Chapter 10
Amplifiers: Specifications and External Characteristics

1. Amplifier basic concepts.
2. Various amplifier models and analysis.
3. Importance of input and output impedances of amplifiers

Basic amplifier concepts

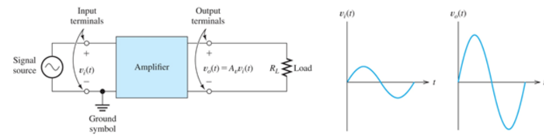

Figure 10.1 Electronic amplifier.

Basic amplifier concepts

Ideally, an amplifier produces an output signal with identical waveshape as the input signal, but with a larger amplitude.

$$v_o(t) = A_v v_i(t)$$

Typical examples

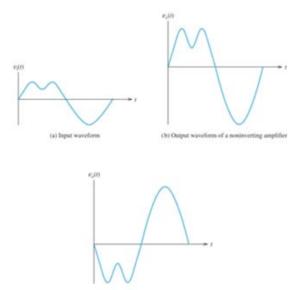

Figure 10.2 Input waveform and corresponding output waveforms.

Inverting versus Noninverting Amplifiers

Inverting amplifiers have negative voltage gain, and the output waveform is an inverted version of the input waveform.

Noninverting amplifiers have positive voltage gain.

Voltage-Amplifier Model

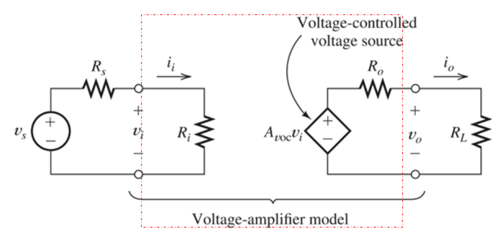

Figure 10.3 Model of an electronic amplifier, including input resistance R_i and output resistance R_o.

Current Gain

$$A_i = \frac{i_o}{i_i}$$

Power Gain

$$G = \frac{P_o}{P_i}$$

Example 10.1

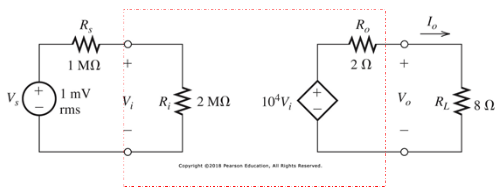

Figure 10.4 Source, amplifier, and load for Example 10.1.

$$Find \quad A_i, G$$

$$V_i = \frac{R_i}{R_i + R_s} V_s = 0.667 mV$$

$$V_o = A_{vo} V_i \frac{R_L}{R_L + R_o} = 5.33V$$

What is loading effect?

Cascaded amplifiers

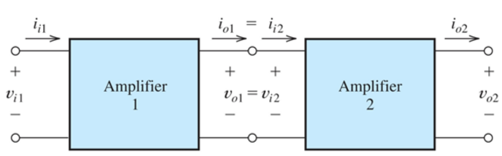

Figure 10.5 Cascade connection of two amplifiers.

$$A_v = A_{v1} A_{v2}$$

Example 10.2

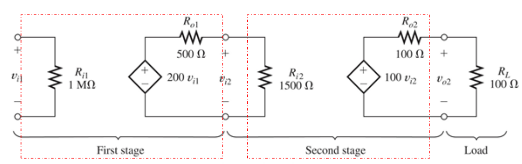

Figure 10.6 Cascaded amplifiers of Examples 10.2 and 10.3.

$$Find \quad A_v, A_i, G$$

$$A_{v1} = \frac{v_{o1}}{v_{i1}} = \frac{v_{i2}}{v_{i1}} = A_{vo1}\frac{R_{i2}}{R_{i2} + R_{o1}} = 150$$

$$A_{v2} = \frac{v_{o2}}{v_{i2}} = A_{vo2}\frac{R_L}{R_L + R_{o2}} = 50$$

$$A_v = A_{v1}A_{v2} = 7500$$

$$A_{i1} = A_{v1}\frac{R_{i1}}{R_{i2}} = 10^5 \qquad A_{i2} = A_{v2}\frac{R_{i2}}{R_L} = 750$$

$$A_i = A_{i1}A_{i2} = 75\times 10^6$$

$$G_1 = A_{v1}A_{i1} = 1.5\times 10^7 \qquad G_2 = A_{v2}A_{i2} = 3.75\times 10^4$$

$$G = G_1G_2 = 5.625\times 10^{11}$$

Simplified Models for Cascaded Amplifier

First, determine the voltage gain of the first stage accounting for loading by the second stage.

