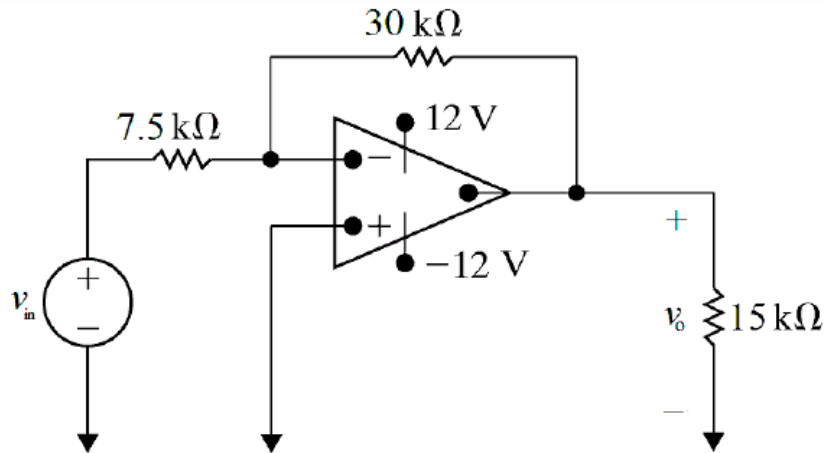


Homework Set #19
DUE Monday, May 1, 2017

1. Problem 5.8 in Nilsson.

$$[a] \quad \frac{30,000}{R_{in}} = 4 \quad \text{so} \quad R_{in} = \frac{30,000}{4} = 7500 = 7.5 \text{ k}\Omega$$



$$[b] \quad -4v_{in} = 12 \quad \text{so} \quad v_{in} = \frac{12}{-4} = -3 \text{ V}$$

$$-4v_{in} = -12 \quad \text{so} \quad v_{in} = \frac{12}{4} = 3 \text{ V}$$

$$\therefore \quad -3 \text{ V} \leq v_{in} \leq 3 \text{ V}$$

$$[c] \quad -\frac{R_f}{7500}(2) = -12 \quad \text{so} \quad R_f = 45 \text{ k}\Omega$$

$$\left| \frac{v_o}{v_{in}} \right| = \frac{R_f}{R_{in}} = \frac{45,000}{7500} = 6$$

The amplifier has a gain of 6.

2. Problem 5.10 in Nilsson.

[a] Let v_{Δ} be the voltage from the potentiometer contact to ground. Then

$$\frac{0 - v_g}{2000} + \frac{0 - v_{\Delta}}{50,000} = 0$$

$$-25v_g - v_{\Delta} = 0, \quad \therefore v_{\Delta} = -25(40 \times 10^{-3}) = -1 \text{ V}$$

$$\frac{v_{\Delta}}{\alpha R_{\Delta}} + \frac{v_{\Delta} - 0}{50,000} + \frac{v_{\Delta} - v_o}{(1 - \alpha)R_{\Delta}} = 0$$

$$\frac{v_{\Delta}}{\alpha} + 2v_{\Delta} + \frac{v_{\Delta} - v_o}{1 - \alpha} = 0$$

$$v_{\Delta} \left(\frac{1}{\alpha} + 2 + \frac{1}{1 - \alpha} \right) = \frac{v_o}{1 - \alpha}$$

$$\therefore v_o = -1 \left[1 + 2(1 - \alpha) + \frac{(1 - \alpha)}{\alpha} \right]$$

$$\text{When } \alpha = 0.2, \quad v_o = -1(1 + 1.6 + 4) = -6.6 \text{ V}$$

$$\text{When } \alpha = 1, \quad v_o = -1(1 + 0 + 0) = -1 \text{ V}$$

$$\therefore -6.6 \text{ V} \leq v_o \leq -1 \text{ V}$$

$$[\text{b}] -1 \left[1 + 2(1 - \alpha) + \frac{(1 - \alpha)}{\alpha} \right] = -7$$

$$\alpha + 2\alpha(1 - \alpha) + (1 - \alpha) = 7\alpha$$

$$\alpha + 2\alpha - 2\alpha^2 + 1 - \alpha = 7\alpha$$

$$\therefore 2\alpha^2 + 5\alpha - 1 = 0 \quad \text{so} \quad \alpha \cong 0.186$$

3. Problem 5.12 in Nilsson.

[a] This circuit is an example of an inverting summing amplifier.

$$[\text{b}] v_o = -\frac{220}{44}v_a - \frac{220}{27.5}v_b - \frac{220}{80}v_c = -5 - 12 + 11 = -6 \text{ V}$$

$$[\text{c}] v_o = -6 - 8v_b = \pm 10$$

$$\therefore v_b = -0.5 \text{ V} \quad \text{when} \quad v_o = 10 \text{ V};$$

$$v_b = 2 \text{ V} \quad \text{when} \quad v_o = -10 \text{ V}$$

$$\therefore -0.5 \text{ V} \leq v_b \leq 2 \text{ V}$$