Tutorial 8

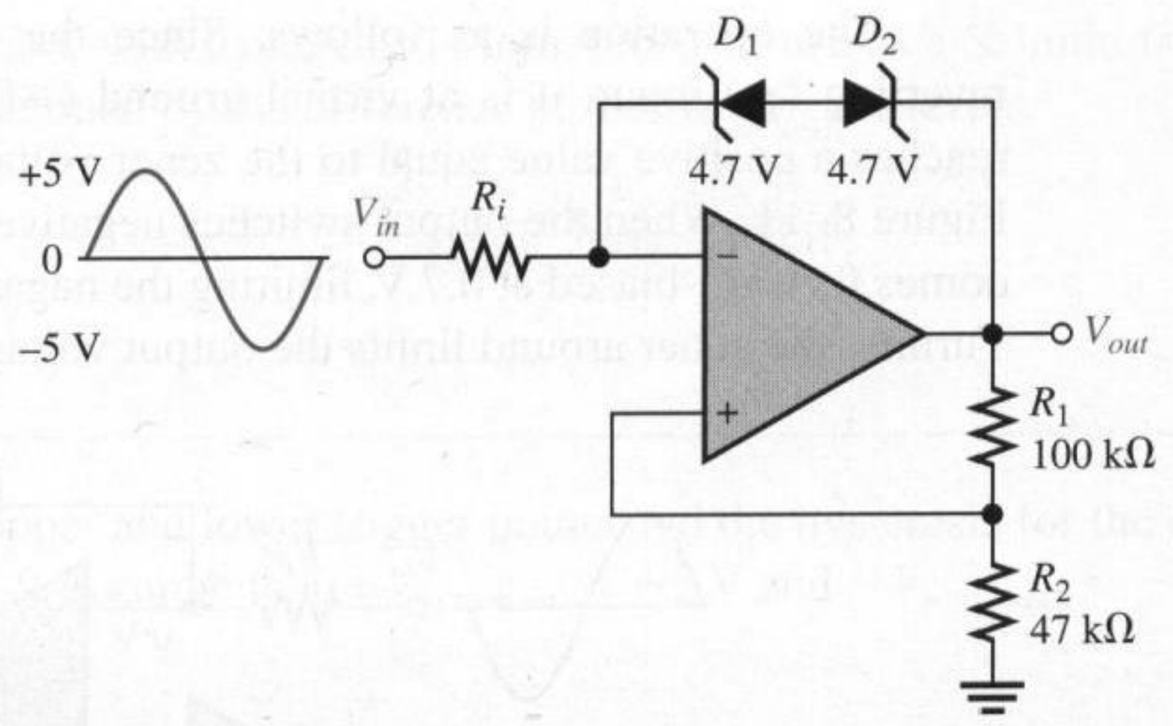
EC103

Comparators, SHA

Q.

Determine the output voltage waveform for Figure 8–13.

FIGURE 8–13



A.

Solution This comparator has both hysteresis and zener bounding.

The voltage across D_1 and D_2 in either direction is 4.7 V + 0.7 V = 5.4 V. This is because one zener is always forward-biased with a drop of 0.7 V when the other one is in breakdown.

The voltage at the inverting (−) op-amp input is $V_{out} \pm 5.4$ V. Since the differential voltage is negligible, the voltage at the noninverting (+) op-amp input is also approximately $V_{out} \pm 5.4$ V. Thus,

$$V_{R1} = V_{out} - (V_{out} \pm 5.4\text{ V}) = \pm 5.4\text{ V}$$

$$I_{R1} = \frac{V_{R1}}{R_1} = \frac{\pm 5.4\text{ V}}{100\text{ k}\Omega} = \pm 54\ \mu\text{A}$$

Since the current at the noninverting input is negligible,

$$I_{R2} = I_{R1} = \pm 54\ \mu\text{A}$$

$$V_{R2} = R_2 I_{R2} = (47\text{ k}\Omega)(\pm 54\ \mu\text{A}) = \pm 2.54\text{ V}$$

$$V_{out} = V_{R1} + V_{R2} = \pm 5.4\text{ V} \pm 2.54\text{ V} = \pm 7.94\text{ V}$$

A.

