_C forward biased.

---

15) Explain and draw Input and output characteristics of Common emitter configuration.

Ans To fully describe the behaviour of a transistor with CE configuration, we need two set of characteristics - a) Input Characteristics.

b) Output Characteristics.

Input characteristics:

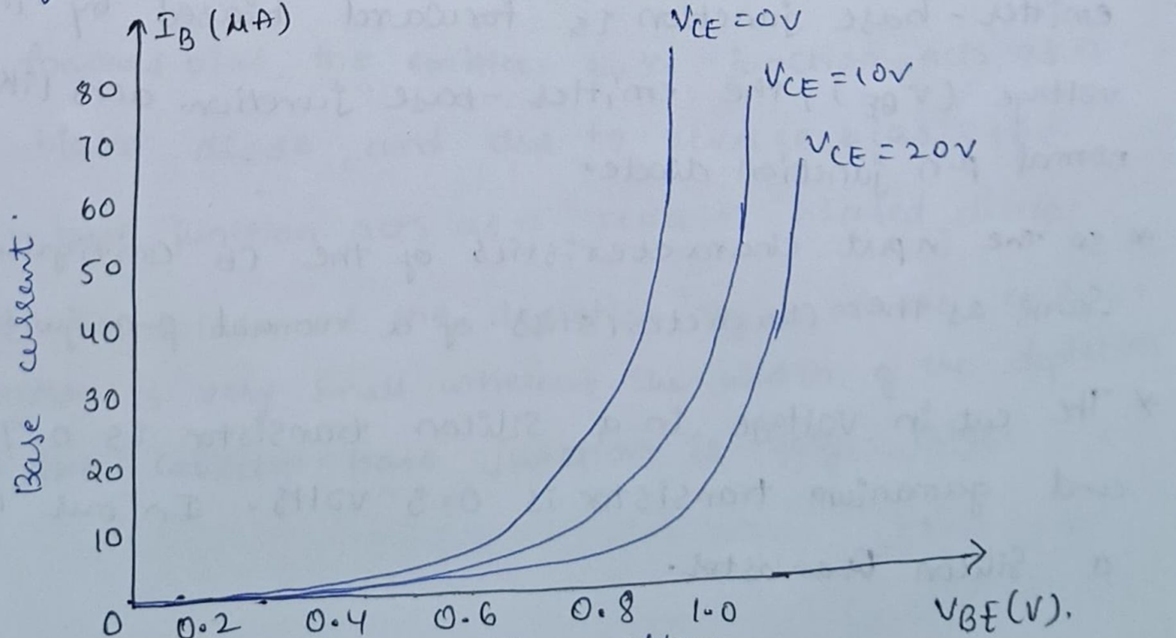
* The input characteristics describe the relationship between input current or base current (I_B) and input voltage or base-emitter voltage (V_{BE}).

* First, draw a vertical line and a horizontal line. The vertical line represents the y-axis and horizontal line represents x-axis.

* The input current or base current (I_B) is taken along y-axis (vertical line) and the input voltage (V_{BE}) is taken along x-axis (horizontal line).

* To determine the input characteristics, the output voltage V_{CE} is kept constant at zero volts and the input voltage V_{BE} is increased from zero volts to different voltage levels.

* For each voltage level of input voltage (V_{BE}), the corresponding input current (I_B) is recorded.



I/p Characteristics CE Configuration.

* A curve is then drawn between input current I_B and input voltage V_{BE} at constant output voltage V_{CE} (0 volts).

* Next, the output voltage (V_{CE}) is increased from zero volts to certain voltage level (10 volts) and the output voltage (V_{CE}) is kept constant at 10 volts.

* while increasing the output voltage (V_{CE}), the input voltage (V_{BE}) is kept constant at zero volts. After we kept the output voltage (V_{CE}) constant at 10 volts, the input voltage (V_{BE}) is increased from zero volts to different voltage levels.

