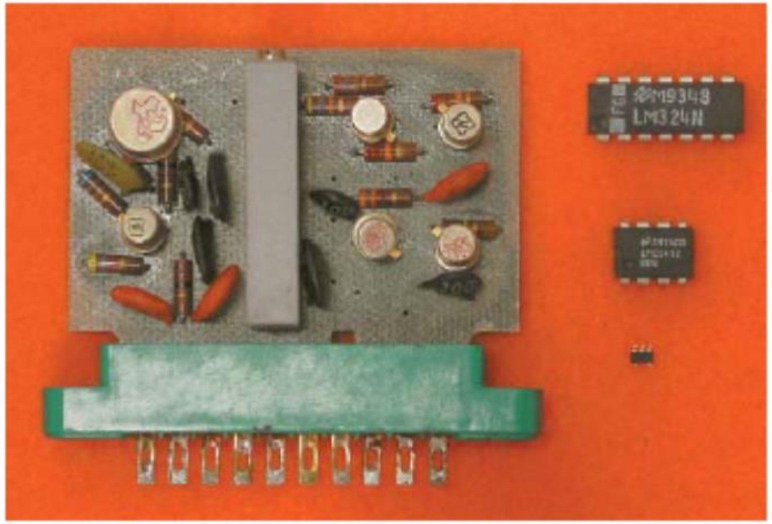
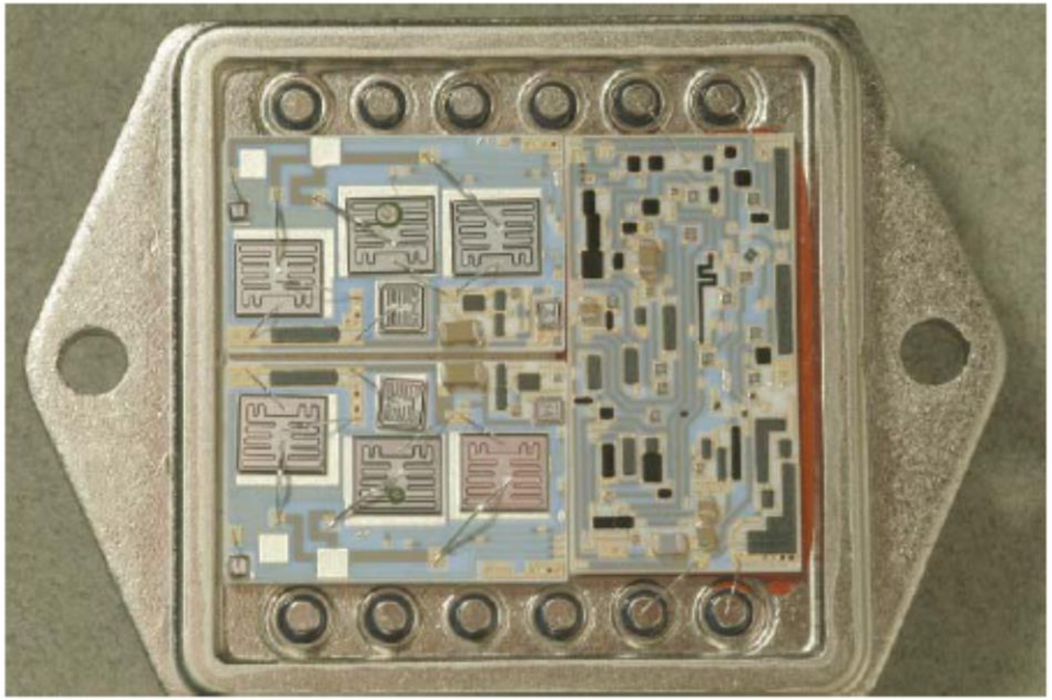
Operational Amplifiers → Chapter #4

Op-amps

- **Amplifier Model**
- **Amplifier Based Circuit Analysis**



(a)



