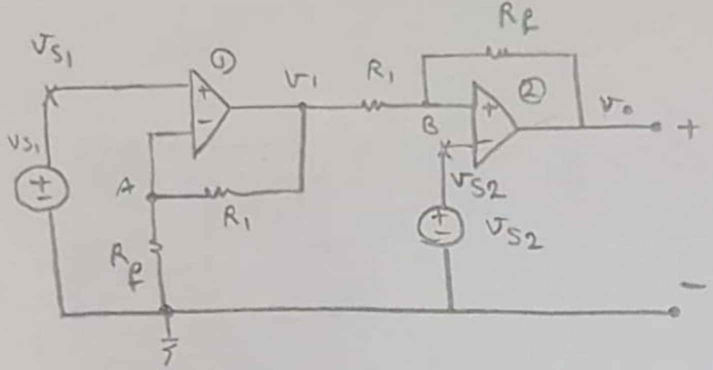
"باسمه تعالی"

3. $v_o = ?$ برحسب v_{s1}, v_{s2}



$$①: \begin{cases} v_{s1} = v_A \\ I_- = I_+ = 0A \end{cases} \qquad KCL @ A: \cancel{I_-}^{0} + \frac{v_A - v_1}{R_1} + \frac{v_A}{R_f} = 0$$

$$v_1 = R_1\left(\frac{v_A}{R_1} + \frac{v_A}{R_f}\right) = v_A\left(1 + \frac{R_1}{R_f}\right)$$

$$②: \begin{cases} v_B = v_{s2} \\ I_- = I_+ = 0A \end{cases} \qquad KCL @ B: \frac{v_B - v_1}{R_1} + \frac{v_B - v_o}{R_f} + \cancel{I_+}^{0} = 0$$

$$v_1 = R_1\left(\frac{v_B}{R_1} + \frac{v_B}{R_f} - \frac{v_o}{R_f}\right)$$

$$\Rightarrow \begin{matrix} v_A = v_{s1} \\ v_B = v_{s2} \end{matrix} \Rightarrow v_{s1}\left(1 + \frac{R_1}{R_f}\right) = v_{s2}\left(1 + \frac{R_1}{R_f}\right) - \frac{R_1}{R_f} v_o$$

$$v_o = \frac{R_f}{R_1} v_{s2}\left(1 + \frac{R_1}{R_f}\right) - \frac{R_f}{R_1} v_{s1}\left(1 + \frac{R_1}{R_f}\right)$$

$$\Rightarrow v_o = v_{s2}\left(\frac{R_f}{R_1} + 1\right) - v_{s1}\left(\frac{R_f}{R_1} + 1\right)$$

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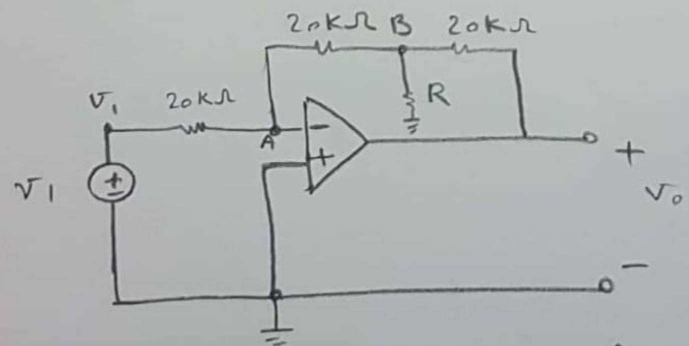
4. $R = ? \Rightarrow v_o = -100 v_1$



$$\begin{cases} v_+ = v_- = v_A = 0v \\ I_+ = I_- = 0A \end{cases}$$

$$KCL @ A: \frac{v_A - v_1}{20} + \frac{v_A - v_B}{20} + \cancel{I_-}^{0} = 0 \Rightarrow 2\cancel{v_A}^{0} - v_B = v_1 \Rightarrow \boxed{v_B = -v_1}$$

$$KCL @ B: \frac{v_B - v_o}{20} + \frac{v_B}{R} + \frac{v_B - \cancel{v_A}^{0}}{20} = 0$$

$$\frac{v_B}{10} - \frac{v_o}{20} + \frac{v_B}{R} = 0 \Rightarrow v_o = 20\left(\frac{v_B}{10} + \frac{v_B}{R}\right)$$

