Operation Configuration of BJTs

The bipolar transistor can be biased in one of three different configurations. Each configuration has own benefit. The configuration chosen depend on the type applications.

1. Common base configuration
2. Common emitter configuration
3. Common collector configuration

1. Common base configuration

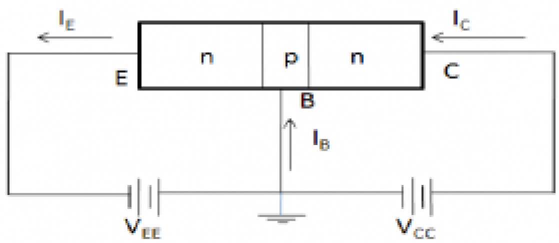

Fig.9: common-base NPN configuration

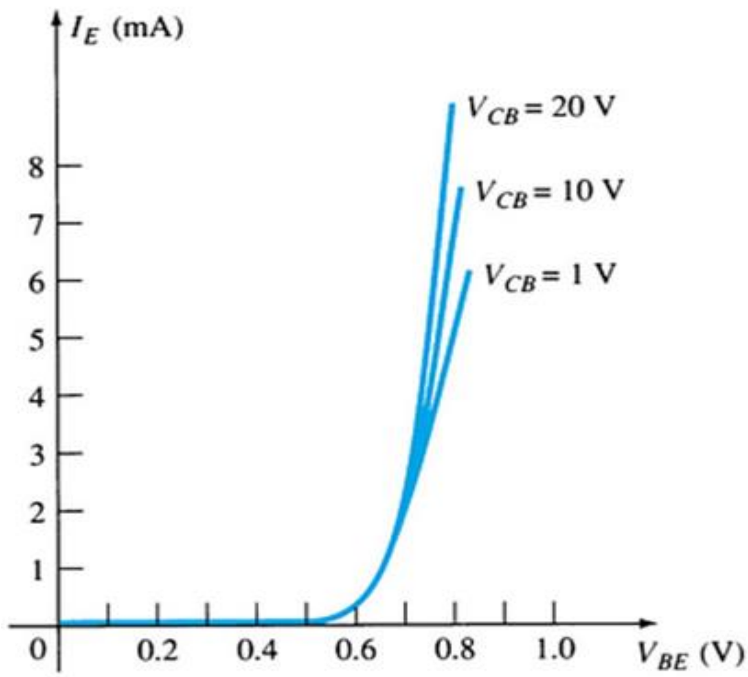

Fig.10: input characteristic for a common –base transistor amplifier

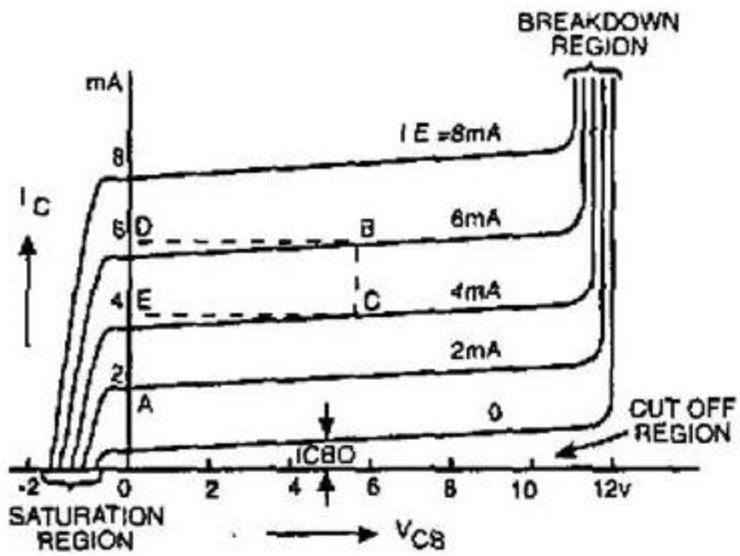

Fig.11: output characteristic for common-base transistor amplifier

- $I_{CO} = I_{CBO}$ measured in µA very small with respect to I_C that measured in mA. I_{CB0} effected by temperature then increased rapidly with temperature.
- Almost negligible effect of V_{CB} on the collector current for the active region
- At active region approximation the relation between I_C and I_E is:
  $I_C \cong I_E$

