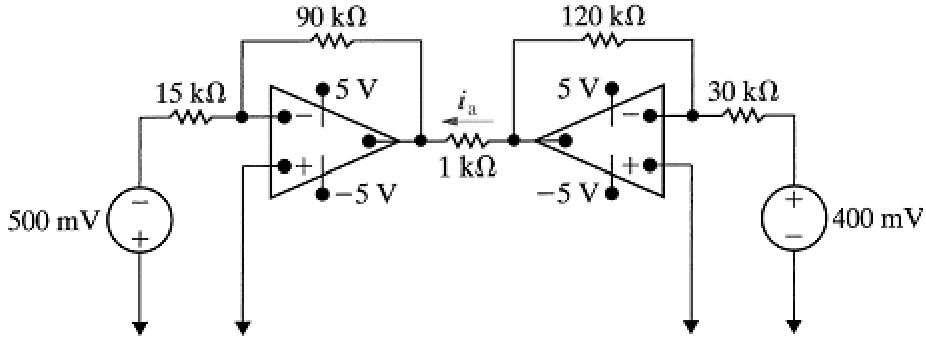
Homework Set #22

DUE Monday, May 8, 2017

1. The op-amps in the following circuit are ideal.



Let v_{o1} = output voltage of the amplifier on the left. Let v_{o2} = output voltage of the amplifier on the right. Then

a) Find i_a.

b) Find the value of the right source voltage for which $i_a = 0$.

[a] Let v_{o1} = output voltage of the amplifier on the left. Let v_{o2} = output voltage of the amplifier on the right. Then

$$v_{o1} = \frac{-90}{15}(-0.5) = 3 \text{ V}; \qquad v_{o2} = \frac{-120}{30}(0.4) = -1.6 \text{ V}$$

$$i_a = \frac{v_{o2} - v_{o1}}{1000} = -4.6\,\text{mA}$$

[b] $i_a = 0$ when $v_{o1} = v_{02}$ so from (a) $v_{o2} = 3$ V

Thus

$$\frac{-120}{30}(v_L) = 3$$

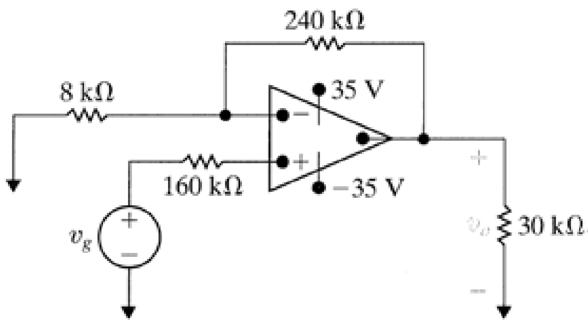
$$v_L = -\frac{90}{120} = -750 \text{ mV}$$

2.

The op amp in the noninverting amplifier circuit of Fig. P5.43 has an input resistance of 440 kΩ, an output resistance of 5 kΩ, and an open-loop gain of 100,000. Assume that the op amp is operating in its linear region.

a) Calculate the voltage gain (v_o/v_g).
b) Find the inverting and noninverting input voltages v_n and v_p (in millivolts) if $v_g = 1$ V.
c) Calculate the difference ($v_p - v_n$) in microvolts when $v_g = 1$ V.
d) Find the current drain in picoamperes on the signal source v_g when $v_g = 1$ V.
e) Repeat (a)–(d) assuming an ideal op amp.

Figure P5.43



[a] $$\frac{v_n}{8000} + \frac{v_n - v_g}{600{,}000} + \frac{v_n - v_o}{240{,}000} = 0 \quad \text{or} \quad 78.5v_n - 2.5v_o = v_g$$

$$\frac{v_o}{30{,}000} + \frac{v_o - v_n}{240{,}000} + \frac{v_o - 100{,}000(v_p - v_n)}{5000} = 0$$

$$57v_o - v_n - 48 \times 10^5(v_p - v_n) = 0$$

$$v_p = v_g + \frac{(v_n - v_g)(160)}{600} = (11/15)v_g + (4/15)v_n$$

$$57v_o - v_n - 48 \times 10^5[(11/15)v_g - (11/15)v_n] = 0$$

$$57v_o + 3{,}520{,}000v_n = 3{,}520{,}000v_g$$

$$\Delta = \begin{vmatrix} 78.5 & -2.5 \\ 3.52 \times 10^6 & 57 \end{vmatrix} = 8{,}804{,}474.5$$