The overall voltage gain is the product of the gains of the separate stages.

The input impedance is that of the first stage, and the output impedance is that of the last stage.

Example 10.3

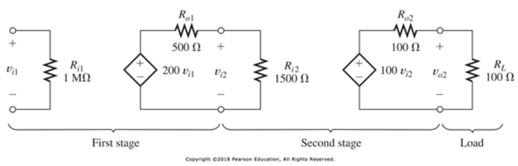

Figure 10.6 Cascaded amplifiers of Examples 10.2 and 10.3.

Example 10.3

$$A_{v1} = A_{vo1}\frac{R_{i2}}{R_{i2} + R_{o1}} = 150$$

$$A_{v2} = A_{vo2} = 100$$

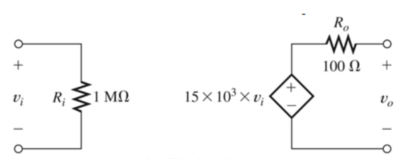

Figure 10.7 Simplified model for the cascaded amplifiers of Figure 10.6. See Example 10.3.

Current-Amplifier Model

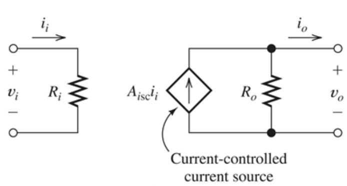

Figure 10.11 Current-amplifier model.

A_{isc} is the current gain of the amplifier with the output short circuited.

Example 10.5

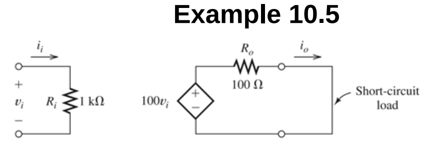

Figure 10.12 Voltage amplifier of Examples 10.5, 10.6, and 10.7.

$$i_i = \frac{v_i}{R_i}, \qquad i_{osc} = \frac{A_{vo}v_i}{R_o}, \qquad A_{isc} = \frac{i_{osc}}{i_i} = \frac{A_{vo}R_i}{R_o} = 10^3$$

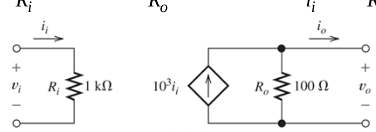

Figure 10.13 Current-amplifier model equivalent to the voltage-amplifier model of Figure 10.12. See Example 10.6.

Importance of amplifier impedances in various applications

Some applications call for amplifiers with high input impedance while others call for low input impedance.

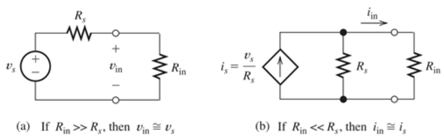

Figure 10.18 If we want to sense the open-circuit voltage of a source, the amplifier should have a high input resistance, as in (a). To sense the short-circuit current of the source, low input resistance is called for, as in (b).

Some applications call for amplifiers with high output impedance while others call for low output impedance.

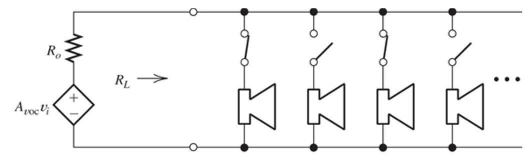

Figure 10.19 If the amplifier output resistance R_o is much less than the (lowest) load resistance, the load voltage is nearly independent of the number of switches closed.

Chapter 10
Amplifiers: Specifications and External Characteristics

Summary of Ideal amplifiers

Amplifier type	Input impedance	Output Impedance	Gain
Voltage	∞	0	A_{vo}
Current	0	∞	A_{isc}

Chapter 10
Amplifiers: Specifications and External Characteristics