Biasing circuits.

* when transistor when it is an amplifier the first thing to remember is that it is has to be biased in the active Region.

* when we give a Small Ac Signal at the input of the transistor then it will be able to amplify it to a large Signal

* faithful Amplification → biased properly.

Biasing

* the proper Selection of the operating point or Maintanance of proper level of Dc Voltage and cnts.

* Common Emitter transistor → high Amplification factor and β.

* for faith full Amplification.

  BEJ → FB   CBJ → RB.

to achieve faithful Amplification, the following basic condition must be satisfied.

FB { i) proper Zero Signal collector cnt
ii) Minimum proper base Voltage (V_{BE}) at any Instant

RB [iii] Minimum collector_emitter Voltage (V_{CE}) at any Instant

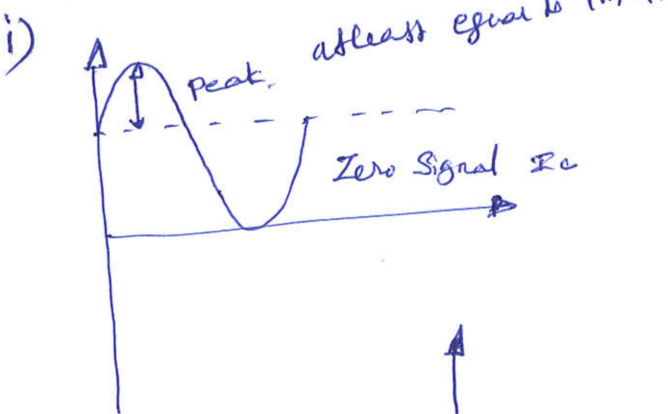
It should ensure the stabilisation of operating point

Methods of transistor Biasing

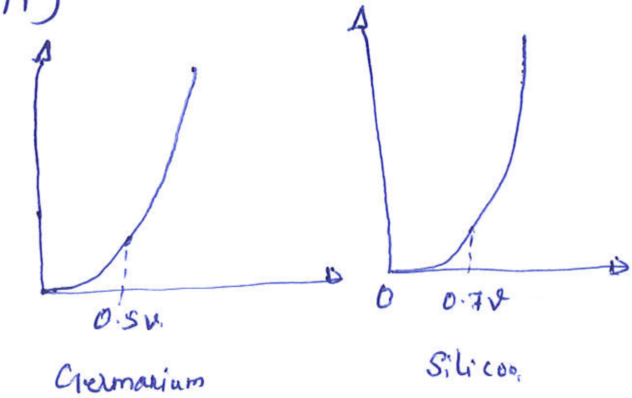
* Fixed Bias ckt [Base Bias]
* collector-to-Base Bias circuit
* Fixed Bias with Emitter Resistor.
* Voltage Divider Bias
* Emitter Bias.

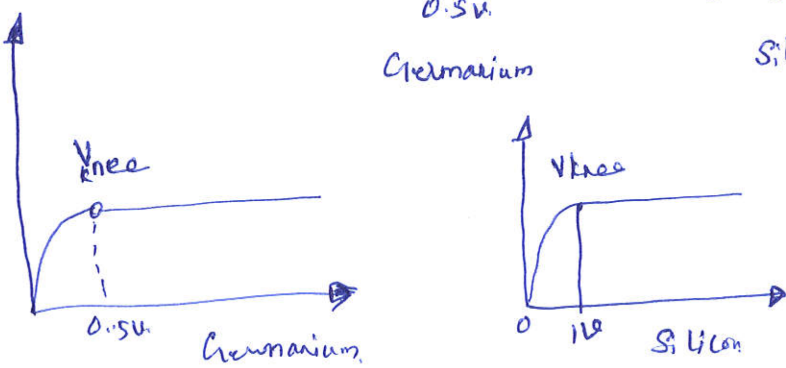
Fixed Bias

i)



ii)





Fixed bias

* This bias also called as Base Bias.

→ I_B Relatively constant.