$$N_o = \begin{vmatrix} 78.5 & v_g \\ 3.52 \times 10^6 & 3.52 \times 10^6 v_g \end{vmatrix} = 272.8 \times 10^6 v_g$$

$$v_o = \frac{N_o}{\Delta} = 30.98v_g; \qquad \frac{v_o}{v_g} = 30.98$$

[b] $$N_1 = \begin{vmatrix} v_g & -2.5 \\ 3.52 \times 10^6 v_g & 57 \end{vmatrix} = 8{,}800{,}057v_g$$

$$v_n = \frac{N_1}{\Delta} = 0.9995v_g; \qquad v_n = 999.5\,\text{mV}$$

$$v_p = (11/15)(1000) + (4/15)(999.5) = 999.87\,\text{mV}$$

[c] $v_p - v_n = 367.94\,\mu$ V

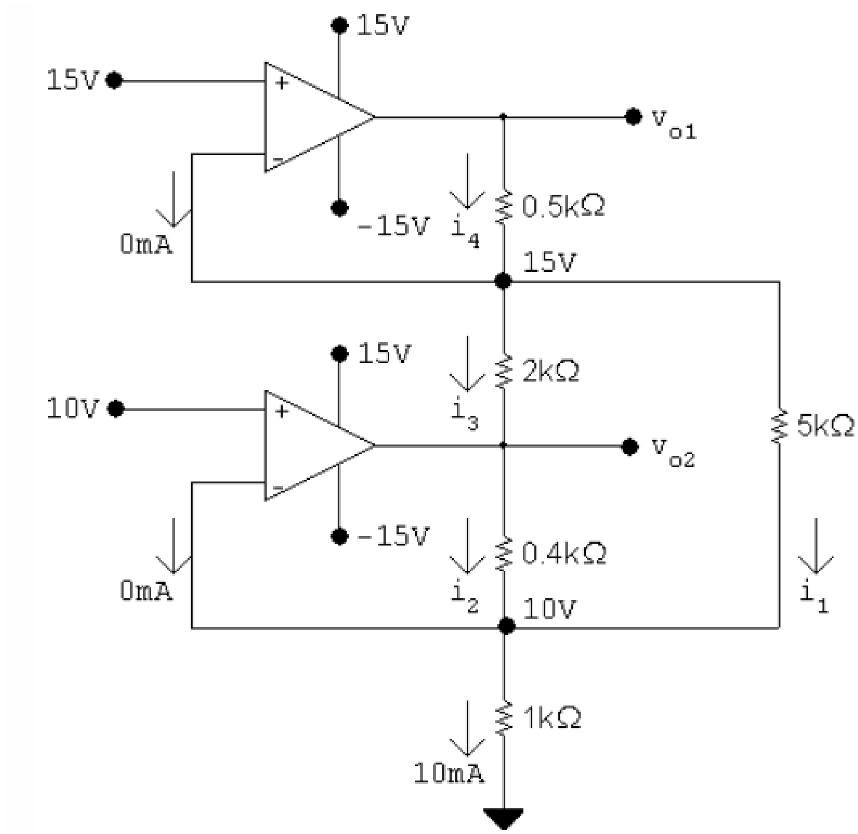
[d] $$i_g = \frac{(1000 - 999.87)10^{-3}}{160 \times 10^3} = 836.22\,\text{pA}$$

[e] $$\frac{v_g}{8} + \frac{v_g - v_o}{240} = 0, \qquad \text{since } v_n = v_p = v_g$$

$$\therefore\ v_o = 31v_g, \qquad \frac{v_o}{v_g} = 31$$

$$v_n = v_p = 1\ \text{V}; \qquad v_p - v_n = 0\ \text{V}; \qquad i_g = 0\ \text{A}$$

3. Problem 5.39 in Nilsson. (v_{o1} is slightly under 16 V)



$$i_1 = \frac{15 - 10}{5000} = 1\,\mathrm{mA}$$

$$i_2 + i_1 + 0 = 10\,\mathrm{mA}; \qquad i_2 = 9\,\mathrm{mA}$$

$$v_{o2} = 10 + (400)(9) \times 10^{-3} = 13.6 \text{ V}$$

$$i_3 = \frac{15 - 13.6}{2000} = 0.7\,\mathrm{mA}$$

$$i_4 = i_3 + i_1 = 1.7\,\mathrm{mA}$$

$$v_{o1} = 15 + 1.7(0.5) = 15.85 \text{ V}$$