Types of transistor biasing

The biasing in transistor circuits is done by using two DC sources V_{BB} and V_{CC}.

It is economical to minimize the DC source to one supply instead of two which also makes the circuit simple.

The commonly used methods of transistor biasing are

- Base Resistor method
- Collector to Base bias
- Biasing with Collector feedback resistor
- Voltage-divider bias

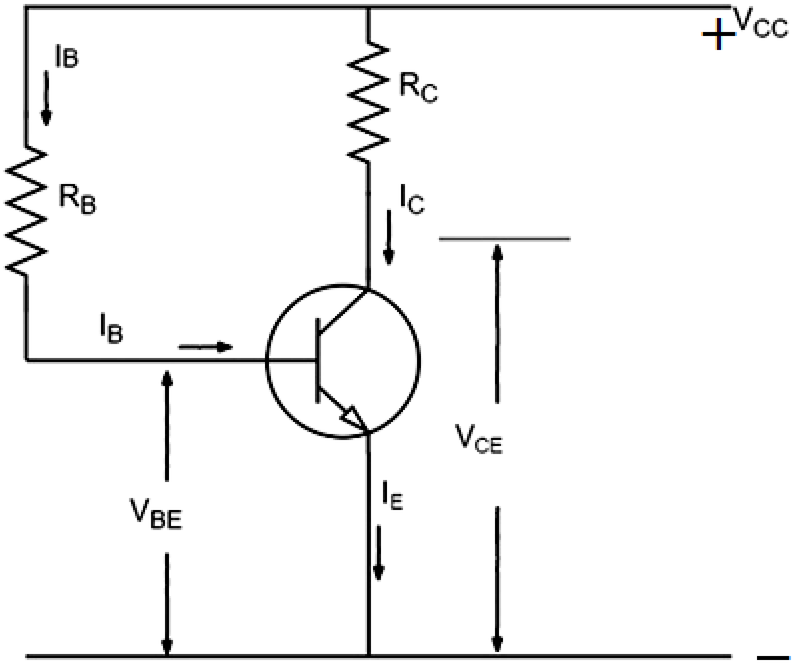
All of these methods have the same basic principle of obtaining the required value of I_B and I_C from V_{CC} in the zero signal conditions.

Base Resistor bias Method
அடிவாய் மின்தடை சார்பு முறை

- In this method, a resistor R_B of high resistance is connected to the base

- The required zero signal base current is provided by V_{CC} which flows through R_B.

- The base emitter junction is forward biased



The required value of zero signal base current and hence the collector current (as $I_C = \beta I_B$) can be made to flow by selecting the proper value of base resistor R_B.

Hence the value of R_B is to be known.

Let I_C be the required zero signal collector current.

Therefore,

$\beta = I_c / I_B$

$I_B = I_C / \beta$

Considering the closed circuit from V_{CC}, base, emitter and ground, while applying the Kirchhoff's voltage law, we get,

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

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

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

Therefore

$R_B = (V_{CC} - V_{BE}) / I_B$

Since V_{BE} is generally quite small as compared to V_{CC} it can be neglected

Then,

$R_B = V_{CC} / I_B$

V_{CC} is a fixed known quantity and I_B is chosen at some suitable value

As R_B can be found directly, this method is called as **fixed bias method**

Hence, this method is rarely employed.

Stability factor

$$S = \frac{\beta + 1}{1 - \beta\left(\frac{dI_B}{dI_C}\right)}$$

In fixed-bias method of biasing, I_B is independent of I_C so that,

$$\left(\frac{dI_B}{dI_C}\right) = 0$$

Substituting the above value in the previous equation,
Stability factor, S=β+1

Thus the stability factor in a fixed bias is (β+1) which means that I_C changes (β+1) times as I_{CO}.

Advantages

1. The circuit is simple.
2. Only one resistor R_B is required.
3. Biasing conditions are set easily.
4. No loading effect as no resistor is present at base-emitter junction.

Disadvantages

1. The stabilization is poor as heat development can't be stopped.
2. The stability factor is very high. So, there are strong chances of thermal run away.

