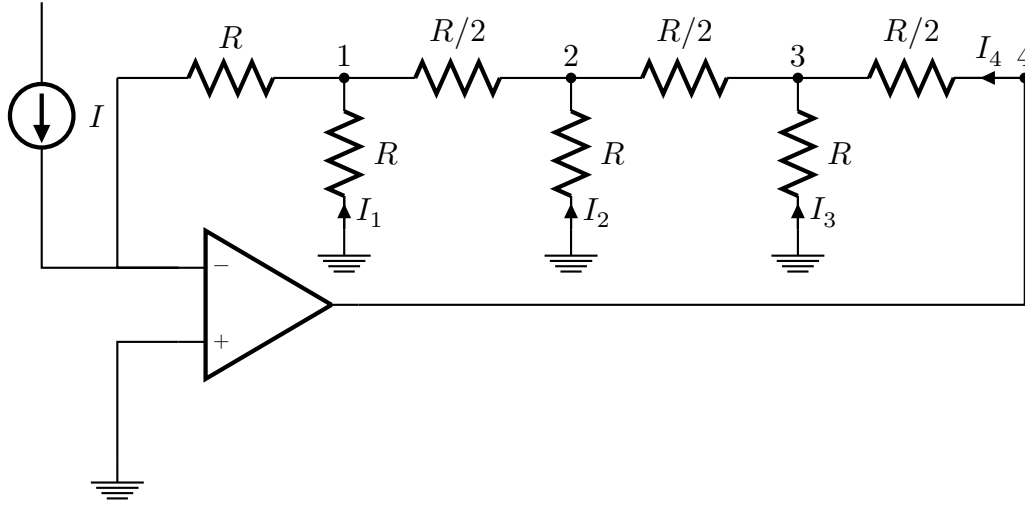


## 1 2.27

The circuit in Fig. P2.27 can be considered to be an extension of the circuit in Fig. 2.8



- (a) Find the resistance looking into node 1, 2, 3, 4.

Ans:

$$R_1 = R$$

$$R_2 = (R \parallel R) + R/2 = R$$

$$R_3 = (R \parallel R) + R/2 = R$$

$$R_4 = (R \parallel R) + R/2 = R$$

- (b) Find the currents  $I_1, I_2, I_3, I_4$ , in terms of  $I$  Ans:

$$I_1 = IR/R = I$$

$$I_2 = ((I + I_1)(R/2) + IR)/R = 2I$$

$$I_3 = (4IR/2 + 2IR)/R = 4I$$

$$I_4 = (8IR/2 + 4IR)/R = 8I$$

- (c) Find the voltages at node 1, 2, 3, 4.

Ans:

$$V_1 = IR$$

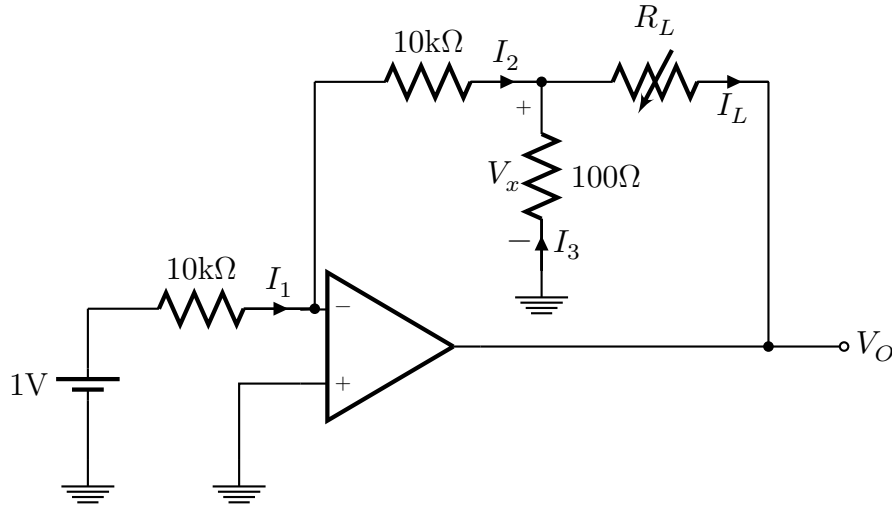
$$V_2 = V_1 + 2IR/2 = 2IR$$

$$V_3 = V_2 + 4IR/2 = 4IR$$

$$V_4 = V_3 + 8IR/2 = 8IR$$

## 2 2.28

The circuit below utilizes an ideal op amp.



