

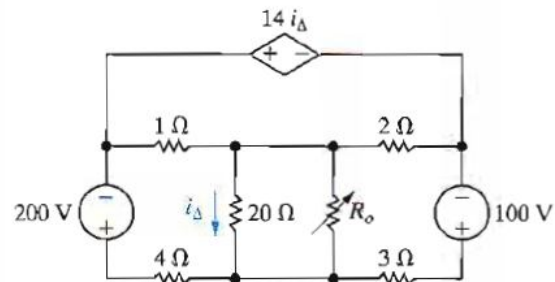
فصل 4 کتاب نیلسون و الکساندر

4.86 The variable resistor (R_o) in the circuit in Fig. P4.86 is adjusted for maximum power transfer to R_o .

PSPICE

- Find the value of R_o .
- Find the maximum power that can be delivered to R_o .

Figure P4.86



فصل 5 کتاب نیلسون و الکساندر، فصل 3* کتاب جبه‌دار

• تقویت‌کننده عملیاتی (OpAmp)

○ معرفی تقویت‌کننده عملیاتی

The **op amp** is an electronic unit that behaves like a voltage-controlled voltage source.

An **op amp** is an active circuit element designed to perform mathematical operations of addition, subtraction, multiplication, division, differentiation, and integration.

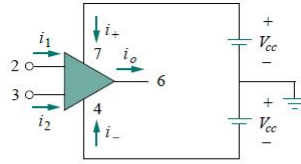


Figure 5.3 Powering the op amp.

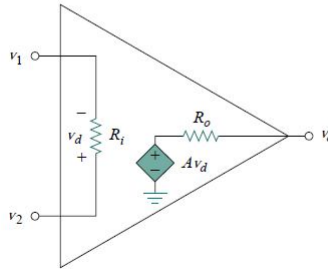


Figure 5.4 The equivalent circuit of the non-ideal op amp.

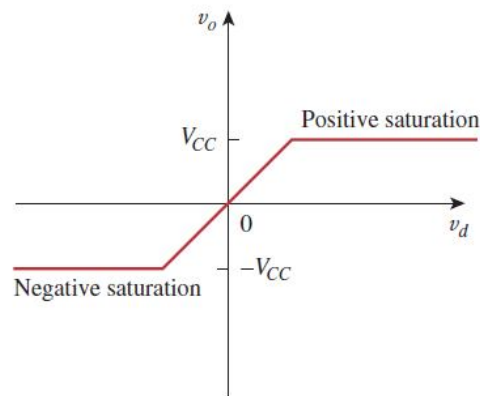
- جریان و ولتاژ ترمینالهای یک تقویت کننده عملیاتی $(v_1, v_2, v_o, V^+, V^-)$ و $(i_1, i_2, i_o, i^+, i^-)$
- محدوده مقادیر واقعی:

TABLE 5.1

Typical ranges for op amp parameters.

Parameter	Typical range	Ideal values
Open-loop gain, A	10^5 to 10^8	∞
Input resistance, R_i	10^5 to $10^{13} \Omega$	$\infty \Omega$
Output resistance, R_o	10 to 100Ω	0Ω
Supply voltage, V_{CC}	5 to 24 V	

- رابطه بین v_d و v_o



- عملکرد تقویت کننده عملیاتی

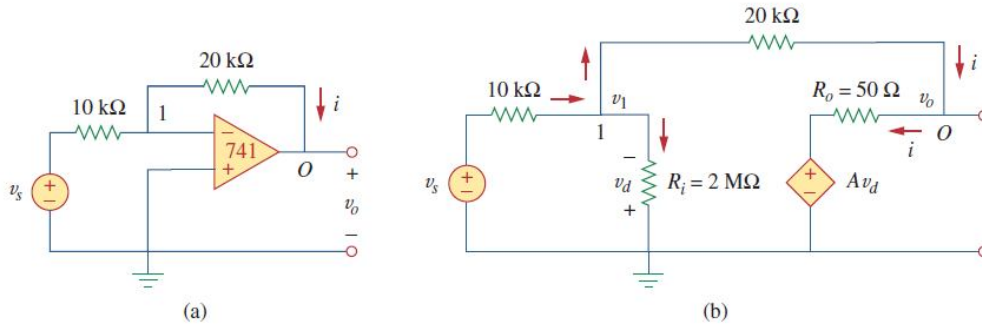
- در ناحیه خطی
- در اشباع

▪ مقایسه کننده

- مثال:

Example 5.1

A 741 op amp has an open-loop voltage gain of 2×10^5 , input resistance of $2 \text{ M}\Omega$, and output resistance of 50Ω . The op amp is used in the circuit of Fig. 5.6(a). Find the closed-loop gain v_o/v_s . Determine current i when $v_s = 2 \text{ V}$.