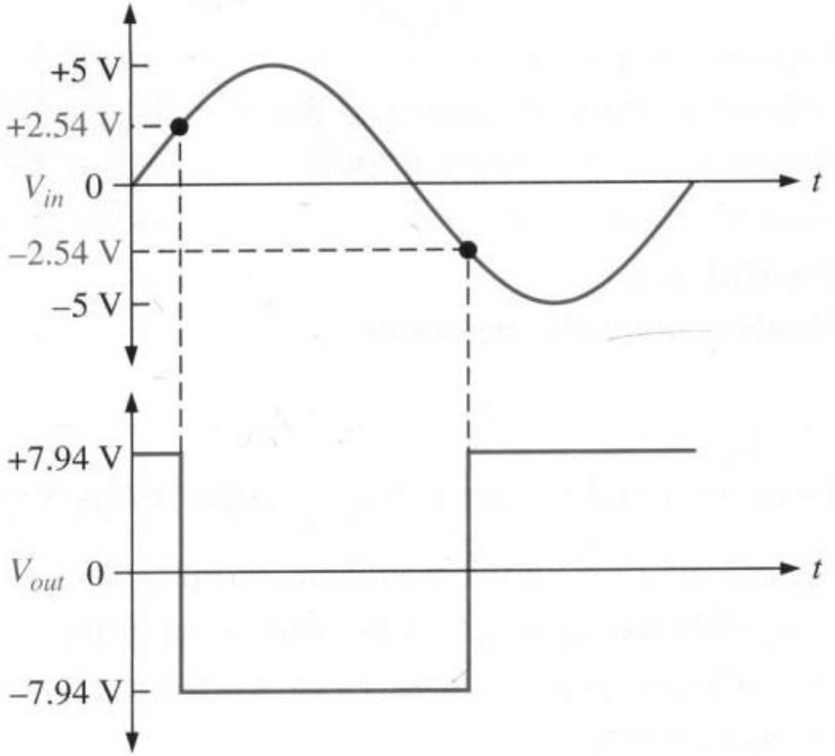
The upper trigger point (UTP) and the lower trigger point (LTP) are as follows:

$$V_{\text{UTP}} = \left(\frac{R_2}{R_1 + R_2}\right)(+V_{out}) = \left(\frac{47\ \text{k}\Omega}{147\ \text{k}\Omega}\right)(+7.94\ \text{V}) = +2.54\ \text{V}$$

$$V_{\text{LTP}} = \left(\frac{R_2}{R_1 + R_2}\right)(-V_{out}) = \left(\frac{47\ \text{k}\Omega}{147\ \text{k}\Omega}\right)(-7.94\ \text{V}) = -2.54\ \text{V}$$

The output waveform for the given input voltage is shown in Figure 8–14.

FIGURE 8–14



Q.

The input signal in Figure 8–3(a) is applied to the comparator circuit in Figure 8–3(b). Make a sketch of the output showing its proper relationship to the input signal. Assume the maximum output levels of the op-amp are ±12 V.

