Basic Electronics

Segment-2
Transistors

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Lecture Outline

Bipolar Junction Transistor and Biasing Techniques:

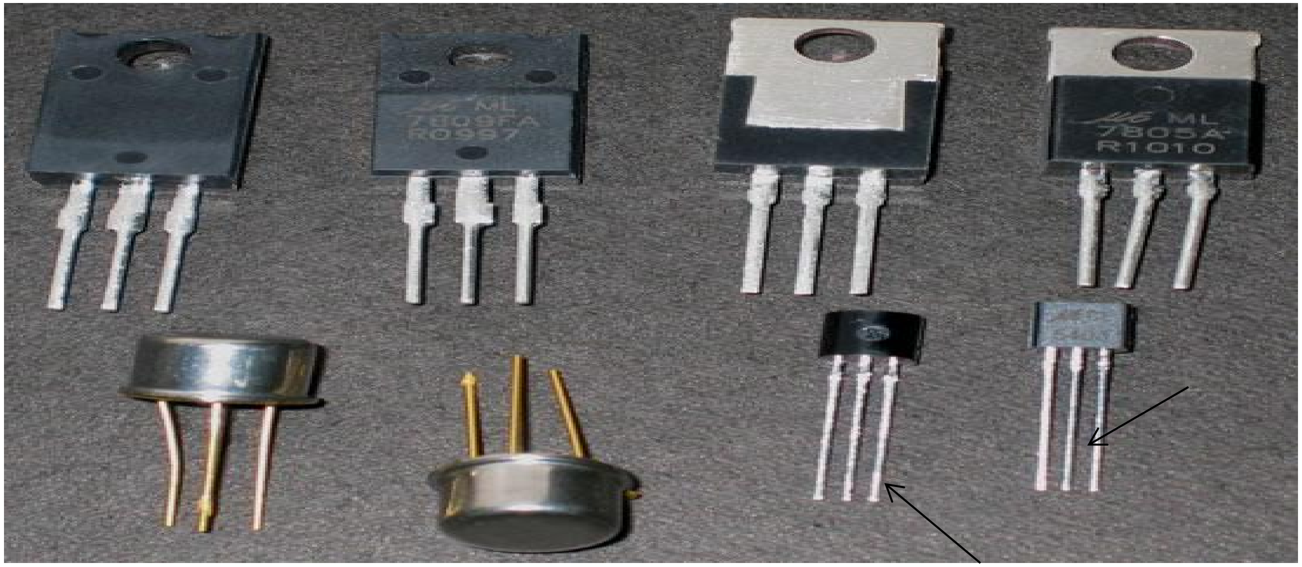
- Definition and Types of BJT.
- Different Parts of BJT & symbol
- Methods of connection (CE, CB, CC)
- Define α, β & γ & establish the different relation between them
- Working Principle of NPN.
- Common-emitter configuration & (Draw + Explain)-- its Input & Output characteristics
- Common-base configuration & its Input & Output characteristics
- Transistor Biasing & its types.
- Emitter bias (Voltage –Divider Bias) –Working Principle, Calculate Collector Emitter Voltage from Circuit Analysis.

Problem related to the above mentioned topics(**V .K. Mehta**)

What is a transistor ?

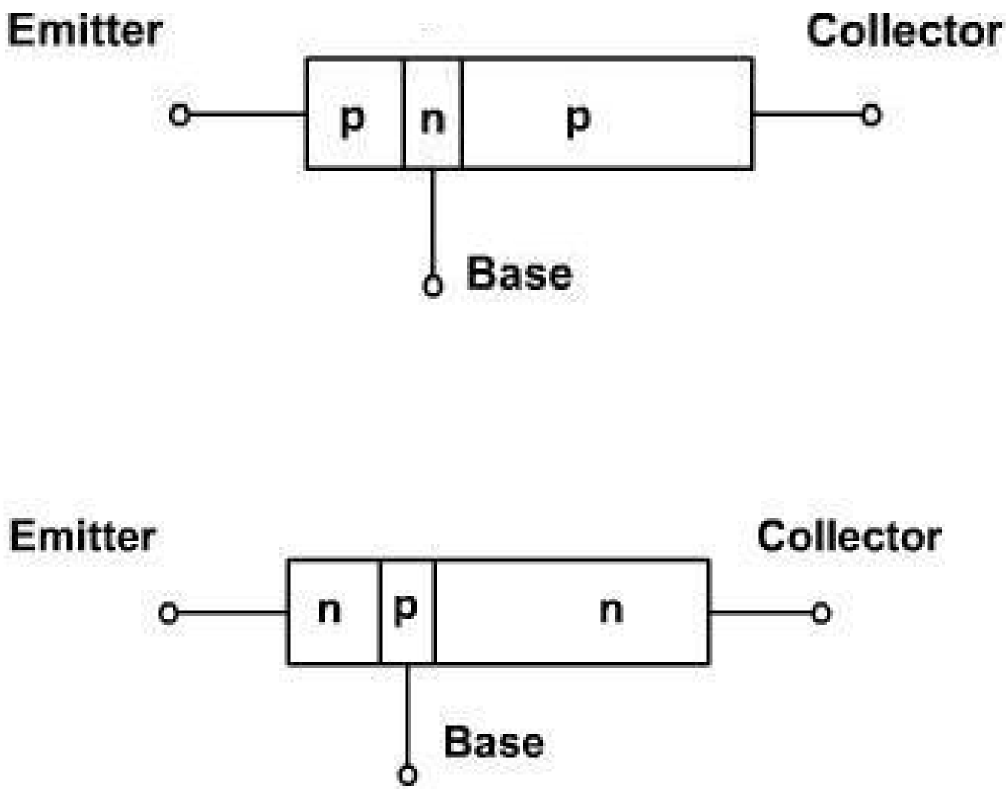
Transfer + resistor

- A transistor is a 3 terminal electronic device made of semiconductor material.
- Semiconductors: ability to change from conductor to insulator
- Can either allow current or prohibit current to flow
- Transistors have many uses, including amplification, switching, voltage regulation, and the modulation of signals
- Essential part of many technological advances

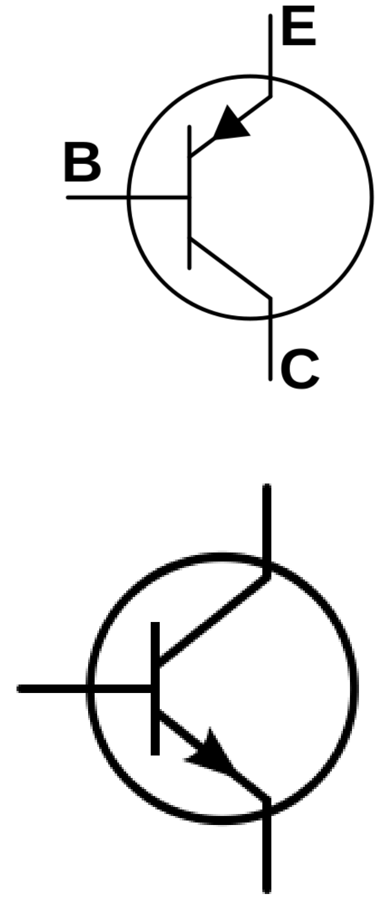


Different types & parts of BJT with Symbol

- A transistor is basically a Si or Ge crystal containing three separate regions.



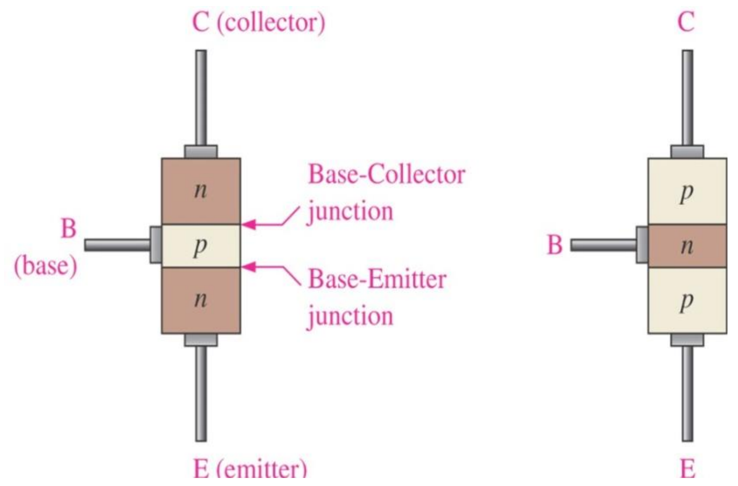
Three different parts



Symbol

Different parts of BJT

- The bipolar junction transistor (BJT) is constructed with three doped semiconductor regions separated by two *pn* junctions
- Regions are called **emitter**, **base** and **collector**
- The emitter layer is heavily doped, with the base and collector only lightly doped. The outer layers have widths much greater than the sandwiched p - or n - type material.
- This lower doping level decreases the conductivity (increases the resistance) of this material by limiting the number of "free" carriers.
- The term bipolar reflects the fact that holes and electrons participate in the injection process into the oppositely polarized material. If only one carrier is employed (electron or hole), it is considered a unipolar device.

