Chapter -

Transistor Biasing & Stabilisation -

The main function of Transistor is amplifier (ampr).

Amplifier, basically it amplify the weak signal.

→ actually it increases the magnitude of signal without any change in shape.

And the condition which allow the transistor to give desired o/p is called Biasing.

In other words,

Transistor Biasing is the process of setting a transistor DC operating voltage or current condition to the correct level, so that any AC i/p signal can be amplified correctly by the transistor.

There are many factors which affects the operation of a transistor. Q - point is one of them.

Q point is the operating point of a transistor (I_{CQ}, V_{CEQ}) at which it is biased. The concept of Q - point is used when the transistor act as an amplifier & hence operated in active region.

Biasing of Transistor

Before applying any AC i/p biasing is applied for proper functioning.

for active region J_E is FB & J_C is RB.

→ After appling DC voltage, DC current starts to flow in circuit. which can be plot by o/p char of transistor.

→ The Q point values can be calculated by drawing the intersection of o/p char & Load line.*

* DC load line is the locus of I_C & V_{CE} at which BJT remain in active region. (i.e it represents all the possible combination of I_C & V_{CE} for a given ampr.

→ Factor affects the operating point.

There are some factors which try to shift Q- point

i) Variation of parameters –

we know α & β are decided at the time of manufacturing.

But what a component is replaced after demage, And Ideally it is not possible for two transistor with same α or β. so they may change Q-point.

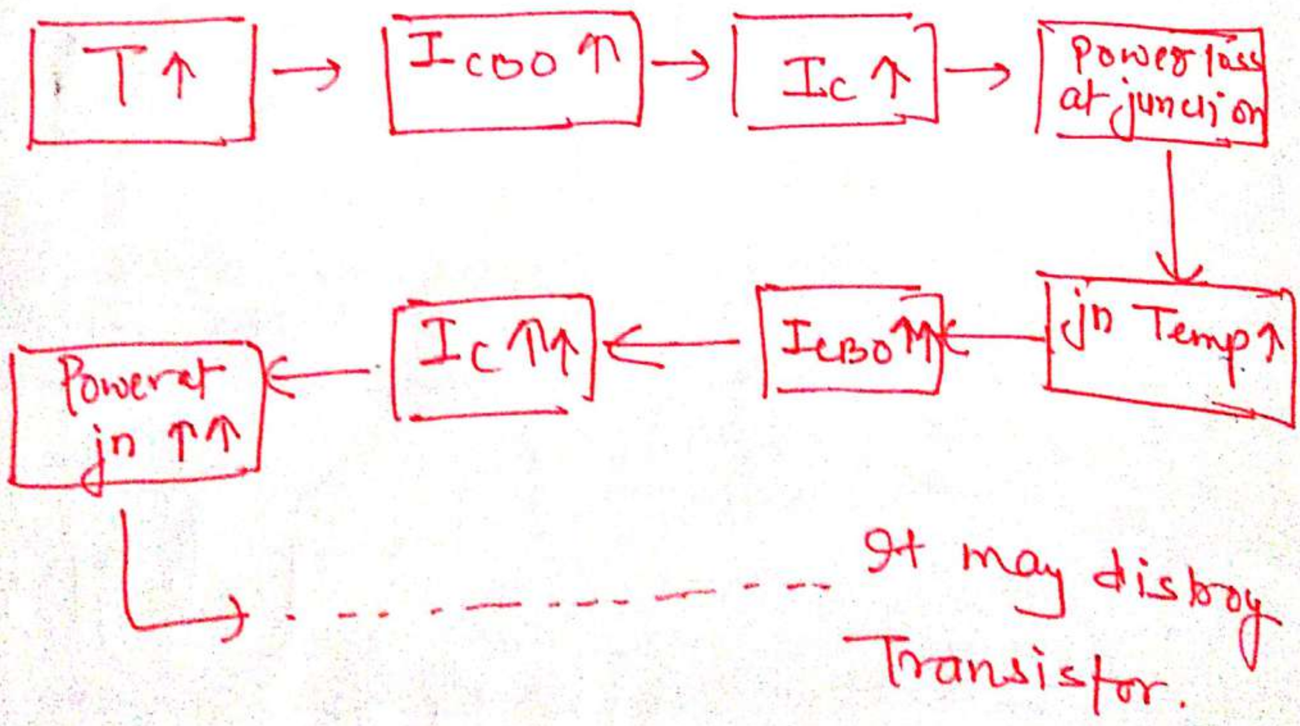
ii) Variation of Temp –

As we know I_C is dependent on I_{CBO}

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

& I_{CBO} is highly dependent to temp as it is developed by minority charge carrier.
So, temp can also affect Q-point.

<u>Thermal runaway</u> – If temp ↑ rapidly it may convert to thermal runaway.



Methods of Transistor Biasing –

There are four methods of transistor biasing.