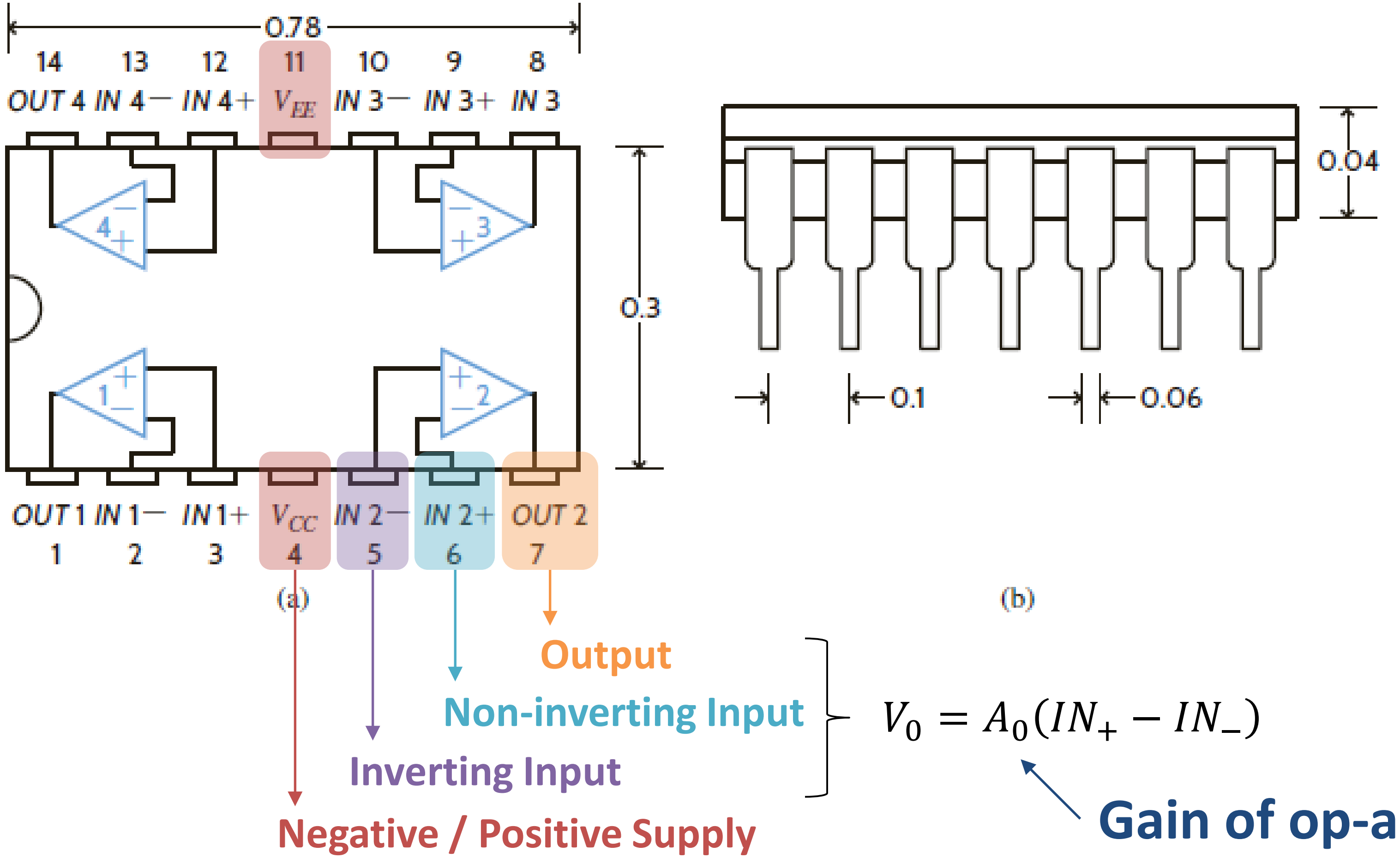
(b)

Op-Amp

- *Is the single most important integrated circuit for analog circuit design*
- *Is a versatile interconnection of transistors and resistors*
- *Is used in a wide range of applications, from engine control systems to cellular phones*
- *Was designed to perform mathematical operations*