↳ by collector bias I_C, V_{CC} and R_B

Since V_{CC}, V_{BE}, and R_B are constant, I_B remains constant at particular level. therefore this type of is called fixed bias type of circuit.

Input section.

KVL around the supply - base - ground circuit we get.

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

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

Solving for I_B.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

here

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

$$\therefore \quad I_B = \frac{V_{CC}}{R_B}$$

The Main purpose of the dc biasing circuit is to setup intial dc Values of.

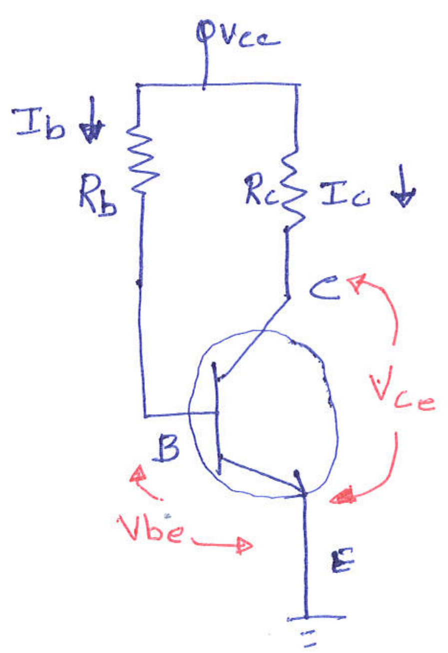
* Base current
* collector current
* colletor - Emitter Voltage, from Single

power supply V_{cc}.

* The initial dc Values are called operating point

also known as bias point, quiesent point, or Q. point,

Fixed bias ckt.



output section.

Applying the KVL around the Supply - collector ground circuit.

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

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

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

particular CE Trs is denoted β or hfe.

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

As per operating point of CE circuit

$$V_{CE} = 0V.$$

$$I_B = \frac{V_{CC}}{\beta R_C} \rightarrow (1) \quad \text{and} \quad I_B = \frac{V_{CC}}{R_B} \rightarrow (2)$$

Solving R_B from equations (1) & (2).

$$\boxed{R_B = \beta R_C}$$

Merits.

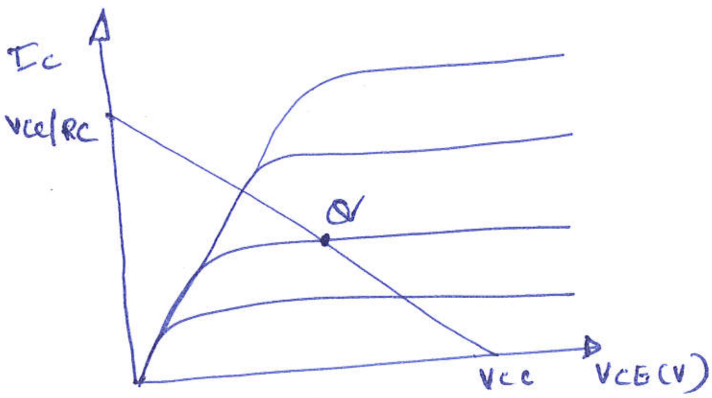
* Simple circuit, very small no of components are Required.
* operations is very Simple.

Demerits.

* I_c does not remain constant with variation in temperature or power supply voltage. ∴ operating point is unstable.

* when the transistor is replaced with another one. β value also change. So Q/P ~~also~~ point will shift.

*

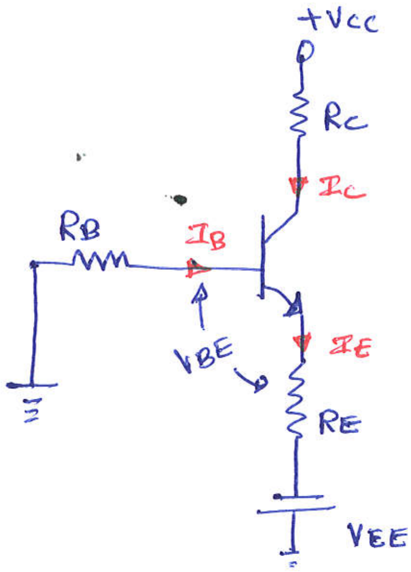


RB is varied
Rc is varied
Vcc is varied
Q point will shift

* It is used only small-signal transistors.
* Stability factor = β+1 → we ensure the s.f.
* Stability factor less than 25 is prefered
* Small signal amplifier transistors have large stability factors.

