Example 6-3

A transistor has a collector current of 2 mA. If the current gain is 135, what is the base current?

SOLUTION Divide the collector current by the current gain to get:

$$I_B = \frac{2\text{ mA}}{135} = 14.8\ \mu\text{A}$$

PRACTICE PROBLEM 6-3 If I_C = 10 mA in Example 6-3, find the transistor's base current.

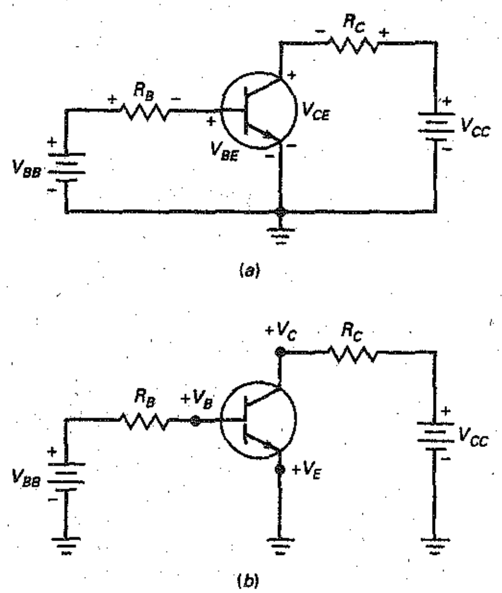
6-4 The CE Connection

There are three useful ways to connect a transistor: with a CE (common emitter), a CC (common collector), or a CB (common base). The CC and CB connections are discussed in later chapters. In this chapter, we will focus on the CE connection because it is the most widely used.

Common Emitter

In Fig. 6-7*a*, the common or ground side of each voltage source is connected to the emitter. Because of this, the circuit is called a **common emitter (CE)** connection. The circuit has two loops. The left loop is the base loop, and the right loop is the collector loop.

Figure 6-7 CE connection. (*a*) Basic circuit; (*b*) circuit with grounds.



In the base loop, the V_{BB} source forward biases the emitter diode with R_B as a current-limiting resistance. By changing V_{BB} or R_B, we can change the base current. Changing the base current will change the collector current. In other words, *the base current controls the collector current.* This is important. It means that a small current (base) controls a large current (collector).

In the collector loop, a source voltage V_{CC} reverse biases the collector diode through R_C. The supply voltage V_{CC} must reverse bias the collector diode as shown, or else the transistor won't work properly. Stated another way, the collector must be positive in Fig. 6-7*a* to collect most of the free electrons injected into the base.

In Fig. 6-7*a*, the flow of base current in the left loop produces a voltage across the base resistor R_B with the polarity shown. Similarly, the flow of collector current in the right loop produces a voltage across the collector resistor R_C with the polarity shown.

Double Subscripts

Double-subscript notation is used with transistor circuits. When the subscripts are the same, the voltage represents a source (V_{BB} and V_{CC}). When the subscripts are different, the voltage is between the two points (V_{BE} and V_{CE}).

For instance, the subscripts of V_{BB} are the same, which means that V_{BB} is the base voltage source. Similarly, V_{CC} is the collector voltage source. On the other hand, V_{BE} is the voltage between points *B* and *E*, between the base and the emitter. Likewise, V_{CE} is the voltage between points *C* and *E*, between the collector and the emitter.

Single Subscripts

Single subscripts are used for node voltages, that is, voltages between the subscripted point and ground. For instance, if we redraw Fig. 6-7*a* with grounds, we get Fig. 6-7*b*. Voltage V_B is the voltage between the base and ground, voltage V_C is the voltage between the collector and ground, and voltage V_E is the voltage between the emitter and ground. (In this circuit, V_E is zero.)

You can calculate a double-subscript voltage of different subscripts by subtracting its single-subscript voltages. Here are three examples:

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

$$V_{CB} = V_C - V_B$$

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

This is how you could calculate the double-subscript voltages for any transistor circuit: Since V_E is zero in this CE connection (Fig. 6-7*b*), the voltages simplify to:

$$V_{CE} = V_C$$

$$V_{CB} = V_C - V_B$$

$$V_{BE} = V_B$$

6-5 The Base Curve

What do you think the graph of I_B versus V_{BE} looks like? It looks like the graph of an ordinary diode as shown in Fig. 6-8*a*. And why not? This is a forward-biased emitter diode, so we would expect to see the usual diode graph of current versus voltage. What this means is that we can use any of the diode approximations discussed earlier.