* For each voltage level of input voltage (V_{BE}), the corresponding input current (I_B) is recorded.

* A curve is drawn between input current I_B and input voltage V_{BE} at constant output voltage V_{CE} (10 volts). This process is repeated for higher fixed values of output voltage (V_{CE}).

* when output voltage (V_{CE}) is at zero volts and emitter-base junction is forward biased, by input voltage (V_{BE}), the emitter-base junction acts like a normal p-n junction diode.

* so the input characteristics of the CE configuration is same as the characteristics of a normal p-n junction diode.

* The cut in voltage in a silicon transistor is 0.7 volts and germanium transistor is 0.3 volts. In our case, it is a silicon transistor.

* So from the above graph, we can see that after 0.7 volts, a small increase in input voltage (V_{BE}) will rapidly increases the input current (I_B).

* In common-emitter configuration, the input current (I_B) is very small as compared to the input current (I_E) in common base (CB) configuration.

* The input current in CE configuration is measured in microamperes (μA) whereas, the input current in CB configuration is measured in milliamperes (mA).

* In CE configuration, the input current (I_B) is produced in the base region which is lightly doped and has small width. So the base region produces only a small input current (I_B)

* On the other hand, in CB configuration, the input current (I_E) is produced in the emitter region which is heavily doped and has large width.

* So, the emitter region produces a large input current (I_E). Therefore, the input current (I_B) produced in the CE configuration is small as compared to CB configuration.

* Due to forward bias, the emitter-base junction acts as a forward biased diode and due to reverse bias, the collector-base junction acts as a reverse biased diode.

* Therefore, the width of the depletion region at the emitter-base junction is very small whereas the width of the depletion region at the collector-base junction is very large.

* If the output voltage V_{CE} applied to the collector-base -base junction is further increased, the depletion region width further increases. The base region is lightly doped as compared to the collector region.

* So the depletion region penetrates more into the base region and less into the collector region. As a result, the width of the base region decreases which in turn reduces the input current (I_B). produced in the base region.

* From the above characteristics, we can see that for higher fixed values of output voltage V_{CE}, the curve shifts to the right side.

* This is because for higher fixed values of output voltage, the cut in voltage is increased above 0.7 volts.