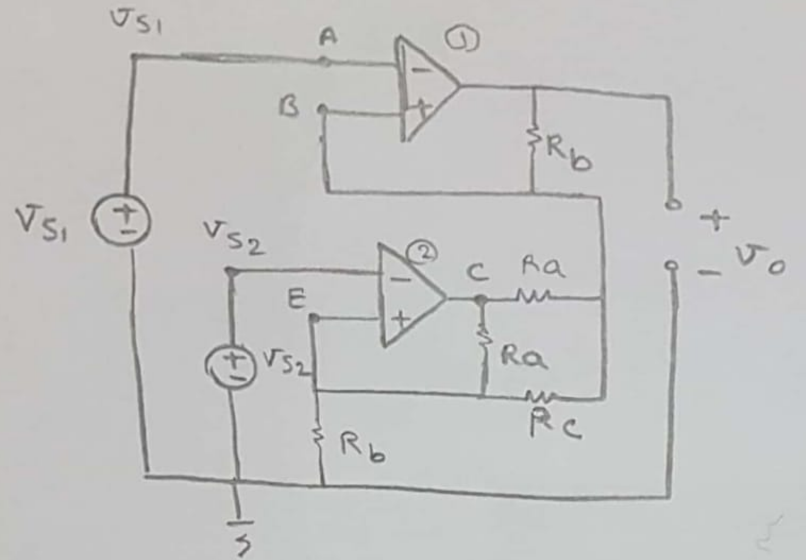
$$v_o = 20 v_B\left(\frac{1}{10} + \frac{1}{R}\right)$$

$$v_o = -20 v_1\left(\frac{1}{10} + \frac{1}{R}\right)$$

$$\frac{1}{10} + \frac{1}{R} = +5$$

$$\frac{1}{R} = +4.9 \Rightarrow R = \frac{10}{49} = 0.204^{k\Omega} = \boxed{204^{\Omega}}$$

6. دسته ۲: عوض تقویت کننده تفاضلی ؟



$$①: \begin{cases} v_A = v_B = v_{s1} \\ I_- = I_+ = 0A \end{cases}$$

$$②: \begin{cases} v_E = v_{s2} \\ I_- = I_+ = 0A \end{cases}$$

$$\text{kcl @ B}: \cancel{I_+}^{\,0} + \frac{v_B - v_o}{R_b} + \frac{v_B - v_C}{R_a} + \frac{v_B - v_{s2}}{R_C} = 0$$

$$v_{s1}\left(\frac{1}{R_b} + \frac{1}{R_a} + \frac{1}{R_C}\right) - \frac{v_{s2}}{R_C} - \frac{v_C}{R_a} = \frac{v_o}{R_b}$$

$$\text{Kcl @ E}: \cancel{I_+}^{\,0} + \frac{v_{s2}}{R_b} + \frac{v_{s2} - v_C}{R_a} + \frac{v_{s2} - \cancel{v_B}^{\,v_{s1}}}{R_C} = 0$$

$$v_{s2}\left(\frac{1}{R_b} + \frac{1}{R_a} + \frac{1}{R_C}\right) - \frac{v_C}{R_a} - \frac{v_{s1}}{R_C} = 0$$

