Al-Mustaqbal University
Department of Electrical Engineering Technique
Class 2st
Subject: Electronic Circuits
Lecturer: Dr. Hasan Muwafaq Gheni

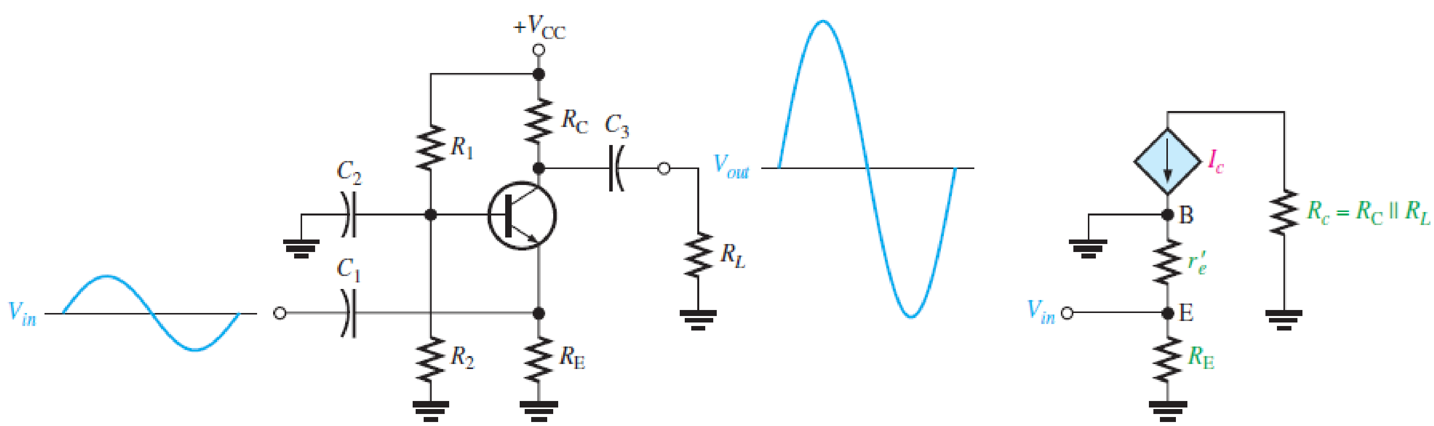
The Common-Base Amplifier

The common-base (CB) amplifier provides high voltage gain with a maximum current gain of 1. Since it has a low input resistance, the CB amplifier is the most appropriate type for certain applications where sources tend to have very low-resistance outputs.

Voltage Gain

The voltage gain from emitter to collector is developed as follows ($V_{in} = V_e$, $V_{out} = V_c$).

$$A_v = \frac{V_{out}}{V_{in}} = \frac{V_c}{V_e} = \frac{I_c R_c}{I_e(r'_e \parallel R_E)} \cong \frac{I_e R_c}{I_e(r'_e \parallel R_E)}$$



(a) Complete circuit with load

(b) AC equivalent model

FIGURE 6–31

If $R_E \gg r'_e$, then

$$A_v \cong \frac{R_c}{r'_e} \qquad \text{Equation 6–18}$$

where $R_c = R_C \parallel R_L$. Notice that the gain expression is the same as for the common-emitter amplifier. However, there is no phase inversion from emitter to collector.

Input Resistance

The resistance, looking in at the emitter, is

$$R_{in(emitter)} = \frac{V_{in}}{I_{in}} = \frac{V_e}{I_e} = \frac{I_e(r'_e \parallel R_E)}{I_e}$$

If $R_E \gg r'_e$, then

$$R_{in(emitter)} \cong r'_e \qquad \text{Equation 6–19}$$

Email: Hasan.muwafaq.gheni@uomus.edu.iq

R_E is typically much greater than r'_e, so the assumption that $r'_e \| R_E \cong r'_e$ is usually valid. The input resistance can be set to a desired value within limits by using a swamping resistor. This is useful in communication systems and other applications where you need to match a source impedance to prevent a reflected signal.

Output Resistance

Looking into the collector, the ac collector resistance, r'_c, appears in parallel with R_C. As you have previously seen in connection with the CE amplifier, r'_c is typically much larger than R_C, so a good approximation for the output resistance is

$$R_{out} \cong R_C$$

Equation 6–20

Current Gain

The current gain is the output current divided by the input current. I_c is the ac output current, and I_e is the ac input current. Since $I_c \cong I_e$, the current gain is approximately 1.

$$A_i \cong 1$$

Equation 6–21

Power Gain

The CB amplifier is primarily a voltage amplifier, so power gain is not too important. Since the current gain is approximately 1 for the common-base amplifier and $A_p = A_v A_i$, the total power gain is approximately equal to the voltage gain.

$$A_p \cong A_v$$

Equation 6–22

This power gain includes power to the collector resistor and to the load resistor. If you want the power gain only to the load, then divide V_{out}^2/R_L by the input power.

EXAMPLE 6–12

Find the input resistance, voltage gain, current gain, and power gain for the amplifier in Figure 6–32. $\beta_{DC} = 250$.

