

ANALYSIS AND DESIGN OF ANALOG INTEGRATED CIRCUITS

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To Liz and Judy

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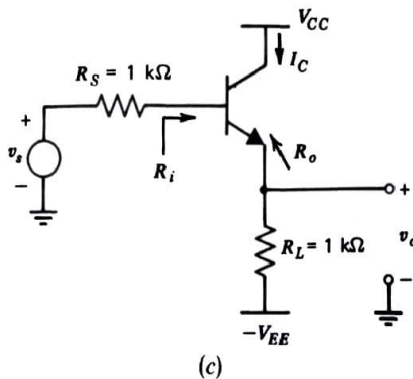


Fig. 3.15c Example emitter follower.

In summary, of the three transistor configurations, the common-emitter is most widely used because it provides both current and voltage gain, and many stages can be cascaded without interstage transformers. The common-base stage can provide voltage gain but no current gain, and the emitter follower provides current gain but no voltage gain.

3.2.4 Common-Emitter Amplifier with Emitter Degeneration

In the common-emitter amplifier considered earlier, the signal is applied to the base, the output is taken from the collector, and the emitter is attached to ac ground. Often, however, the common-emitter circuit is used with a resistance in series with the emitter as shown in Fig. 3.16a. The resistance has several effects, including a reduction in transconductance, an increase in output resistance, and an increase in input resistance. Since the gain is decreased, the presence of an

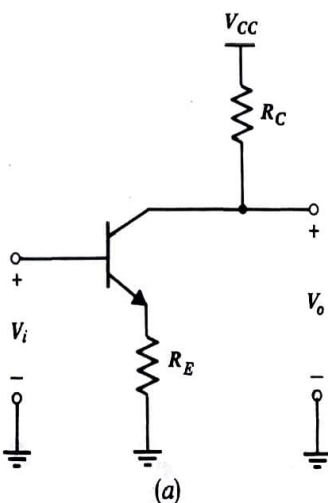


Fig. 3.16a Common-emitter amplifier with emitter degeneration.

emitter resistor is termed emitter degeneration. The resistor actually causes feedback to occur since the voltage across the emitter resistor, which is proportional to output current, subtracts directly from the input voltage. This circuit is examined from a feedback standpoint in Chapter 8.

In this section we calculate the input resistance, output resistance, and transconductance of the emitter-degenerated common-emitter amplifier. The small-signal equivalent circuit is shown in Fig. 3.16b. The input resistance is exactly the same as the emitter follower with a load resistor equal to R_E , or:

$$R_i = r_\pi + R_E(\beta_o + 1) \quad (3.27)$$

$$\approx r_\pi(1 + g_m R_E) \quad (3.28)$$

Thus the input resistance is increased by a factor $(1 + g_m R_E)$ over the undegenerated case. The transconductance can be calculated by first calculating the small-signal voltage across r_π .

$$v_i = i_b r_\pi + (i_b + i_c) R_E = \frac{i_c}{\beta_o} r_\pi + i_c \left(1 + \frac{1}{\beta_o}\right) R_E \quad (3.29)$$

and thus,

$$v_i = i_c \left[\frac{1}{g_m} + R_E \left(1 + \frac{1}{\beta_o}\right) \right] \quad (3.30)$$

from which we obtain

$$G_m = \frac{i_c}{v_i} \approx \frac{g_m}{1 + g_m R_E} \quad (3.31)$$

Thus the transconductance is *decreased* by a factor $(1 + g_m R_E)$ compared with the case for $R_E = 0$.

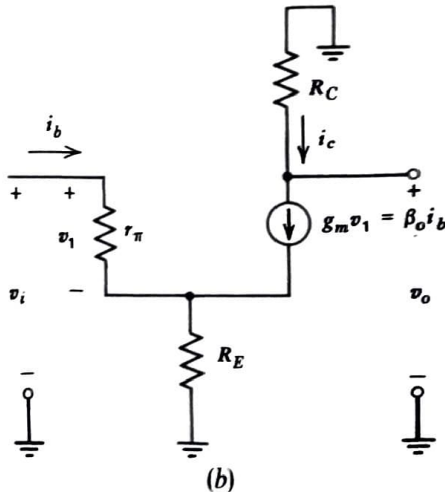


Fig. 3.16b Small-signal equivalent circuit for emitter-degenerated, common-emitter amplifier.