Transistor Bias Methods

Muhammad Adeel

M.Sc. Electronics (KU)

M.Phil. ISPA (KU)

VOLTAGE DIVIDER BIAS

- Voltage divider bias is also called as Universal Bias and is the most commonly used bias configuration.
- This bias circuit contains a voltage divider in its base circuit.
- Alike with simple Base Bias circuit, it uses a single power supply.
- Whereas provide Q-point stability like an Emitter Bias circuit.

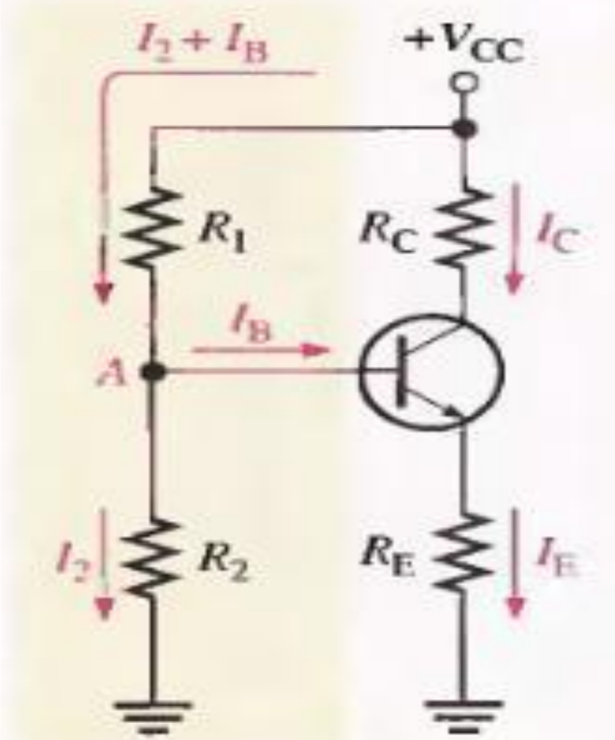


FIGURE 5–9

Voltage-divider bias.

$$V_B \cong \left(\frac{R_2}{R_1 + R_2}\right)V_{CC}$$

$$V_E = V_B - V_{BE}$$

$$I_C \cong I_E = \frac{V_E}{R_E}$$

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

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

Advantages

Beta independent output values i.e., Q-point stability.

Do not require the use of a dual-polarity power supply.

Input Resistance at Transistor Base

By Ohm's law,

$$R_{IN(base)} = \frac{V_{IN}}{I_{IN}}$$

Kirchhoff's voltage law applied around the base-emitter circuit yields

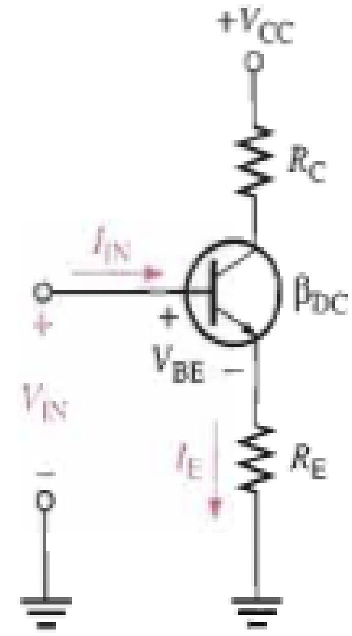
$$V_{IN} = V_{BE} + I_E R_E$$

With the assumption that $V_{BE} << I_E R_E$, the equation reduces to

$$V_{IN} \cong I_E R_E$$

Now, since $I_E \cong I_C = \beta_{DC} I_B$,

$$V_{IN} \cong \beta_{DC} I_B R_E$$



The input current is the base current:

$$I_{IN} = I_B$$

By substitution,

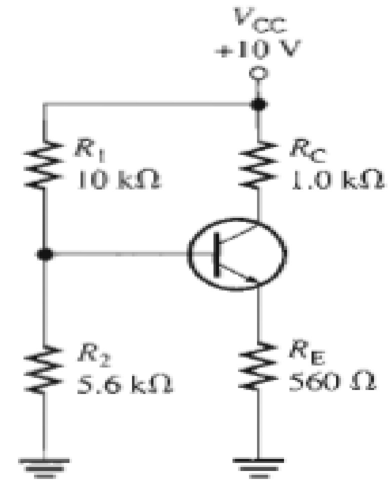
$$R_{IN(base)} = \frac{V_{IN}}{I_{IN}} \cong \frac{\beta_{DC} I_B R_E}{I_B}$$

Cancelling the I_B terms gives

$$R_{IN(base)} \cong \beta_{DC} R_E$$

Example

Determine V_{CE} and I_C in the voltage-divider biased transistor circuit of Figure 5–14 if $\beta_{DC} = 100$.