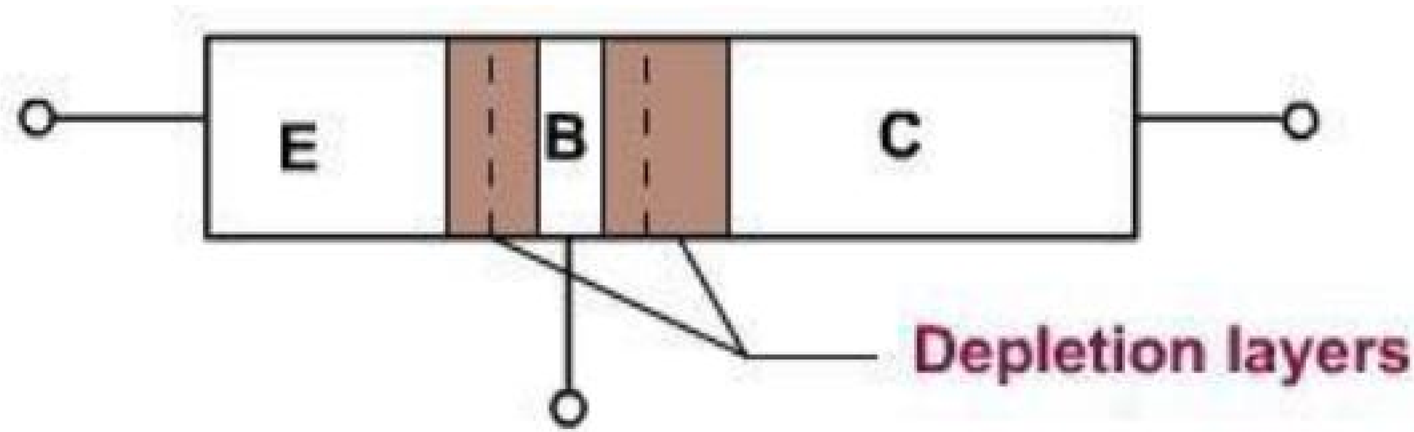


How Transistors Work

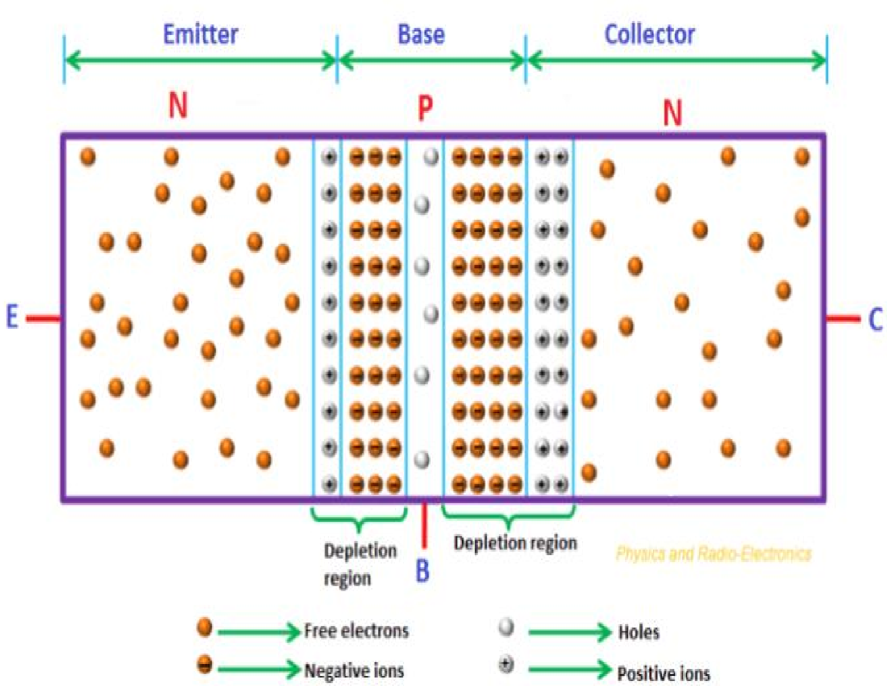
- Doping: adding small amounts of other elements to create additional protons or electrons
- P-Type: dopants lack a third valence electron (Boron, Aluminum)
- N-Type: dopants have an additional (5^{th}) valence electron (Phosphorus, Arsenic)
- Importance: Current only flows from P to N

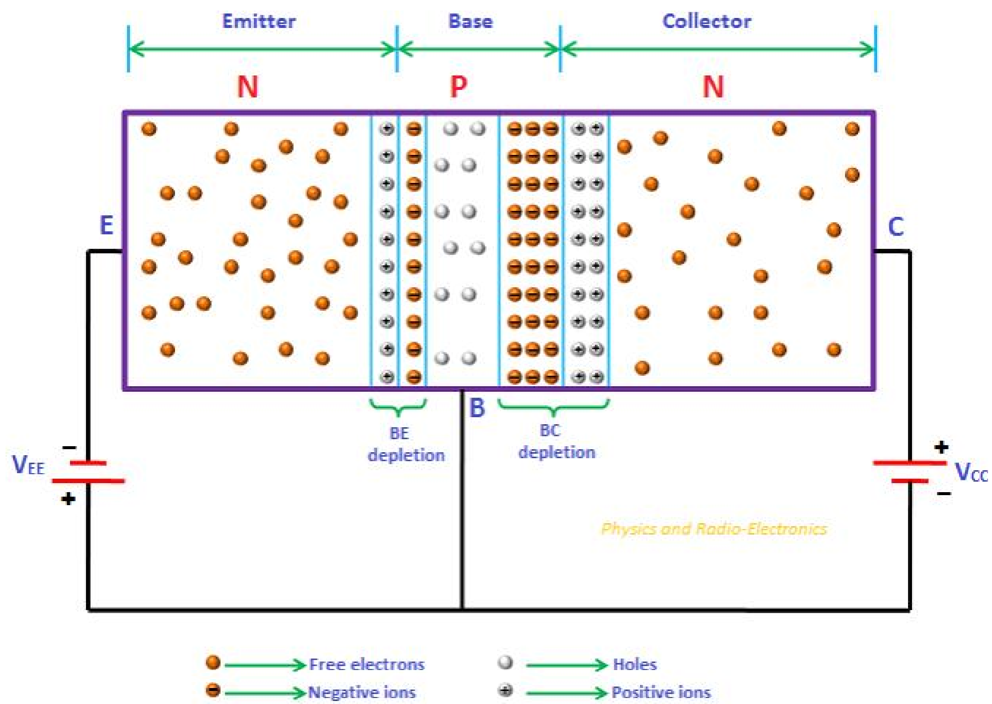
Bipolar Transistor

- The depletion layers do not have the same width, because different regions have different doping levels.



Unbiasing & Biasing Condition(NPN)



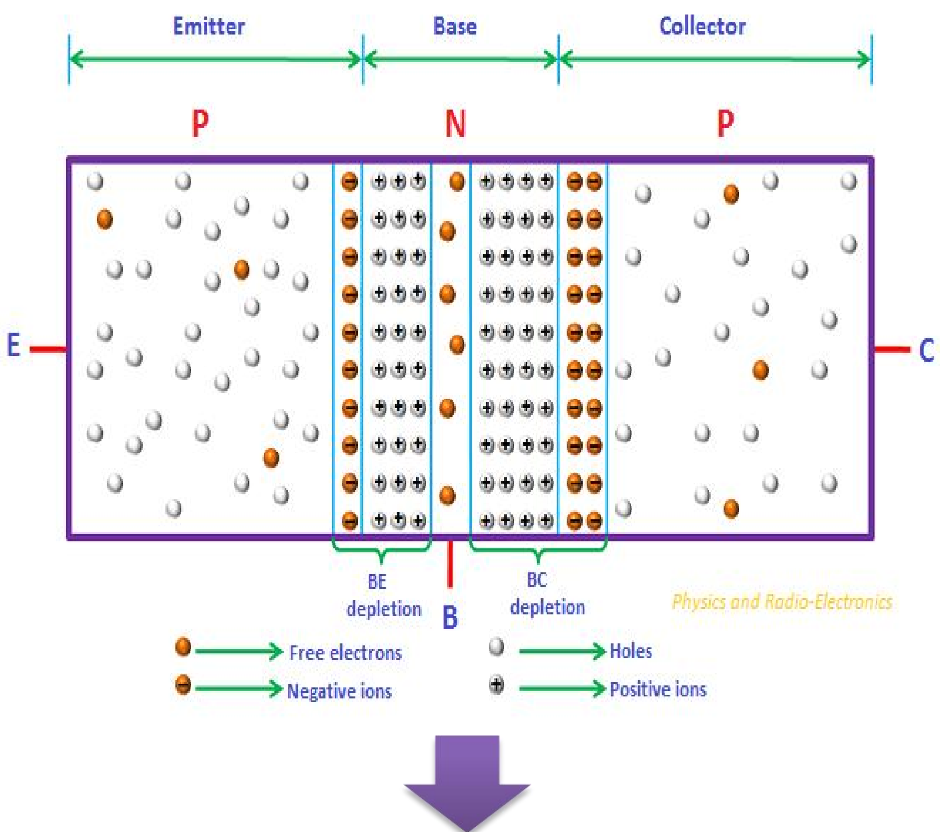


Unbiased condition

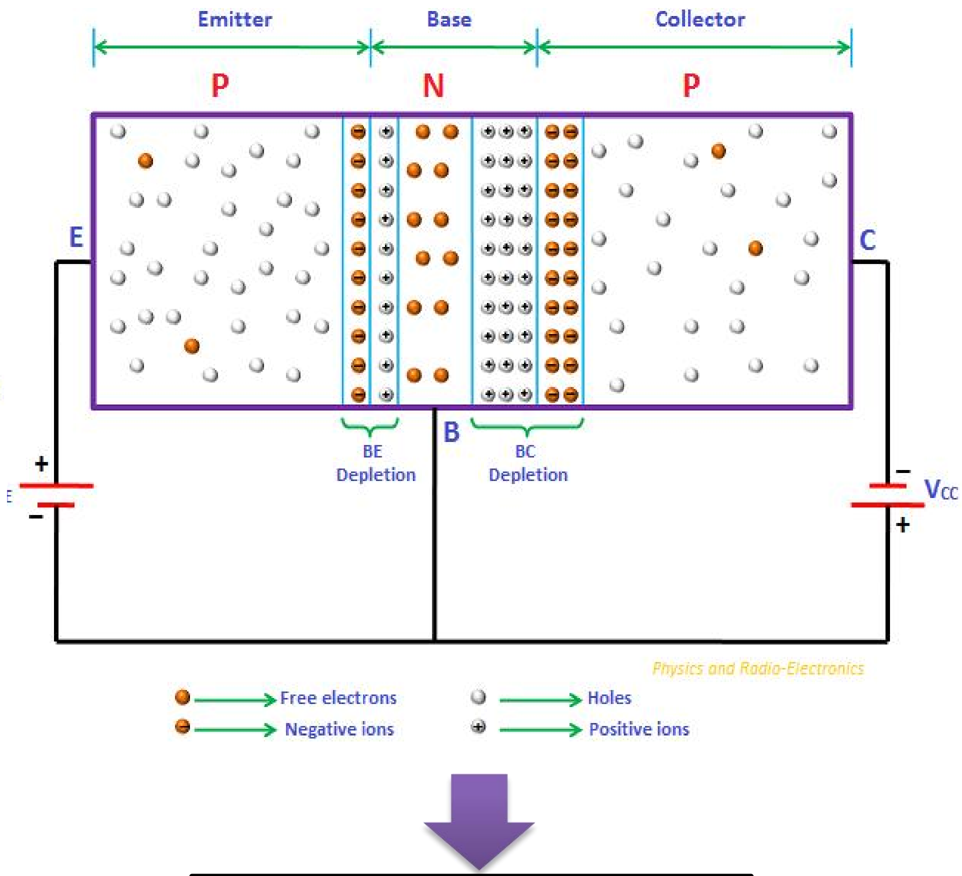
Biased condition

https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/transistors/bipolarjunctiontransistor/npntransistor.html

Unbiasing & Biasing Condition(PNP)



