Other Bias Methods

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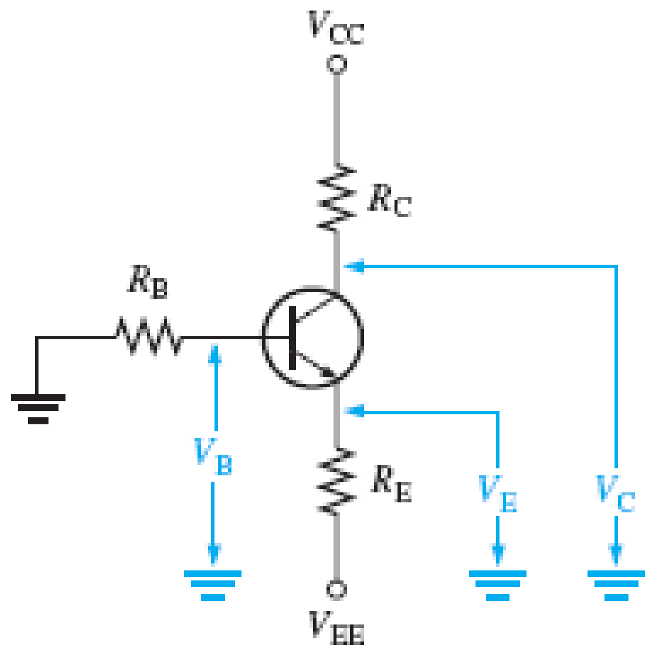
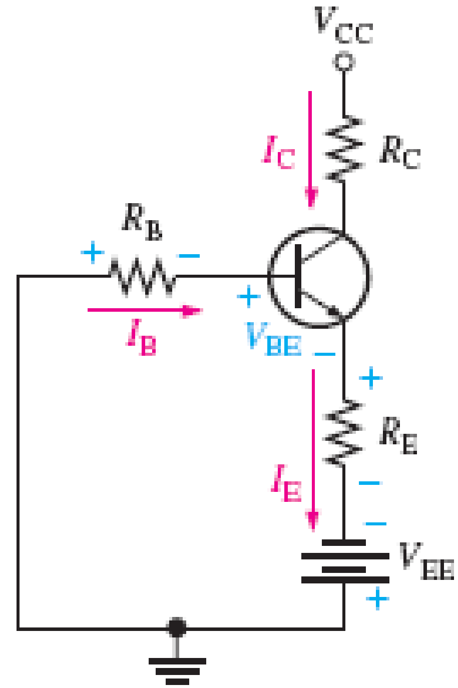
Emitter Bias



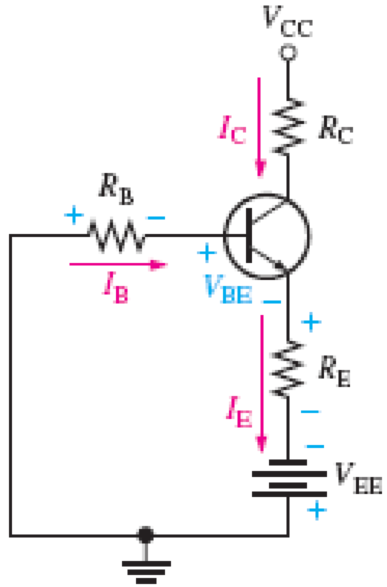


Emitter bias provides excellent bias stability in spite of changes in β or temperatures.

$$V_{EE} + V_{R_B} + V_{BE} + V_{R_E} = 0$$

Substituting, using Ohm's law,

$$V_{EE} + I_B R_B + V_{BE} + I_E R_E = 0$$



Substituting for $I_B \cong I_E/\beta_{DC}$ and transposing V_{EE},

$$\left(\frac{I_E}{\beta_{DC}}\right)R_B + I_E R_E + V_{BE} = -V_{EE}$$

Factoring out I_E and solving for I_E,

$$\boldsymbol{I_E = \frac{-V_{EE} - V_{BE}}{R_E + R_B/\beta_{DC}}}$$

Voltages with respect to ground are indicated by a single subscript. The emitter voltage with respect to ground is

$$V_E = V_{EE} + I_E R_E$$

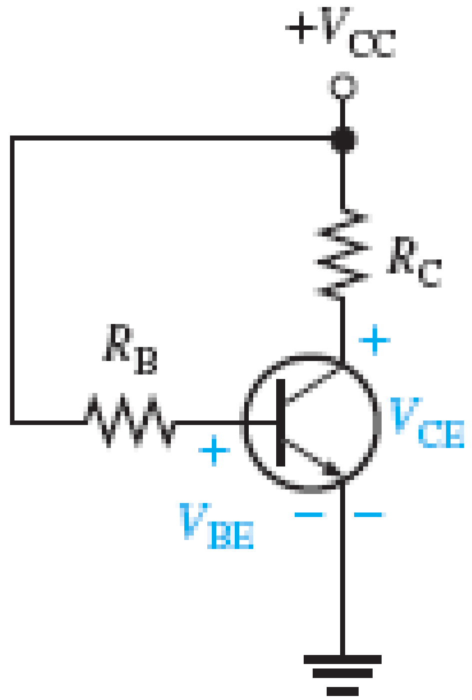
The base voltage with respect to ground is