Example:-

$V_i = 200$ mV, $R_i = 20\ \Omega$, and $R_o = 100\ K\ \Omega$ for circuit below

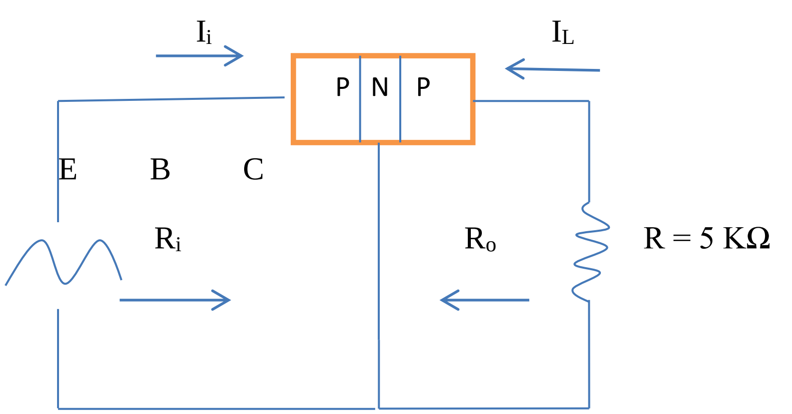

Fig.12: Base voltage amplifier

Solution:-

$$I_i = \frac{Vi}{Ri} = \frac{200\ mV}{20\ \Omega} = 10\ mA$$

If we assume for the moment that $\alpha_{ac} = 1$ ($I_c = I_e$) ;$I_L = I_i = 10$ mA

$V_L = I_L*R = 10mA*5K\Omega = 50$ V

$A_V = \frac{VL}{Vi} = \frac{50}{200mV} = 250$

- Typical values of voltage amplification for common-base vary from 50 t0 300.
- Always α less than 1

2. Common emitter configuration

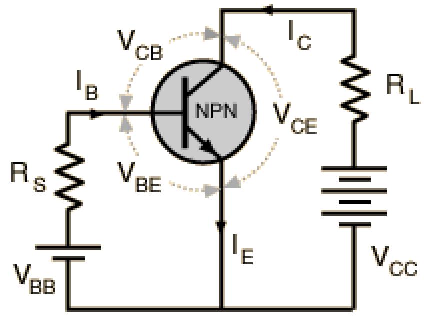

Fig.13: a: npn transistor for common emitter configuration

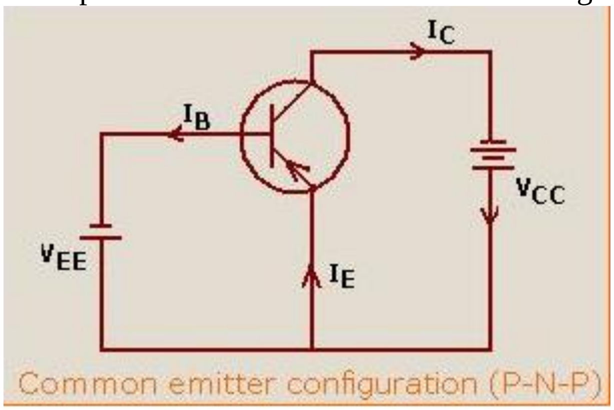

Fig.13:b: pnptransistor for common emitter configuration

- Also $I_E = I_C + I_B$ and $I_C = \alpha I_E$
- In common emitter the output characteristics are plot output current(I_C) versus output voltage (V_{CE}) for a range of values of input current (I_B)
- The input characteristics are plot of the input current (I_B) versus the input voltage (V_{BE}) or a range o output voltage (V_{CE})
- $I_{CE0} = \beta * I_{CB0}$
- For V_{CE} is increase will influence on the magnitude of the collector current
- The collector current in common emitter is different from case common base, the reason is :