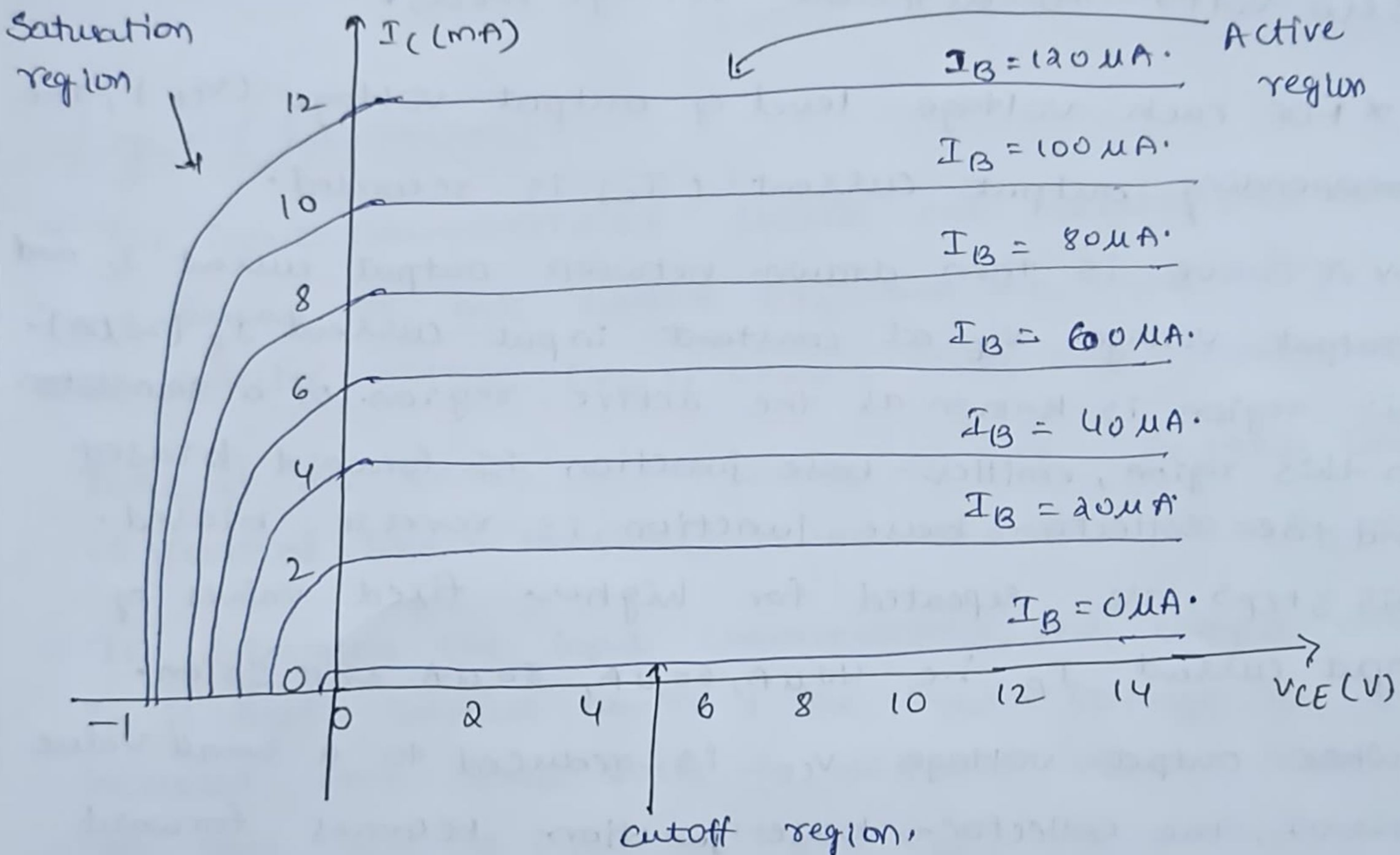
* Therefore, to overcome this cut in voltage, more input voltage, V_{BE} is needed than previous case.

Output Characteristics:

* The output characteristics describe the relationship between output current (I_C) and output voltage (V_{CE}).

* First, draw a vertical line and a horizontal line. The vertical line represents the Y-axis and the horizontal line represents the X-axis. The output current or collector current (I_C) is taken along Y-axis and the output voltage (V_{CE}) is taken along X-axis.

* To determine the output characteristics, the input current or base current I_B is kept constant at 0 μA. and the output voltage V_{CE} is increased from zero volts to different voltage levels. For each level of output voltage, the corresponding output current (I_C) is recorded.



o/p characteristics CE configuration.

* A curve is then drawn between output current (I_C) and output voltage V_{CE} at constant input current I_B (0 μA).
* When the base current or input current I_B = 0 μA, the transistor operates in the cut-off region. In this region, both junctions are reverse-biased.
* Next, the input current (I_B) is increased from 0 μA to 20 μA by adjusting the input voltage (V_{BE}). The input current (I_B) is kept constant at 20 μA.

* while increasing the input current (I_B), the output voltage (V_{CE}) is kept constant at 0 volts.

* After we kept the input current (I_B) constant at 20 μA, the output voltage (V_{CE}) is increased from zero volts to different voltage levels.

* For each voltage level of output voltage (V_{CE}), the corresponding output current (I_C) is recorded.

* A curve is then drawn between output current I_C and output voltage V_{CE} at constant input current I_B (20 μA). This region is known as the active region of a transistor. In this region, emitter - base junction is forward biased and the collector - base junction is reverse biased.

* This steps are repeated for higher fixed values of input current I_B i.e 40 μA, 60 μA, 80 μA and so on.

