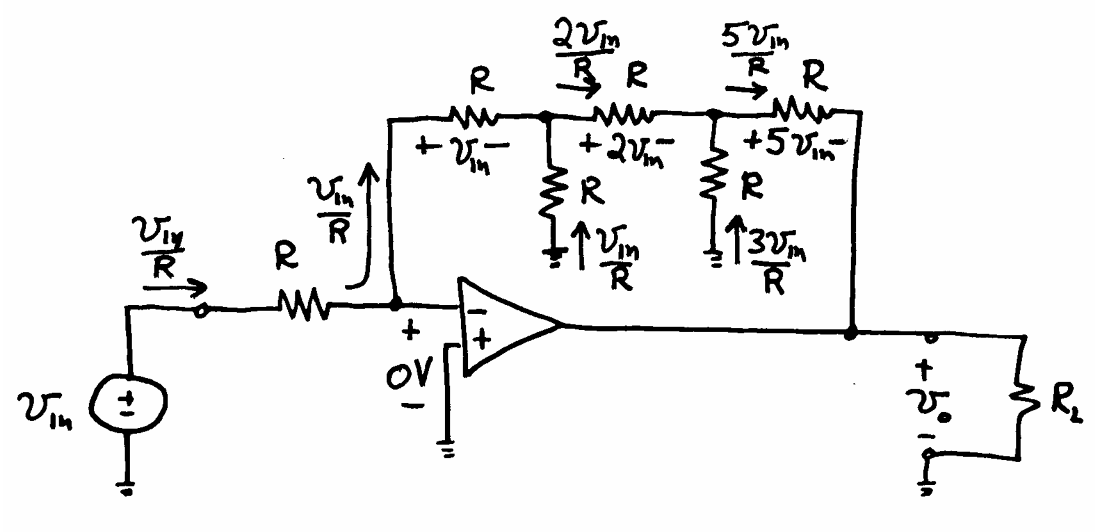
CHAPTER 14

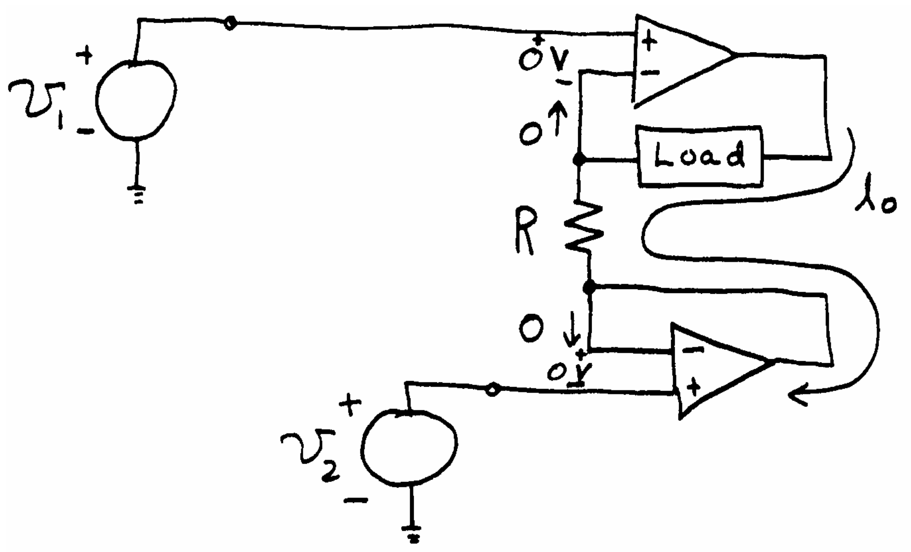
P14.9* The circuit has negative feedback so we can employ the summing-point constraint. Then successive application of Ohm's and Kirchhoff's laws starting from the left-hand side of the circuit produces the results shown:



From these results we can use KVL to determine that $v_o = -8v_{\text{in}}$ from which we have $A_v = -8$.

P14.16 If the source has a non-zero series impedance, loading (reduction in voltage) will occur when the load is connected directly to the source. On the other hand, the input impedance of the voltage follower is very high (ideally infinite) and loading does not occur. If the source impedance is very high compared to the load impedance, the voltage follower will deliver a much larger voltage to the load than direct connection.

