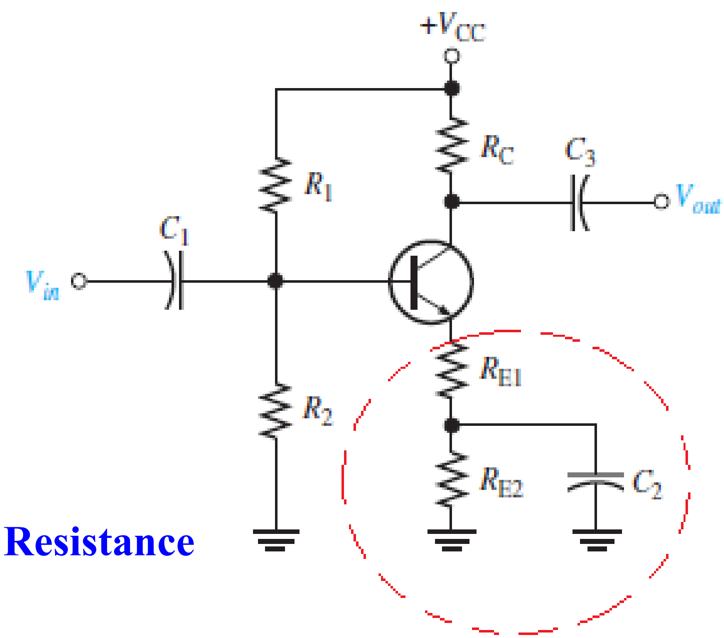
The Common-Emitter Amplifier

Swamping : To Stabilize the Gain

- R_E is partially bypassed, the effect of r'e on the gain is reduced (**better stability**)
- Both R_{E1} and R_{E2} affect the dc bias while only R_{E1} affects the ac gain



$$A_v = \frac{R_C}{r'_e + R_{E1}}$$

If R_{E1} > 10 times r'e: $A_v \cong \frac{R_C}{R_{E1}}$

❑ The Effect of Swamping on the Amplifier's Input Resistance

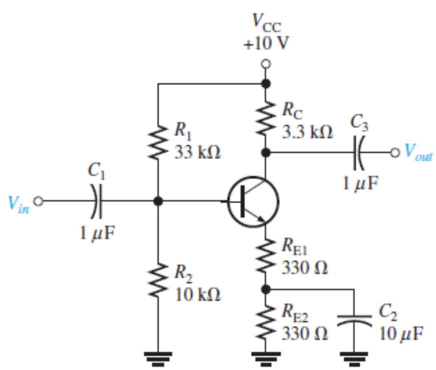
$$R_{in(base)} = \beta_{ac}(r'_e + R_{E1})$$

EXAMPLE 6–7

Determine the voltage gain of the swamped amplifier in Figure 6–19. Assume that the bypass capacitor has a negligible reactance for the frequency at which the amplifier is operated. Assume $r'_e = 20\ \Omega$.

Solution R_{E2} is bypassed by C_2. R_{E1} is more than ten times r'_e so the approximate voltage gain is

$$A_v \cong \frac{R_C}{R_{E1}} = \frac{3.3\text{ k}\Omega}{330\ \Omega} = \mathbf{10}$$