* When output voltage V_{CE} is reduced to a small value (0.2V), the collector - base junction becomes forward biased. This is because the output voltage V_{CE} has less effect on collector - base junction than input voltage V_{BE}.

* As we know that the emitter - base junction is already forward - biased. Therefore, when both the junctions are forward - biased, the transistor operates in the saturation region. In this region, a small increase in output voltage (V_{CE}) will rapidly increases the output current (I_C).

⑥ Explain the Input and output characteristics and draw them? For common collector configuration.

Ans To fully describe the transistor behaviour in CC configuration, we need two set of characteristics — A) Input characteristics.

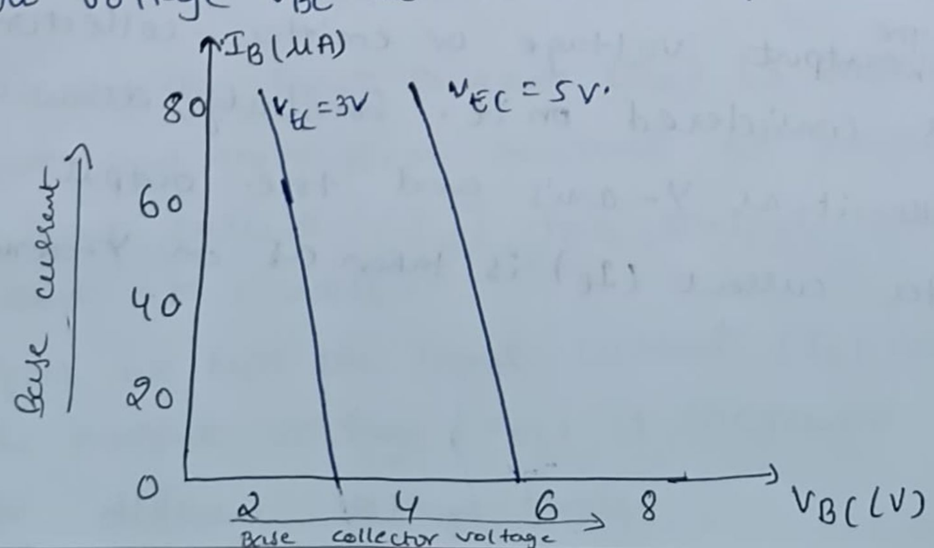
B) Output characteristics.

Input Characteristics:

* The input characteristics describe the relationship between input current or base current (I_B) and the input voltage or base-collector voltage (V_{BC}). Draw 2 lines one horizontal line, take it as x axis & take V_{BC} on it. Another line is vertical line. Consider it as Y-axis & take I_B on it.

* To determine the input characteristics, the output voltage V_{EC} is kept constant at 3V & the input voltage V_{BC} is increased from zero volts to different voltage levels. For each level of input voltage V_{BC}, the corresponding input current I_B is noted.

* A curve is then drawn between input current I_B and input voltage V_{BC} at constant output voltage V_{EC} (3V)



I/p Characteristics.

* Next, the output voltage V_{EC} is increased from 3 V to different voltage level, say for example 5 V and then kept constant at 5V. While increasing the output voltage V_{EC}, the input voltage V_{BC} is kept constant at zero volts.

* After we kept the output voltage V_{EC} constant at 5V, the input voltage V_{BC} is increased from zero volts to different voltage levels. For each level of input voltage V_{BC}, the corresponding input current I_B is noted.

* A curve is then drawn between input current I_B and input voltage V_{BC} at constant output voltage V_{EC} (5V).. This process is repeated for higher fixed values of output voltage (V_{EC}).