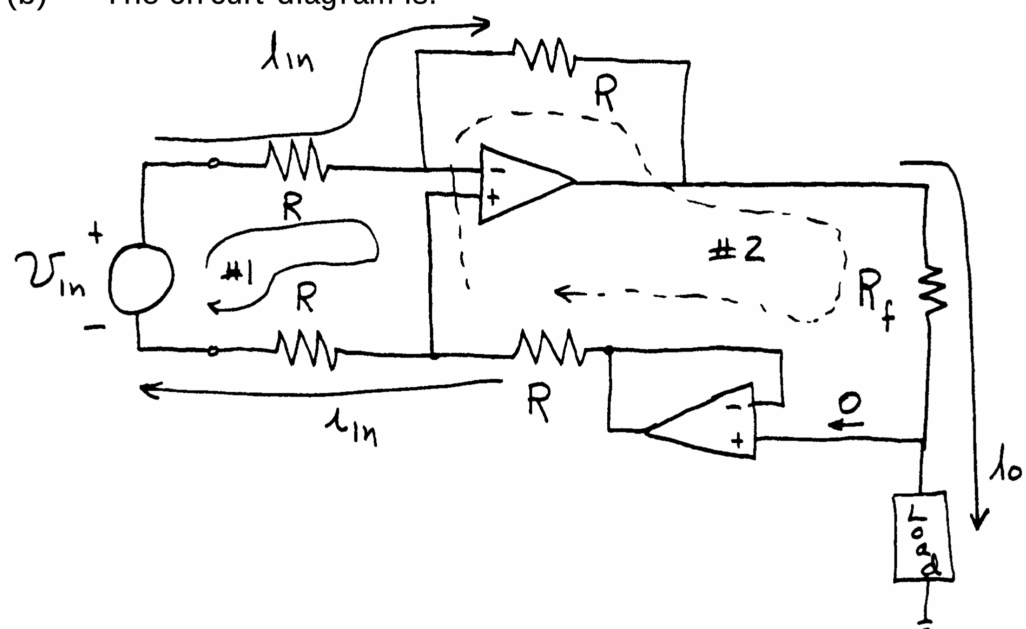
P14.21 (a)



$v_1 = 0 + Ri_o + 0 + v_2 \qquad\qquad i_o = \dfrac{v_1 - v_2}{R}$

Since i_o is independent of the load, the output impedance is infinite.

(b) The circuit diagram is:

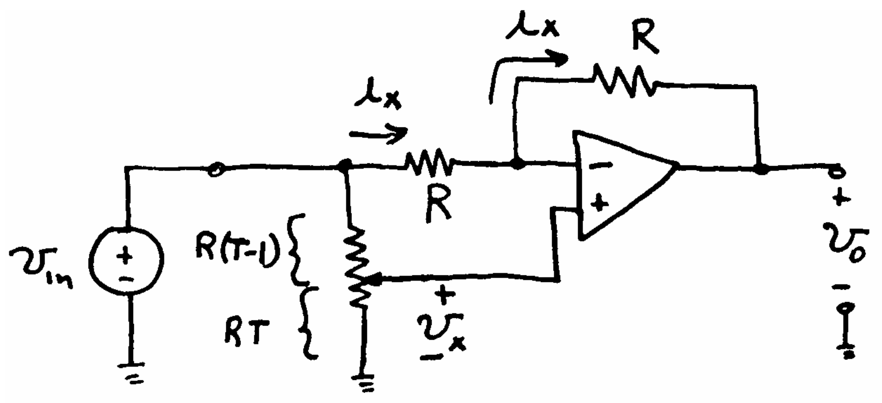


Writing KVL around loop #1, we have $v_{in} = Ri_{in} + 0 + Ri_{in}$

Writing KVL around loop #2, we have $Ri_{in} + R_f i_o + Ri_{in} = 0$

Algebra produces $i_o = -v_{in}/R_f$. Since i_o is independent of the load, the output impedance is infinite.

P14.27



By the voltage-division principle, we have

$$v_x = \frac{RT}{RT + (1-T)R} v_{in} = Tv_{in}$$

Then, we can write

$$i_x = \frac{v_{in} - v_x}{R} = \frac{v_{in}(1-T)}{R}$$

$$\begin{aligned} v_o &= -Ri_x + v_x \\ &= -v_{in}(1-T) + Tv_{in} \\ &= v_{in}(2T-1) \end{aligned}$$

Thus, as T varies from 0 to unity, the circuit gain varies from -1 through to 0 to +1.