Unbiased condition

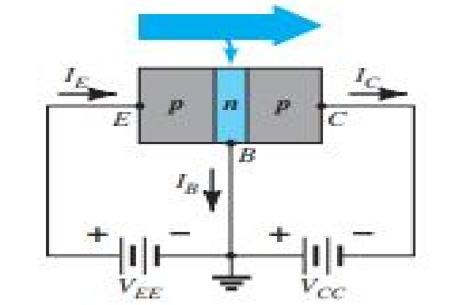


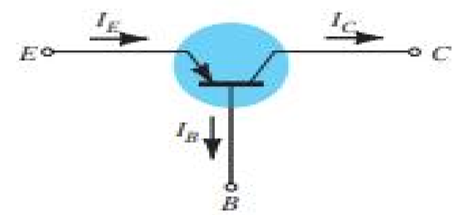
Biased condition

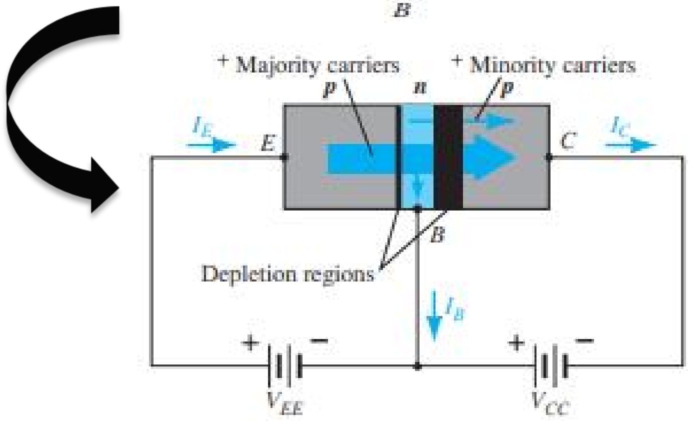
https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/transistors/bipolarjunctiontransistor/pnptransistor.html

Biasing(PNP)

- When the emitter junction is forward biased and collector junction is reverse biased then one expect large emitter current and small collector current but collector current is almost as large as emitter current.
- (This concept is same for both pnp & npn transitor)

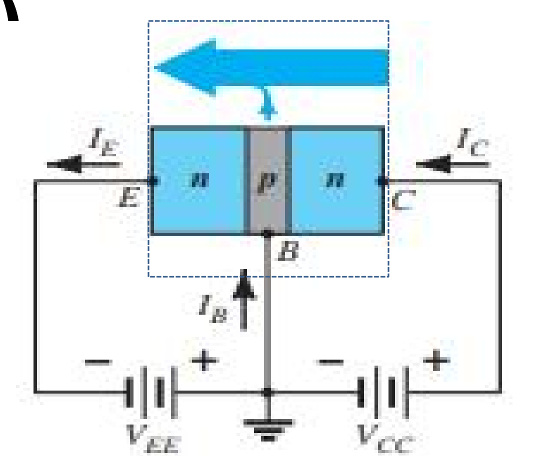




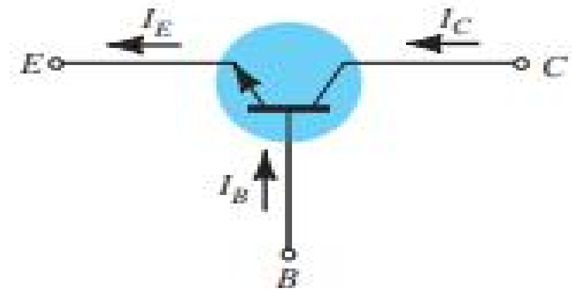


Majority and minority carrier flow of a pnp transistor.

Biasing(NPN)

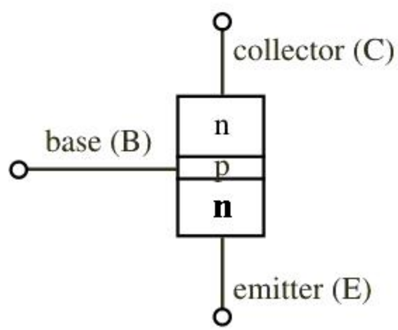


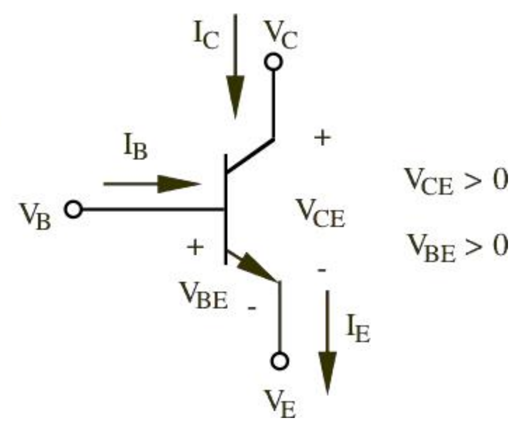
- $\underline{\text{1 thin layer of p-type}}$, sandwiched between $\underline{\text{2 layers of n-type}}$.
- N-type of emitter: $\underline{\text{more heavily doped}}$ than collector.
- $\underline{\text{With } V_C > V_B > V_E\text{:}}$
  - $\underline{\text{Base-Emitter}}$ junction $\underline{\text{forward biased}}$, $\underline{\text{Base-Collector}}$ $\underline{\text{reverse biased}}$. Electrons diffuse from Emitter to Base (from n to p).
  - There's a $\underline{\text{depletion layer}}$ on the Base-Collector junction → no flow of e^- allowed.
  - **BUT** the $\underline{\text{Base is thin and Emitter region is } n^+ \text{ (heavily doped)}}$ → electrons have enough momentum to cross the Base into the Collector. The small base current I_B controls a large current I_C