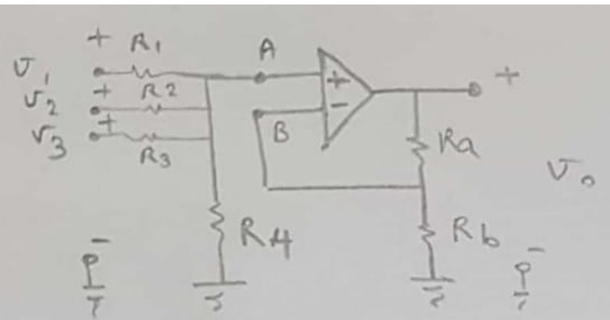
$$\frac{v_C}{R_a} = v_{s2}\left(\frac{1}{R_b} + \frac{1}{R_a} + \frac{1}{R_C}\right) - \frac{v_{s1}}{R_C}$$

$$\frac{v_C}{R_a} = v_{s1}\left(\frac{1}{R_b} + \frac{1}{R_a} + \frac{1}{R_C}\right) - \frac{v_{s2}}{R_C} - \frac{v_o}{R_b}$$

$$\frac{v_o}{R_b} = v_{s1}\left(\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_C}\right) - \frac{v_{s2}}{R_C} - v_{s2}\left(\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_C}\right) + \frac{v_{s1}}{R_C}$$

$$\Rightarrow v_o = R_b\left[\left(\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_C}\right)(v_{s1} - v_{s2}) + \frac{1}{R_C}(-v_{s2} + v_{s1})\right]$$

$$\Rightarrow v_o = (v_{s1} - v_{s2})\left(\frac{R_b}{R_a} + \frac{R_b}{R_C} + 1 + \frac{R_b}{R_C}\right) \Rightarrow \underline{v_o = \left(\frac{R_b}{R_a} + \frac{2R_b}{R_C} + 1\right)(v_{s1} - v_{s2})}$$



$v_o = ?$ · 15

$v_o = k_1 v_1 + k_2 v_2 + k_3 v_3$

$$\begin{cases} v_A = v_B \\ I_- = I_+ = 0A \end{cases}$$

KCl @ A: $\cancel{I_+}^{0} + \frac{v_A - v_1}{R_1} + \frac{v_A - v_2}{R_2} + \frac{v_A - v_3}{R_3} + \frac{v_A}{R_4} = 0$

$$v_A \Big(\underbrace{\tfrac{1}{R_1} + \tfrac{1}{R_2} + \tfrac{1}{R_3} + \tfrac{1}{R_4}}_{k} \Big) = \frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3}$$

$$\hookrightarrow v_A = \frac{1}{k}\left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

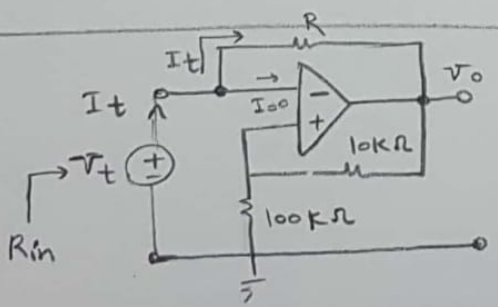
KCl @ B: $\cancel{I_-}^{0} + \frac{v_B - v_o}{R_a} + \frac{v_B - 0}{R_b} = 0$

$$\left(\frac{1}{R_a} + \frac{1}{R_b} \right) v_B = \frac{v_o}{R_a} \Rightarrow v_B = \frac{v_o}{\cancel{R_a}} \left(\frac{\cancel{R_a} R_b}{R_a + R_b} \right)$$

$$\frac{v_o}{R_a + R_b} \times R_b = \frac{1}{k} \left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

$$\Rightarrow v_o = \overbrace{\frac{R_a + R_b}{k R_b}}^{k'} \left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

$$\Rightarrow v_o = \frac{k'}{R_1} v_1 + \frac{k'}{R_2} v_2 + \frac{k'}{R_3} v_3 \Rightarrow \boxed{v_o = k_1 v_1 + k_2 v_2 + k_3 v_3}$$



