



Transistor Biasing

Transistor Biasing is the process of setting a transistors DC operating voltage or current conditions to the correct level so that any AC input signal can be amplified correctly by the transistor



Need for Biasing

- A transistors steady state of operation depends a great deal on its base current, collector voltage, and collector current and therefore, if a transistor is to operate as a linear amplifier, it must be properly biased to have a suitable operating point.
- Establishing the correct operating point requires the proper selection of bias resistors and load resistors to provide the appropriate input current and collector voltage conditions.



Q Point

- The correct biasing point for a bipolar transistor, either NPN or PNP, generally lies somewhere between the two extremes of operation with respect to it being either "fully-ON" or "fully-OFF" along its load line. This central operating point is called the "Quiescent Operating Point", or **Q-point** for short.

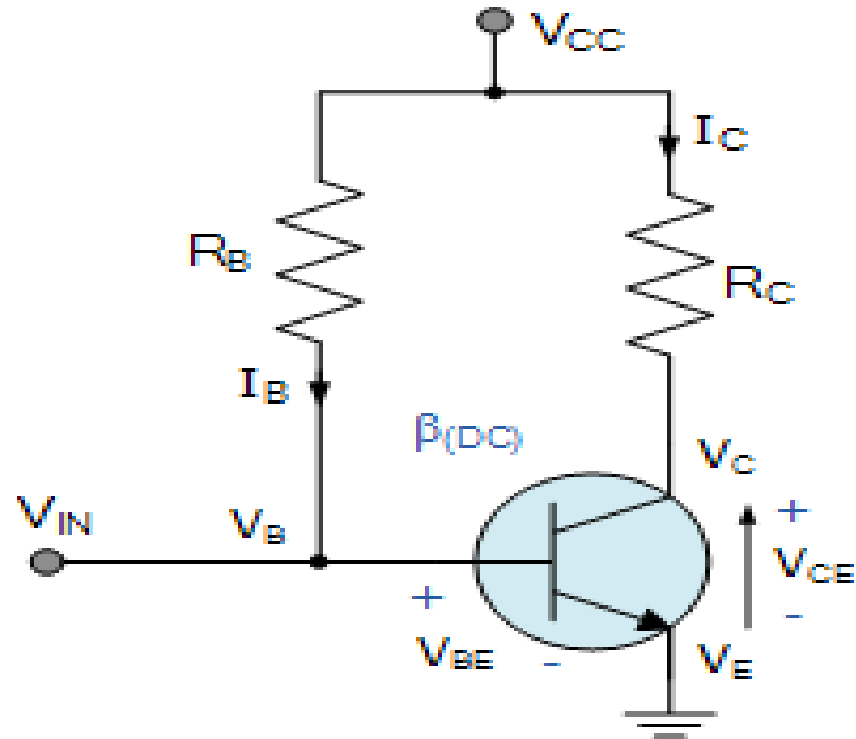


BJT Biasing methods

- The various types of biasing methods are:
 - Fixed Bias
 - Collector to base bias
 - Voltage divider bias



Fixed Bias



- The transistors base current, I_B remains constant for given values of V_{CC} , and therefore the transistors operating point must also remain fixed. Hence referred as fixed biasing



Fixed Bias

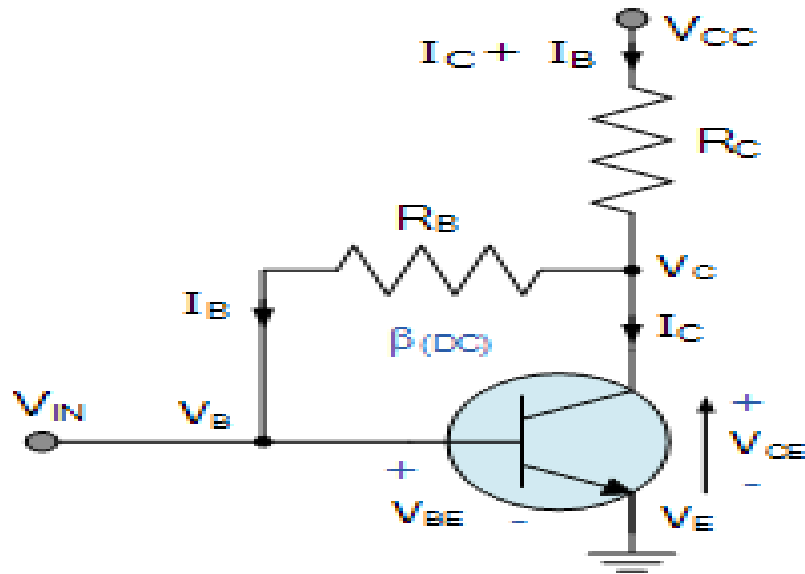
➤ This two resistor biasing network is used to establish the initial operating region of the transistor using a fixed current bias.

$$\begin{aligned}V_C &= V_{CC} - R_C(I_C + I_B) \\V_E &= 0V \\V_B &= V_{BE} \\I_B &= \frac{V_C - V_B}{R_B} \\I_C &= \beta_{(DC)} I_B \\I_E &= (I_C + I_B) \cong I_C\end{aligned}$$

➤ This type of transistor biasing arrangement is also beta dependent biasing as the steady-state condition of operation is a function of the transistors beta β value.



