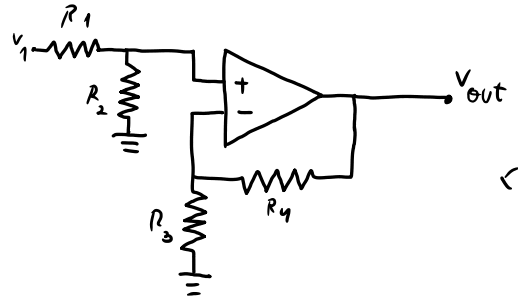
7.1) a) $V_2 = 0$

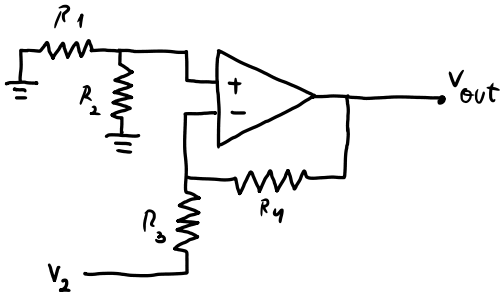


$V_- = V_+ \quad i_- = i_+ = 0 \quad V_+ = V_1 \cdot \frac{R_2}{R_1 + R_2}$

$\frac{V_-}{R_3} = \frac{V_0 - V_-}{R_4} \iff \frac{V_-}{R_3} + \frac{V_-}{R_4} = \frac{V_0}{R_4} \iff$

$\iff V_1 \cdot \frac{R_2}{R_1 + R_2} \cdot \left(\frac{1}{R_3} + \frac{1}{R_4}\right) \cdot R_4 = V_0 \iff V_0 = \left(1 + \frac{R_4}{R_3}\right) \cdot \frac{R_2}{R_1 + R_2} \cdot V_1$

b)



$i_- = i_+ = 0 \quad V_- = V_+ = 0$

$\frac{V_- - V_2}{R_3} = \frac{V_0 - V_-}{R_4} \iff -\frac{V_2}{R_3} = \frac{V_0}{R_4} \iff V_0 = -\frac{R_4}{R_3} V_2$

c) $V_0 = V_{0_{V_1}} + V_{0_{V_2}} = \left(1 + \frac{R_4}{R_3}\right) \cdot \frac{R_2}{R_1 + R_2} \cdot V_1 - \frac{R_4}{R_3} V_2$

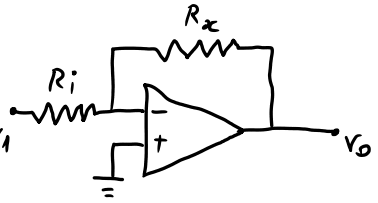
d) $-\frac{R_4}{R_3} = -2 \iff R_4 = 2R_3$

$(1+2) \cdot \frac{R_2}{R_1 + R_2} = 2 \iff R_2 = 2R_1$

Logo 1. exemplo $R_4 = 2R_3 = R_2 = 2R_1 = 10k\Omega$

7.2) $\frac{V_0}{V_1} = -50$

$R_i = 1k\Omega$



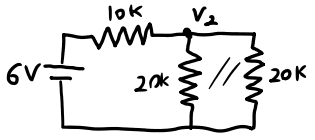
$\frac{V_- - V_1}{R_i} + \frac{V_- - V_0}{R_x} = 0 \iff -\frac{R_x}{1k} = \overbrace{\frac{V_0}{V_1}}^{-50} \iff R_x = 50k\Omega!$

Logo $R_x = 50k\Omega$ e $R_1 = 1k\Omega$

7.3) Montagem: seguidor de tensão

Logo $V_2 = \frac{20K}{10K + 20K} \cdot 6 = 4V$ ou $\frac{V_+ - 6}{10K} + \frac{V_-}{20K} = 0 \; ; \; V_+ = V_- = V_2 \iff V_2 - 6 = -\frac{1}{2} V_2 \iff \frac{3}{2} V_2 = 6 \iff V_2 = 4V$