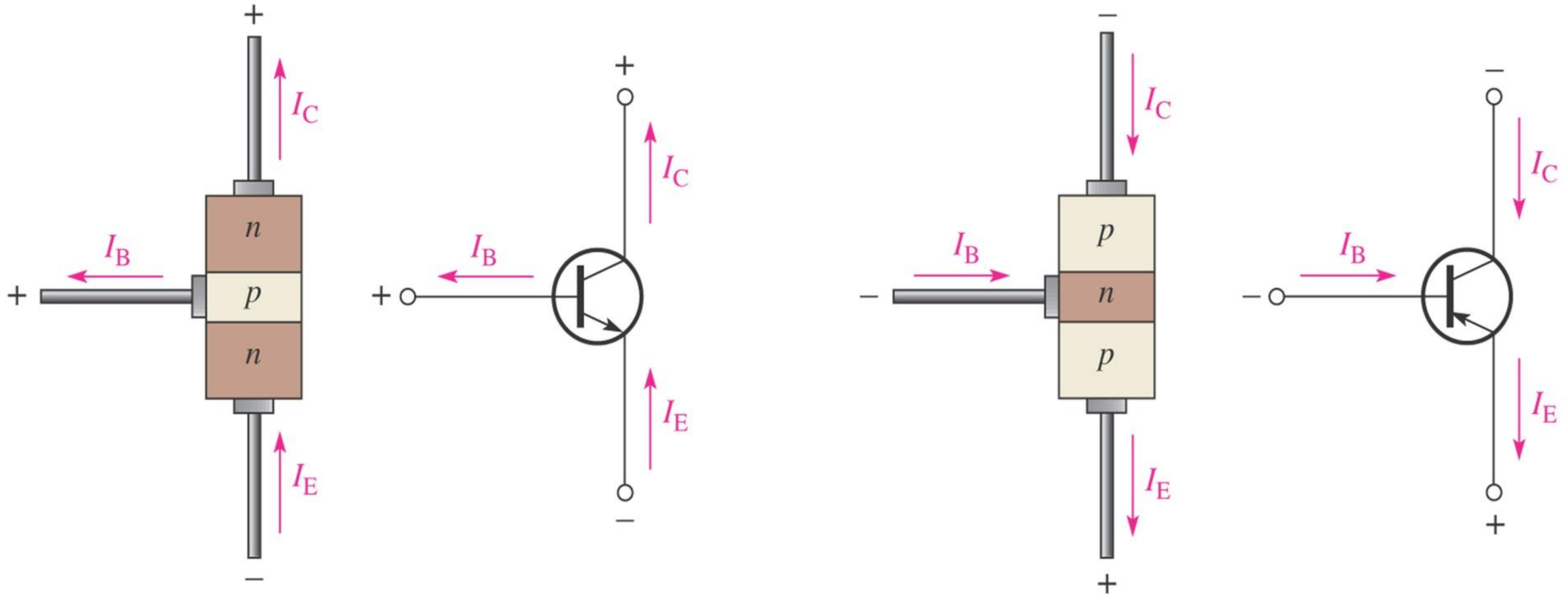
$$V_C > V_B > V_E$$

$$I_E = I_C + I_B$$
$$V_{BE} = V_B - V_E$$
$$V_{CE} = V_C - V_E$$
$$I_C = \beta I_B$$





Transistor Current

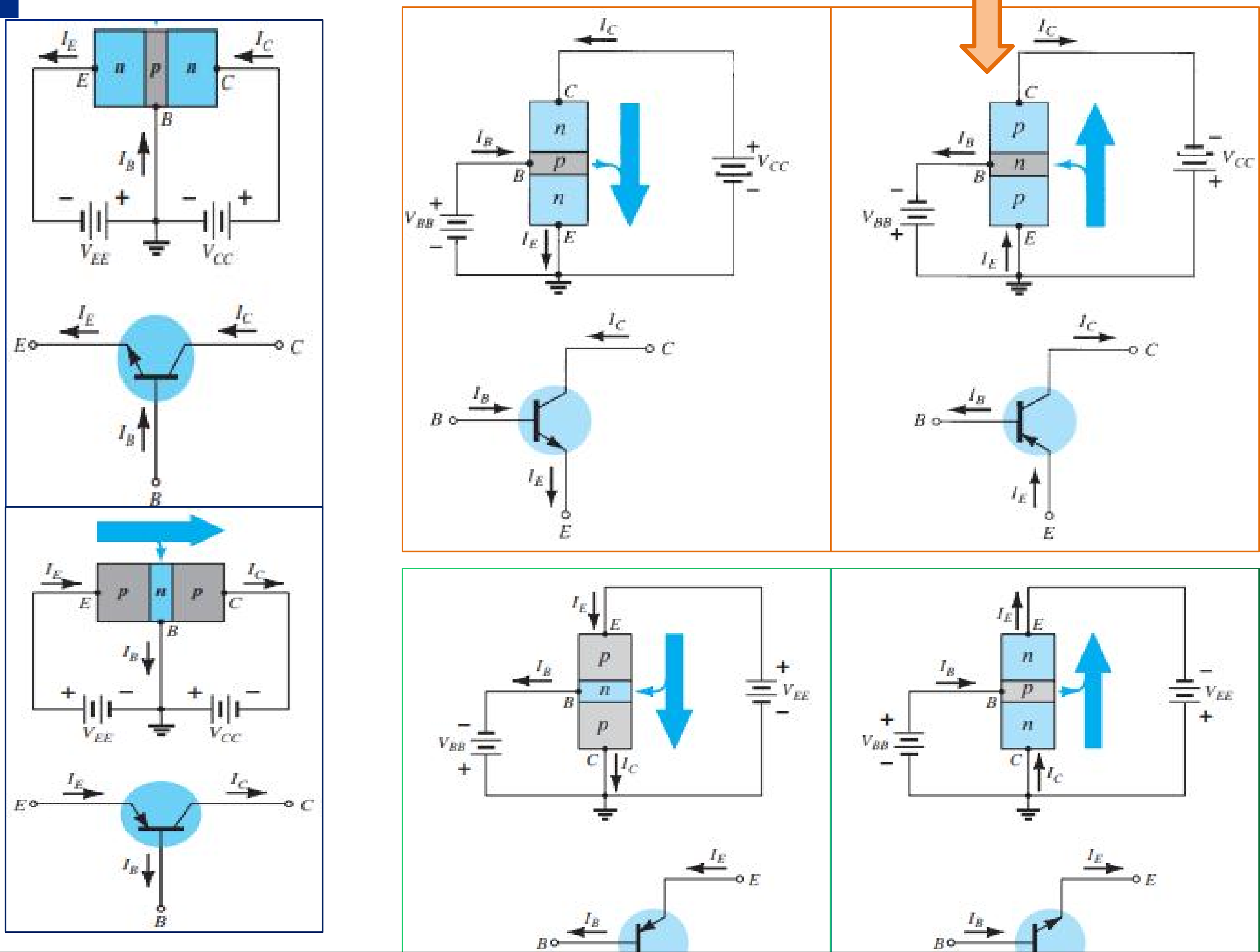


(a) *npn* (b) *pnp*

- The total current flowing into the transistor must be equal to the total current flowing out of it.

$$I_E = I_C + I_B$$

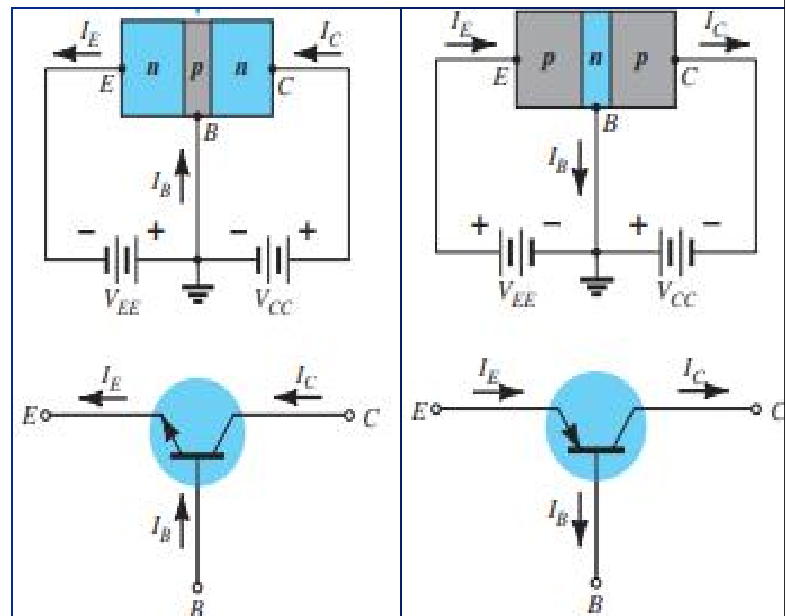
Methods of connection (CB ,CE & CC)



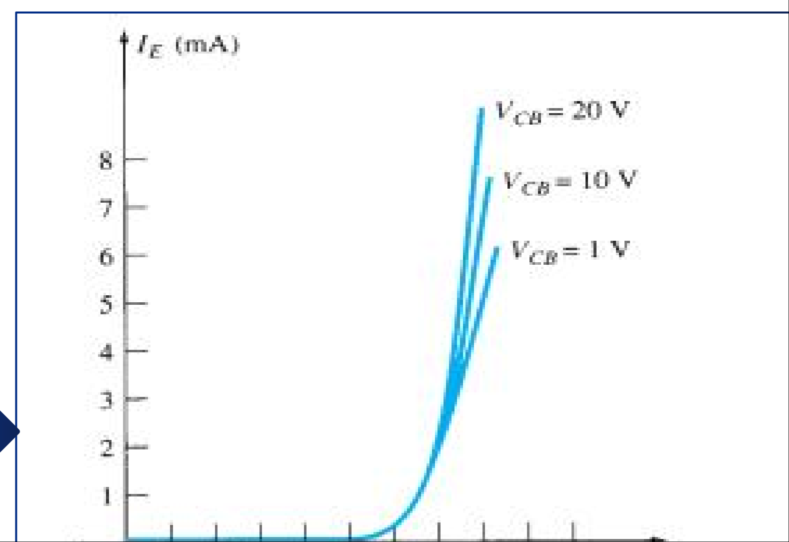
Methods of connection (CB)

- Note in each case that $I_E = I_C + I_B$. Note also that the applied biasing (voltage sources) are such as to establish current in the direction indicated for each branch. That is, compare the direction of I_E to the polarity of V_{EE} for each configuration and the direction of I_C to the polarity of V_{CC} .

- To fully describe the behavior of a three-terminal device such as the common-base amplifiers of CB configuration for both npn & pnp transistor requires two sets of characteristics—one for the driving point or input parameters and the other for the output side. The input set for the common-base amplifier as shown in input curve of CB relates an input current (I E) to an input voltage (V BE) for various levels of output voltage (V CB).

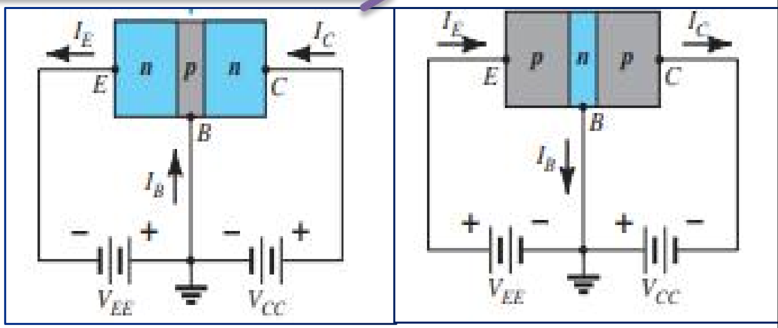


Input or driving point characteristics for a common-base silicon transistor amplifier.

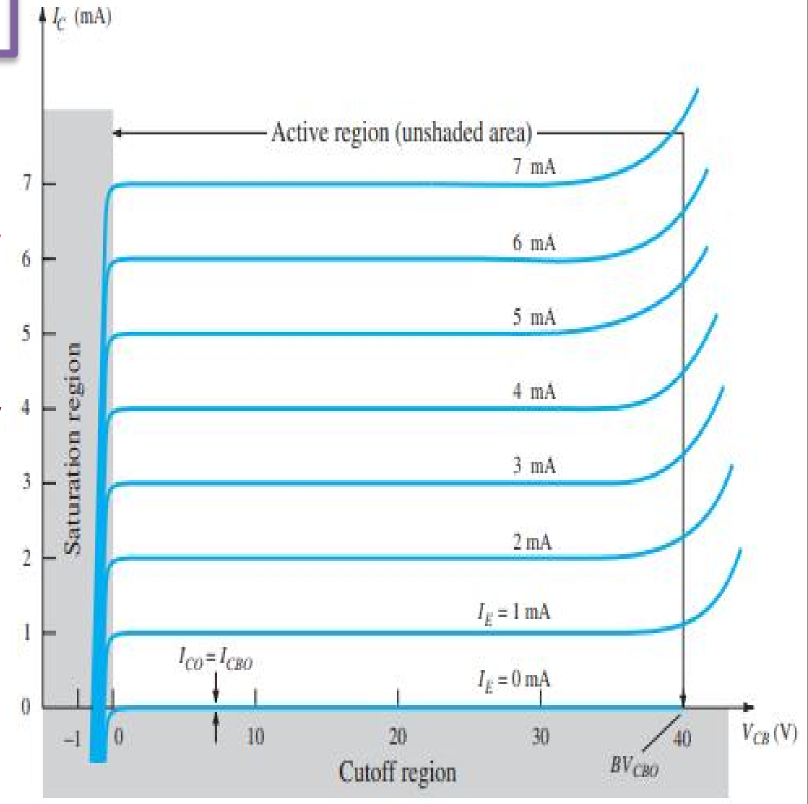


Methods of connection (CB)

- The output set relates an output current (I_C) to an output voltage (V_{CB}) for various levels of input current (I_E) as shown in output characteristics curve . The output or collector set of characteristics has three basic regions of interest, as indicated in output characteristics curve : ***the active , cutoff , and saturation regions.***



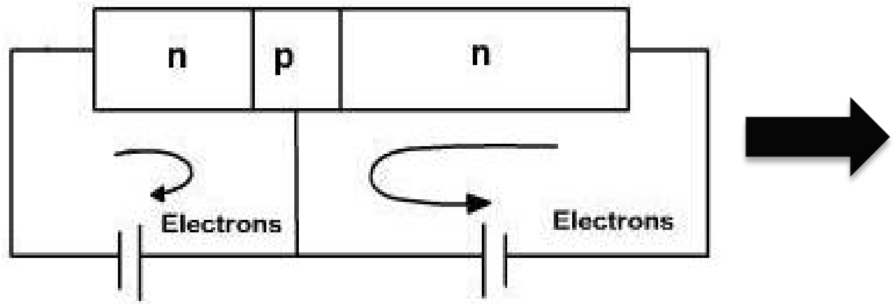
- ***In the active region the base–emitter junction is forward-biased, whereas the collector–base junction is reverse-biased.***
- ***In the cutoff region the base–emitter and collector–base junctions of a transistor are both reverse-biased.***
- ***In the saturation region the base–emitter and collector–base junctions are forward-biased.***



Output or collector characteristics for a common-base transistor amplifier.

Methods of connection (CB)

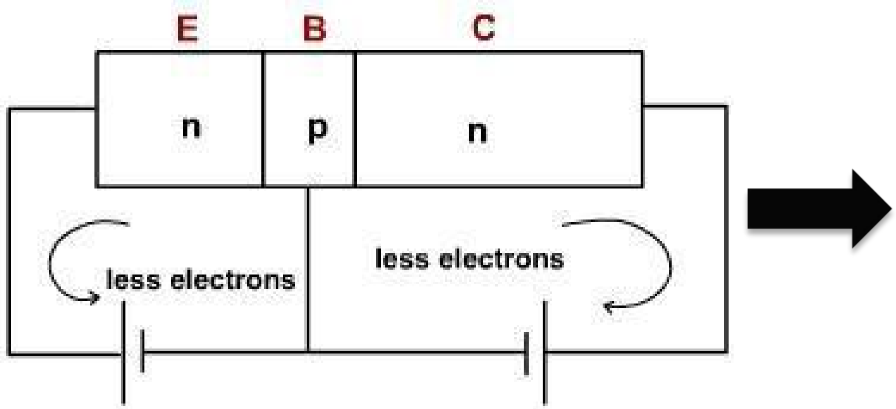
- If both the junctions are forward biased free electrons enter the emitter and collector of the transistor, joins at the base and come out of the base.



