MAE140 Win12 HW5 Solutions

T R & T, 4.20, 4.22, 4.24, 4.26, 4.28, 4.30, 4.36, 4.38, 4.42, 4.44

4-20

Looking at Circuit 1, we can get

$$v_O = \frac{9k\Omega + 1k\Omega}{1k\Omega} v_{IN} = 10v_{IN} \Rightarrow K_1 = \frac{v_O}{v_{IN}} = 10$$

For Circuit 2, we can find

$$v_O = -\frac{10k\Omega}{1k\Omega} v_{IN} = -10v_{IN} \Rightarrow K_2 = \frac{v_O}{v_{IN}} = -10$$

To amplify the output of the source by -100, we can connect the output of Circuit 1 to the input of Circuit 2. Then

$$K = K_1 K_2 = -100$$

4-22

Define the resistance of the potentiometer is $R \in [0,100]$. Then we can find,

$$v_O = -\frac{100 + R}{10} v_S \Rightarrow \frac{v_O}{v_S} = -\frac{100 + R}{10} \in [-20, -10]$$

4-24

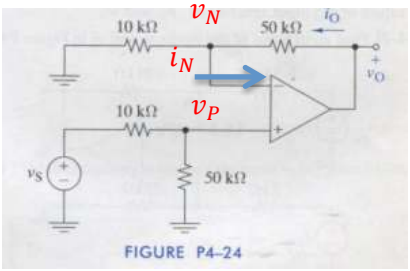


FIGURE P4-24

a) Recalling the operating condition of OpAmps, we can get $v_N = v_P, i_N = 0$. Then

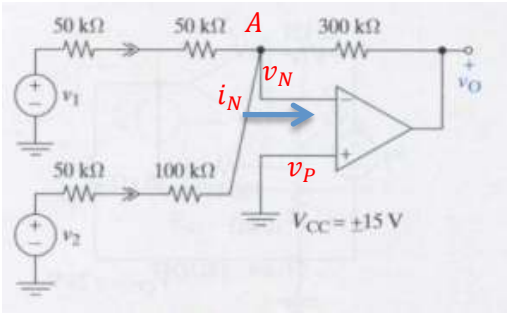
$$v_P = \frac{50}{10 + 50} v_S = \frac{5}{6} v_S$$

Apply KCL at node N.

$$\frac{v_N}{10} - \frac{v_O - v_N}{50} = 0 \Rightarrow v_O = 6v_N = 6v_P = 5v_S$$

b) $i_O = \frac{v_O - v_N}{50k\Omega} = \frac{\left(5 - \frac{5}{6}\right)v_S}{50k\Omega} = 0.167\ mA$

4-26



a) This is a summing amplifier or adder circuit problem. Since the noninverting input is grounded, we have the condition $v_P = v_N = 0$ and $i_N = 0$. Then we apply KCL to write the sum of currents entering node A.

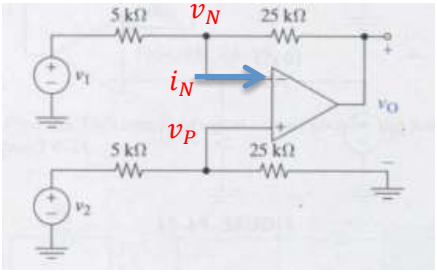
$$\frac{v_1 - v_N}{50 + 50} + \frac{v_2 - v_N}{50 + 100} + \frac{v_0 - v_N}{300} - i_N = 0$$

Solving the equation for v_O, we can get

$$v_O = -3v_1 - 2v_2$$

b) Without saturation, we know $-V_{CC} < v_O < V_{CC}$. So $-15 < -3v_1 - 2v_2 < 15 \Rightarrow -9V < v_2 < 6V$

4-28



The circuit is a differential amplifier.

First, we turn off source v_2, in which case there is no excitation at the noninverting input and $v_P = 0$. In effect, the noninverting input is grounded and the circuit acts like an inverting amplifier.

$$v_{O1} = -\frac{25}{5}v_1 = -5v_1$$

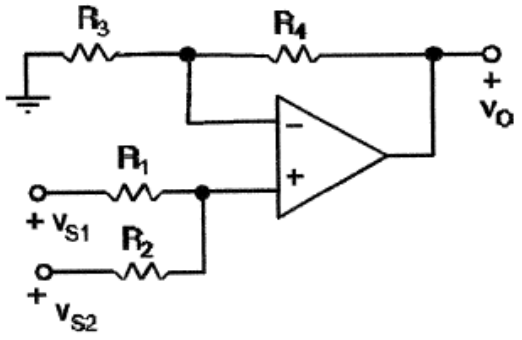
Next, turning v_2 back on and turning $v_1$off, we see that the circuit looks like a noninverting amplifier with a voltage divider connected at its input. In this case, we can write