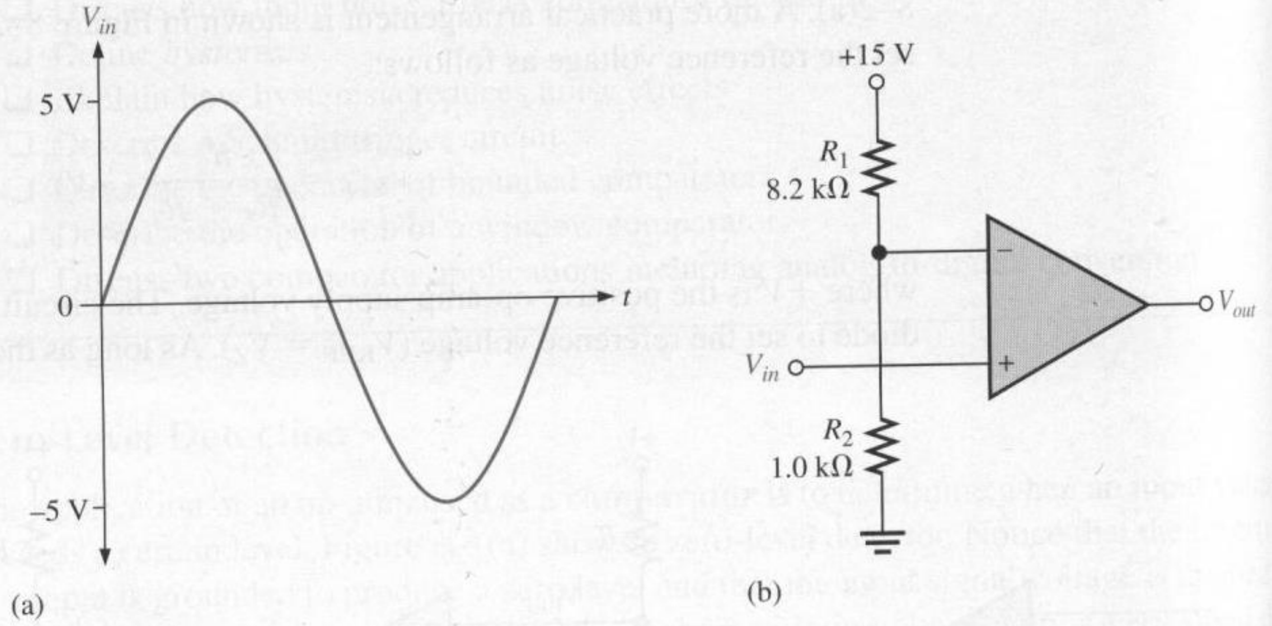


FIGURE 8–3

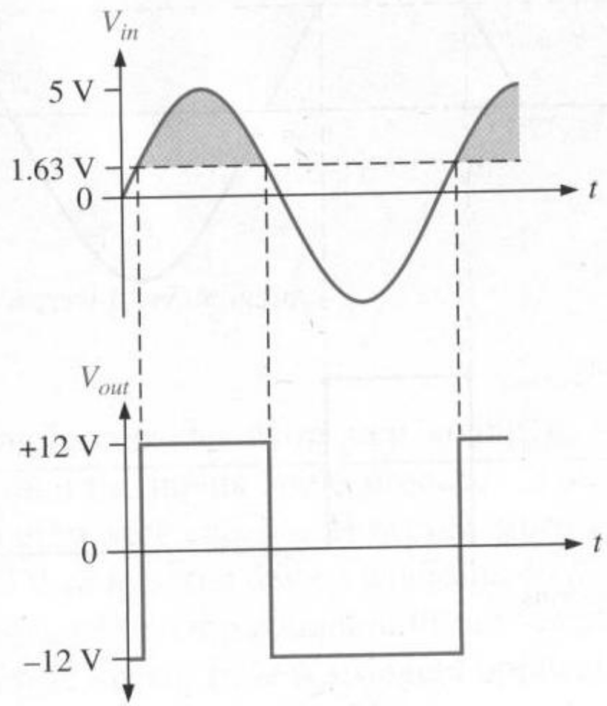
A.

Solution The reference voltage is set by R_1 and R_2 as follows:

$$V_{REF} = \frac{R_2}{R_1 + R_2}(+V) = \frac{1.0\ \text{k}\Omega}{8.2\ \text{k}\Omega + 1.0\ \text{k}\Omega}(+15\ \text{V}) = 1.63\ \text{V}$$

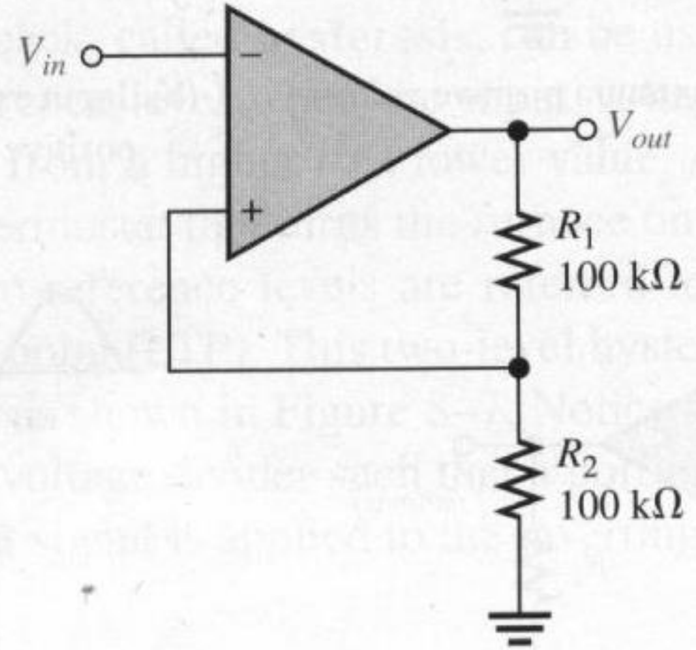
As shown in Figure 8–4, each time the input exceeds +1.63 V, the output voltage switches to its +12 V level, and each time the input goes below +1.63 V, the output switches back to its −12 V level.