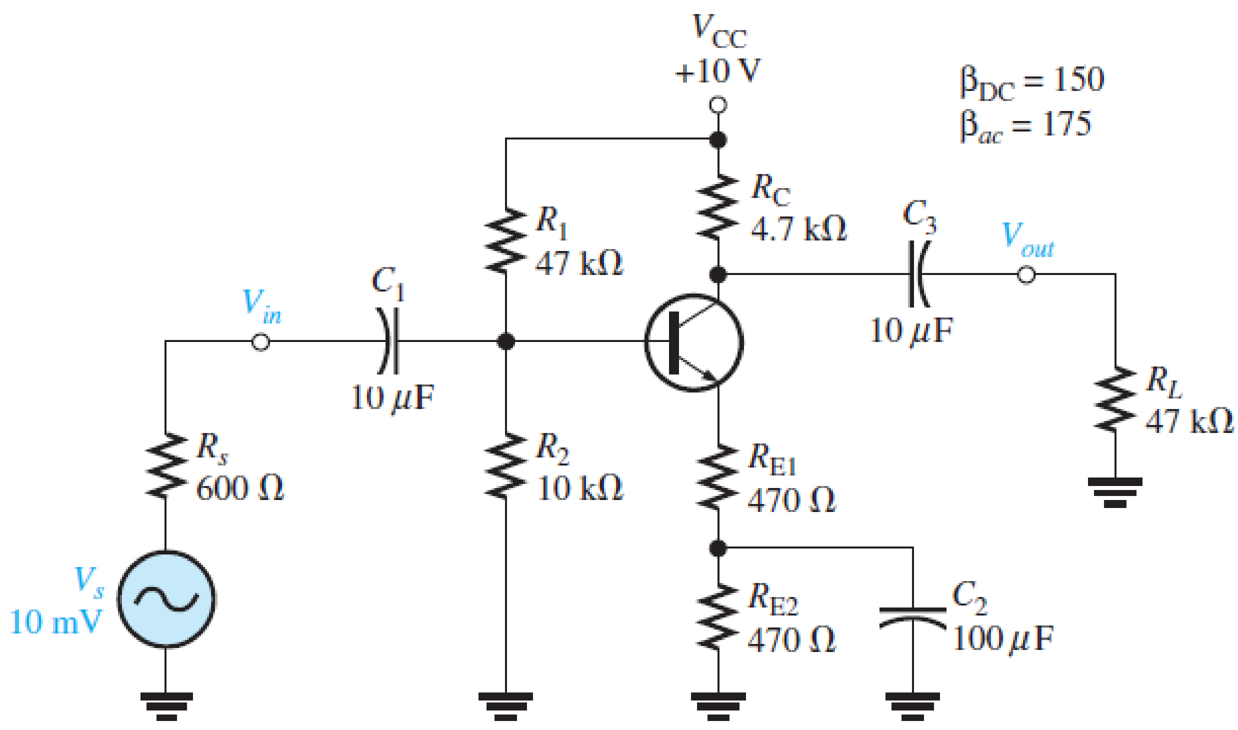
EXAMPLE 6–8

For the amplifier in Figure 6–20,

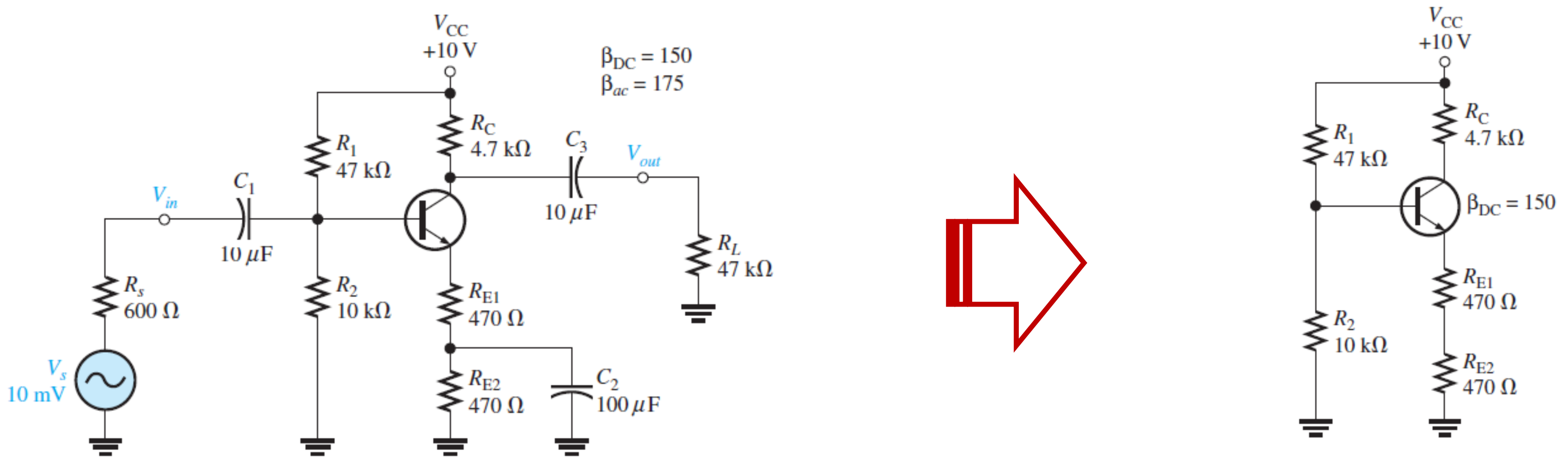
(a) Determine the dc collector voltage.