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

The collector voltage with respect to ground is

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

Base Bias



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

Substituting $I_B R_B$ for V_{R_B}, you get

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

Then solving for I_B,

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

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

Solving for V_{CE},

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

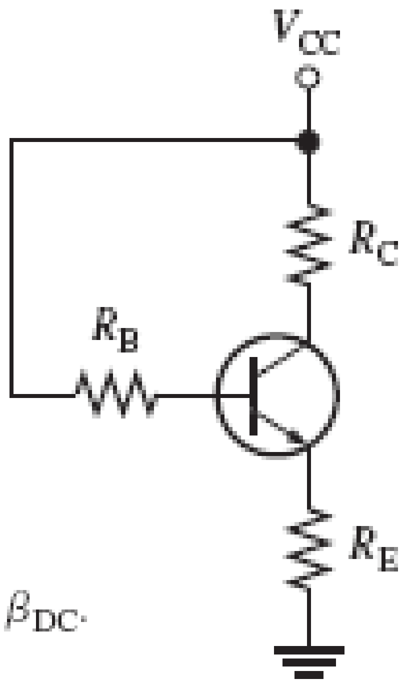
Substituting the expression for I_B into the formula $I_C = \beta_{DC} I_B$ yields

$$I_C = \beta_{DC}\left(\frac{V_{CC} - V_{BE}}{R_B}\right)$$

Q-Point Stability of Base Bias Notice that Equation 5–11 shows that I_C is dependent on β_{DC}. The disadvantage of this is that a variation in β_{DC} causes I_C and, as a result, V_{CE} to change, thus changing the Q-point of the transistor. This makes the base bias circuit extremely beta-dependent and unpredictable.

Recall that β_{DC} varies with temperature and collector current. In addition, there is a large spread of β_{DC} values from one transistor to another of the same type due to manufacturing variations. For these reasons, base bias is rarely used in linear circuits but is discussed here so you will be familiar with it.

Emitter Feedback Bias



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

Substituting I_E/β_{DC} for I_B, you can see that I_E is still dependent on β_{DC}.

$$I_E = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{DC}}$$

Collector Feedback Bias

Analysis of a Collector-Feedback Bias Circuit By Ohm's law, the base current can be expressed as

$$I_B = \frac{V_C - V_{BE}}{R_B}$$

Let's assume that $I_C \gg I_B$. The collector voltage is

$$V_C \cong V_{CC} - I_C R_C$$

Also,

$$I_B = \frac{I_C}{\beta_{DC}}$$

Substituting for V_C in the equation $I_B = (V_C - V_{BE})/R_B$,

$$\frac{I_C}{\beta_{DC}} = \frac{V_{CC} - I_C R_C - V_{BE}}{R_B}$$

The terms can be arranged so that

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

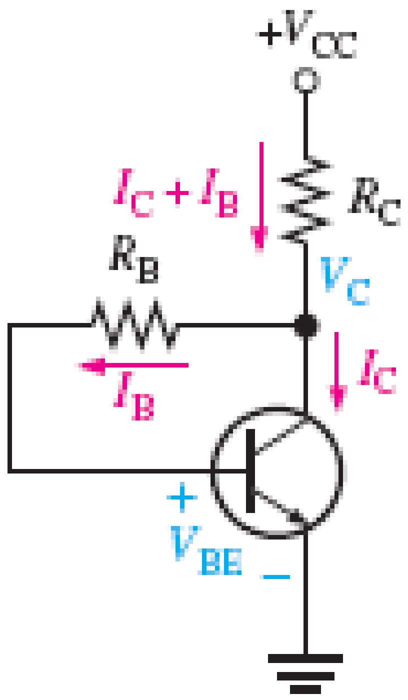
Then you can solve for I_C as follows:

$$I_C\left(R_C + \frac{R_B}{\beta_{DC}}\right) = V_{CC} - V_{BE}$$

$$\mathbf{I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta_{DC}}}$$

Since the emitter is ground, $V_{CE} = V_C$.

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



Q-Point Stability Over Temperature Equation 5–13 shows that the collector current is dependent to some extent on β_{DC} and V_{BE}. This dependency, of course, can be minimized by making $R_C \gg R_B/\beta_{DC}$ and $V_{CC} \gg V_{BE}$. An important feature of collector-feedback bias is that it essentially eliminates the β_{DC} and V_{BE} dependency even if the stated conditions are met.