Collector to base bias



$$\begin{aligned}V_C &= V_{CC} - R_C(I_C + I_B) \\V_E &= 0V \\V_B &= V_{BE} \\I_B &= \frac{V_C - V_B}{R_B} \\I_C &= \beta_{(DC)} I_B \\I_E &= (I_C + I_B) \cong I_C\end{aligned}$$

➤ This self biasing collector feedback configuration is another **beta dependent biasing method** that requires only two resistors to provide the necessary DC bias for the transistor.



Collector to base bias

- The collector to base feedback configuration ensures that the transistor is always biased in the active region regardless of the value of Beta (β) as the DC base bias voltage is derived from the collector voltage, V_C providing good stability.
- The biasing voltage is derived from the voltage drop across the load resistor, R_L .
- So if the $I_L \uparrow$ ses $\rightarrow V_C \downarrow$ ses $\rightarrow I_B \uparrow$ ses back to normal.

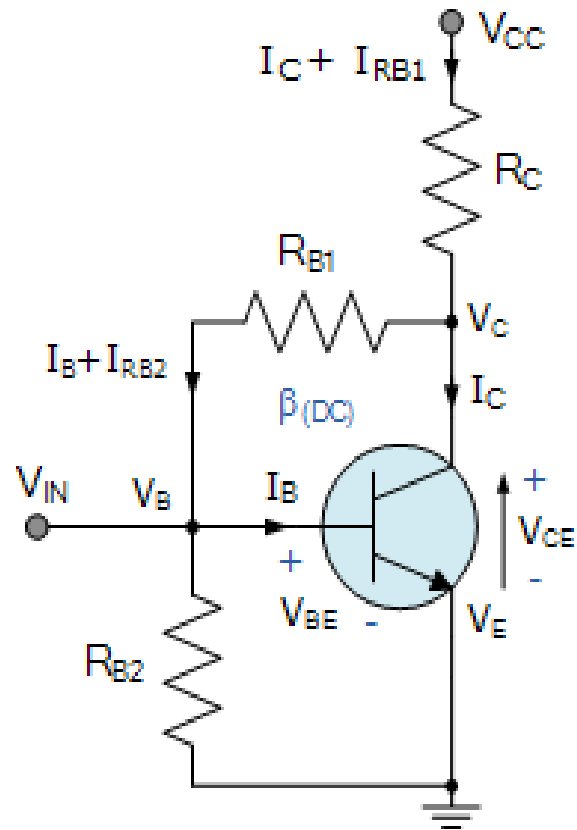


Collector to base bias

- The base bias resistor, R_B is connected to the transistors collector C , instead of to the supply voltage rail, V_{CC} . Now if the collector current increases, the collector voltage drops, reducing the base drive and thereby automatically reducing the collector current to keep the transistors Q-point fixed.
- Then this method of collector feedback biasing produces negative feedback as there is feedback from the output to the input through resistor, R_B .



Dual Feedback Transistor Biasing



$$\begin{aligned}V_C &= V_{CC} - R_C(I_C + I_{RB1}) \\V_E &= 0V \\V_B &= V_{BE} \\I_{RB2} &= \frac{V_B}{R_{B2}} \\I_{RB1} &= I_B + I_{RB2} = \frac{V_C - V_B}{R_{B1}} \\I_C &= \beta(DC)I_B \\I_E &= (I_C + I_B) \cong I_C\end{aligned}$$

An additional resistor to the base bias network of the previous configuration improves stability even more with respect to variations in Beta, (β) by increasing the current flowing through the base biasing resistors.