(b) Determine the ac collector voltage.

(c) Draw the total collector voltage waveform and the total output voltage waveform.



(a) Determine the dc collector voltage.



$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(47\ \text{k}\Omega)(10\ \text{k}\Omega)}{47\ \text{k}\Omega + 10\ \text{k}\Omega} = 8.25\ \text{k}\Omega$$

$$V_{TH} = \left(\frac{R_2}{R_1 + R_2}\right)V_{CC} = \left(\frac{10\ \text{k}\Omega}{47\ \text{k}\Omega + 10\ \text{k}\Omega}\right)10\ \text{V} = 1.75\ \text{V}$$

$$I_E = \frac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}} = \frac{1.75\ \text{V} - 0.7\ \text{V}}{940\ \Omega + 55\ \Omega} = 1.06\ \text{mA}$$

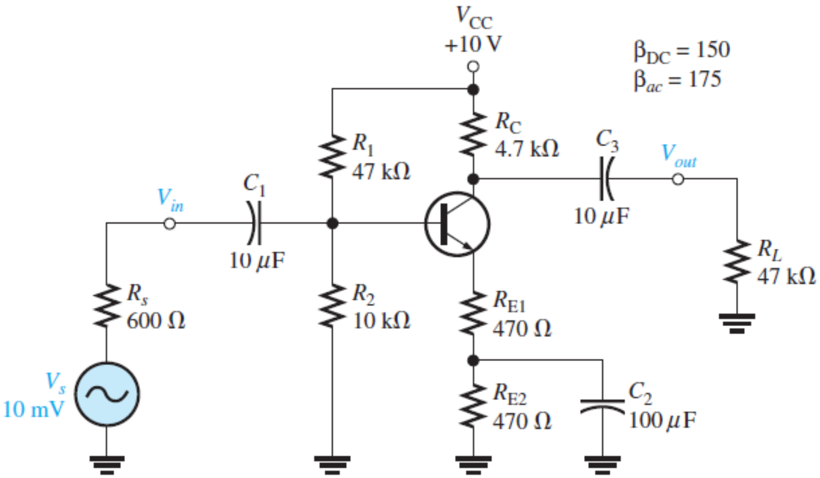
$$I_C \cong I_E = 1.06\ \text{mA}$$

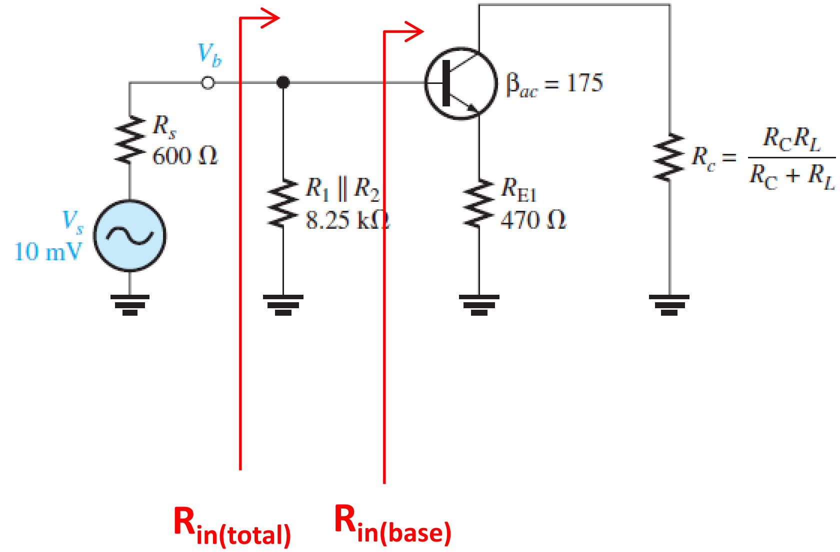
$$V_E = I_E(R_{E1} + R_{E2}) = (1.06\ \text{mA})(940\ \Omega) = 1\ \text{V}$$

$$V_B = V_E + 0.7\ \text{V} = 1\ \text{V} - 0.7\ \text{V} = 0.3\ \text{V}$$

$$V_C = V_{CC} - I_C R_C = 10\ \text{V} - (1.06\ \text{mA})(4.7\ \text{k}\Omega) = \mathbf{5.02\ V}$$

(b) Determine the ac collector voltage.





$$r'_e \cong \frac{25\text{ mV}}{I_E} = \frac{25\text{ mV}}{1.06\text{ mA}} = 23.6\ \Omega$$

Next, determine the attenuation in the base circuit.

$$R_{in(base)} = \beta_{ac}(r'_e + R_{E1}) = 175(494\ \Omega) = 86.5\text{ k}\Omega$$

$$R_{in(tot)} = R_1 \parallel R_2 \parallel R_{in(base)}$$