$R = ?$ · 20

$R_{in} = 1M\Omega$

$$\begin{cases} v_- = v_+ = v_t \\ I_+ = I_- = 0A \end{cases}$$

$v_t - v_o = R I_t$

KCl @ v_+:

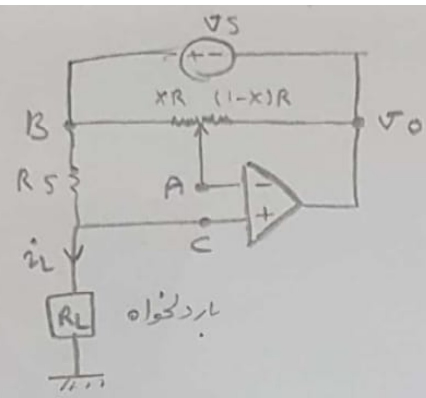
$$\cancel{I_+}^{0} + \frac{v_t}{100} + \frac{v_t - v_o}{10} = 0$$

$$v_o = 10 \left(\frac{v_t}{100} + \frac{v_t}{10} \right) = v_t (1 + 0.1) = \boxed{1.1 v_t}$$

$$\overbrace{v_t - 1.1 v_t}^{-0.1 v_t} = R I_t$$

$$\frac{v_t}{I_t} = \frac{R}{-0.1} \Rightarrow \left| \frac{v_t}{I_t} \right| = \frac{R}{0.1} = 10^3 \Rightarrow \boxed{R = 100k\Omega}$$

32.



$$\begin{cases} V_A = V_C \\ I_- = I_+ = 0A \end{cases}$$

اثبات: i_L مستقل از R_L

$$V_B - V_A = \frac{X\cancel{R}}{\cancel{R}} V_S = \boxed{X V_S}$$

$$V_B - V_C = X V_S$$

$$i_L = \frac{V_B - V_C}{R_S} = \boxed{\frac{X V_S}{R_S}}$$

بنابراین i_L مستقل از R_L خواهد بود.

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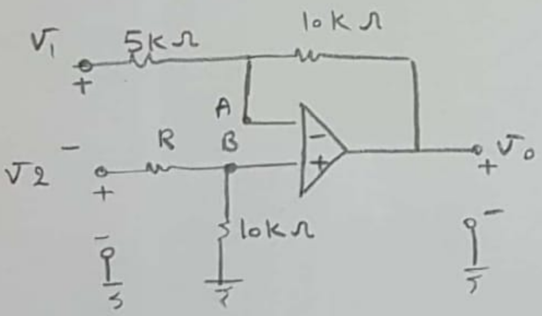
44. $R = ?$ ← $V_o = \frac{V_2}{3} - 2V_1$



$$\begin{cases} V_A = V_B \\ I_+ = I_- = 0A \end{cases}$$

$$KCL@B: \frac{V_B - V_2}{R} + \frac{V_B}{10} + \cancel{I_+}^{0} = 0$$

$$V_B\left(\frac{1}{R} + \frac{1}{10}\right) = \frac{V_2}{R} \Rightarrow$$

$$V_B = \frac{10R}{R(R+10)} V_2$$

$$KCL@A: \cancel{I_-}^{0} + \frac{V_A - V_1}{5} + \frac{V_A - V_o}{10} = 0$$

$$\Rightarrow 2V_A - 2V_1 + V_A - V_o = 0 \xRightarrow{V_A = V_B} \frac{10\cancel{R}}{\cancel{R}(R+10)} V_2 = \frac{2}{3}V_1 + \frac{1}{3}V_o$$

$$V_A = \frac{2}{3}V_1 + \frac{1}{3}V_o$$

$$V_o = \frac{30}{R+10} V_2 - 2V_1 = V_o$$

$$\frac{30}{R+10} = \frac{1}{3} \Rightarrow R + 10 = 90 \Rightarrow \boxed{R = 80K\Omega}$$

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