* so fixed bias is rarely NOT used in linear circuits.

Emitter bias.



* This circuit differ from Base circuit in two Important Respects.

* first
  ↳ two separate d.c. Voltage source.
    * one +ve Vcc
    * other -ve VEE

* Normally two supply will be equal.
  for example $V_{CC} = +20V$
  $V_{EE} = -20V$.

* Secondly.
  There is a Resistor R_E in the emitter circuit

Circuit Analysis.

i) Collector current. [I_C]

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

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

$I_C \simeq I_E$ $I_C = \beta I_B$ $\therefore I_B \simeq \frac{I_E}{\beta}$.

putting $I_B = I_E/\beta$

$$V_{EE} = \left[I_E/\beta\right] R_B + I_E R_E + V_{BE}$$

$$V_{EE} - V_{BE} = I_E \left(R_B/\beta + R_E \right)$$

$$I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} \Rightarrow \frac{V_{EE} - V_{BE}}{R_E}$$

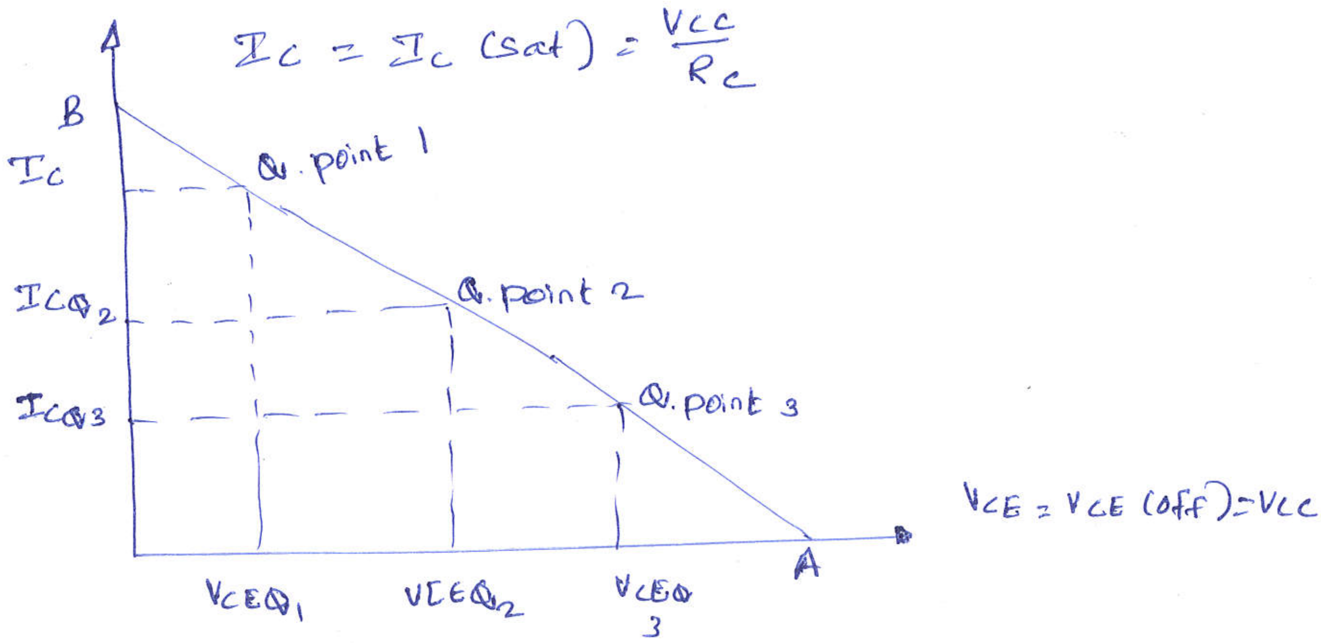
Since $I_C \simeq I_E$

$$I_C = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta}$$

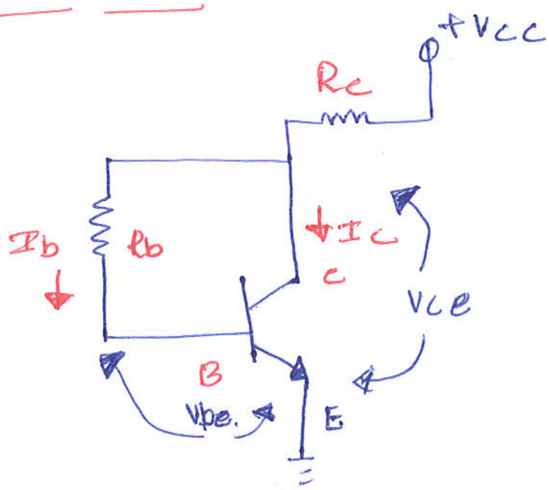
The operating point is independant of β

$$\text{if} \quad R_E >> \frac{R_B}{\beta}.$$