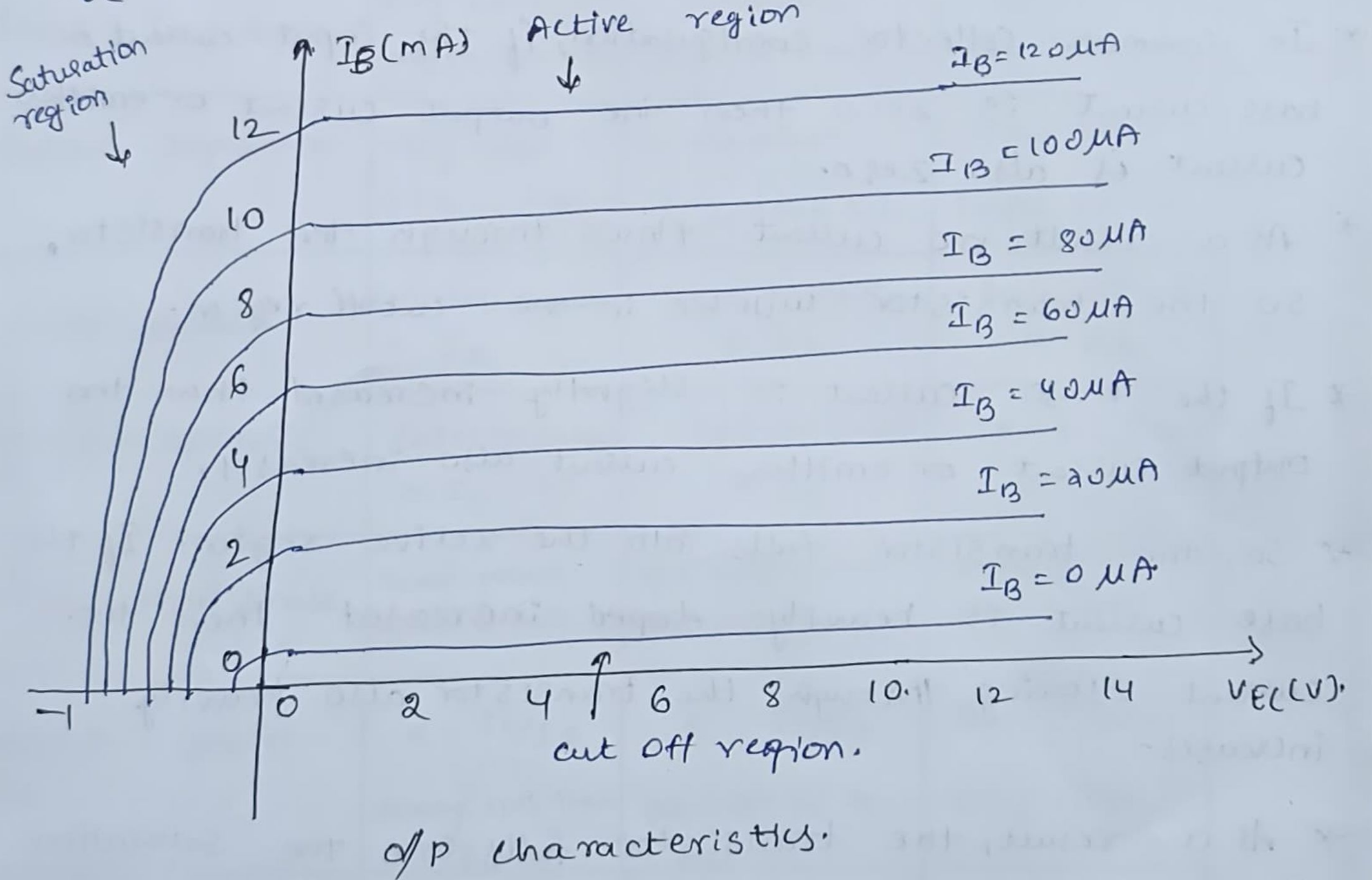
Output Characteristics :

* The output characteristics describe the relationship between output current or emitter current (I_E) and output voltage or Emitter - collector voltage (V_{EC}).