$I_C = \alpha I_E + I_{CB0}$; By substitution the gives

$I_C = \alpha(I_C+I_B) + I_{CB0}$

Rearranging:- $I_C = \frac{\alpha IB}{1-\alpha} + \frac{ICB0}{1-\alpha}$

If I_B= 0 A, and typically α = 0.996 then we get

$I_C = \frac{\alpha(o)}{1-\alpha} + \frac{ICB0}{1-0.996} = \frac{ICB0}{0.004} = 250 I_{CB0}$ if $I_{CB0} = 1\mu A$ ➡ $I_C = 0.25$ mA

So $I_C = \frac{ICB0}{1-\alpha}$ for $I_B = 0$

- So Beta , $\beta_{dc} = \frac{IC}{IB}$ but for $\beta_{ac} = \frac{\Delta IC}{\Delta IB}$ for V_{CE} is constant

3. Common collector configuration

The common collector is used primarily for impedance-matching purposes since it has high input impedance and low output impedance, opposite to that of the common-base and common emitter configuration.

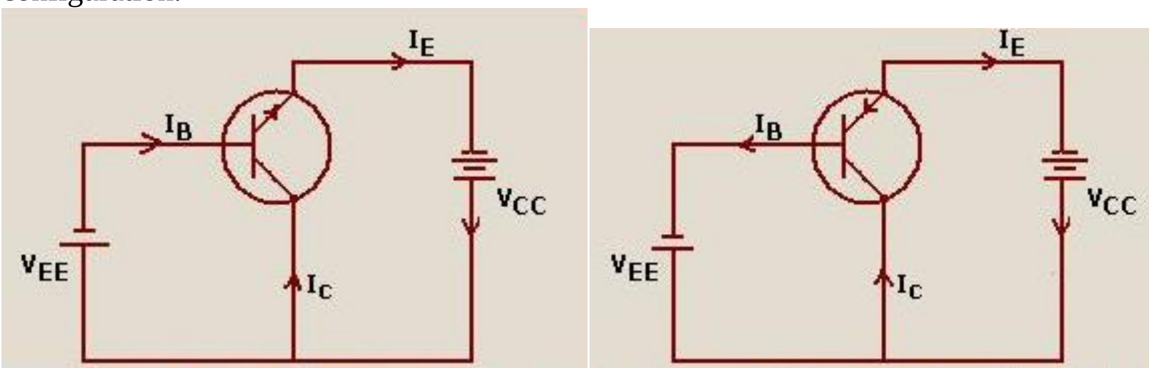

Fig.14:a: pnpCommon collector configuration b: npnCommon collector configuration

- For the common-collector the output characteristics are a plot of I_E versus V_{EC} for a range of values of $I_{B.}$
- The input current is the same for both the common-emitter and common collector characteristics
- The horizontal voltage axis for common collector is obtained by simple changing the sign of the collector to emitter voltage of the common emitter characteristics.

Limit of operation

$P_C = V_{CE} * I_C$
$I_{CE0} \leq I_C \leq I_{Cmax}$
$V_{CEsat} \leq V_{CE} \leq V_{CEmax}$
$V_{CE} I_C \leq P_{Cmax}$

For the common-base characteristics the maximum power is defined by the following product of output quantities:
$P_{Cmax} = V_{CB} * I_C$

Problems: 31-determine the region of operation for a transistor having the characteristics of fig. 3.8 (in the book)ifI_{Cmax}= 6 mA, V_{CBmax}= 15 V, P_{Cmax}= 30 mA

$$I_C = I_{C_{max}},\ V_{CE} = \frac{P_{C_{max}}}{I_{C_{max}}} = \frac{30\ \text{mW}}{6\ \text{mA}} = \mathbf{5\ V}$$

$$V_{CB} = V_{CB_{max}},\ I_C = \frac{P_{C_{max}}}{V_{CB_{max}}} = \frac{30\ \text{mW}}{15\ \text{V}} = \mathbf{2\ mA}$$

$$I_C = 4\ \text{mA},\ V_{CB} = \frac{P_{C_{max}}}{I_C} = \frac{30\ \text{mW}}{4\ \text{mA}} = \mathbf{7.5\ V}$$

$$V_{CB} = 10\ \text{V},\ I_C = \frac{P_{C_{max}}}{V_{CB}} = \frac{30\ \text{mW}}{10\ \text{V}} = \mathbf{3\ mA}$$