- (a) Find  $I_1, I_2, I_3, V_x$

Ans:

$$I_1 = 1\text{V}/10\text{k}\Omega = 0.1\text{mA}$$

$$I_2 = I_1 = 0.1\text{mA}$$

$$V_x = 0 - (0.1\text{mA})(10\text{k}\Omega) = -1\text{V}$$

$$I_3 = 1/100\Omega = 10\text{mA}$$

- (b) If  $V_O$  is not to be lower than  $-13\text{V}$ , find the maximum allowed value of  $R_L$

Ans:

$$\begin{aligned} V_O &= V_x + R_L I_L = V_x + R_L (I_2 + I_3) \\ &= -1\text{V} - (10.1\text{mA})R_L \end{aligned}$$

so

$$R_L \leq 12\text{V}/10.1\text{mA} \approx 1.19$$

- (c) If  $R_L$  is varied in the range  $100\Omega$  to  $1\text{k}\Omega$ , what is the corresponding change in  $I_L$  and in  $V_O$ ?  $I_L$  would not change

$$V_O|_{R_L=100\Omega} = 2.02\text{V}, V_O|_{R_L=1\text{k}\Omega} = 11.2\text{V}$$

## 3 2.37

Figure P2.37 shows a circuit for a digital-to-analog converter. Show that  $v_O$  is given by

$$v_O = -\frac{R_f}{16} \sum_{i=0}^3 2^i a_i$$

## 4 2.51

Figure shows a circuit that provides an output voltage  $v_o$  whose value can be varied by turning the wiper of the  $100\text{k}\Omega$  potentiometer. Find the range over which  $v_o$  can be varied. If the potentiometer is a "20-turn" device, find the change in  $v_o$  corresponding to each turn of the pot.

## 5 2.63

For an instrumentation amplifier of the type shown in Fig 2.20(b), a designer proposes to make  $R_2 = R_3 = R_4 = 100\text{k}\Omega$  and  $2R_1 = 10\text{k}\Omega$ . For ideal components, what difference-mode gain, common-mode gain, and CMRR result? Reevaluate the worst-case values for these for the situation in which all resistors are specified as  $\pm 1\%$  units. Repeat the latter analysis for the case in which  $2R_1$  is reduced to  $1\text{k}\Omega$ . What do you conclude about the importance of the relative difference gains of the first and second stages?

## 6 2.65

The circuit shown in Fig is intended to supply a voltage to floating loads (those for which both terminals are ungrounded) while making possible use of available power supply.

## 7 2.66

The two circuits in Fig are intended to function as voltage-to-current converters; that is, they supply the load impedance  $Z_L$  with a current proportional to  $v_I$  and independent of the value of  $Z_L$ . Show that this is indeed the case, and find for each circuit  $i_o$  as a function of  $v_I$ . Comment on the differences between the two circuits.

## 8 2.69

An op-amp-based inverting integrator is measured at  $1\text{kHz}$  to have a voltage gain of  $-100\text{V/V}$ . At what frequency is its gain reduced to  $-1\text{V/V}$ ? What is the integrator time constant?

## 9 2.79

Derive the transfer function of the circuit in Fig and show that it can be written in the form

$$\frac{V_o}{V_i} = \frac{-R_2/R_1}{(1 + (\omega_1/(i\omega))) (1 + (\omega/(i\omega_2)))}$$

## 10 2.100

A designer, wanting to achieve a stable gain of  $100\text{V/V}$  at  $5\text{MHz}$ , considers her choice of amplifier topologies. What unity-gain frequency would a single operational amplifier require to satisfy her need? Unfortunately, the best available amplifier has an  $f_t$  of  $40\text{MHz}$ . How many such stages would she need to achieve her goal? What is the  $3\text{dB}$  frequency of each stage she can use? What is the overall  $3\text{dB}$  frequency?

## 11 2.102

Consider an inverting summer with two inputs  $V_1$  and  $V_2$  and with  $V_O = -(V_1 + V_2)$ . Find the  $3\text{dB}$  frequency of each of the gain functions  $V_O/V_1$  and  $V_O/V_2$  in terms of the op amp  $f_1$ .

## 12 2.104

An op amp having a slew rate of  $20\text{V}/\mu\text{s}$  is to be used in the unity-gain follower configuration, with input pulses that rise from  $0$  to  $3\text{V}$ . What is the shortest pulse that can be used while ensuring full-amplitude output? For such a pulse, describe the outputting resulting.