• تقویت کننده عملیاتی ایده آل

1. Infinite open-loop gain, $A \approx \infty$.
2. Infinite input resistance, $R_i \approx \infty$.
3. Zero output resistance, $R_o \approx 0$.

○ حل یک مدار شامل تقویت کننده‌ی عملیاتی بر اساس:

- $i_1 = i_2 = 0$
- $v_1 = v_2$

▪ برای حل مدار فقط از آنالیز گره استفاده کرده و KCL را برای گره متصل به خروجی نیز ننویسید

(خروجی سر منبع ولتاژ وابسته‌ای است که سر دیگر آن گره مرجع است).

○ تقویت کننده معکوس کننده.

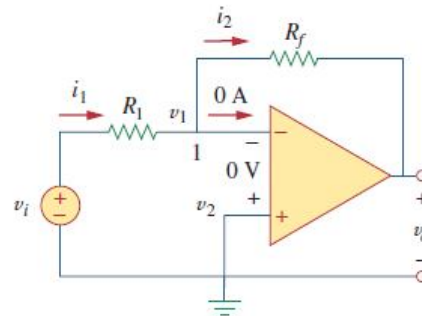
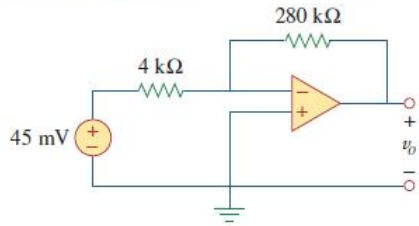


Figure 5.10
The inverting amplifier.

Practice Problem 5.3

Find the output of the op amp circuit shown in Fig. 5.13. Calculate the current through the feedback resistor.



Answer: -3.15 V , $26.25 \mu\text{A}$.

Figure 5.13

For Practice Prob. 5.3.

Two kinds of current-to-voltage converters (also known as *transresistance amplifiers*) are shown in Fig. 5.15.

Practice Problem 5.4

(a) Show that for the converter in Fig. 5.15(a),

$$\frac{v_o}{i_s} = -R$$

(b) Show that for the converter in Fig. 5.15(b),

$$\frac{v_o}{i_s} = -R_1 \left(1 + \frac{R_3}{R_1} + \frac{R_3}{R_2} \right)$$

Answer: Proof.

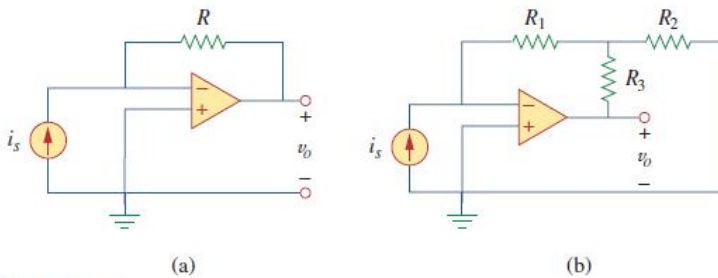


Figure 5.15

For Practice Prob. 5.4.

○ تقویت کننده معکوس نکننده.

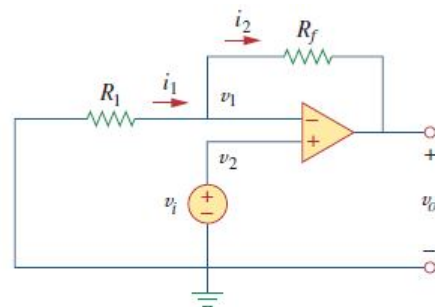


Figure 5.16

The noninverting amplifier.

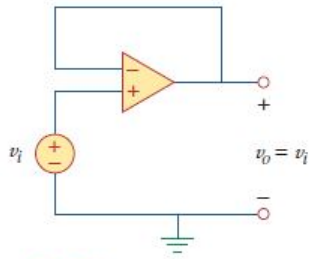


Figure 5.17
The voltage follower.

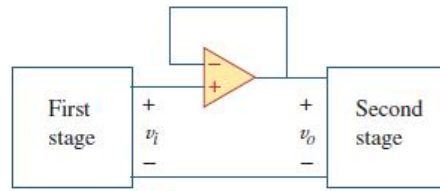


Figure 5.18
A voltage follower used to isolate two cascaded stages of a circuit.