Saturation region

On state

- If both the junction are reverse biased then small currents flows through both junctions only due to thermally produced minority carriers and surface leakage.



Cut off region

Off state

In the CB configuration, the input current is the emitter current IE and the output current is the collector current IC.

Current Amplification Factor (α)

The ratio of change in collector current (ΔIC) to the change in emitter current (ΔIE) when collector voltage V_{CB} is kept constant, is called as Current amplification factor. It is denoted by α.

$\alpha=\Delta I_C/\Delta I_E$ at constant V_{CB}

Along with the emitter current flowing, there is some amount of base current IB which flows through the base terminal due to electron hole recombination. As collector-base junction is reverse biased, there is another current which is flown due to minority charge carriers. This is the leakage current which can be understood as leakage. This is due to minority charge carriers and hence very small.

The emitter current that reaches the collector terminal is αI_E

Total collector current $I_C=\alpha I_E+I_{leakage}$ If the emitter-base voltage $V_{EB} = 0$, even then, there flows a small leakage current, which can be termed as I_{CBO} (collector-base current with output open).The collector current therefore can be expressed as

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

$I_E=I_C+I_B$

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

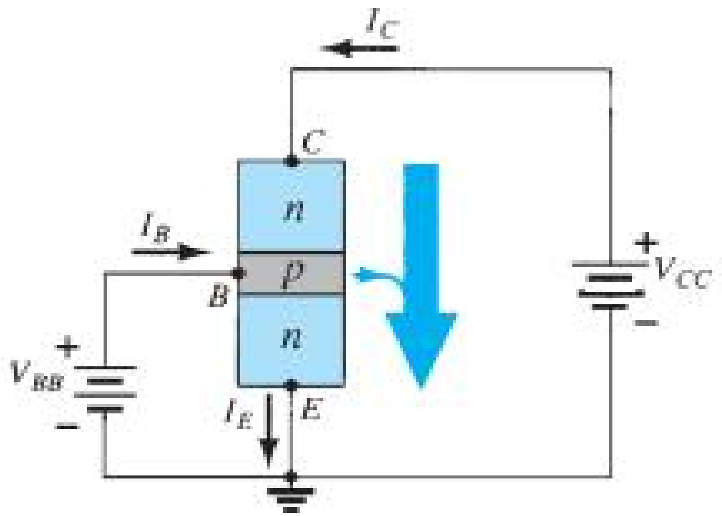
$$I_C(1-\alpha) = \alpha I_B + I_{CBO}$$

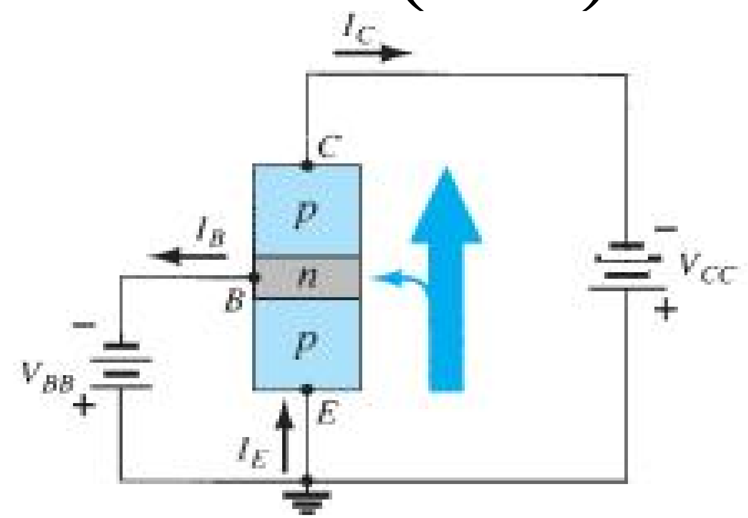
$$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{I_{CBO}}{1-\alpha}$$

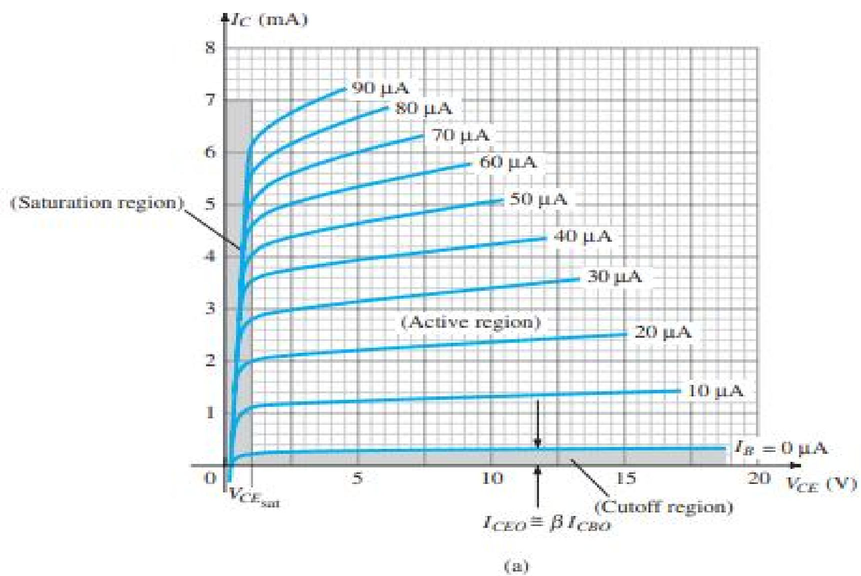
$$I_C = \left(\frac{\alpha}{1-\alpha}\right) I_B + \left(\frac{1}{1-\alpha}\right) I_{CBO}$$

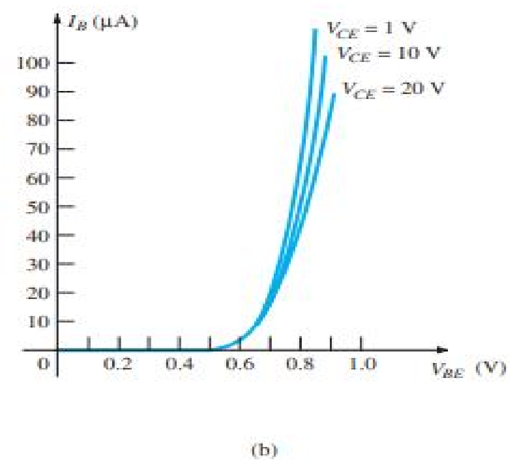
expression for collector current. The value of collector current depends on base current and leakage current along with the current amplification factor of that transistor in use.

Methods of connection (CE)









Characteristics of a silicon transistor in the common-emitter configuration: (a) collector characteristics; (b) base characteristics.

Methods of connection (CE)

- The input current is the base current $\mathbf{I_B}$ and the output current is the collector current $\mathbf{I_C}$ here.

Base Current Amplification factor (β)

The ratio of change in collector current (ΔI_C) to the change in base current (ΔI_B) is known as Base Current Amplification Factor. It is denoted by β.

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

Expression for Collector Current

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

If base circuit is open, i.e. if $I_B = 0$,

$$I_{CEO} = \frac{1}{1-\alpha} I_{CBO}$$

The collector emitter current with base open is Substituting the value of this in the previous equation, we get,

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

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

Hence the equation for collector current is obtained.

Methods of connection (CC)

Current Amplification Factor (γ)

The ratio of change in emitter current (ΔI_E) to the change in base current (ΔI_B) is known as Current Amplification factor in common collector (CC) configuration. It is denoted by γ.

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

The current gain in CC configuration is same as in CE configuration.

The voltage gain in CC configuration is always less than 1.

Relation between α , β and γ .

We know that,

Relation between β and α. A simple relation exists between β and α. This can be derived as follows :

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad ...(i)$$

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad ...(ii)$$

Now $I_E = I_B + I_C$

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

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

Substituting the value of ΔI_B in exp. (*i*), we get,

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C} \quad ...(iii)$$

Dividing the numerator and denominator of R.H.S. of exp. (*iii*) by ΔI_E, we get,

$$\beta = \frac{\Delta I_C / \Delta I_E}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} = \frac{\alpha}{1-\alpha} \quad \left[\because \alpha = \frac{\Delta I_C}{\Delta I_E}\right]$$

$$\therefore \quad \beta = \frac{\alpha}{1-\alpha}$$

or,

$$\beta = \frac{I_C}{I_E - I_C} = \frac{I_C / I_E}{1 - I_C / I_E} = \frac{\alpha}{1-\alpha}$$

$$\beta(1-\alpha) = \alpha \text{ or } \beta - \beta\alpha = \alpha$$

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

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

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

$$\gamma = \frac{I_E}{I_B} \text{ and } \alpha = \frac{I_C}{I_E}$$

$$I_B = I_E - I_C$$

$$\gamma = \frac{I_E}{I_E - I_C} = \frac{1}{1-(I_C/I_E)} = \frac{1}{1-\alpha}$$

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

Note:

For ac, $\beta = \frac{\Delta I_C}{\Delta I_B}$

For dc, $\beta = \frac{I_C}{I_B}$

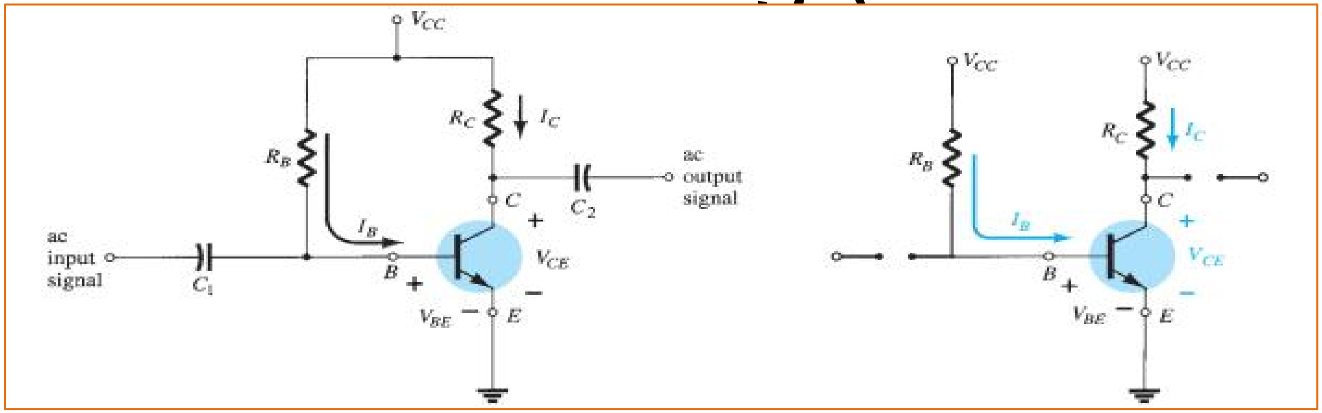
But the relationship between Alpha(à), Vita(ß) and Gamma(Ý) can be done either AC or DC. Without del(Δ) or with del(Δ).