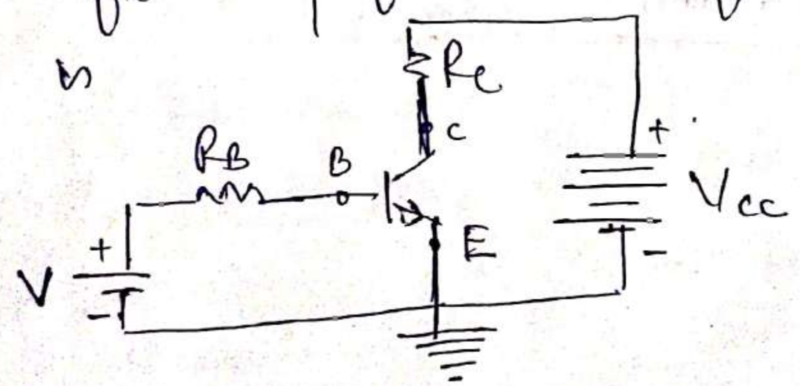
i) Fixed Bias
ii) Collector to Base Bias.
iii) Emitter Bias.
iv) Self Bias or voltage devider Bias.

i) Fixed Bias Circuit –

The fixed Bias Circuit is the simplest transistor DC Biasing.

Even pnp tr is used in place of npn the configuration will be same by changing all the current direction & voltage polarities.

After simplification the final circuit obtain is



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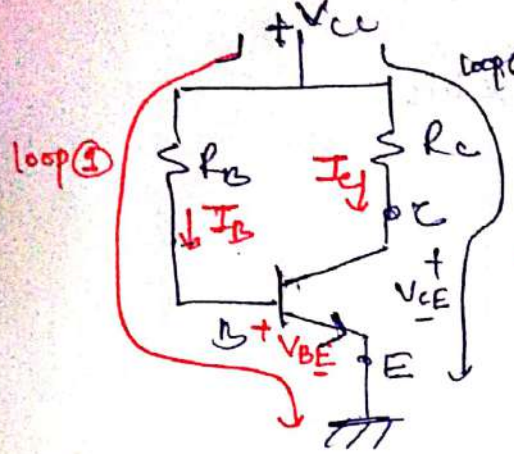


By applying KVL in loop ①

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

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

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

Circuit with only one Battery.

V_{CC} & V_{BE} are constant values, so I_B depends upon R_B.

By applying KVL in loop ②

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

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

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

$I_C = \beta I_B$ (assume $I_{CBO} = 0$)
(Actually $I_{CBO} \simeq 0$)

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

$$\boxed{V_{CE} = V_C - V_E}$$

Stability factor of fixed Bias.

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

for fixed Bias

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

So, $$S = \frac{\beta+1}{1-\beta\cdot 0} = \beta+1$$

Advantage

Simple in connection

construction is simple

disadvantage

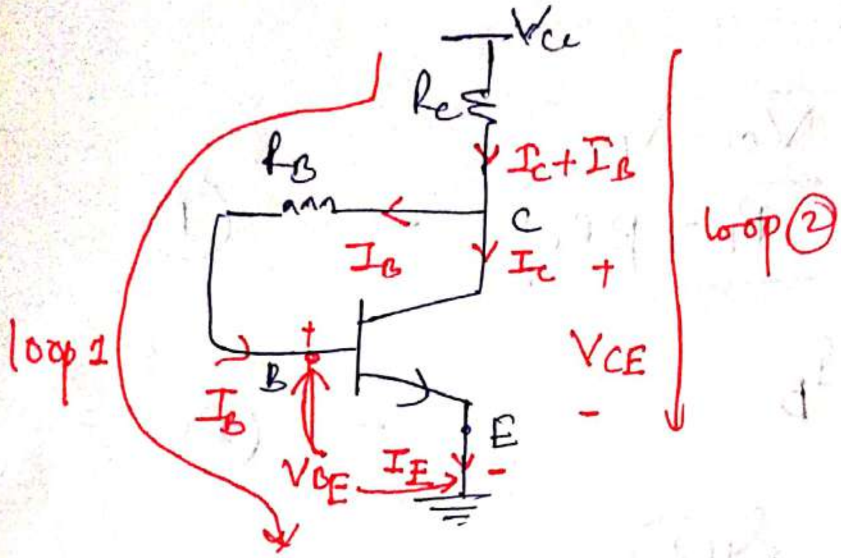
Poor thermal stability.

Collector to Base Bias ckt -

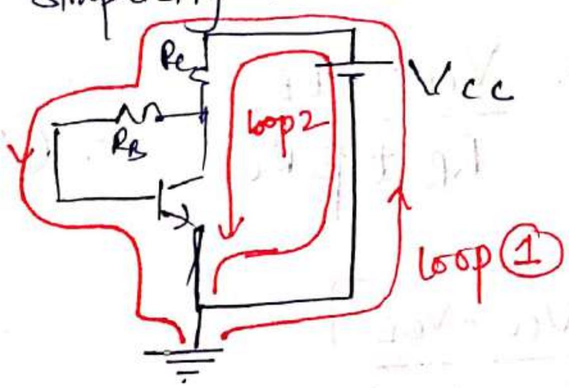
In this configuration, bias voltage to the base is given by collector instead of direct V_{cc} (as in fixed biasing ckt).