در شکل زیر خروجی را یکبار با استفاده از جمع آثار و یکبار مستقیم بدست آورید. ○

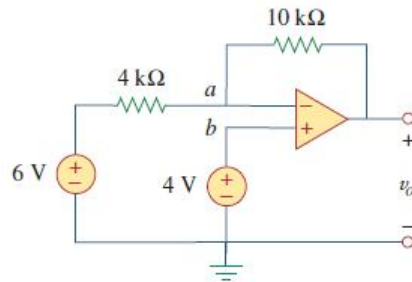


Figure 5.19
For Example 5.5.

Calculate v_o in the circuit of Fig. 5.20.

Answer: 7 V.

Practice Problem 5.5

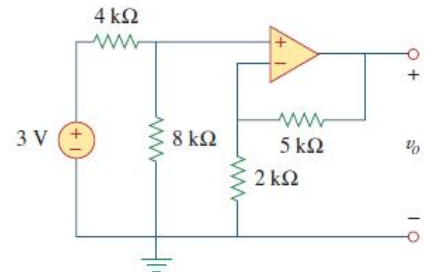


Figure 5.20
For Practice Prob. 5.5.

تقویت کننده جمع کننده (Summing Amplifier) ○

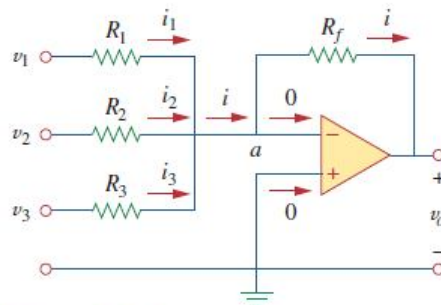


Figure 5.21
The summing amplifier.

Practice Problem 5.6

Find v_o and i_o in the op amp circuit shown in Fig. 5.23.

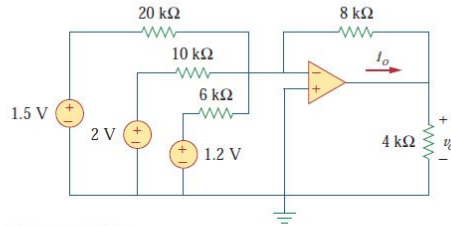


Figure 5.23
For Practice Prob. 5.6.

Answer: -3.8 V , -1.425 mA .

○ تقویت کننده تفاضل (Difference Amplifier)

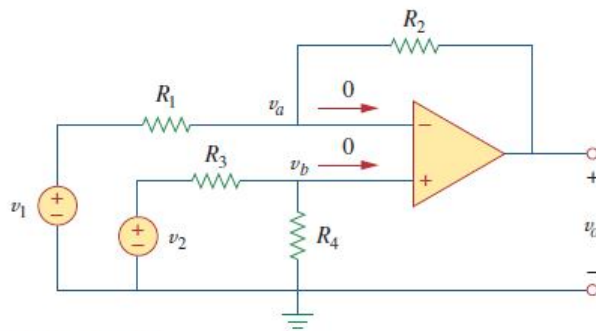


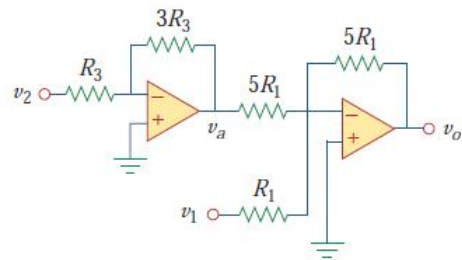
Figure 5.24
Difference amplifier.

Practice Problem 5.7

Design a difference amplifier with gain 7.5.

Answer: Typical: $R_1 = R_3 = 20 \text{ k}\Omega$, $R_2 = R_4 = 150 \text{ k}\Omega$.

در مدار شکل زیر v_o را بدست آورید



An instrumentation amplifier shown in Fig. 5.26 is an amplifier of low-level signals used in process control or measurement applications and commercially available in single-package units. Show that

$$v_o = \frac{R_2}{R_1} \left(1 + \frac{2R_3}{R_4} \right) (v_2 - v_1)$$

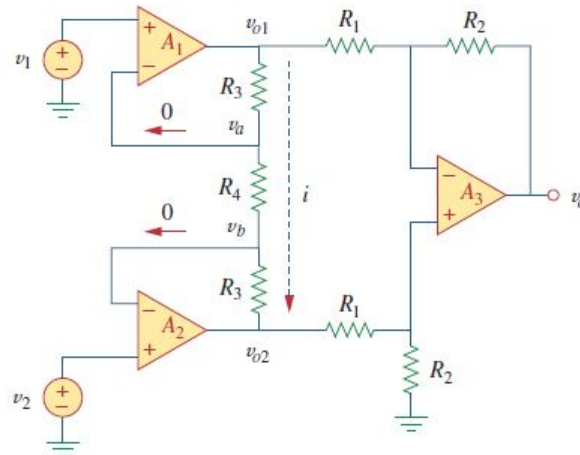


Figure 5.26 Instrumentation amplifier; for Example 5.8.