Voltage Divider Bias Method
மின்னழுத்தப் பகுப்பான் சார்பு முறை

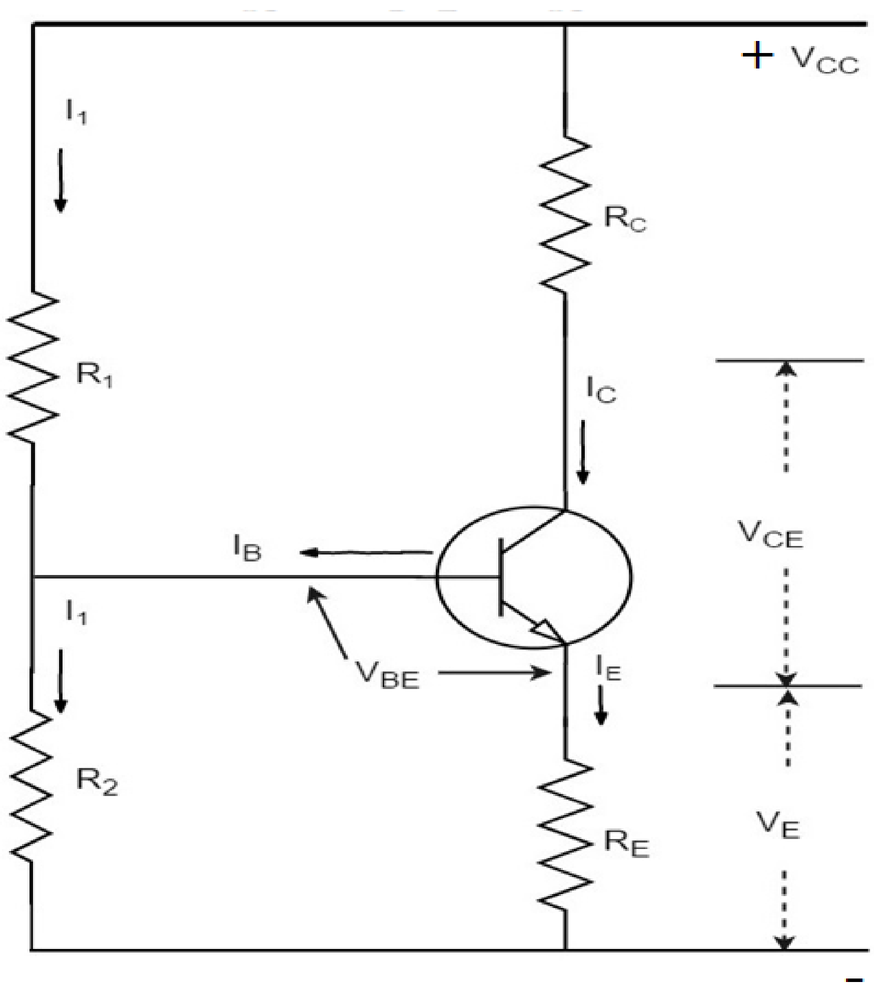
Among all the methods of providing biasing and stabilization, the **voltage divider bias method** is the most prominent one.

Here, two resistors R_1 and R_2 are employed, which are connected to V_{CC} and **provide biasing.**

The resistor R_E employed in the emitter provides **stabilization.**

The name voltage divider comes from the voltage divider formed by R_1 and R_2.

The figure below shows the circuit of voltage divider bias method.



- The voltage drop across R_2 forward biases the base-emitter junction

- This causes the base current and hence collector current flow in the zero signal conditions.

- Suppose that the current flowing through resistance R_1 is I_1.

- As base current I_B is very small, therefore, it can be assumed with reasonable accuracy that current flowing through R_2 is also I_1.