D.C. load line



Collector to Base Bias.



* This configuration employs -ve feedback to prevent thermal runway

* R_B is connected to the collector.

Input Section.

KVL

$$V_{CC} = V_{R_C} + V_{R_b} + V_{be}$$

Voltage across the Base Resistor.

Voltage drop across Rc

$$V_{Rb} = V_{CC} - (I_C + I_b)R_C - V_{be}$$

↳ Voltage at base

from

$$I_C = \beta I_B$$

$$V_{Rb} = V_{CC} - [\beta I_B + I_b] R_C - V_{be}$$

$$= V_{CC} - I_b(\beta+1)R_C - V_{be}$$

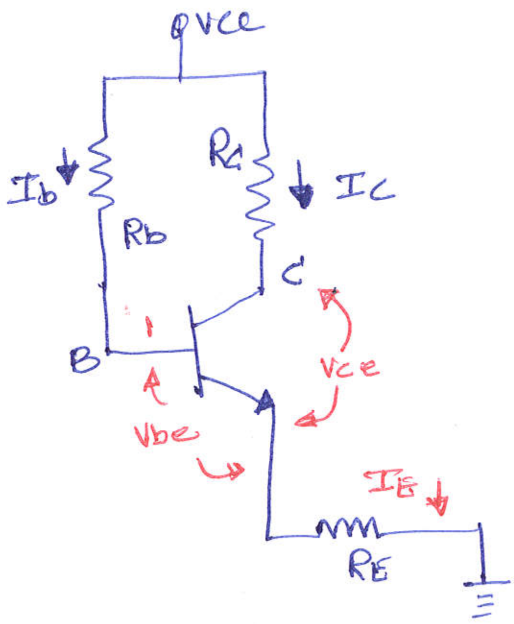
From ohms law at Base current

$$I_b = V_{Rb}/R_b \rightarrow V_{Rb} = I_b R_b$$

$$I_b R_B = V_{CC} - I_b(\beta+1)R_C - V_{be}$$

$$I_b = \frac{V_{CC} - V_{be}}{R_b + (\beta+1)R_C}$$

Fixed bias with Emitter resistor.



Input Section.

Applying KVL

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

Voltage across Base Resistor is

$$V_{RB} = V_{CC} - I_E R_E - V_{BE}.$$

from ohms law

Base cnt is $I_B = \frac{V_{RB}}{R_B}$ →

I_E increases the emitter voltage

$V_E = I_E R_E$ $I_C = \beta I_B$

for $I_B << \beta I_B$ $\rightarrow$ $$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta R_C}$$

Output Section.