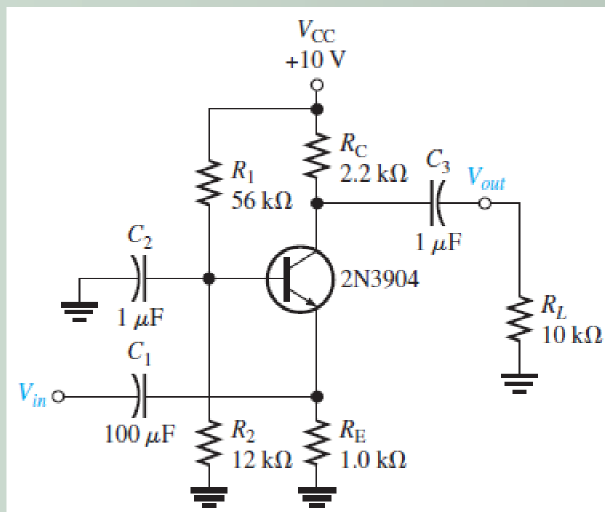
Solution First, find I_E so that you can determine r'_e. Then $R_{in} \cong r'_e$.

$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(56\text{ k}\Omega)(12\text{ k}\Omega)}{56\text{ k}\Omega + 12\text{ k}\Omega} = 9.88\text{ k}\Omega$$

$$V_{TH} = \left(\frac{R_2}{R_1 + R_2}\right)V_{CC} = \left(\frac{12\text{ k}\Omega}{56\text{ k}\Omega + 12\text{ k}\Omega}\right)10\text{ V} = 1.76\text{ V}$$

$$I_E = \frac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}} = \frac{1.76\text{ V} - 0.7\text{ V}}{1.0\text{ k}\Omega + 39.5\ \Omega} = 1.02\text{ mA}$$

▶ FIGURE 6–32



Therefore,

$$R_{in} \cong r'_e = \frac{25\text{ mV}}{I_E} = \frac{25\text{ mV}}{1.02\text{ mA}} = \mathbf{24.5\ \Omega}$$

Calculate the voltage gain as follows:

$$R_c = R_C \| R_L = 2.2\text{ k}\Omega \| 10\text{ k}\Omega = 1.8\text{ k}\Omega$$

$$A_v = \frac{R_c}{r'_e} = \frac{1.8\text{ k}\Omega}{24.5\ \Omega} = \mathbf{73.5}$$

Also, $A_i \cong$ **1** and $A_p \cong A_v =$ **73.5.**

Related Problem Find A_v in Figure 6–32 if $\beta_{DC} = 50$.

Multistage Amplifiers

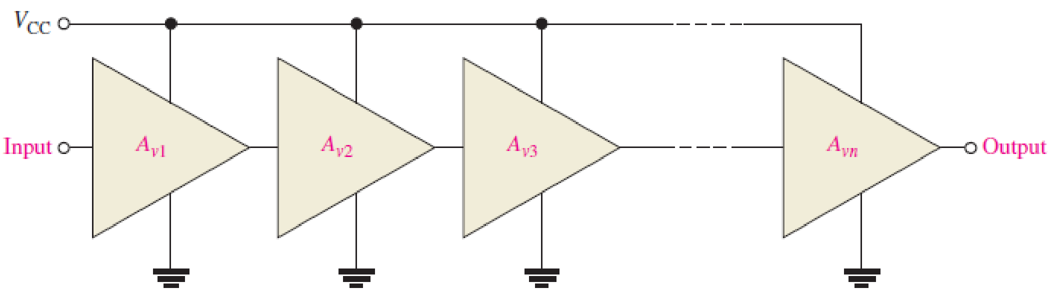
Two or more amplifiers can be connected in a cascaded arrangement with the output of one amplifier driving the input of the next. Each amplifier in a cascaded arrangement is known as a stage. The basic purpose of a multistage arrangement is to increase the overall voltage gain. Although discrete multistage amplifiers are not as common as they once were, a familiarization with this area provides insight into how circuits affect each other when they are connected together.

Email: Hasan.muwafaq.gheni@uomus.edu.iq

The overall voltage gain, A'_v, of cascaded amplifiers, as shown in Figure 6–33, is the product of the individual voltage gains.

$$A'_v = A_{v1}A_{v2}A_{v3}\ldots A_{vn}$$ Equation 6–23

where n is the number of stages.



▲ FIGURE 6–33

Cascaded amplifiers. Each triangular symbol represents a separate amplifier.

Amplifier voltage gain is often expressed in **decibels** (dB) as follows:

$$A_{v(\mathrm{dB})} = 20 \log A_v$$ Equation 6–24

This is particularly useful in **multistage** systems because the overall voltage gain in dB is the *sum* of the individual voltage gains in dB.

$$A'_{v(\mathrm{dB})} = A_{v1(\mathrm{dB})} + A_{v2(\mathrm{dB})} + \cdots + A_{vn(\mathrm{dB})}$$

EXAMPLE 6–13

A certain cascaded amplifier arrangement has the following voltage gains: $A_{v1} = 10$, $A_{v2} = 15$, and $A_{v3} = 20$. What is the overall voltage gain? Also express each gain in decibels (dB) and determine the total voltage gain in dB.

Solution

$$A'_v = A_{v1}A_{v2}A_{v3} = (10)(15)(20) = \mathbf{3000}$$

$$A_{v1(\mathrm{dB})} = 20 \log 10 = \mathbf{20.0\ dB}$$

$$A_{v2(\mathrm{dB})} = 20 \log 15 = \mathbf{23.5\ dB}$$

$$A_{v3(\mathrm{dB})} = 20 \log 20 = \mathbf{26.0\ dB}$$

$$A'_{v(\mathrm{dB})} = 20.0\ \mathrm{dB} + 23.5\ \mathrm{dB} + 26.0\ \mathrm{dB} = \mathbf{69.5\ dB}$$