$$v_{O2} = \frac{25}{25 + 5}\frac{25 + 5}{5}v_2 = 5v_2$$

We add outputs in the above equations to obtain the output with both sources on:

$$v_O = v_{O1} + v_{O2} = -5v_1 + 5v_2$$

4-30



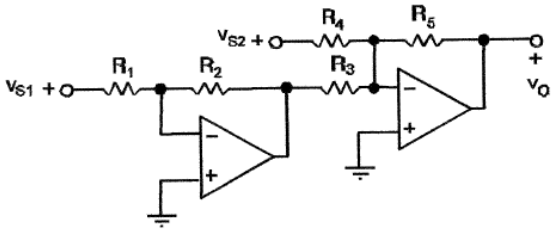
v_{S2} off $\quad v_{O1} = \dfrac{R_3 + R_4}{R_3} \cdot \dfrac{R_2}{R_1 + R_2} \cdot v_{S1}$

v_{S1} off $\quad v_{O2} = \dfrac{R_3 + R_4}{R_3} \cdot \dfrac{R_1}{R_1 + R_2} \cdot v_{S2}$

Using superposition

$$v_O = v_{O1} + v_{O2} = \frac{R_3 + R_4}{R_3 \cdot (R_1 + R_2)} \cdot (R_2 \cdot v_{S1} + R_1 \cdot v_{S2})$$

4-36



v_{S2} off $\quad v_{O1} = \left(\dfrac{-R_2}{R_1}\right) \cdot \left(\dfrac{-R_5}{R_3}\right) \cdot v_{S1}$

v_{S1} off $\quad v_{O2} = \left(\dfrac{-R_5}{R_4}\right) \cdot v_{S2}$

Using superposition

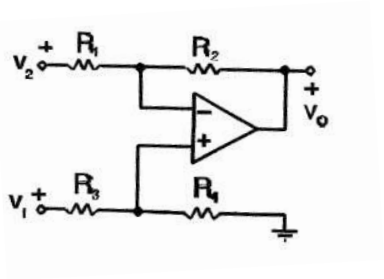
$v_O = v_{O1} + v_{O2}$

$$v_O = \frac{R_2 \cdot R_5}{R_1 \cdot R_3} \cdot v_{S1} - \frac{R_5}{R_4} \cdot v_{S2}$$

a) Substituting the values of R, we can get

$$v_O = 5v_{S1} - 10v_{S2}$$

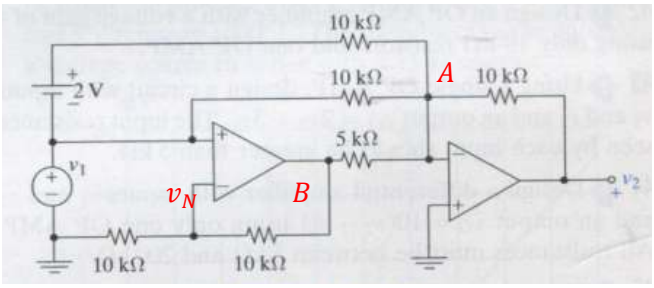
b) Looking at the expression of v_O, we can find that it's an expression for differential amplifier. Design the circuit as shown in the following figure.



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

Let $R_1 = 1k\Omega, R_2 = 10k\Omega, R_3 = 6k\Omega, R_4 = 5k\Omega$. Then we can get the output that we need.

4-38



By using OP AMP property, we can find $v_A = 0$ and $v_N = v_1$.
Applying KCL at node A, we can get

$$\frac{v_1 + 2}{10} + \frac{v_1}{10} + \frac{v_2}{10} + \frac{v_B}{5} = 0 \quad (1)$$

Applying KCL at node B, we can get

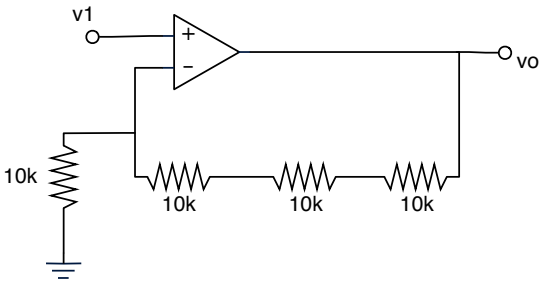
$$-\frac{v_B - v_N}{10} - \frac{v_B}{5} = 0 \Rightarrow v_B = \frac{1}{3}v_1$$

Substituting $v_B = \frac{1}{3}v_1$ into Equation (1), we can get:

$$v_2 = -\frac{8}{3}v_1 - 2$$

4-42

The common way is to use noninverting circuit. Set K=4.



4-44

We can use subtractor circuit to design. Set K1=-10, K2=10