* First, draw a horizontal line, take it as X-axis and ~~(consider)~~ the output voltage or emitter - collector voltage (V_{EC}) is considered on it. Similarly, draw a vertical line, take it as Y-axis and the output current or emitter current (I_E) is taken as on Y-axis.

* To determine the output characteristics, the input current I_B, is kept constant at zero micro amperes. and the output voltage V_{EC} is increased from zero volts to different voltage levels.

* For each level of output voltage V_{EC}, the corresponding output current I_E is noted. A curve is then drawn between output current (I_E) and output voltage V_{EC} at constant input current I_B (0 μA).



o/p characteristics.

* Next, the input current (I_B) is increased from 0 μA to 20 μA and then kept constant at 20 μA. While increasing the input current (I_B), the output voltage (V_{EC}) is kept constant at 0 volts.

* After we kept the input current (I_B) constant at 20 μA, the output voltage (V_{EC}) is increased from zero volts to different voltage levels.

* For each level of output voltage (V_{EC}), the corresponding output current (I_E) is recorded.

* A curve is then drawn between output current I_E and output voltage V_{EC} at constant input current I_B (20 μA). This region is known as the active region of a transistor.

* This process is repeated for higher fixed values of input current I_B (i.e 40 μA, 60 μA, 80 μA and so on).

* In common collector configuration, if the input current or base current is zero then the output current or emitter current is also zero.

* As a result, no current flows through the transistor, so the transistor will be in the cutoff region.

* If the base current is slightly increased then the output current or emitter current also increases.

* So, the transistor falls into the active region. If the base current is heavily ~~doped~~ increased then the current flowing through the transistor also heavily increases.

* As a result, the transistor falls into the saturation region.

---

(7) Differentiate between CB, CE and CC configurations of BJT.

Characteristics	CB	CE	CC
common Terminal for Input and output	Base Terminal	Emitter Terminal	Collector Terminal.
Input voltage applied between	Emitter and Base Terminal.	Base and Emitter Terminal	Base and Collector terminal.
output voltage taken across	Collector and Base Terminal.	collector and Emitter Terminal	Emitter and collector Terminal.
Input Impedance	Very Low (only 50-500 Ω)	Medium (500-5000 Ω)	very high (200-750 kΩ)
Output Impedance	Very High (1 to 10 mega Ω)	medium (50-500k Ω)	very Low (upto 50 Ω)
Input current.	Emitter current or I_E	Base current or I_B	Base current or I_B
Output current	collector current or I_C	Collector current or I_C	Emitter current or I_E
output signal phase	Same phase with input	180 degree out of phase	Same phase with input.
current gain.	$\alpha = I_C/I_E$ Always less than unity	$\beta = I_C/I_B$ Between 35 to 500	$\gamma = I_E/I_B$. Very High.
Voltage gain	About 150	About 500	less than unity.
Leakage current	Very small	Very large	Very Large
Power gain.	Medium.	High.	Medium.
Application	High frequency Circuits	RF signal processing.	switching circuits.

(17) write the applications of CB, CC, CE configurations of a bipolar junction transistor.

Ans. **Applications of CB configuration of a BJT:**

(1) Commonly used for amplifiers that requires low input impedance, such as microphones.

(2) used in very high and ultra high frequency amplifiers because it performs better at high frequencies. It is due to the input-output impedance and high voltage amplifications.

(3) It is used for impedance matching. If the circuit has high input resistance, the common base provides it with the low output resistance. It is known as Impedance matching.

Applications of CC configuration of a BJT:

(1) It is used as an impedance matching circuit.

(2) It is used as a switching circuit.

(3) Also used for circuit isolation.

(4) high current gain combined with near unity voltage gain makes this circuit a great voltage buffer.

Applications of CE configuration of a BJT:

(1) Used in audio amplifications. Audio amplifiers are typically used to amplify low-level signals, such as those from a microphone or music player.

(2) used in power amplifiers, they (power amplifiers) are used to amplify high power signals, such as those from a radio transmitter.