Transistor Biasing & Its Types

- Fixed Bias configuration
- Emitter Bias Configuration
- Voltage Devider Bias Configuration

Transistor Biasing (Fixed Biasing)

No need to mid exam preparation

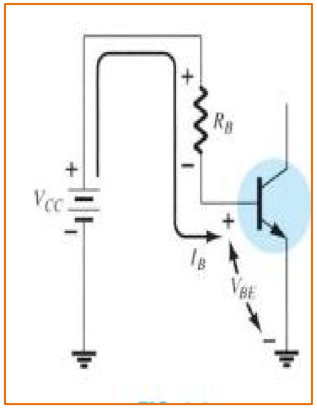


Consider first the base–emitter circuit loop of foread bias circuit .Writing Kirchhoff’s voltage equation in the **clockwise** direction for the loop, we obtain

$$+V_{CC} - I_B R_B - V_{BE} = 0$$

Note the polarity of the voltage drop across R_B as established by the indicated direction of I_B. Solving the equation for the current I_B results in the following:

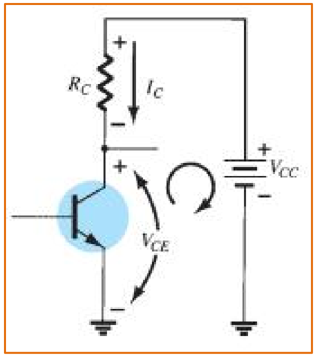
$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B}} \qquad (4.4)$$



$$V_{CE} + I_C R_C - V_{CC} = 0$$

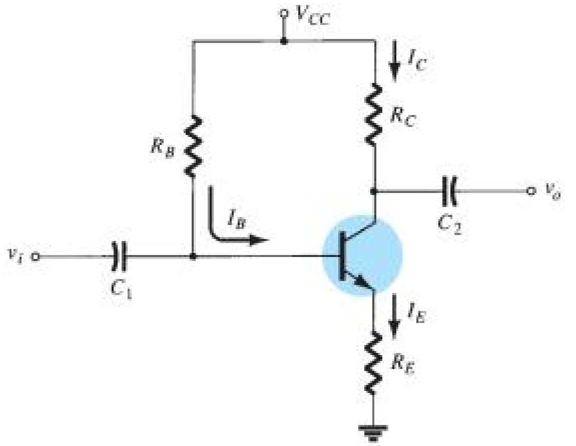
$$\boxed{V_{CE} = V_{CC} - I_C R_C}$$

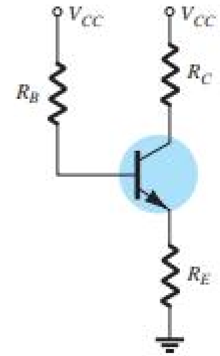
$$\boxed{I_C = \beta I_B}$$



Transistor Biasing (Emitter Biasing)

No need to mid exam preparation





Writing Kirchhoff's voltage law around the indicated loop in the clockwise results in the following equation:

$$+V_{CC} - I_BR_B - V_{BE} - I_ER_E = 0$$

Recall from Chapter 3 that

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

Substituting for I_E in Eq. (4.15) results in

$$V_{CC} - I_BR_B - V_{BE} - (\beta + I)I_BR_E = 0$$

Grouping terms then provides the following:

$$-I_B(R_B + (\beta + 1)R_E) + V_{CC} - V_{BE} = 0$$

Multiplying through by (−1), we have

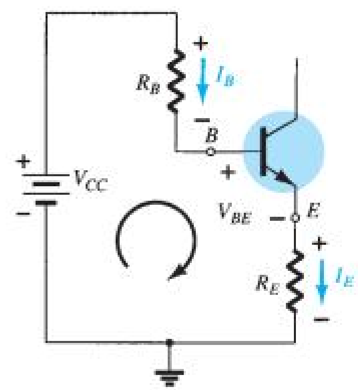
$$I_B(R_B + (\beta + 1)R_E) - V_{CC} + V_{BE} = 0$$

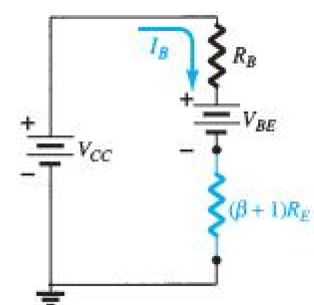
with

$$I_B(R_B + (\beta + 1)R_E) = V_{CC} - V_{BE}$$

and solving for I_B gives

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E}}$$





Voltage Regulation or Voltage Divider Bias

It's called voltage divider bias, because of the voltage divider network in Base terminal (shown blue rectangular box) is used to bias the transistor

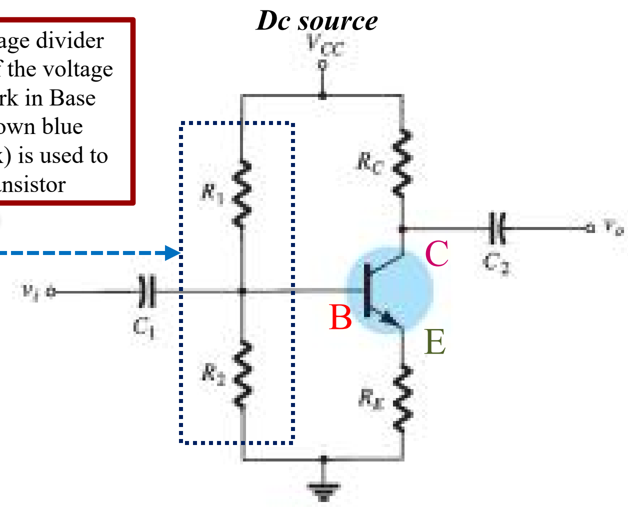
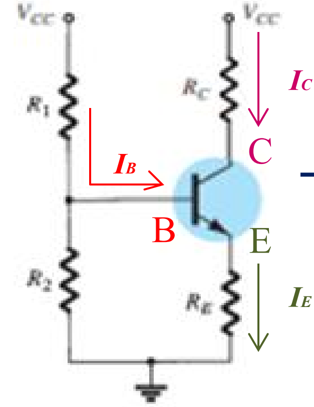


FIG. 4.28
Voltage-divider bias configuration.

Main voltage divider bias configuration circuit

1st Step

Locate capacitors and replace them with a open circuit due to dc voltage source of Vcc

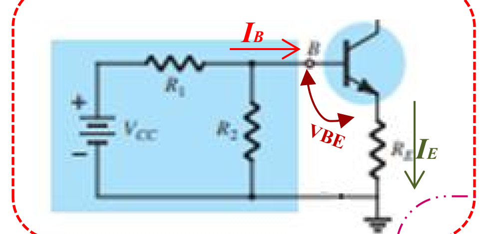


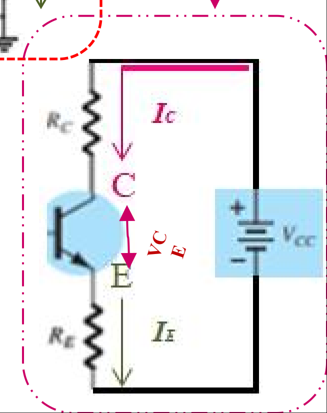
2nd Step

Simplified circuit using thevnin theorem

3rd Step

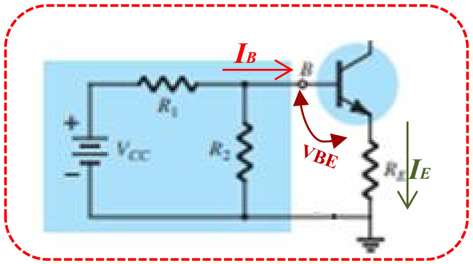
Locate 2 main loop which are BE(Base and Emitter) loop , and CE(Collector and Emitter) loop





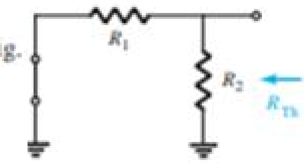
Voltage Regulation or Voltage Divider Bias

For BE(Base and Emitter) loop :



Using Thevnin theorem

R_{Th} The voltage source is replaced by a short-circuit equivalent as shown in Fig.

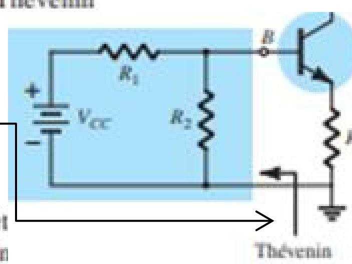


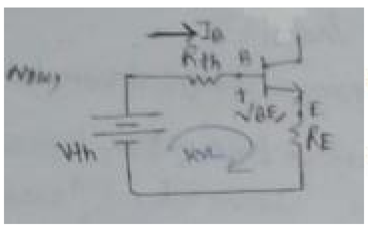
$$R_{Th} = R_1 \| R_2$$

E_{Th} The voltage source V_{CC} is returned to the network and the open-circuit Thévenin voltage of Fig determined as follows:

Applying the voltage-divider rule gives

$$E_{Th} = V_{R_2} = \frac{R_2 V_{CC}}{R_1 + R_2}$$





$R_{Th} + (\beta + 1)R_E$

The Thévenin network is then redrawn as shown in Fig. and I_{B_Q} can be det by first applying Kirchhoff's voltage law in the clockwise direction for the loop in

$$E_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$$

Substituting $I_E = (\beta + 1)I_B$ and solving for I_B yields

$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$$

<u>Note:</u>

$I_E = (\beta + 1)I_B$

$R_{Th} + (\beta + 1)R_E$

From emitter bis configuration

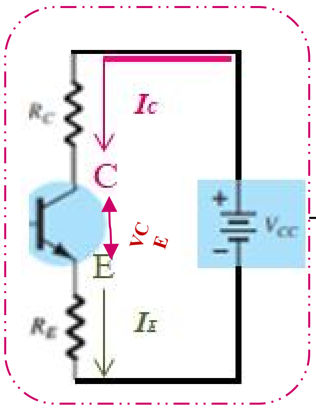
& $R_{Th} << (\beta + 1)R_E$

Ic independent in beta

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

Voltage Regulation or Voltage Divider Bias

For CE(Collector and Emitter) loop : *Derivation to find emitter current(I_E) and collector to emitter voltage(V_{CE})*



