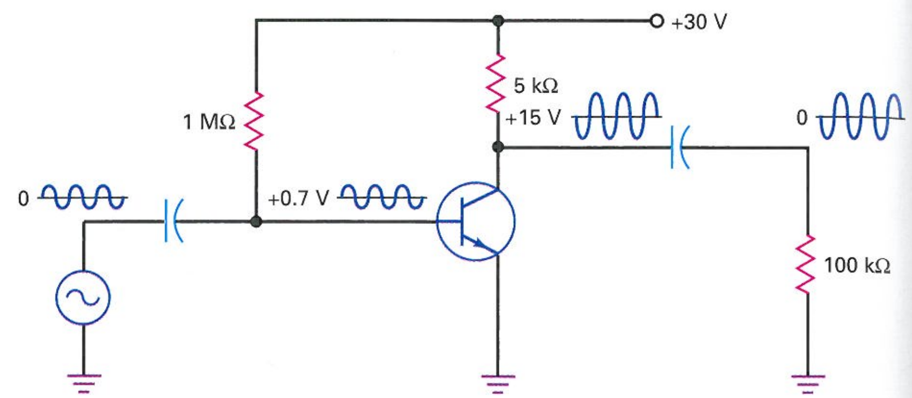
Figure 9-4 Base-biased amplifier with waveforms.



Voltage Gain

The **voltage gain** of an amplifier is defined as the ac output voltage divided by the ac input voltage. As a definition:

$$A_V = \frac{v_{out}}{v_{in}} \tag{9-2}$$

For instance, if we measure an ac load voltage of 50 mV with an ac input voltage of 100 μV, the voltage gain is:

$$A_V = \frac{50 \text{ mV}}{100\ \mu\text{V}} = 500$$

This says that the ac output voltage is 500 times larger than the ac input voltage.

Calculating Output Voltage

We can multiply both sides of Eq. (9-2) by v_{in} to get this derivation:

$$v_{out} = A_V v_{in} \tag{9-3}$$

This is useful when you want to calculate the value of v_{out}, given the values of A_V and v_{in}.

For instance, the triangular symbol shown in Fig. 9-5*a* is used to indicate an amplifier of any design. Since we are given an input voltage of 2 mV and a voltage gain of 200, we can calculate an output voltage of:

$$v_{out} = (200)(2 \text{ mV}) = 400 \text{ mV}$$

Calculating Input Voltage

We can divide both sides of Eq. (9-3) by A_V to get this derivation:

$$v_{in} = \frac{v_{out}}{A_V} \tag{9-4}$$

This is useful when you want to calculate the value of v_{in}, given the values v_{out} and A_V. For instance, the output voltage is 2.5 V in Fig. 9-5*b*. With a voltage gain of 350, the input voltage is:

$$v_{in} = \frac{2.5 \text{ V}}{350} = 7.14 \text{ mV}$$

Figure 9-5 (*a*) Calculating output voltage; (*b*) calculating input voltage.

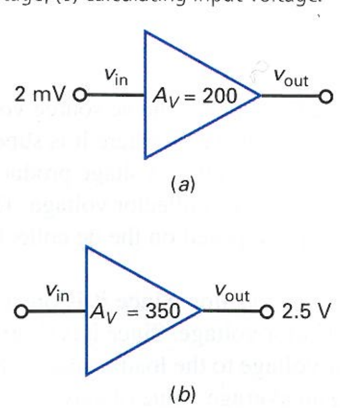
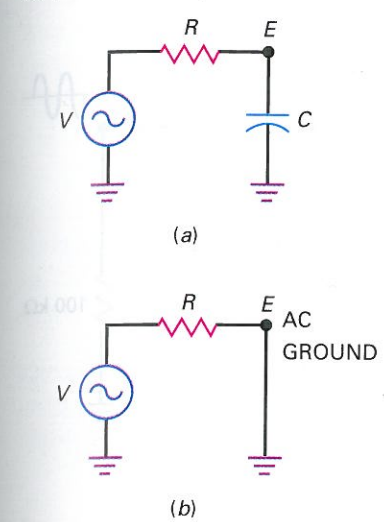


Figure 9-6 (*a*) Bypass capacitor; (*b*) point *E* is an ac ground.



9-2 Emitter-Biased Amplifier

The base-biased amplifier has an unstable *Q* point. For this reason, it is not used much as an amplifier. Instead, an emitter-biased amplifier (either VDB or TSEB) with its stable *Q* point is preferred.

Bypass Capacitor

A **bypass capacitor** is similar to a coupling capacitor because it appears open to direct current and shorted to alternating current. But it is not used to couple a signal between two points. Instead, it is used to create an **ac ground.**

Figure 9-6*a* shows an ac voltage source connected to a resistor and a capacitor. The resistance *R* represents the Thevenin resistance as seen by the capacitor. When the frequency is high enough, the capacitive reactance is much smaller than the resistance. In this case, almost all the ac source voltage appears across the resistor. Stated another way, point *E* is effectively shorted to ground.

When used in this way, the capacitor is called a *bypass capacitor* because it bypasses or shorts point *E* to ground. A bypass capacitor is important because it allows us to create an ac ground in an amplifier without disturbing its *Q* point.

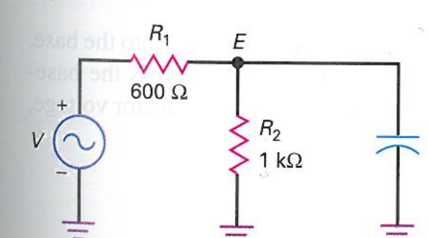
For a bypass capacitor to work properly, its reactance must be much smaller than the resistance at the *lowest frequency of the ac source*. The definition for good bypassing is identical to that for good coupling:

$$\textbf{Good bypassing: } X_C < 0.1R \tag{9-5}$$

When this rule is satisfied, Fig. 9-6*a* can be replaced by the equivalent circuit of Fig. 9-6*b*.

Example 9-2

Figure 9-7



In Fig. 9-7, the input frequency of *V* is 1 kHz. What value of *C* is needed to effectively short point *E* to ground?

SOLUTION First, find the Thevenin resistance as seen by the capacitor *C*.

$$R_{TH} = R_1 \| R_2$$

$$R_{TH} = 600\ \Omega \| 1\text{ k}\Omega = 375\ \Omega$$

Next, X_C should be ten times smaller than R_{TH}. Therefore, $X_C < 37.5\ \Omega$ at 1 kHz. Now solve for *C* by

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(1\text{ kHz})(37.5\ \Omega)}$$

$$C = 4.2\ \mu\text{F}$$

PRACTICE PROBLEM 9-2 In Fig. 9-7, find the value of *C* needed if *R* is 50 Ω.