R_B is used as feedback.

for DC analysis circuit shown is figure.



for simplicity we can redraw the circuit



the loops drawn in ckt 1 & 2 are same

$$+V_{cc} - R_c(I_c + I_B) - R_B I_B - V_{BE} = 0 \quad \text{--- (A)}$$

$$V_{cc} - V_{BE} = R_c(I_c + I_B) + R_B I_B$$

$$= I_B(R_c + R_B) + R_c I_c$$

$$= I_B(R_c + R_B) + \beta I_B R_c$$

$$= I_B(R_c + R_B + \beta R_c)$$

$$V_{cc} - V_{BE} = I_B(R_B + R_c(1+\beta))$$

$$I_B = \frac{V_{cc} - V_{BE}}{R_B + R_c(1+\beta)}$$

As β is very large so,

$\beta + 1 \simeq \beta$

so $$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta R_e}} \quad \text{--- (1)}$$

$$I_C = \beta I_B \quad \text{--- (2)}$$

from (1) & (2)

$$I_C = \beta \frac{V_{CC} - V_{BE}}{R_B + \beta R_e} \quad \text{--- (3)}$$

$$\boxed{I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta}}$$

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

$$\boxed{I_C = \frac{V_{CC}}{R_C + R_B/\beta}} \quad \text{--- (4)}$$

from loop (2)

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

as $I_C >> I_B$

so $$\boxed{V_{CE} = V_{CC} - I_C R_C} \quad \text{--- (5)}$$

Stability factor

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

from eq^n (A)

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

$$V_{CC} - V_{BE} - I_C R_C = I_B(R_C + R_B)$$

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

differentiating w.r.t I_C

$$\frac{dI_B}{dI_C} = \frac{0 - 0 - 1 R_C}{R_C + R_B}$$

$$= \frac{-R_C}{R_C + R_B}$$

$$S = \frac{1+\beta}{1-\beta\left(\frac{-R_C}{R_C+R_B}\right)}$$

$$\boxed{S = \frac{1+\beta}{1+\beta\left(\frac{R_C}{R_C+R_B}\right)}}$$

Advantage —

Simple Biasing, only R_B is required.

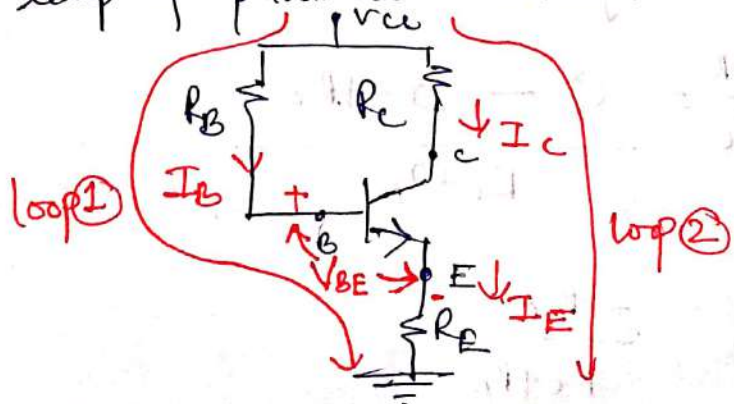
disadvantage

S is very high.

Emitter Bias

It is also known as base bias with emitter feedback.

It contains R_E to improve stability. the more stable a configuration, the less its response will change due to undesirable change in temp. & parameter variation.



KVL in loop①

$$V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0 \quad \text{—— (1)}$$

$$I_E = (\beta+1) I_B \quad \text{—— (2)}$$

from ① & ②

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_E}} \quad \text{—— (3)}$$

$$I_C = \beta I_B$$

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

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

$$I_C = \frac{V_{CC}}{R_E + R_B/\beta}$$

from loop (2)

$$V_{CE} + I_E \cdot R_E - V_{CC} + I_C R_C = 0$$

Since $I_E \cong I_C$

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

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

$$\boxed{V_E = I_E R_E = I_C R_E}$$

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

Stability factor.

from eqn (1)

$$V_{BE} + I_E R_E - V_{CC} + I_B R_B = 0 \quad \text{— (A)}$$

$$I_E = I_B + I_C \quad \text{— (B)}$$

from eqn (A) & (B)

$$V_{BE} + (I_B + I_C) R_E - V_{CC} + I_B R_B = 0$$

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

diff. w.r.t I_C

$$\frac{dI_B}{dI_C} = \cancel{V_{CC}} \; \frac{0 - 0 - R_E}{R_E + R_B}$$

$$S = \frac{1+\beta}{1 - \beta\left(-R_E / (R_E + R_B)\right)}$$

$$\boxed{S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_E+R_B}\right)}}$$

<u>Advantage</u>

Has better stablization.

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