Op-Amp Model

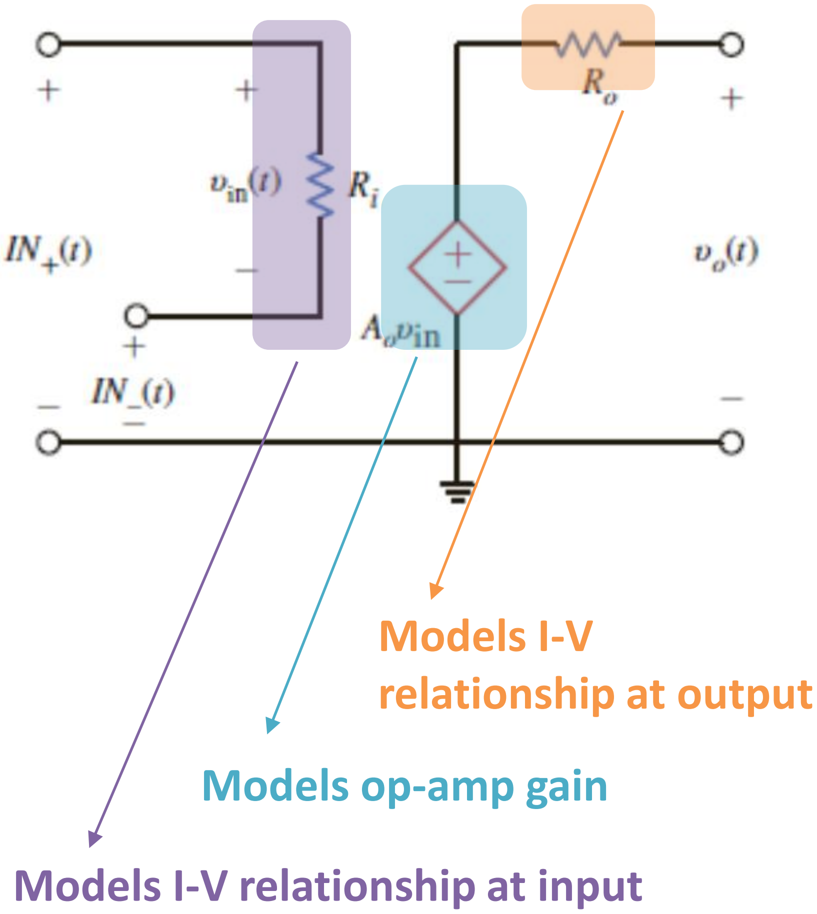
- **LM324 – Dip Package - Pinout**



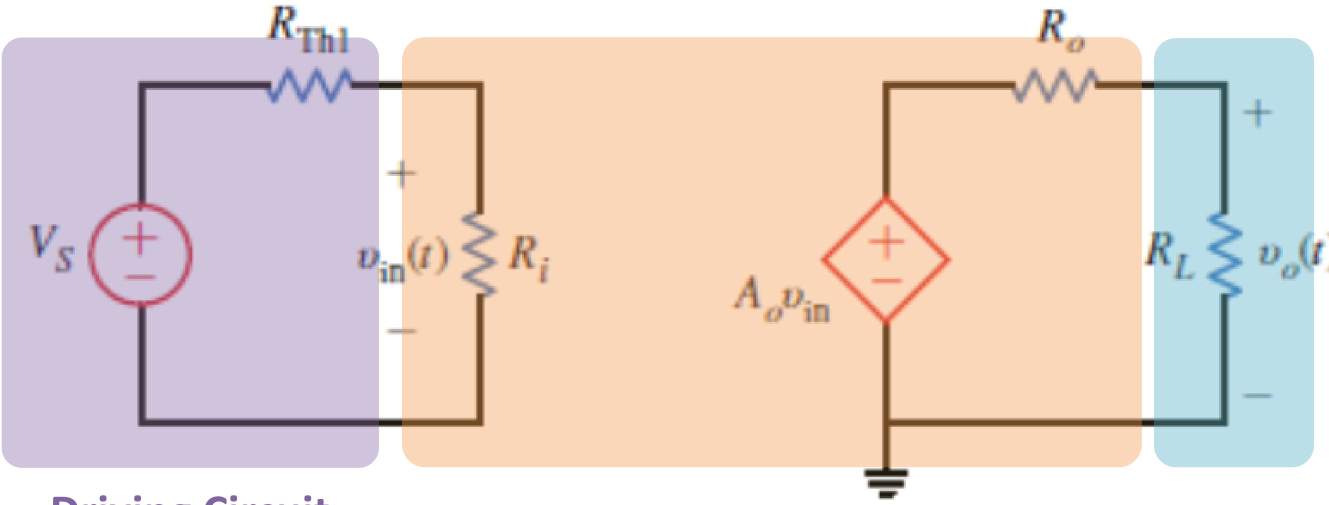
$$V_0 = A_0(IN_+ - IN_-)$$

Gain of op-amp ~ (10,000 – 1,000,000)

