Unit -> 1 Diode Circuits

Subject -> Analog Circuits

Faculty -> Dr Nidhi chauhan

Paper code -> BT 402

Lecture 4 -> BJt biasing

Bias Stabilization

- Stabilization is a process of making Q-point independent of changes in temperature and changes in transistor parameter.
- If I_{CO}, V_{BE} and β changes simultaneously then net change in I_C

$$\Delta I_C = \frac{\partial I_C}{\partial I_{CO}} \Delta I_{CO} + \frac{\partial I_C}{\partial V_{BE}} \times \Delta V_{BE} + \frac{\partial I_C}{\partial \beta} \Delta \beta$$

where, $\frac{\partial I_C}{\partial I_{CO}} = S \rightarrow$ Current stability factor

$\frac{\partial I_C}{\partial V_{BE}} = S' \rightarrow$ Voltage stability factor

$\frac{\partial I_C}{\partial \beta} = S_\beta = S'' \rightarrow$ Amplification stability factor

Note:

Out of three stability factor S is most significant reason being, if S is within tolerable limit then other S' and S'' are guaranteed to remain within tolerable limit.

$$S_{\text{ideal}} = 1$$

Practically S should be less than 20.

$$\text{Alternate evaluation of } S = \frac{1+\beta}{1-\beta\frac{\partial I_B}{\partial I_C}}$$

BJT Biasing

Biasing refers to providing appropriate DC voltage and DC current to an electronics device to operate it in a desired way.

A BJT is biased:

(i) To operate the BJT in active region so that it can be used as amplifier.

(ii) To maintain I_C stable so that the operating point does not drift and thermal run away does not happen.

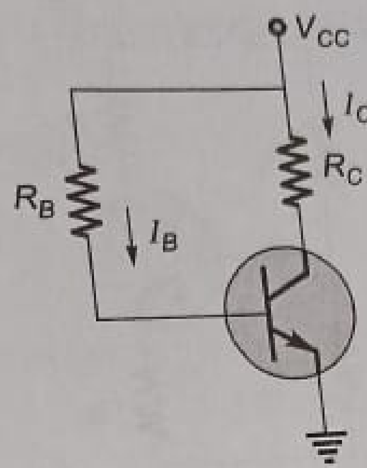
Commonly Used BJT Biasing Circuit are:

(i) Fixed biased circuit

(ii) Collector to base bias circuit.

(iii) Self bias circuit

(i) Fixed biased circuit

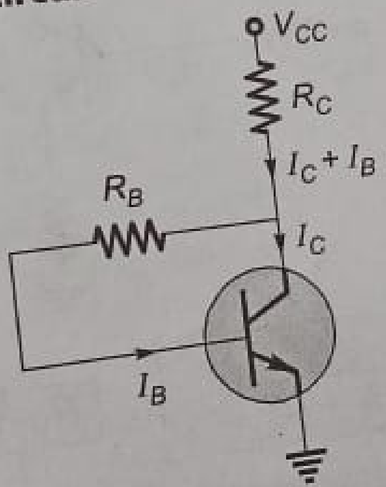


$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \quad ; \quad I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

I_B is constant or fixed. Hence circuit is called fixed biased circuit.

$S = 1 + \beta$; since S is very large I_C will be unstable.

(ii) Collector to Base bias circuit



$$I_C = \frac{V_{CC} - V_{BE}}{R_C}$$ (Assuming β to be large or $I_B \approx 0$)

$$I_C = \left[\frac{V_{CC} - V_{BE}}{R_C}\right] \times \left[\frac{\beta}{\beta + 1}\right]$$

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

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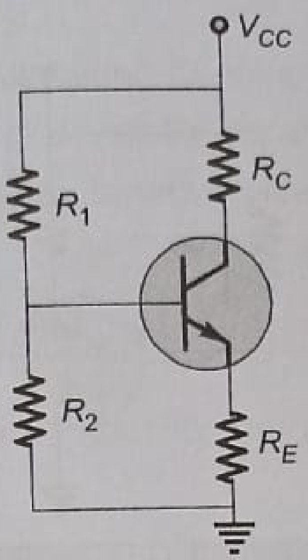
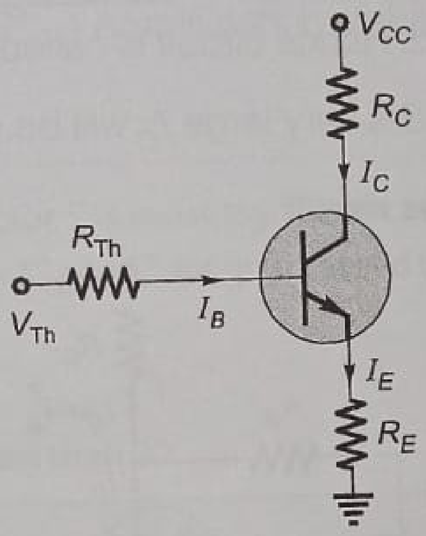
Advantage: It gives more stable I_C than fixed biased circuit.