FIGURE 8–4



Q. Determine the upper and lower trigger points and the hysteresis for the comparator circuit in Figure 8–9. Assume that $+V_{out(max)} = +5\text{ V}$ and $-V_{out(max)} = -5\text{ V}$.

FIGURE 8–9



A.

Solution

$$V_{\text{UTP}} = \frac{R_2}{R_1 + R_2}[+V_{out(max)}] = 0.5(5\text{ V}) = \mathbf{+2.5\ V}$$

$$V_{\text{LTP}} = \frac{R_2}{R_1 + R_2}[-V_{out(max)}] = 0.5(-5\text{ V}) = \mathbf{-2.5\ V}$$

$$V_{\text{HYS}} = V_{\text{UTP}} - V_{\text{LTP}} = 2.5\text{ V} - (-2.5\text{ V}) = \mathbf{5\ V}$$

EXAMPLE 14–2 Q.

Determine the output waveform of the analog multiplexer in Figure 14–6 for the control inputs and the analog inputs shown.

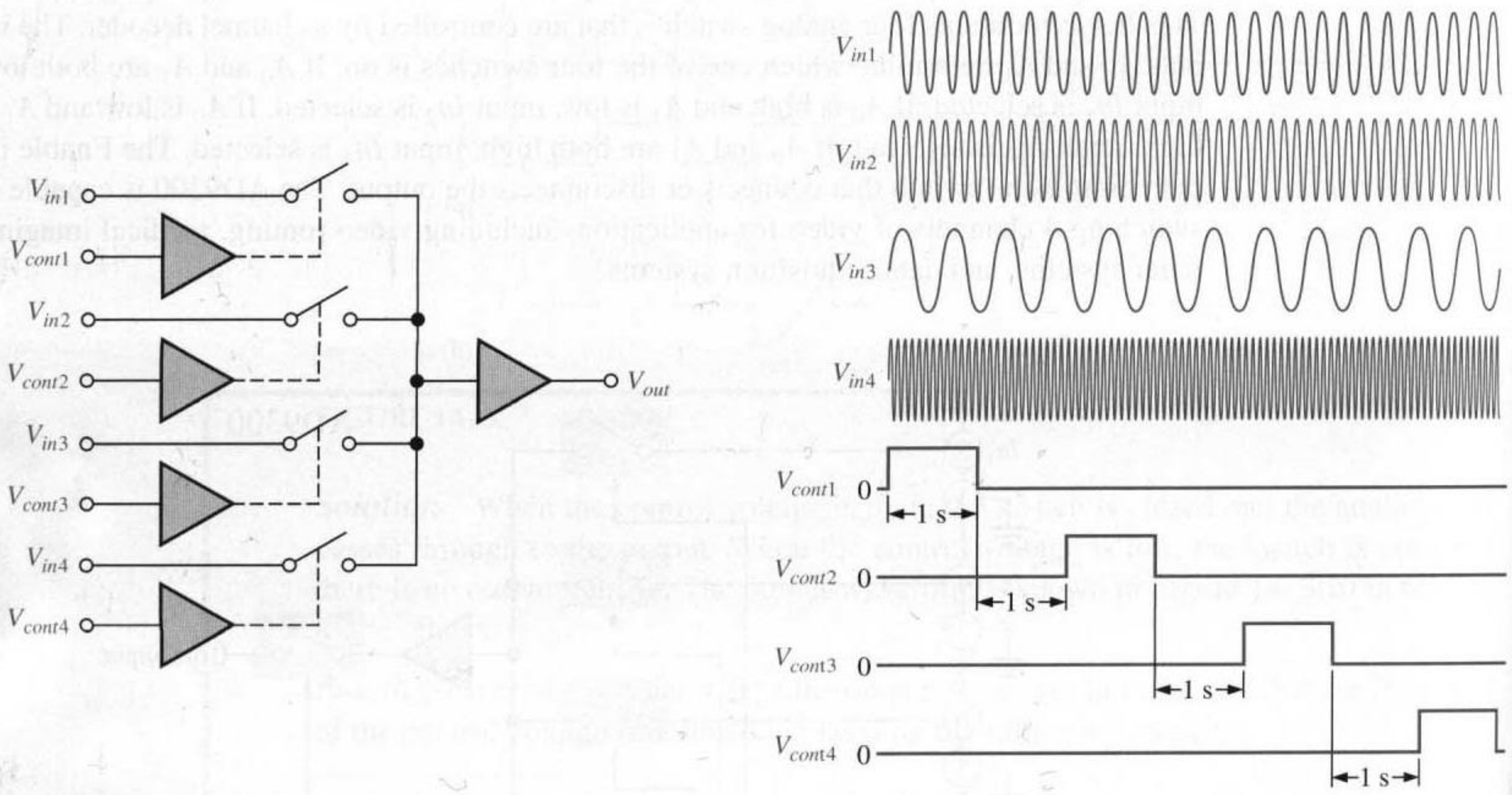
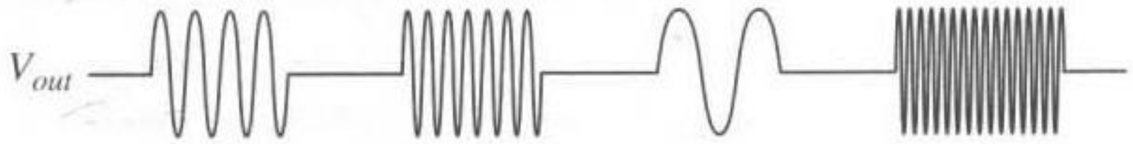


