Microelectronics Circuit Analysis and Design Homework(1st)

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9.6 Assume the op-amps in Figure P9.6 are ideal. Find the voltage gain $A_v = v_O/v_I$ and the input resistance R_i of each circuit.

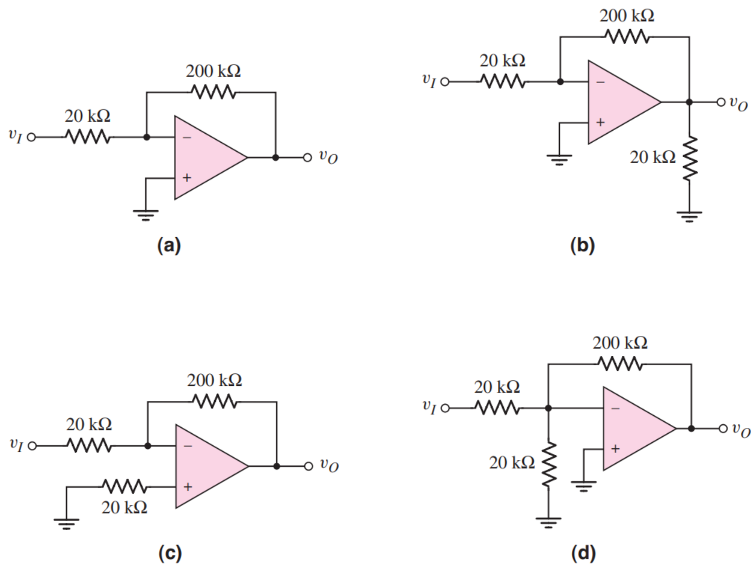

Figure 1: Problem 9.6

Solution:

(a)Actually,$(v_2 - v_1) \to 0, i_+, i_- \to 0$, and we have these equations as follow:

$$\begin{cases} \dfrac{v_I - v_-}{20k\Omega} = \dfrac{v_- - v_O}{200k\Omega} \\ v_+ = 0 \end{cases} \Rightarrow \frac{v_O}{v_I} = -10$$

The input resistance $R_i = \dfrac{v_I}{\dfrac{v_I - v_-}{20k\Omega}} = 20k\Omega$

(b)(c)(d) In fact the new resistances of $20k\Omega$ in Figure (a)(b)(c) don't make differences to their circuits.

So the answers do not change: $\dfrac{v_O}{v_I} = -10, R_i = 20k\Omega$

9.14 (a) The input to the circuit shown in Figure P9.14 is $v_I = -0.20$ V. (i) What is v_O? (ii) Determine i_2, i_O , and i_L . (b) Repeat part (a) for $v_I = +0.05$ V. (c) Repeat part (a) for v_I = $8 sin\omega t$ mV.

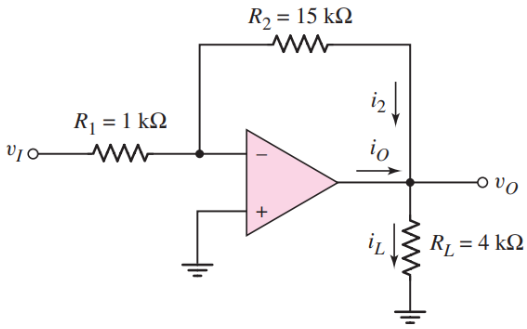

Figure 2: Problem 9.14

Solution:

We provide a general solution in most instances first.

Because of "virtual short" , "virtual open" and KCL , we have euqations as follow:

$$\begin{cases} \dfrac{v_I - v_-}{R_1} = \dfrac{v_- - v_O}{R_2} = i_2 \\ v_+ = v_- = 0 \\ i_O + i_2 = i_L \\ i_L = \dfrac{v_O}{R_L} \end{cases} \Rightarrow \begin{cases} v_O = -\dfrac{R_2}{R_1} v_I \\ i_2 = \dfrac{v_I}{R_1} \\ i_O = \dfrac{v_O}{R_L} - \dfrac{v_I}{R_1} \\ i_L = \dfrac{v_O}{R_L} \end{cases}$$

(a)$v_O = 3V, i_2 = -0.2mA, i_O = 0.95mA, i_L = 0.75mA$

(b)$v_O = -0.75V, i_2 = 0.05mA, i_O = -0.2375mA, i_L = -0.1875mA$

(c)$v_O = -120 \sin \omega t V, i_2 = 8 \sin \omega t mA, i_O = -38 \sin \omega t mA, i_L = -30 \sin \omega t mA$

9.37 A summing amplifier can be used as a digital-to-analog converter (DAC). An example of a 4-bit DAC is shown in Figure P9.37. When switch S_3 is connected to the -5 V supply, the most significant bit is $a_3 = 1$; when S_3 is connected to ground, the most significant bit is $a_3 = 0$. The same condition applies to the other switches S_2, S_1, and S_o, corresponding to bits a_2, a_1, and a_o, where a_o is the least significant bit. (a) Show that the output voltage is given by

$$v_O = \frac{R_F}{10}\left[\frac{a_3}{2} + \frac{a_2}{4} + \frac{a_1}{8} + \frac{a_o}{16}\right](5)$$

(5) where R_F is in $k\Omega$. (b) Find the value of R_F such that $v_O = 2.5V$ when the digital input is $a_3a_2a_1a_o = 1000$. (c) Using the results of part (b), find v_o for: (i) $a_3a_2a_1a_o = 0001$, and (ii) $a_3a_2a_1a_o =$.

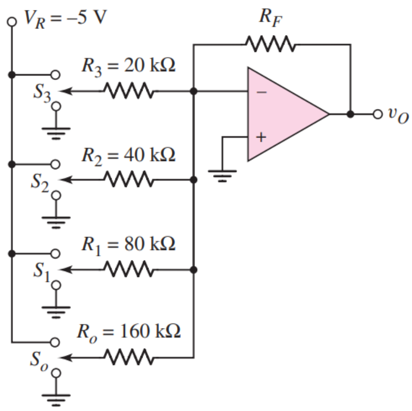

Figure 3: Problem 9.37

Solution:

(a)Because of "virtual short" , "virtual open" , we have euqations as follow:

$$\begin{cases} a_o\dfrac{v_R - v_-}{R_o} + a_1\dfrac{v_R - v_-}{R_1} + a_2\dfrac{v_R - v_-}{R_2} + a_3\dfrac{v_R - v_-}{R_3} = \dfrac{v_- - v_O}{R_F} \\ v_+ = v_- = 0 \end{cases}$$

$\Rightarrow v_O = \dfrac{R_F}{2}\left[\dfrac{a_3}{2} + \dfrac{a_2}{4} + \dfrac{a_1}{8} + \dfrac{a_o}{16}\right]$(Maybe there is a problem with this question?)

(b)substitute$v_O = 2.5V$, $a_3a_2a_1a_o = 1000$ into the (5) $\Rightarrow R_F = 10k\Omega$

(c)Now $R_F = 10k\Omega$

so (i) substitute $a_3a_2a_1a_o = 0001$ into the (5) $\Rightarrow v_O = 0.3125V$

so (ii) substitute $a_3a_2a_1a_o = 1111$ into the (5) $\Rightarrow v_O = 4.6875V$