- **Circuit Model**



Op-Amp Circuit



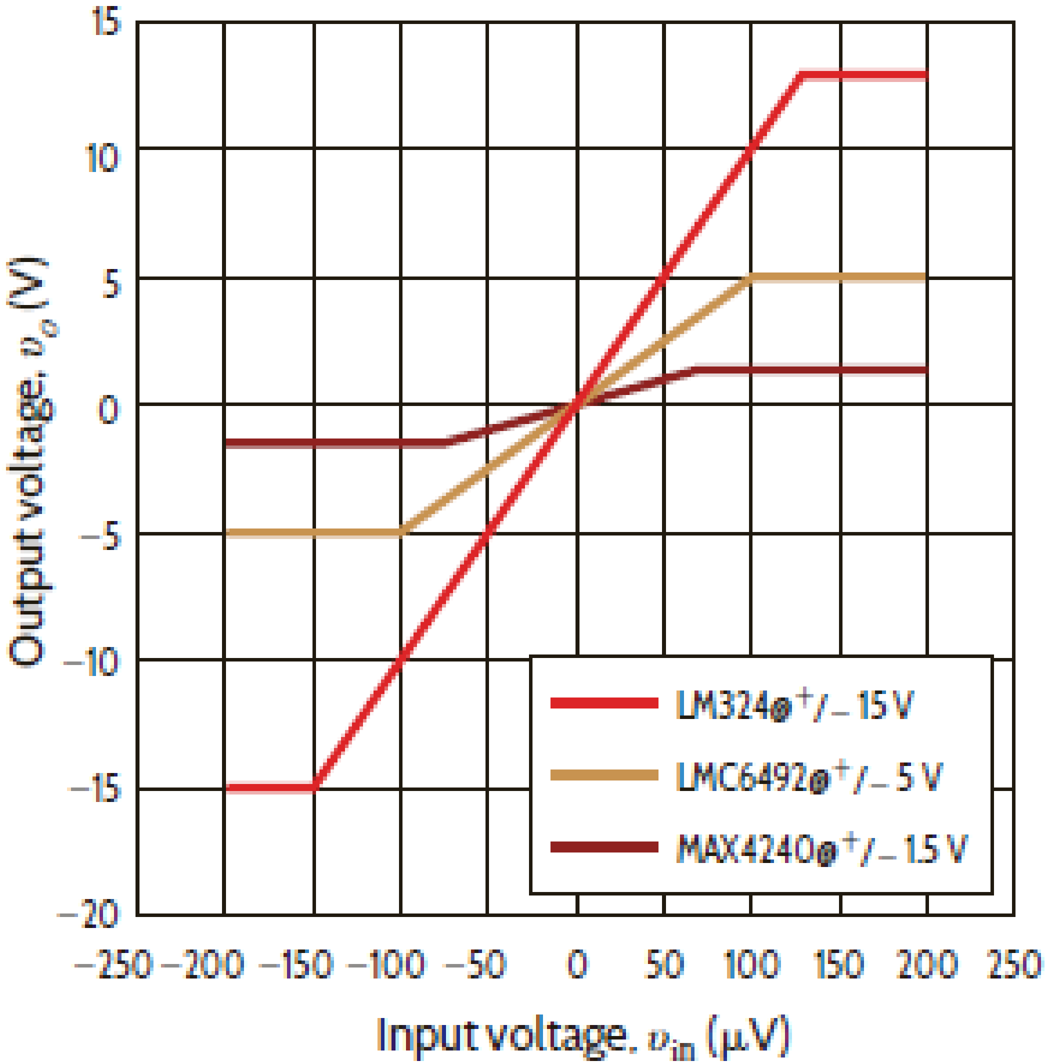
Driving Circuit Model

Op-Amp

Load

$$\frac{V_0}{V_S} = \left[\frac{R_i}{R_i + R_{TH1}}\right][A_0]\left[\frac{R_L}{R_L + R_0}\right]$$