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

$$V_{CE} = V_{CC} - I_C R_C = V_{CC} - \beta I_B R_C.$$

$$I_C = \beta I_B$$

$$= \frac{\beta (V_{cc} - V_{be})}{R_b + R_c + \beta R_c} \simeq \frac{V_{cc} - V_{be}}{R_c}$$

- Operating point is kept stable

lesser $\rightarrow$ $I_C \uparrow$ temp $\rightarrow$ opposed.

Merits

Circuit stabilizes the operating point against variations in temperature and β.

De-merits

I_C independant of β. $\rightarrow$ Reduce voltage gain
trade off
$\rightarrow$ Q. point stability.

Merits

The circuit has the tendancy to stabilize operating point against changes in temperature and β value.

De-merits,

$$I_C = \beta I_B = \frac{\beta (V_{CC} - V_{be})}{R_B + (\beta+1) R_E} \simeq \frac{V_{CC} - V_{be}}{R_E}$$

$\therefore (\beta+1) R_E >> R_B$

R_E causes the ac feedback which reduces the voltage gain.

Applications

* The feedback also increases the input impedance of the amplifier when seen from the base,
* only can be used only with careful consideration of the trade-offs.

Collector cnt and emitter cnt related by $I_C = \alpha I_E$.

with $\alpha \simeq 1$ so

Increase in emitter current with temp opposed.

* operating kept stable

$\therefore$

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

$I_E = I_C + I_B$.

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

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

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

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

Output Section.

$I_C = \beta I_B$.

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

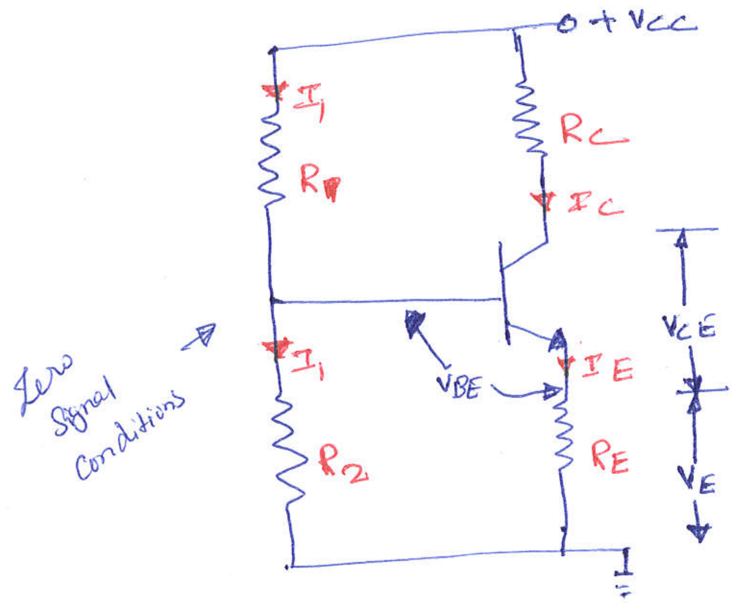
$V_{CE} = V_{CC} - (I_C R_C + I_E R_E)$

$I_C \simeq I_E$

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

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

Voltage divider Bias Method.



* Most widely used Method of providing biasing and stabilisation to a transistor.

* R_1 & R_2 provide Biasing

* R_E provide stabilisation.

* "Voltage divider" comes from the voltage divider formed by R_1 and R_2.

Circuit analysis.

i) Collector current I_c

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

∴ Voltage across Resistor R_2 is

$$V_2 = \left[\frac{V_{cc}}{R_1 + R_2}\right] R_2.$$

$V_E = I_E R_E$

or

$V_2 = V_{BE} + V_E \Rightarrow V_2 = V_{BE} + I_E R_E$

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

$$I_E \simeq I_C$$

$$I_C = \frac{V_2 - V_{BE}}{R_E}.$$

∴ I_C practically Independant of V_{BE}.

* so due to I_C → provide good stabilisation is ensured.

* It is Universal Method for providing transistor biasing.

Collector emitter voltage. V_{CE}

Applying KVL to the collector side.

$I_E \simeq I_C$

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

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

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

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

∴ In this circuit Excellent stabilisation is provided by R_E.