$$R_{in(tot)} = 47\text{ k}\Omega \parallel 10\text{ k}\Omega \parallel 86.5\text{ k}\Omega = 7.53\text{ k}\Omega$$

$$\text{Attenuation} = \frac{V_s}{V_b} = \frac{R_s + R_{in(tot)}}{R_{in(tot)}} = \frac{600\ \Omega + 7.53\text{ k}\Omega}{7.53\text{ k}\Omega} = 1.08$$

$$R_c = \frac{R_C R_L}{R_C + R_L} = \frac{(4.7\text{ k}\Omega)(47\text{ k}\Omega)}{4.7\text{ k}\Omega + 47\text{ k}\Omega} = 4.27\text{ k}\Omega$$

$$A_v \cong \frac{R_c}{R_{E1}} = \frac{4.27\text{ k}\Omega}{470\ \Omega} = 9.09$$

The overall voltage gain is the reciprocal of the attenuation times the amplifier voltage gain.

$$A'_v = \left(\frac{V_b}{V_s}\right)A_v = (0.93)(9.09) = 8.45$$

The source produces 10 mV rms, so the rms voltage at the collector is

$$V_c = A'_v V_s = (8.45)(10\text{ mV}) = \mathbf{84.5\text{ mV}}$$

(c) Draw the total collector voltage waveform and the total output voltage waveform.

- The total collector voltage is the signal voltage of 84.5 mV rms riding on a dc level of 4.74 V. The approximate peak values are determined as follows:

$$\text{Max } V_{c(p)} = V_C + 1.414\,V_c = \mathbf{5.02} + (84.5\text{ mV})(1.414) = \mathbf{5.13\ V}$$
$$\text{Min } V_{c(p)} = V_C - 1.414\,V_c = \mathbf{5.02} - (84.5\text{ mV})(1.414) = \mathbf{4.9\ V}$$

- The coupling capacitor, *C*3, keeps the dc level from getting to the output. So, V_{out} is equal to the ac component of the collector voltage:

$$Vout(p) = (84.5\text{ mV})(1.414) = \mathbf{119\ mV}$$