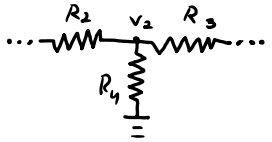
Sem seguidor



$V_2 = \frac{10K}{10K + 10K} \cdot 6 = 3V!$

7.4) $V_+ = V_- = 0$

$i_+ = i_- = 0$



$$\begin{cases} \frac{V_- - V_1}{R_1} + \frac{V_- - V_2}{R_2} = \\ \frac{V_2 - V_-}{R_2} + \frac{V_2 - V_0}{R_3} + \frac{V_2}{R_4} = 0 \end{cases} \iff \begin{cases} V_1 = -\frac{R_1}{R_2} \cdot V_2 \\ V_2 = \frac{V_0}{R_3\left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)} \end{cases}$$

Logo $\frac{V_0}{V_1} = -\frac{R_2 R_3 \left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)}{R_1}$

7.5) a) $V_2 = 1V$

$V_3 = 0V$

$V_1 = V_{1m}\cos(\omega t)$

Por sobreposição V_2: $V_1 = 0 = V_-$, $V_2 = 1V$

$\frac{V_- - V_2}{1k} + \frac{V_- - V_4}{10k} = 0 \Leftrightarrow V_4 = -10V$

V_1: $V_2 = 0 = V_-$, $V_1 = V_{1m}\cos(\omega t)$

$\frac{V_- - V_1}{2K} + \frac{V_- - V_0}{10K} = 0 \Leftrightarrow V_0 = -5V_1(t)$

$V_0 = V_{0_{V_2}} + V_{0_{V_1}} = -10 - 5V_1(t)$

$-16 = -10 - 5V_{1m} \Leftrightarrow \frac{6}{5} = V_{1m} = 1,2V$

$16 = -10 - 5V_{1m} \Leftrightarrow -\frac{26}{5} = V_{1m} = -5,2V$

Logo $V_{1m\,Max} = 1,2V$

b) $V_1 = V_2 = 0$

$V_3 = V_- = V_+$

$\frac{V_3}{2K} + \frac{V_3}{1K} + \frac{V_3 - V_4}{10K} = 0 \Leftrightarrow V_0 = 16V_3$ Logo $V_0(t) = \begin{cases} -16 & V, V_3 \leq -1V \\ 16V_3\ V, & -1V < V_3 < 1V \\ 16 & V, 1V \leq V_3 \end{cases}$

7.6) $V_- = V_+$

$i_- = i_+$

$\begin{cases} \frac{V_- - V_S}{R_1} + \frac{V_- - V_0}{R_2} = 0 \\ \frac{V_+ - 0}{R_3} + \underbrace{\frac{V_+ - 0}{Z_L}}_{\downarrow i_L} + \frac{V_+ - V_0}{R_4} = 0 \end{cases} \Leftrightarrow \begin{cases} V_+\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\cdot R_2 - \frac{R_2}{R_1}V_S = V_0 \\ \left(\frac{V_+}{R_3} + i_L + \frac{V_+}{R_4}\right)\cdot R_4 = V_0 \end{cases}$

$\Leftrightarrow V_+\left(\frac{R_2}{R_1} + 1\right) - \frac{R_2}{R_1}V_S = \frac{R_4}{R_3}V_+ + i_L R_4 + V_+ \Leftrightarrow$

$\Leftrightarrow i_L = -\frac{R_2}{R_1 \cdot R_4}V_S = -\frac{V_S}{R_3}$

7.7) a) $V_- = V_+ = 0$

$Z_f = \frac{1}{j\omega C} // R_2 = \frac{R_2}{j\omega C R_2 + 1}$

$\frac{V_- - V_1}{R_1} + \frac{V_- - V_0}{Z_f} = 0 \Leftrightarrow \frac{V_0}{V_1} = -\frac{Z_f}{R_1} = -\frac{R_2}{R_1}\cdot\frac{1}{j\omega C R_2 + 1}$

b) Sem R_2: $-\frac{V_1}{R_1} = j\omega C V_0 \Leftrightarrow \frac{V_0}{V_1} = -\frac{1}{j\omega C R_1}$ $\Rightarrow$ Com R_2 temos o ganho limitado a $-\frac{R_2}{R_1}$