P14.41* Equation 14.34 states:

$$f_t = A_{0CL} f_{BCL} = A_{0OL} f_{BOL}$$

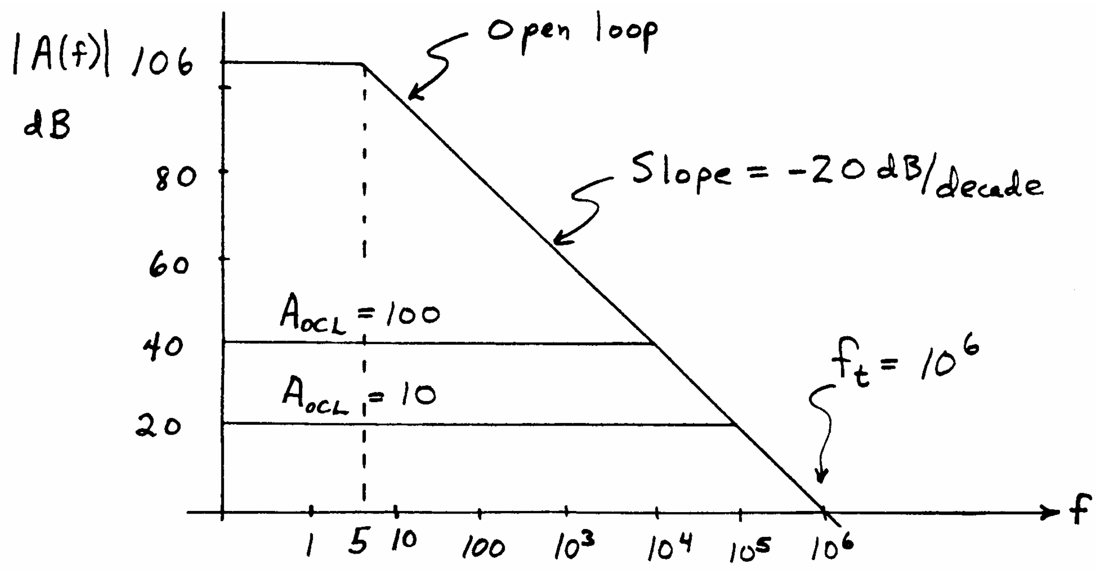
Thus, for $A_{0CL} = 10$, we have

$$f_{BCL} = \frac{f_t}{A_{0CL}} = \frac{15 \text{ MHz}}{10} = 1.5 \text{ MHz}$$

For $A_{0CL} = 100$, we have

$$f_{BCL} = 150 \text{ kHz}$$

P14.46*



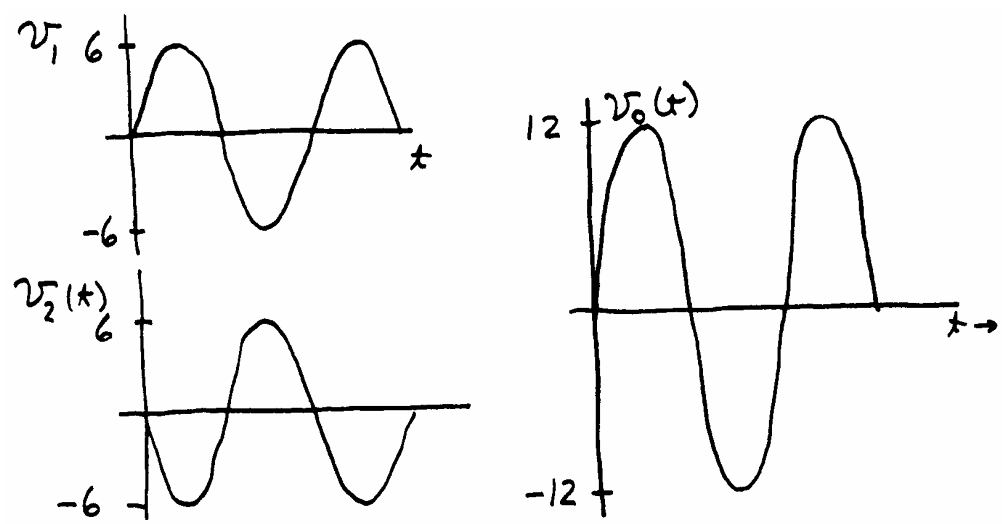
P14.53 (a) One op amp is configured as an inverting amplifier with a gain of -2 and the other op amp is configured as a noninverting amplifier with a gain +2. Thus, we can write:

$$v_2(t) = -2v_s(t)$$

$$v_1(t) = 2v_s(t)$$

$$v_o(t) = v_1(t) - v_2(t) = 4v_s(t) \qquad A_v = v_o/v_s = 4$$

(b)



(c) The peak value of $v_o(t)$ at the threshold of clipping is 28 V.

