QUIZ NO. 3 - SOLUTION

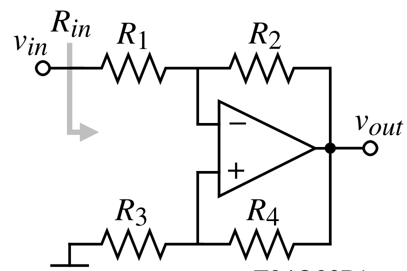
(Average score = 6.8/10 of those taking the quiz)

The voltage amplifier shown uses an ideal op amp.

a.) Find the voltage gain, v_{out}/v_{in} in terms of the resistors R_1, R_2, R_3 and R_4.

b.) Find the input resistance, R_{in}, in terms of resistors R_1, R_2, R_3 and R_4.

c.) If $R_1 = R_4 = 90\text{k}\Omega$ and $R_2 = R_3 = 100\text{k}\Omega$ numerically evaluate v_{out}/v_{in} and R_{in}.



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Solution

a.) This problem cannot be worked using the inverting and voltage amplifier configurations so we must use that fact that the input voltage to the op amp is zero.

$$\therefore \qquad v_{id} = v^+ - v^- = \frac{v_{out} R_3}{R_3 + R_4} - \left[\frac{v_{in} R_2}{R_1 + R_2} + \frac{v_{out} R_1}{R_1 + R_2}\right] = 0$$

$$v_{out}\left[\frac{R_3}{R_3 + R_4} - \frac{R_1}{R_1 + R_2}\right] = \left(\frac{R_2}{R_1 + R_2}\right) v_{in} \qquad \rightarrow \qquad \frac{v_{out}}{v_{in}} = \frac{\dfrac{R_2}{R_1 + R_2}}{\dfrac{R_3}{R_3 + R_4} - \dfrac{R_1}{R_1 + R_2}}$$

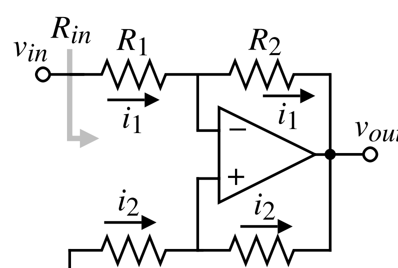
Thus,

$$\boxed{\frac{v_{out}}{v_{in}} = \frac{R_2}{R_3\left(\dfrac{R_1 + R_2}{R_3 + R_4}\right) - R_1} = \frac{R_2(R_3 + R_4)}{R_2 R_3 - R_1 R_4}}$$

b.) $v_{in} = i_1 R_1 - i_2 R_3$ but $i_1 R_2 = i_2 R_4$ so we get,

$$v_{in} = i_1 R_1 - R_3\left(\frac{R_2}{R_4}\right) i_1 = i_1\left(R_1 - \frac{R_2 R_3}{R_4}\right)$$

$$\therefore \qquad \boxed{R_{in} = R_1 - \frac{R_2 R_3}{R_4} = \frac{R_1 R_4 - R_2 R_3}{R_4}}$$



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c.) The numerical values become,

$$\frac{v_{out}}{v_{in}} = \frac{100\text{k}\Omega}{100\text{k}\Omega(1) - 90\text{k}\Omega} = 10\text{V/V} \quad \text{and} \quad R_{in} = 90\text{k}\Omega - \frac{100\text{k}\Omega \cdot 100\text{k}\Omega}{90\text{k}\Omega} = -21.11\text{k}\Omega$$

$$\boxed{\frac{v_{out}}{v_{in}} = 10\text{ V/V}} \qquad \text{and} \qquad \boxed{R_{in} = -21.11\text{k}\Omega}$$

Obviously, the voltage source driving this voltage amplifier must have a source resistance greater than 21.11kΩ for the circuit to remain stable.