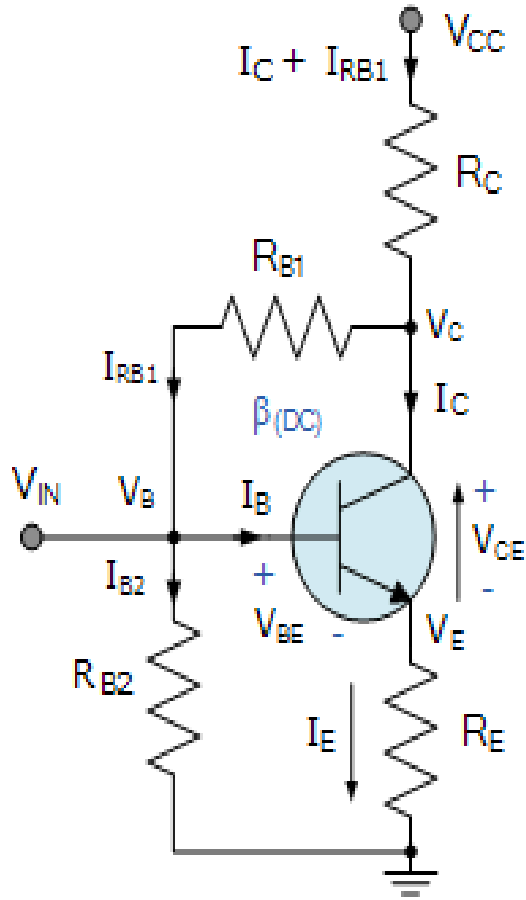


Dual Feedback Transistor Biasing

- The current flowing through R_{B1} is generally set at a value equal to about 10% of collector current, I_C . Obviously it must also be greater than the base current required for the minimum value of Beta, β .
- One of the advantages of this type of self biasing configuration is that the resistors provide both automatic biasing and R_f feedback at the same time



Transistor Biasing with Emitter Feedback



$$\begin{aligned}V_C &= V_{CC} - R_C(I_C + I_{RB1}) \\V_E &= I_E R_E = V_B - V_{BE} \\V_{CE} &= V_C - V_E \\V_B &= V_{BE} + V_E \\I_{RB2} &= \frac{V_B}{R_{B2}} \\I_{RB1} &= I_B + I_{RB2} = \frac{V_C - V_B}{R_{B1}} \\I_C &= \beta(DC) I_B \\I_E &= (I_C + I_B) \cong I_C\end{aligned}$$

- It uses both emitter and base-collector feedback to stabilize the collector current even more as resistors R_{B1} and R_E as well as the base-emitter junction of the transistor are all effectively connected in series with the supply voltage, V_{CC} .
- This type of transistor biasing configuration works best at relatively low power supply voltages.

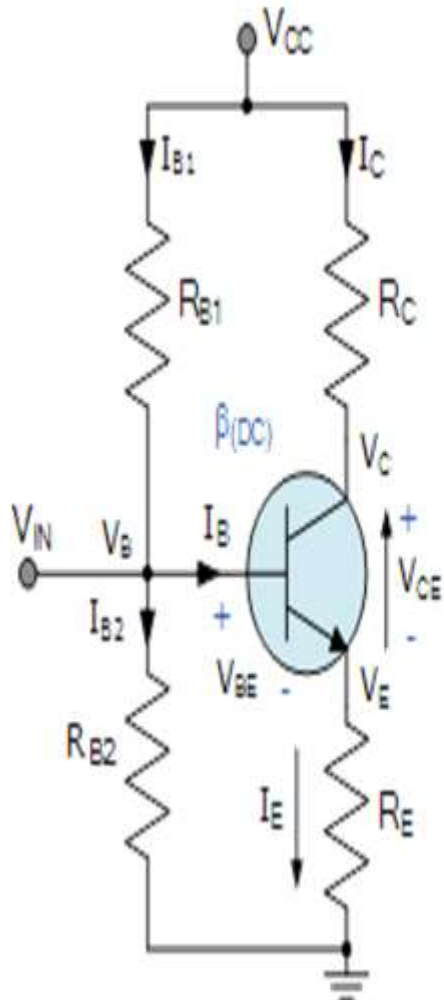


Transistor Biasing with Emitter Feedback

- The current flowing from the emitter, I_E (which is a combination of $I_C + I_B$) causes a voltage drop to appear across R_E in such a direction, that it **reverse biases the base-emitter junction**.
- So if the emitter current increases, voltage drop $I \cdot R_E$ also increases. Since the polarity of this voltage reverse biases the base-emitter junction, I_B automatically decrease.

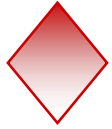


Voltage Divider Bias



$$\begin{aligned}V_C &= V_{CC} - R_C I_C = (V_E + V_{CE}) \\V_E &= I_E R_E = V_B - V_{BE} \\V_{CE} &= V_C - V_E = V_{CC} - (I_C R_C + I_E R_E) \\V_B &= V_{BE} + V_E = V_{RB2} = \left(\frac{R_{B2}}{R_{B1} + R_{B2}} \right) V_{CC} \\I_{B2} &= \frac{V_B}{R_{B2}} \\I_{B1} &= I_B + I_{B2} = \frac{V_{CC} - V_B}{R_{B1}} \\R_B &= \frac{R_{B1} \times R_{B2}}{R_{B1} + R_{B2}} \quad I_B = \frac{V_B - V_{BE}}{R_B + (1 + \beta) R_E} \\I_C &= \beta(DC) I_B \\I_E &= I_C + I_B = \frac{V_E}{R_E}\end{aligned}$$

- This voltage divider biasing configuration is the most widely used transistor biasing method, as the emitter diode of the transistor is forward biased by the voltage dropped across resistor R_{B2} .



Voltage Divider Bias

- Also, voltage divider network biasing makes the transistor circuit independent of changes in beta as the voltages at the transistors base, emitter, and collector are dependant on external circuit values.