Applying KVL rules,

$V_{cc} - I_c R_c - V_{CE} - I_E R_E = 0$

$\Rightarrow V_{cc} - I_c R_c - V_{CE} - I_c R_E = 0$

$\therefore$ while $I_c \cong I_E$

$\Rightarrow V_{cc} - I_c(R_c + R_E) - V_{CE} = 0$

$\Rightarrow I_c = \dfrac{V_{cc} - V_{CE}}{R_c + R_E}$

$V_E = I_E R_E$

$\Rightarrow V_{CE} = V_C - V_E$ $\quad\Rightarrow V_{CE} = V_{cc} - I_c(R_c + R_E)$

$\Rightarrow V_C = V_{CE} + V_E$

or, $V_C = V_{cc} - I_c R_c$

$V_{BE} = V_B - V_E$

$\Rightarrow V_B = V_{BE} + V_E$

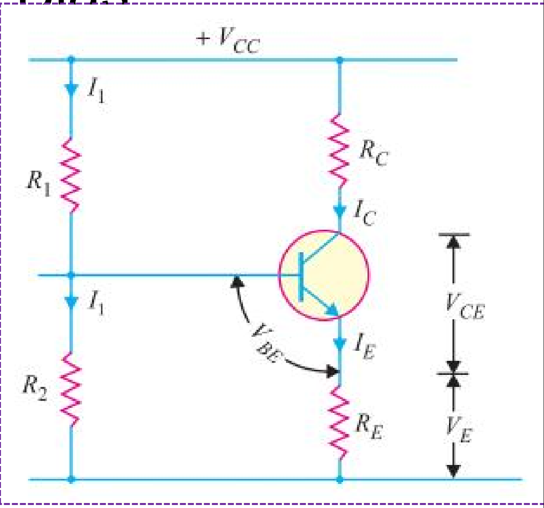
or, $V_B = V_{cc} - I_B R_B$

Ic independent in beta

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

Voltage Regulation or Voltage Divider Bias

"Or" ***another process to find emitter current(I_E) and collector to emitter voltage(V_{CE}) from*** **V.K Metha [Chapter 9(Atricle 9.12)]**



Circuit analysis. Suppose that the current flowing through resistance R_1 is I_1. As base current I_B is very small, therefore, it can be assumed with reasonable accuracy that current flowing through R_2 is also I_1.

(i) Collector current I_C :

$$I_1 = \frac{V_{CC}}{R_1 + R_2}$$

∴ Voltage across resistance R_2 is

$$V_2 = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2$$

Applying Kirchhoff's voltage law to the base circuit of Fig. 9.24

$$V_2 = V_{BE} + V_E$$

or
$$V_2 = V_{BE} + I_E R_E$$

or
$$I_E = \frac{V_2 - V_{BE}}{R_E}$$

Since $I_E \simeq I_C$

∴
$$\boxed{I_C = \frac{V_2 - V_{BE}}{R_E}} \quad \text{...(i)}$$

It is clear from exp. (i) above that I_C does not at all depend upon β. Though I_C depends upon V_{BE} but in practice $V_2 >> V_{BE}$ so that I_C is practically independent of V_{BE}. Thus I_C in this circuit is almost independent of transistor parameters and hence good stabilisation is ensured. It is due to this reason that potential divider bias has become universal method for providing transistor biasing.

(ii) Collector-emitter voltage V_{CE}. Applying Kirchhoff's voltage law to the collector side,

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

$$= I_C R_C + V_{CE} + I_C R_E \qquad (\because I_E \simeq I_C)$$

$$= I_C (R_C + R_E) + V_{CE}$$

$$\boxed{V_{CE} = V_{CC} - I_C (R_C + R_E)}$$

Math (From V.K Metha)
Chapter 8 & 9

Example 8.2. *In a common base connection, $I_E = 1mA$, $I_C = 0.95mA$. Calculate the value of I_B.*

Solution. Using the relation, $I_E = I_B + I_C$

or $1 = I_B + 0.95$

$\therefore$ $I_B = 1 - 0.95 = \mathbf{0.05\ mA}$

Example 8.3. *In a common base connection, current amplification factor is 0.9. If the emitter current is 1mA, determine the value of base current.*

Solution. Here, $\alpha = 0.9$, $I_E = 1$ mA

Now $\alpha = \dfrac{I_C}{I_E}$

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

Also $I_E = I_B + I_C$

$\therefore$ Base current, $I_B = I_E - I_C = 1 - 0.9 = \mathbf{0.1\ mA}$

Example 8.4. *In a common base connection, $I_C = 0.95$ mA and $I_B = 0.05$ mA. Find the value of α.*

Solution. We know $I_E = I_B + I_C = 0.05 + 0.95 = 1$ mA

$\therefore$ Current amplification factor, $\alpha = \dfrac{I_C}{I_E} = \dfrac{0.95}{1} = \mathbf{0.95}$

Example 8.6. *In a common base connection, $\alpha = 0.95$. The voltage drop across 2 kΩ resistance which is connected in the collector is 2V. Find the base current.*

Solution. Fig. 8.12 shows the required common base connection. The voltage drop across R_C (= 2 kΩ) is 2V.

$\therefore$ $I_C = 2\text{ V}/2\text{ k}\Omega = 1$ mA

Now $\alpha = I_C/I_E$

$\therefore$ $I_E = \dfrac{I_C}{\alpha} = \dfrac{1}{0.95} = 1.05$ mA

Using the relation, $I_E = I_B + I_C$

$\therefore$ $I_B = I_E - I_C = 1.05 - 1$

$= \mathbf{0.05\ mA}$

Math (From V.K Metha)
Chapter 8 & 9

Previous question

Example 8.7. *For the common base circuit shown in Fig. 8.13, determine I_C and V_{CB}. Assume the transistor to be of silicon.*

Solution. Since the transistor is of silicon, $V_{BE} = 0.7V$. Applying Kirchhoff's voltage law to the emitter-side loop, we get,

$$V_{EE} = I_E R_E + V_{BE}$$

or $$I_E = \frac{V_{EE} - V_{BE}}{R_E}$$

$$= \frac{8V - 0.7V}{1.5\ k\Omega} = 4.87\ mA$$

$$\therefore \quad I_C \simeq I_E = \mathbf{4.87\ mA}$$

Applying Kirchhoff's voltage law to the collector-side loop, we have,

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

$$\therefore \quad V_{CB} = V_{CC} - I_C R_C$$

$$= 18\ V - 4.87\ mA \times 1.2\ k\Omega = \mathbf{12.16\ V}$$

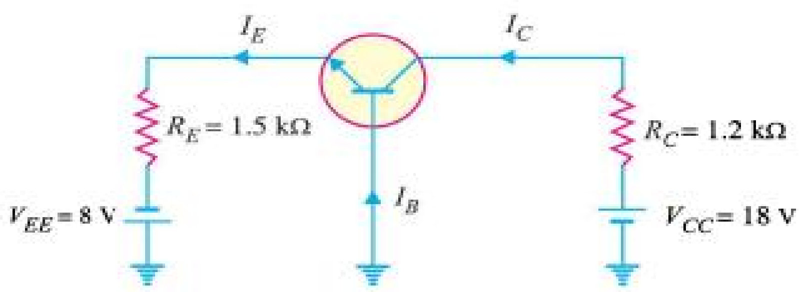


Fig. 8.13

Math (From V.K Metha)
Chapter 8 & 9

Example 8.8. *Find the value of β if (i) $\alpha = 0.9$ (ii) $\alpha = 0.98$ (iii) $\alpha = 0.99$.*

Solution. (*i*)
$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{1-0.9} = \mathbf{9}$$

(*ii*)
$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = \mathbf{49}$$

(*iii*)
$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = \mathbf{99}$$

Example 8.9. *Calculate I_E in a transistor for which $\beta = 50$ and $I_B = 20\ \mu A$.*

Solution. Here $\beta = 50$, $I_B = 20\mu A = 0.02$ mA

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

$\therefore$
$$I_C = \beta I_B = 50 \times 0.02 = 1 \text{ mA}$$

Using the relation, $I_E = I_B + I_C = 0.02 + 1 = \mathbf{1.02\ mA}$

Example 8.10. *Find the α rating of the transistor shown in Fig. 8.20. Hence determine the value of I_C using both α and β rating of the transistor.*

Solution. Fig. 8.20 shows the conditions of the problem.

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

The value of I_C can be found by using either α or β rating as under :

$$I_C = \alpha I_E = 0.98 \text{ (12 mA)} = \mathbf{11.76\ mA}$$

Also $$I_C = \beta I_B = 49 \text{ (240 } \mu\text{A)} = \mathbf{11.76\ mA}$$

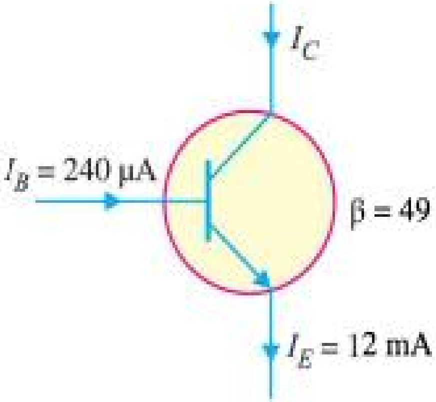


Fig. 8.20

Math (From V.K Metha)
Chapter 8 & 9

Example 8.11. *For a transistor, $\beta = 45$ and voltage drop across 1kΩ which is connected in the collector circuit is 1 volt. Find the base current for common emitter connection.*

Solution. Fig. 8.21 shows the required common emitter connection. The voltage drop across R_C (= 1 kΩ) is 1volt.

$$\therefore \quad I_C = \frac{1\,V}{1\,k\Omega} = 1\text{ mA}$$

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

$$\therefore \quad I_B = \frac{I_C}{\beta} = \frac{1}{45} = \mathbf{0.022\ mA}$$

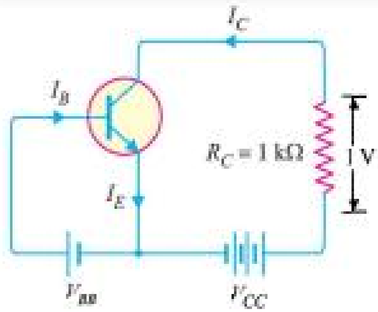


Fig. 8.21

Previous question

Example 8.12. *A transistor is connected in common emitter (CE) configuration in which collector supply is 8V and the voltage drop across resistance R_C connected in the collector circuit is 0.5V. The value of $R_C = 800\ \Omega$. If $\alpha = 0.96$, determine :*

(i) collector-emitter voltage

(ii) base current

Solution. Fig. 8.22 shows the required common emitter connection with various values.