First, determine the dc input resistance at the base to see if it can be neglected.

$$R_{IN\,(base)} \cong \beta_{DC} R_E = (100)(560\ \Omega) = 56\ k\Omega$$

A common rule-of-thumb is that if two resistors are in parallel and one is at least ten times the other, the total resistance is approximately equal to the smaller value. However, in some cases, this may result in unacceptable inaccuracy.

In this case, $R_{IN(base)} = 10R_2$, so neglect $R_{IN(base)}$. In the related exercise, you will rework this example taking $R_{IN(base)}$ into account and compare the difference. Proceed with the analysis by determining the base voltage.

$$V_B \cong \left(\frac{R_2}{R_1 + R_2}\right)V_{CC} = \left(\frac{5.6\ k\Omega}{15.6\ k\Omega}\right)10\ V = 3.59\ V$$

So,

$$V_E = V_B - V_{BE} = 3.59\text{ V} - 0.7\text{ V} = 2.89\text{ V}$$

and

$$I_E = \frac{V_E}{R_E} = \frac{2.89\text{ V}}{560\ \Omega} = 5.16\text{ mA}$$

Therefore,

$$I_C \cong I_E = \mathbf{5.16\ mA}$$

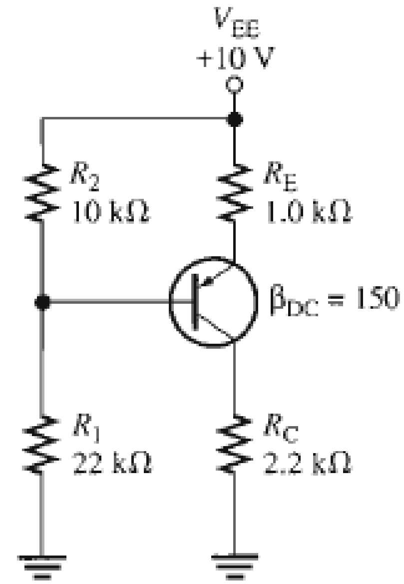
and

$$V_{CE} \cong V_{CC} - I_C(R_C + R_E) = 10\text{ V} - 5.16\text{ mA}(1.56\text{ k}\Omega) = \mathbf{1.95\ V}$$

Since $V_{CE} > 0$ V (or greater than a few tenths of a volt), you know that the transistor is *not* in saturation.

Example

Find I_C and V_{EC} for the *pnp* transistor circuit in Figure .



First, check to see if $R_{IN(base)}$ can be neglected.

$$R_{IN(base)} = \beta_{DC} R_E = (150)(1.0\ \text{k}\Omega) = 150\ \text{k}\Omega$$

Since 150 kΩ is more than ten times R_2, the condition $\beta_{DC} R_E >> R_2$ is met and $R_{IN(base)}$ can be neglected. Now, calculate V_B.

$$V_B \cong \left(\frac{R_1}{R_1 + R_2}\right) V_{EE} = \left(\frac{22\ \text{k}\Omega}{32\ \text{k}\Omega}\right) 10\ \text{V} = 6.88\ \text{V}$$

Then

$$V_E = V_B + V_{BE} = 6.88\ \text{V} + 0.7\ \text{V} = 7.58\ \text{V}$$

and

$$I_E = \frac{V_{EE} - V_E}{R_E} = \frac{10\ \text{V} - 7.58\ \text{V}}{1.0\ \text{k}\Omega} = 2.42\ \text{mA}$$

From I_E, you can determine I_C and V_{CE} as follows:

$$I_C \cong I_E = \mathbf{2.42\ mA}$$

and

$$V_C = I_C R_C = (2.42\ \text{mA})(2.2\ \text{k}\Omega) = 5.32\ \text{V}$$

Therefore,

$$V_{EC} = V_E - V_C = 7.58\ \text{V} - 5.32\ \text{V} = \mathbf{2.26\ V}$$