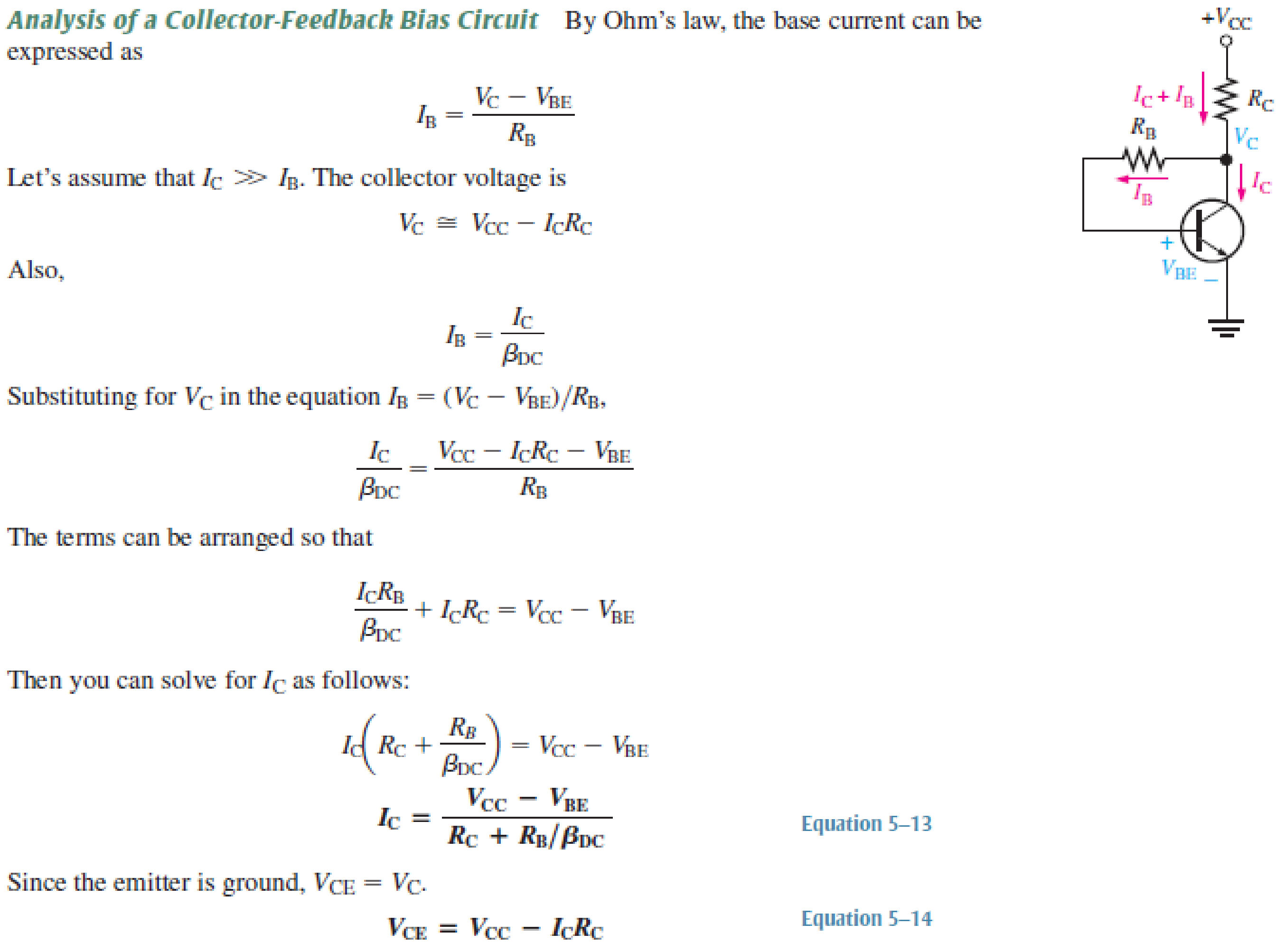
Collector-Feedback Bias

In Figure, the base resistor RB is connected to the collector rather than to VCC, as it was in the base bias arrangement discussed earlier. The collector voltage provides the bias for the base-emitter junction. The negative feedback creates an “offsetting” effect that tends to keep the Q-point stable. If IC tries to increase, it drops more voltage across RC, thereby causing VC to decrease. When VC decreases, there is a decrease in voltage across RB, which decreases IB. The decrease in IB produces less IC which, in turn, drops less voltage across RC and thus offsets the decrease in VC.



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:

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

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

Equation 5–13

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

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

Equation 5–14

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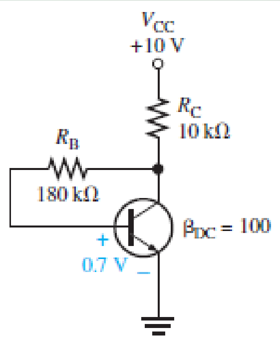
Q-Point Stability Over Temperature Equation 5–13 shows that the collector current is dependent to some extent on β_{DC} and V_{BE}. This dependency, of course, can be minimized by making $R_C \gg R_B/\beta_{DC}$ and $V_{CC} \gg V_{BE}$. An important feature of collector-feedback bias is that it essentially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

EXAMPLE 5–10 Calculate the Q-point values (I_C and V_{CE}) for the circuit in Figure 5–23.

▶ FIGURE 5–23



Solution Using Equation 5–13, the collector current is

$$I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta_{DC}} = \frac{10\text{ V} - 0.7\text{ V}}{10\text{ k}\Omega + 180\text{ k}\Omega/100} = \mathbf{788\ \mu A}$$

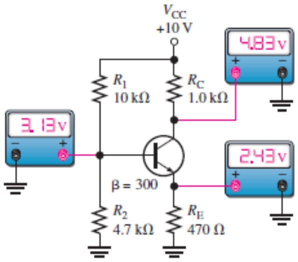
Using Equation 5–14, the collector-to-emitter voltage is

$$V_{CE} = V_{CC} - I_C R_C = 10\text{ V} - (788\ \mu\text{A})(10\text{ k}\Omega) = \mathbf{2.12\ V}$$

Related Problem Calculate the Q-point values in Figure 5–23 for $\beta_{DC} = 200$ and determine the percent change in the Q-point from $\beta_{DC} = 100$ to $\beta_{DC} = 200$.

Troubleshooting a Voltage-Divider Biased Transistor

An example of a transistor with voltage-divider bias is shown in Figure 5–24. For the specific component values shown, you should get the voltage readings approximately as indicated when the circuit is operating properly.



◀ FIGURE 5–24

A voltage-divider biased transistor with correct voltages.

For this type of bias circuit, a particular group of faults will cause the transistor collector to be at V_{CC} when measured with respect to ground. Five faults are indicated for the circuit in Figure 5–25(a). The collector voltage is equal to 10 V with respect to ground for each of the faults as indicated in the table in part (b). Also, for each of the faults, the base voltage and the emitter voltage with respect to ground are given.

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