$$for R_i \to \infty, R_0 \to 0 \qquad \frac{V_0}{V_S} = A$$



Example 4.1

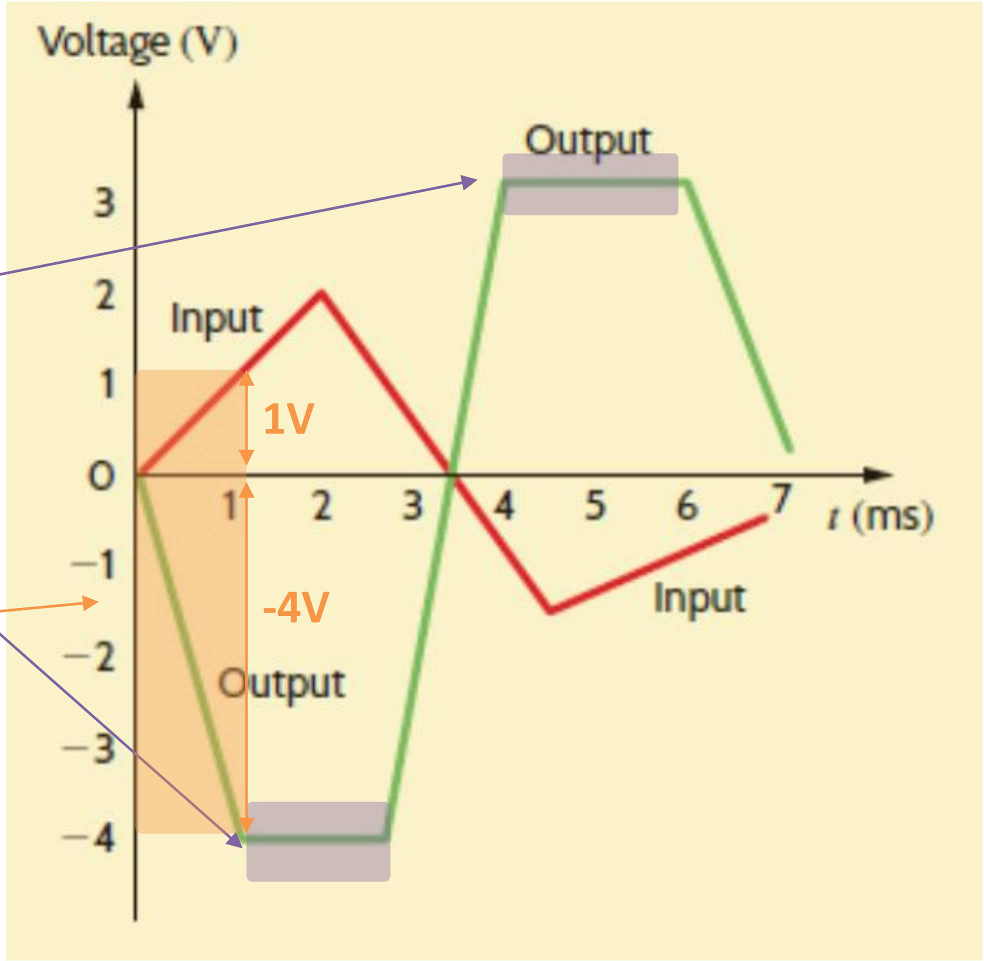
The input and output signals for an op-amp circuit are shown in figure below. Determine:

a) if the op-amp circuit is linear, and

b) the circuit's gain

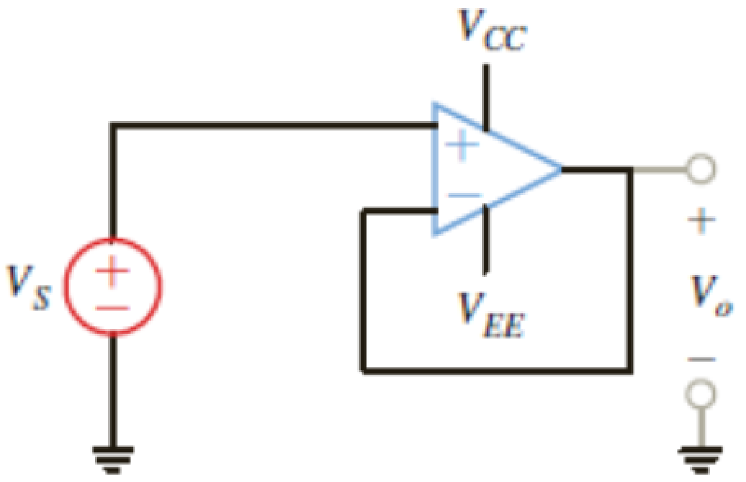
Op-amp saturates, therefore not linear

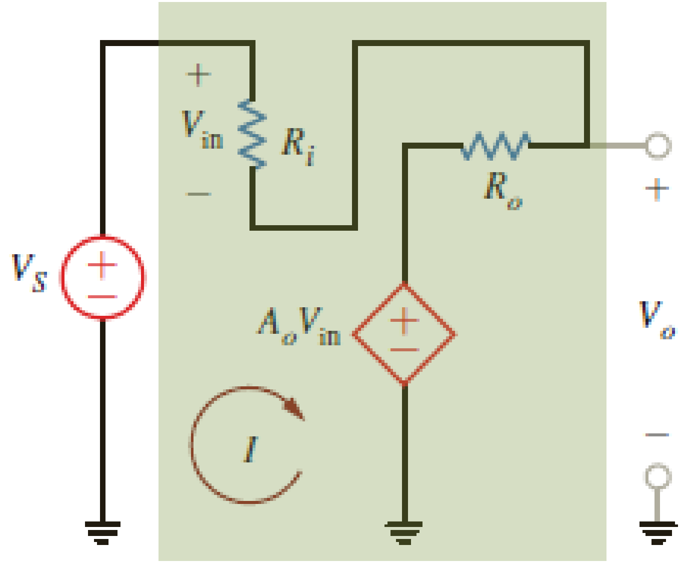
$$\frac{V_0}{V_s} = \frac{-4}{1} = -4V/V$$



Unity Gain Buffer

Using the op-amp model find the expression for the transfer function V_o/V_s.





Op-Amp Ideal Behavior

- $R_i = \infty$
- $A_0 = \infty$
- $R_o = 0$

$$i_{R_i} = \frac{V_{in}}{R_i} = 0$$

$$\therefore i_+ = i_- = 0$$

$$\frac{V_0}{V_s} = \frac{1}{1 + \frac{1}{A_0 + \frac{R_0}{R_i}}} \approx \frac{1}{1 + \frac{1}{A_0}} \approx 1$$

$R_i=\infty$, $R_0=0$

$A_0=\infty$

$$V_0 = A_0(V_+ - V_-)$$

$$(V_+ - V_-) = \frac{V_0}{A_0} = 0 \qquad \therefore V_+ = V_-$$