To derive the expressions for collector current and collector voltage

Collector Current, I_C

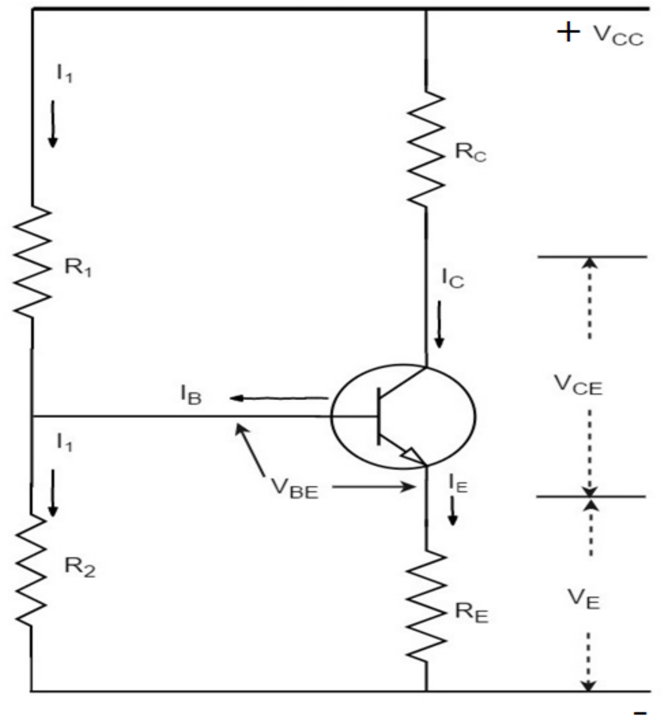
From the circuit, it is evident that,

$I_1 = V_{CC}/_{(}R_1 + R_{2)}$

Therefore, the voltage across resistance R_2 is

$V_2 = (V_{CC}/(R_1 + R_2)R_2$

Applying Kirchhoff's voltage law to the base circuit,



$V_2 = V_{BE} + V_E$

$V_2 = V_{BE} + R_E I_E$

$I_E = (V_2 - V_{BE}) / R_E$

Since $I_E \approx I_C$,

$I_C = (V_2 - V_{BE}) / R_E$

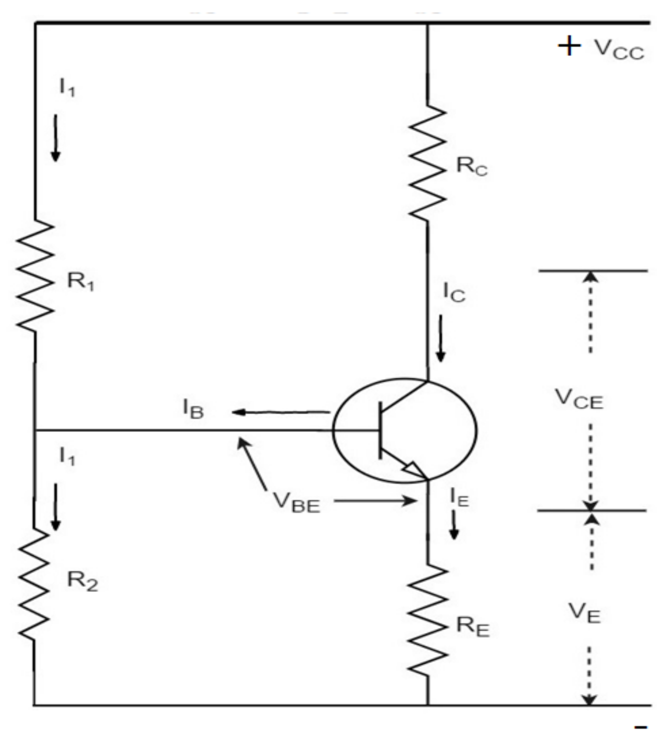
From the above expression, it is evident that I_C doesn't depend upon β.

V_{BE} is very small that I_C doesn't get affected by V_{BE} at all.

Thus I_C in this circuit is almost independent of transistor parameters and hence good stabilization is achieved.

Collector-Emitter Voltage, V_{CE}

Applying Kirchhoff's voltage law to the collector side,



$V_{CC}=I_CR_C+V_{CE}+I_ER_E$

Since $I_E \cong I_C$

$V_{CC}=I_CR_C+V_{CE}+I_CR_E$

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

Therefore,

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

R_E provides excellent stabilization in this circuit.

$V_2=V_{BE}+I_ER_E$

$V_2 = V_{BE} + I_C R_E$

$V_2 = R_2 V_{CC} / (R_1 + R_2)$

Suppose there is a rise in temperature, then the collector current I_C increases

This causes the voltage drop across R_E to increase.

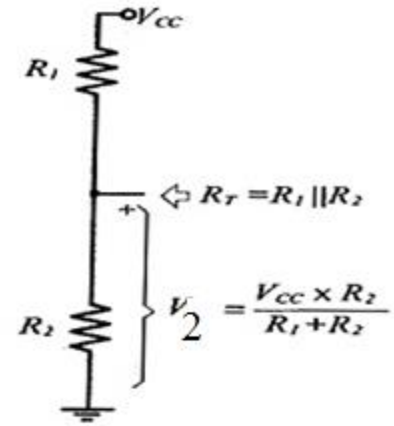
As the voltage drop across R_2 is V_2, which is independent of I_C, the value of V_{BE} decreases.

The reduced value of I_B tends to restore I_C to the original value.

