Homework for Chapter 2

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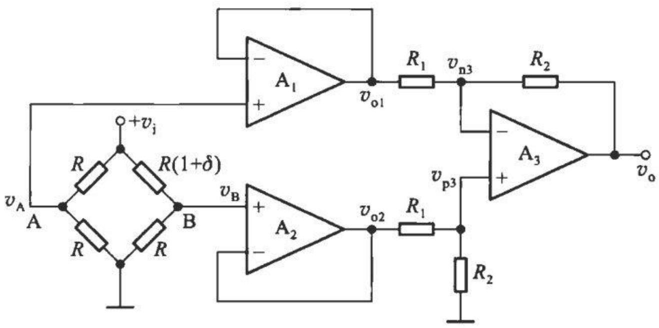
2.4.2 一高输入电阻的桥式放大电路如图题 2.4.2 所示。(1) 试写出 $v_o=f(\delta)$ 的表达式 ($\delta=\Delta R/R$)；(2) 当 $v_i=7.5$ V，$\delta=0.01$ 时，求 v_A、v_B、v_{AB} 和 v_o。



图题 2.4.2

Solution According to the "Virtual-Open-Circuited" theory, the current will not either go left at node A nor go right at node B

$$v_A = \frac{v_i}{2}$$
$$v_B = \frac{v_i}{2+\delta}$$

For the 2 operational amplifiers A_1 and A_2

$$v_{o2} = v_B = \frac{v_i}{2+\delta}$$
$$v_{o1} = v_A = \frac{v_i}{2}$$

Then we can calculate the input voltage of operational amplifier A_3

$$v_{p3} = \frac{R_2}{R_1+R_2} v_{o2} = \frac{R_2}{R_1+R_2}\frac{v_i}{2+\delta}$$
$$v_{n3} = v_{p3} = \frac{R_2}{R_1+R_2}\frac{v_i}{2+\delta}$$

Since A_3 is an ideal operational amplifier

$$I_{R1} = I_{R2} = \frac{v_{o1}-v_{n3}}{R_1} = \left(\frac{v_i}{2} - \frac{R_2}{R_1+R_2}\frac{v_i}{2+\delta}\right)\frac{1}{R_1}$$

$$v_{n3} - v_o = I_{R1}R_2 = \frac{v_{o1}-v_{n3}}{R_1} = \left(\frac{v_i}{2} - \frac{R_2}{R_1+R_2}\frac{v_i}{2+\delta}\right)\frac{R_2}{R_1}$$

Finally, we get

$$
\begin{aligned}
v_o &= \frac{R_2}{R_1 + R_2}\frac{v_i}{2+\delta} - \left(\frac{v_i}{2} - \frac{R_2}{R_1 + R_2}\frac{v_i}{2+\delta}\right)\frac{R_2}{R_1} \\
&= \left(\frac{R_1}{R_1 + R_2}\frac{v_i}{2+\delta} - \frac{v_i}{2} + \frac{R_2}{R_1 + R_2}\frac{v_i}{2+\delta}\right)\frac{R_2}{R_1} \\
&= \frac{R_2}{R_1}\left(-\frac{1}{2} + \frac{1}{2+\delta}\right)v_i \\
&= \frac{R_2}{R_1}\left(\frac{-\delta}{4+2\delta}\right)v_i
\end{aligned}
$$

When $v_i = 7.5$ V, $\delta = 0.01$

$$
v_o = -0.01866 \times \frac{R_2}{R_1}
$$