Drawback: Stability factor depend upon R_C, if R_C becomes smaller or zero, stability factor becomes very large and I_C does not remain stable.

(iii) Self-Bias Circuit (Voltage Divider Circuit)



Thevenin Equivalent



$$V_{Th} = \frac{R_2}{R_1 + R_2} V_{CC} \quad ; \quad R_{Th} = R_1 \| R_2$$

$$I_C \cong \frac{V_{CC} - V_{CE}}{R_C + R_E} \quad ; \quad I_E = \frac{V_{Th} - V_{BE}}{\left(R_E + \dfrac{R_{Th}}{\beta + 1}\right)}$$ (Assuming β to be large)

$$S = \frac{1 + \beta}{1 + \beta\left(\dfrac{R_E}{R_{Th} + R_E}\right)}$$ if $(1 + \beta) R_E >> R_{Th}$.

Advantages:

(i) Self bias circuit has least stability factor among all biasing circuits.

(ii) Stability factor is independent of R_C.

(iii) Self bias circuit can be used to bias BJT for any configuration.

Drawback:

(i) Resistance R_E creates negative feedback due to which voltage gain $\frac{V_o}{V_i}$ or $\frac{V_o}{V_s}$ becomes smaller.

Thermal Run-away

It is the process of self destruction or damage of a transistor where an increase in temperature increase the collector current, causing a further increase in the temperature.

Thermal resistance (θ)

$$\theta = \frac{T_j - T_A}{P_D} \quad (^\circ\text{C/Watt or } ^\circ\text{K/Watt})$$

where, $T_j \rightarrow$ Junction temperature (collector junction)

$T_A \rightarrow$ Ambient temperature in Kelvin

$P_D \rightarrow$ Power dissipated across collector junction

Condition to avoid thermal run away

A transistor will be thermally stable if

$$\boxed{\frac{\partial P_C}{\partial T_j} \leq \frac{\partial P_D}{\partial T_j} = \frac{1}{\theta}}$$

where, $\frac{\partial P_C}{\partial T_j} \rightarrow$ Rate at which heat is released

$\frac{\partial P_D}{\partial T_j} \rightarrow$ Rate at which heat is dissipated

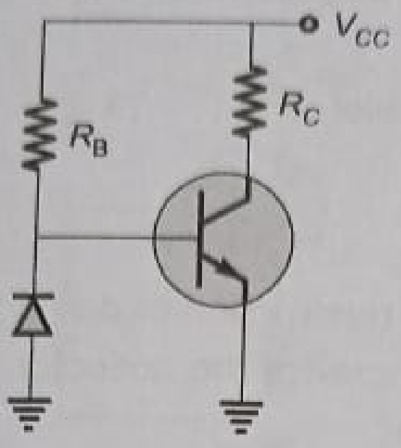
- For thermal stability $\boxed{V_{CE} < \frac{V_{CC}}{2}}$

Compensation Method

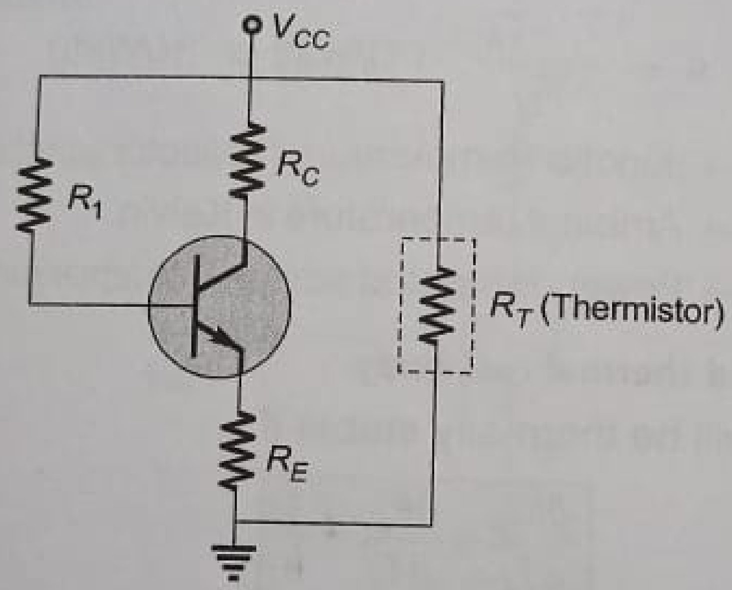
- In this method collector current is made stable by connecting temperature dependent devices such as diode, thermistor, sensistor.
- Thermistor and sensistor are temperature dependent resistors.

Thermistor	Sensistors
1. Temperature coefficient is negative	1. Temperature coefficient is positive
2. Fabricated from pure semiconductor	2. Fabricated from heavily doped semiconductor

1. Diode compensation for I_{co}



2. Thermistor compensation for I_{co}



3. Compensation in self bias circuit