FIGURE 14–6

A.

Solution When a control input is a high level, the corresponding switch is closed and the analog voltage on its input is switched through to the output. Notice that only one control voltage is high at a time. The inputs to the switches are sinusoidal waves, each having a different frequency. The resulting output is a sequence of different sinusoidal waves that last for one second and that are separated by a one-second interval, as indicated in Figure 14–7.

FIGURE 14–7



Q. Determine the output voltage waveform for the sample/track-and-hold amplifier in Figure 14–11, given the input and control voltage waveforms.

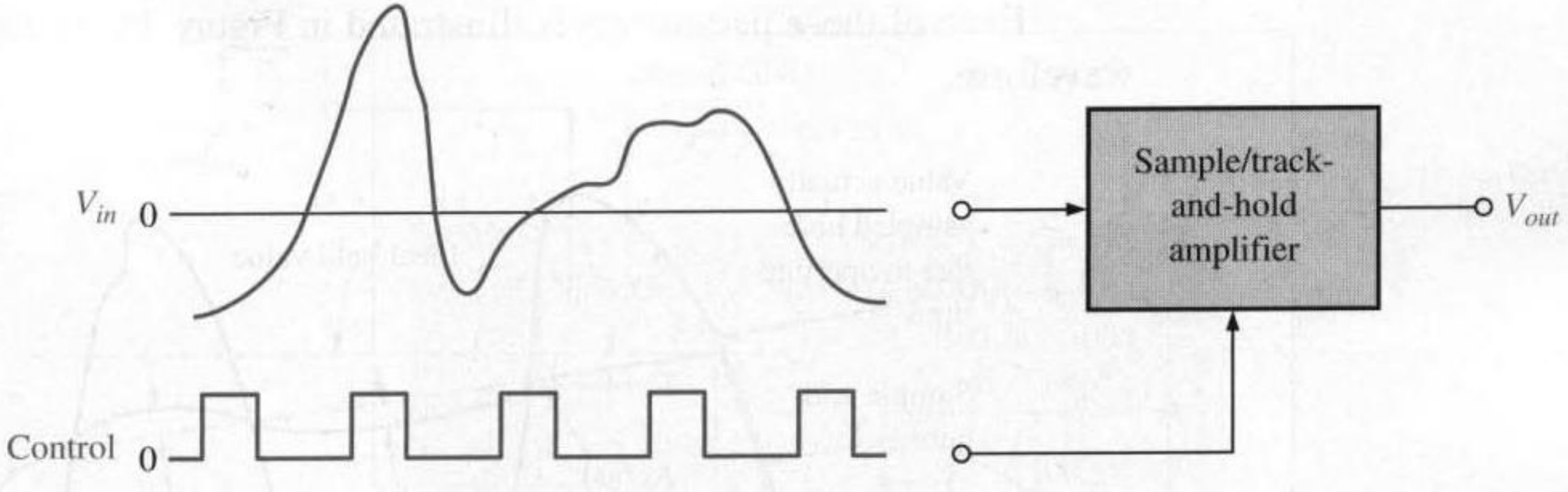


FIGURE 14–11

A.

Solution During the time that the control voltage is high, the analog switch is closed and the circuit is tracking the input. When the control voltage goes low, the analog switch opens; and the last voltage value is held at a constant level until the next time the control voltage goes high. This is shown in Figure 14–12.

FIGURE 14–12