در یک Inst. Amp:

$$v_o = A_v(v_2 - v_1) \quad (5.24)$$

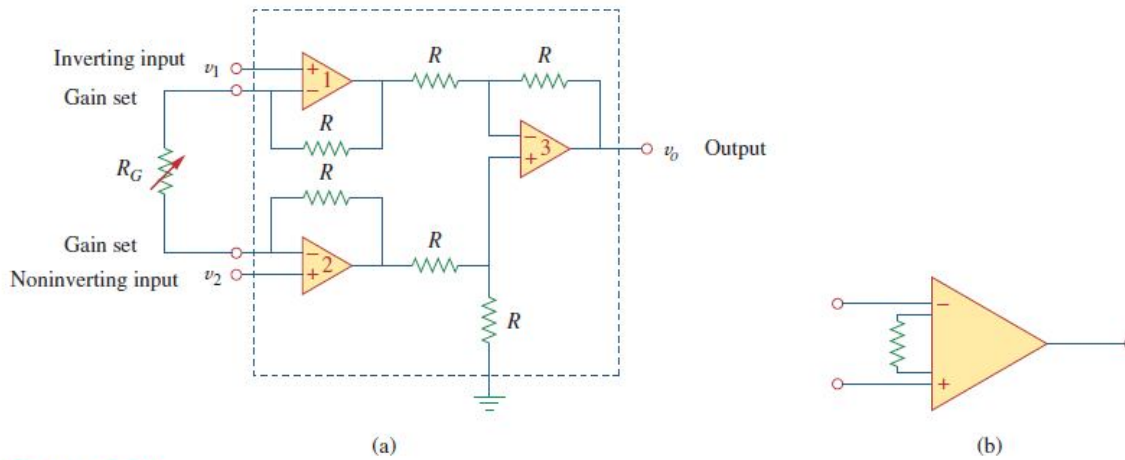


Figure 5.38 (a) The instrumentation amplifier with an external resistance to adjust the gain, (b) schematic diagram.

where the voltage gain is

$$A_v = 1 + \frac{2R}{R_G} \quad (5.25)$$

Practice Problem 5.8

Obtain i_o in the instrumentation amplifier circuit of Fig. 5.27.

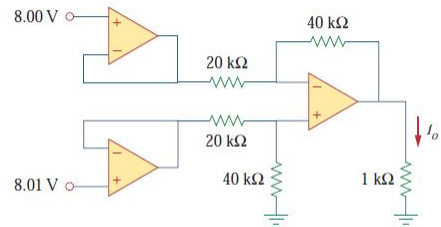
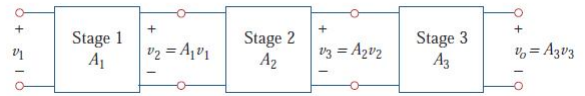


Figure 5.27
Instrumentation amplifier; for Practice Prob. 5.8.

Answer: $20 \mu\text{A}$.

○ اتصال آبشاری (cascade) مدارى شامل تقويت كننده‌ى عملیاتی



Practice Problem 5.10

If $v_1 = 4 \text{ V}$ and $v_2 = 3 \text{ V}$, find v_o in the op amp circuit of Fig. 5.33.

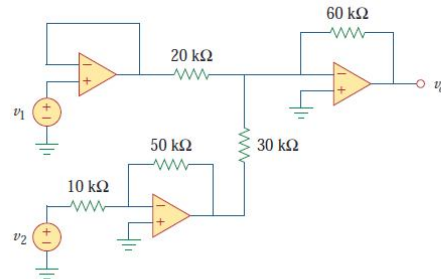


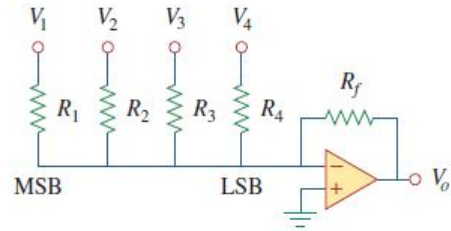
Figure 5.33
For Practice Prob. 5.10.

کاربردها

- مبدل دیجیتال به آنالوگ



(a)



(b)

Figure 5.36
Four-bit DAC: (a) block diagram,
(b) binary weighted ladder type.

• مبدل آنالوگ به دیجیتال