P14.57* The worst-case outputs due to the offset voltage are:

$$V_{o,voff} = V_{off}\left(1+\frac{R_2}{R_1}\right) = \pm 44 \text{ mV}$$

For the bias current, the worst case output voltages are:

$$V_{o,bias} = R_2 I_B = 10 \text{ mV and } 20 \text{ mV}$$

For the offset current, the worst-case output voltages are:

$$V_{o,ioff} = R_2\left(I_{off}/2\right) = \pm 2.5 \text{ mV}$$

Due to all of the imperfections, the extreme output voltages are:

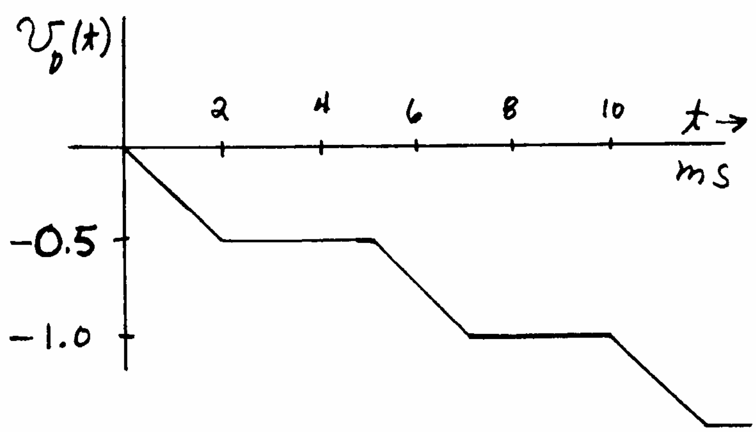
$$V_{o.\max} = 44 + 20 + 2.5 = 66.5 \text{ mV}$$

$$V_{o,\min} = -44 + 10 - 2.5 = -36.5 \text{ mV}$$

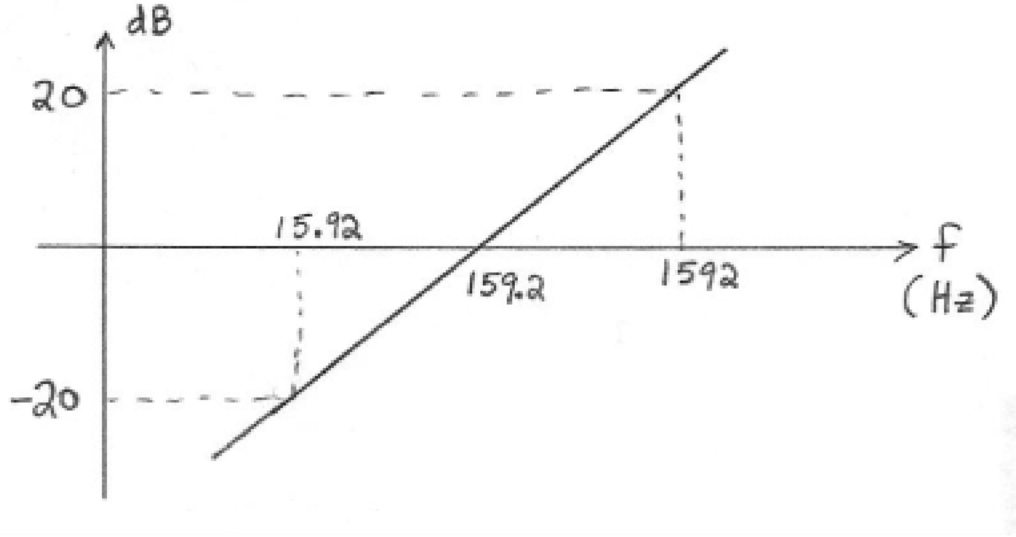
P14.63* This is an integrator circuit, and the output voltage is given by:

$$v_o(t) = -\frac{1}{RC}\int_0^t v_{in}(t)dt$$

$$v_o(t) = -50\int_0^t v_{in}(t)dt$$



Each pulse reduces v_o by 0.5 V. Thus, 20 pulses are required to produce v_o = -10V.


dB
20
-20
15.92
159.2
1592
f
(Hz)