(*i*) Collector-emitter voltage,

$$V_{CE} = V_{CC} - 0.5 = 8 - 0.5 = \mathbf{7.5\ V}$$

(*ii*) The voltage drop across R_C (= 800 Ω) is 0.5 V.

$$\therefore \quad I_C = \frac{0.5\text{ V}}{800\ \Omega} = \frac{5}{8}\text{ mA} = 0.625\text{ mA}$$

Now $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$$

$$\therefore \text{ Base current, } I_B = \frac{I_C}{\beta} = \frac{0.625}{24} = \mathbf{0.026\ mA}$$

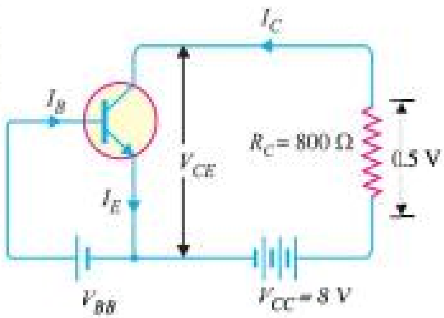
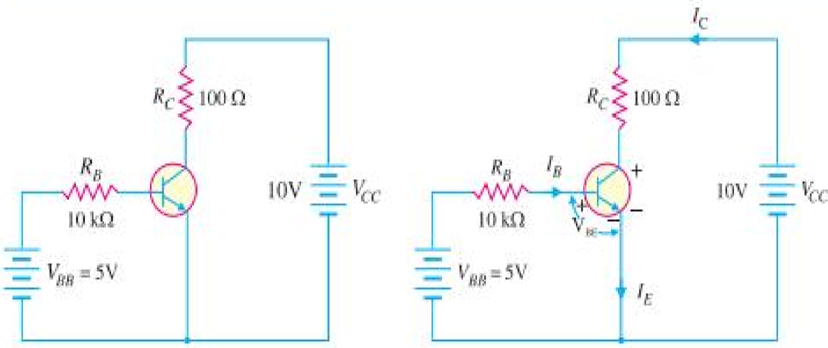


Fig. 8.22

Example 8.17 *Determine V_{CB} in the transistor * circuit shown in Fig. 8.26 (i). The transistor is of silicon and has $\beta = 150$.*



(*i*) (*ii*)

Fig. 8.26

Solution. Fig. 8.26 (*i*) shows the transistor circuit while Fig. 8.26 (*ii*) shows the various currents and voltages along with polarities.

Applying Kirchhoff's voltage law to base-emitter loop, we have,

$$V_{BB} - I_B R_B - V_{BE} = 0$$

or $$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5\text{V} - 0.7\text{V}}{10\ k\Omega} = 430\ \mu\text{A}$$

$$\therefore \quad I_C = \beta I_B = (150)(430\ \mu\text{A}) = 64.5\text{ mA}$$

Now $$V_{CE} = V_{CC} - I_C R_C$$
$$= 10\text{V} - (64.5\text{ mA})(100\Omega) = 10\text{V} - 6.45\text{V} = 3.55\text{V}$$

We know that : $$V_{CE} = V_{CB} + V_{BE}$$

$$\therefore \quad V_{CB} = V_{CE} - V_{BE} = 3.55 - 0.7 = \mathbf{2.85V}$$

Example 8.18. *In a transistor, $I_B = 68\ \mu A$, $I_E = 30$ mA and $\beta = 440$. Determine the α rating of the transistor. Then determine the value of I_C using both the α rating and β rating of the transistor.*

Solution.

$$\alpha = \frac{\beta}{\beta+1} = \frac{440}{440+1} = \mathbf{0.9977}$$

$$I_C = \alpha I_E = (0.9977)(30\text{ mA}) = \mathbf{29.93\ mA}$$

Also $$I_C = \beta I_B = (440)(68\ \mu\text{A}) = \mathbf{29.93\ mA}$$

Math (From V.K Metha)
Chapter 8 & 9

More math of Chapter 8 (V.K Metha)

Previous question

Example: 8.24, 8.28, 8.33, 8.34,8.37

Example 9.22. *Calculate the emitter current in the voltage divider circuit shown in Fig. 9.27. Also find the value of V_{CE} and collector potential V_C.*

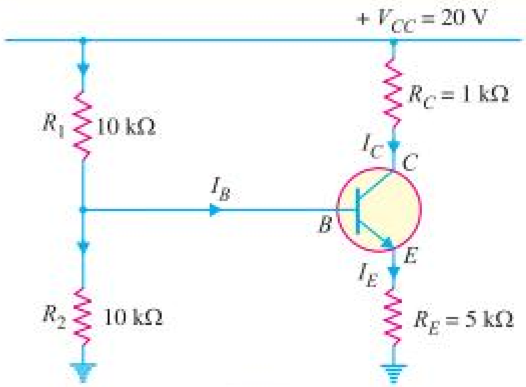


Fig. 9.27

Solution.

Voltage across R_2, $V_2 = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2 = \left(\frac{20}{10+10}\right) 10 = 10$ V

Now $V_2 = V_{BE} + I_E R_E$

As V_{BE} is generally small, therefore, it can be neglected.

$\therefore$ $I_E = \frac{V_2}{R_E} = \frac{10 \text{ V}}{5 \text{ k}\Omega} = $ **2 mA**

Now $I_C \simeq I_E = 2$ mA

$\therefore$ $V_{CE} = V_{CC} - I_C(R_C + R_E) = 20 - 2 \text{ mA} (6 \text{ k}\Omega)$

$= 20 - 12 = $ **8 V**

Collector potential, $V_C = V_{CC} - I_C R_C = 20 - 2 \text{ mA} \times 1 \text{ k}\Omega$

$= 20 - 2 = $ **18 V**

More math of Chapter 9 (V.K Metha)

Example: 9.21

Previous Question

a) What is transistor?

b) Draw the circuit diagrams for CB, CE, CC configurations.

c) Draw the circuit diagram and explain the working principle of n-p-n transistor.

d) Determine the dc current gain β_{dc} and the emitter current gain I_E for a transistor where I_B-50 μA and I_C=3.65 mA.

a) What is semiconductor? Give its classification.

b) Define β. Show that: β=α/1-α.

Draw the symbol of an N-P-N transistor and briefly explain it's construction and working principle. **6**

Or

Draw the three transistor configurations – Common Base, Common Emitter, and Common Collector configurations. For a Common Emitter configuration, establish the relation between α and β as given by –

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

For the common base circuit shown in Fig. 2(b), determine I_C and V_{CB}. Assume the transistor to be Silicon. **4**

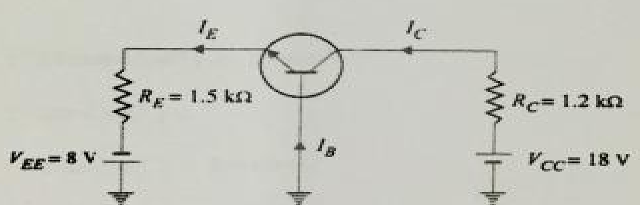


Fig. 2(b)

Or

A transistor is connected in Common Emitter configuration in which collector supply is 8 Volts and voltage drop across R_C connected in the collector circuit is 0.5 Volts. The value of R_C = 800 Ω. If α = 0.96, determine:

(i) Collector emitter voltage (V_{CE}).

(ii) Base current (I_B).

Previous Question

a) What is transistor? Draw the symbol of n-p-n and p-n-p transistor and specify the leads.
b) Draw the circuit diagram of n-p-n transistor in three possible configurations.
c) Draw the input and output characteristics curve of a transistor in CE configuration.
d) In a transistor $I_B = 68\ \mu A$, $I_E = 30$ mA and $\beta = 440$. Determine the value of α of the transistor. Hence find the value of I_C.

a) What is a P-N junction? Draw the circuit diagram of a P-N junction under forward and reverse biasing. 03
b) Establish the relation between α and β. 02
c) Mention the various methods for transistor biasing. Draw the circuit diagram of any of them. 02

What is transistor? Explain the working principle of a transistor with necessary circuit diagram. (CO4) 05
Suppose an n-p-n transistor has current gainin CE configuration (α) of 0.998 and emitter current of 4mA. Draw the symbol of the mentioned transistor and determine base current (I_B), collector current (I_C) and current gain of CB configuration (β). (CO4) 05

or

Suppose you have given a transistor, draw three types of configuration to operate it. Also, show the relation between current gains of CB (α) and CE (β). (CO4)

Previous Question

2. a) What do you understand by transistor biasing? Derive expressions for collector current and collector-emitter voltage of a transistor amplifier that used the voltage divider bias method. 7

Or

Define (i) cut-off, (ii) saturation, (iii) active region, and (iv) operating point. Show them in the output characteristics curve of a common emitter transistor amplifier.

b) Calculate the emitter current in the voltage divider circuit shown in Fig. 2(b). Also find the value of V_{CE} and collector potential V_C. 3

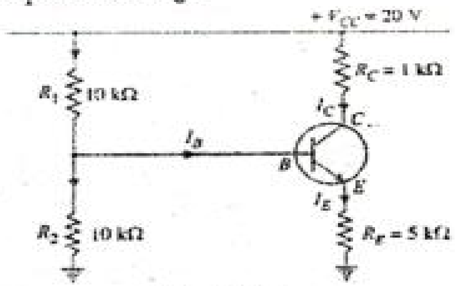


Fig. 2(b)

Or

Determine whether or not the transistor in Fig. 2(b-or) is in stauration. Assume V_{knee} = 0.2V.

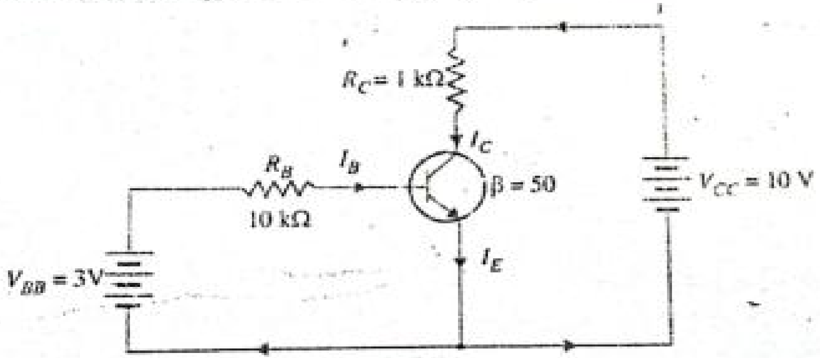


Fig. 2(b-or)