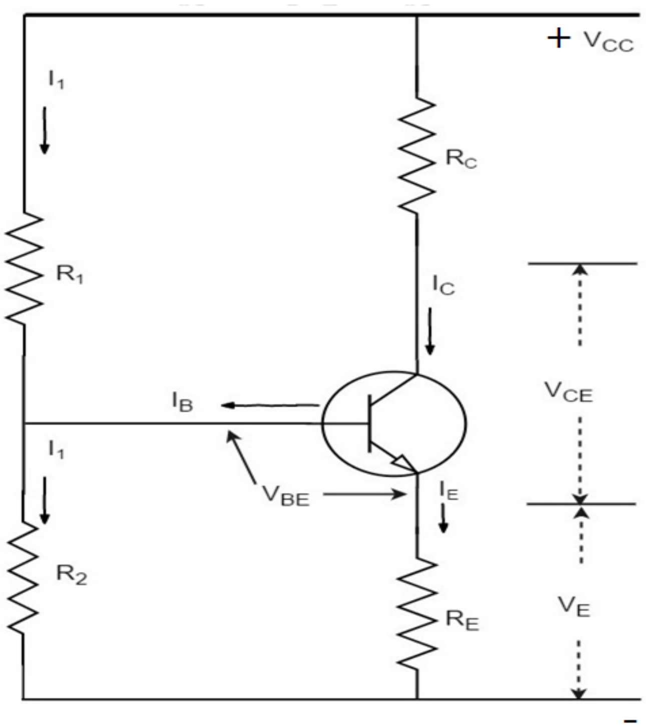
Stability Factor

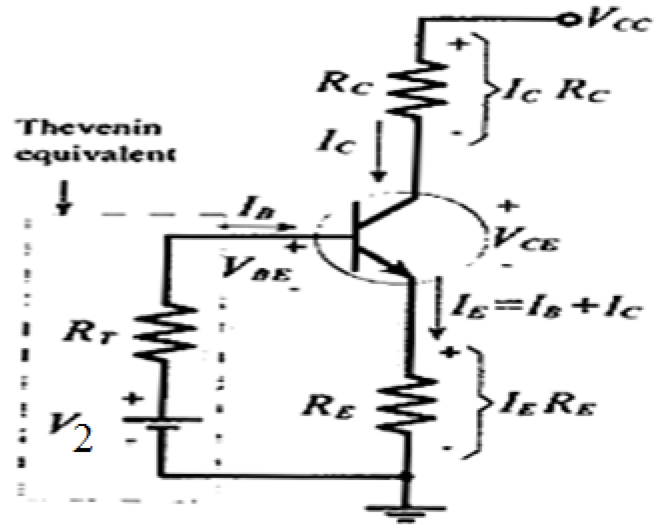
To get the equation for Stability factor of this circuit draw the equivalent circuit using thevenin theorem

$R_T = R_1 R_2/(R_1+R_2)$



(a) Determining the *Thevenin equivalent circuit* for the voltage divider





(b) Voltage divider bias with *Thevenin equivalent circuit* of the voltage divider

Apply Kirchoff's law to the B-E circuit

$$I_B R_T + V_{BE} + I_E R_E = V_2$$

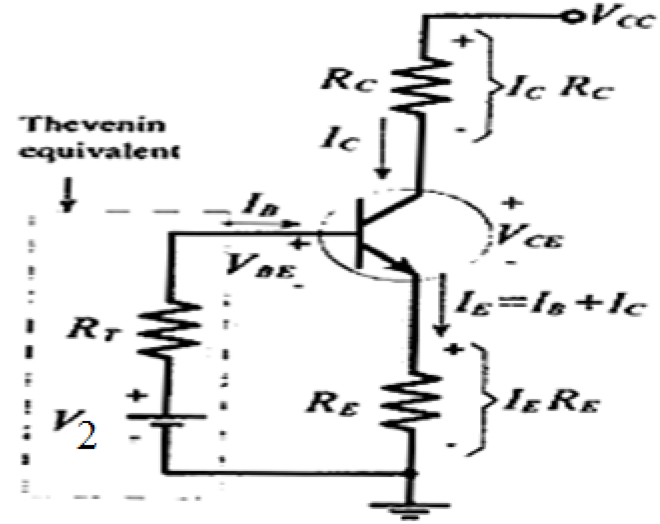
$$I_B R_T + V_{BE} + (I_C + I_B) R_E - V_2 = 0$$

$$I_B (R_T + R_E) + V_{BE} + I_C R_E - V_2 = 0$$

$$I_B = \frac{-V_{BE} - I_C R_E + V_2}{R_T + R_E}$$

$$\frac{dI_B}{dI_C} = \frac{0 - R_E - 0}{R_T + R_E}$$

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



(b) Voltage divider bias with *Thevenin equivalent circuit* of the voltage divider

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

$$S = \frac{(\beta + 1)(R_T + R_E)}{R_T + R_E + \beta R_E}$$

$$S = \frac{(\beta + 1)\,\frac{(R_T + R_E)}{R_E}}{(R_T + R_E + \beta R_E)/R_E}$$

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

$$S = \frac{(\beta + 1)}{1 + \beta} = 1$$

If the ratio R_T/R_E is very small

R_T/R_E can be neglected as compared to 1

Stability factor becomes $S=(\beta+1)\times 1/(\beta+1)=1$

This is the smallest possible value of S and leads to the maximum possible thermal stability.