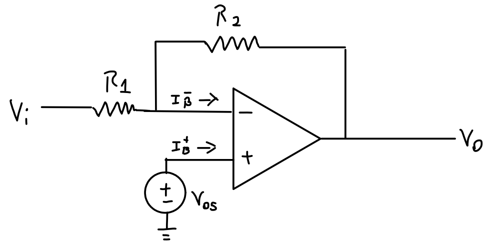
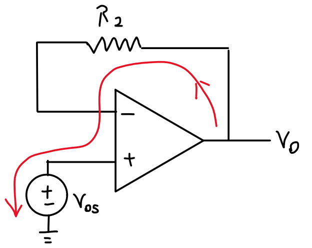
1. $G = -100$

a) $R_1 = 100\,k\Omega$

b) $R_2 = 10\,M\Omega$



$V_i \Rightarrow$ C. A.



$V_o^{\bullet} = 5.3V$

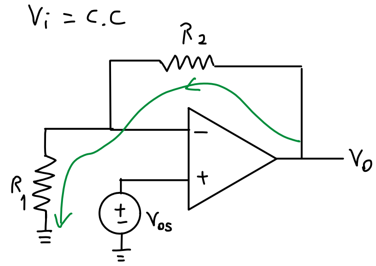
$* \; V_o^{\bullet} - R_2 I_2 - V_{os} = 0$

Mas $I_2 = I_B^-$!

Logo

$V_o^{\bullet} = R_2 I_B^- + V_{os}$

$V_i = $ C.C



$V_o^{\bullet} = 5V$

$* \; V_o^{\bullet} - V^- = R_2 I_2 \Leftrightarrow$

$\Leftrightarrow V_o^{\bullet} - V^+ = R_2 (I_B^- + I_1) \Leftrightarrow$

$\Leftrightarrow V_o^{\bullet} - V_{os} = R_2 \left(I_B^- + \frac{V_{os}}{R_1}\right) \Leftrightarrow$

$\Leftrightarrow V_o^{\bullet} = V_{os}\left(1 + \frac{R_2}{R_1}\right) + R_2 I_B^-$

$I_2 = I_B^- + I_1$

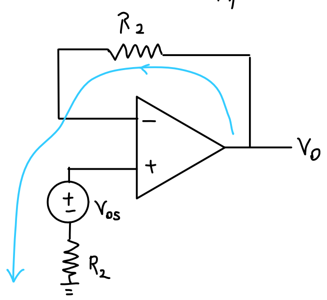
$V^+ = V^- = V_{os}$

$I_1 = \frac{V_{os}}{R_1}$

$$\begin{cases} V_o^{\bullet} = R_2 I_B^- + V_{os} \\ V_o^{\bullet} = V_{os}\left(1 + \frac{R_2}{R_1}\right) + R_2 I_B^- \end{cases} \Leftrightarrow \begin{cases} V_{os} = -3\,mV \,// \\ I_B^- = 530\,nA \end{cases}$$

$I_B = \frac{I_B^- + I_B^+}{2} \approx 530\,nA \,//$

c)

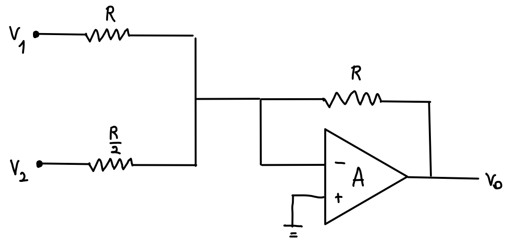


$* \; V_o^{\bullet} = R_2 I_B^- + V_{os} - R_2 I_B^+ \Leftrightarrow$

$\Leftrightarrow -\frac{V_o^{\bullet} - R_2 I_B^- - V_{os}}{R_2} = I_B^+ = 589.7\,nA \approx 590\,nA$

$I_{os} = |I_B^+ - I_B^-| = 60\,nA$

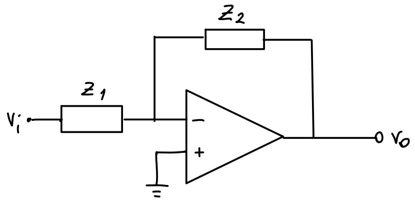
2



$$\begin{cases} \frac{V_1 - V^-}{R} + \frac{V_2 - V^-}{R/2} + \frac{V_o - V^-}{R} = 0 \\ A(V^+ - V^-) = V_o \end{cases} \Leftrightarrow \begin{cases} V_1 + 2V_2 + V_o = 4V^- \\ V_o = -AV^- \end{cases}$$

$\Rightarrow V_o = -A\,\frac{V_1 + 2V_2 + V_o}{4} \Leftrightarrow V_o = -(V_1 + 2V_2)\,\frac{A}{4 + A} \,//$

3. a)



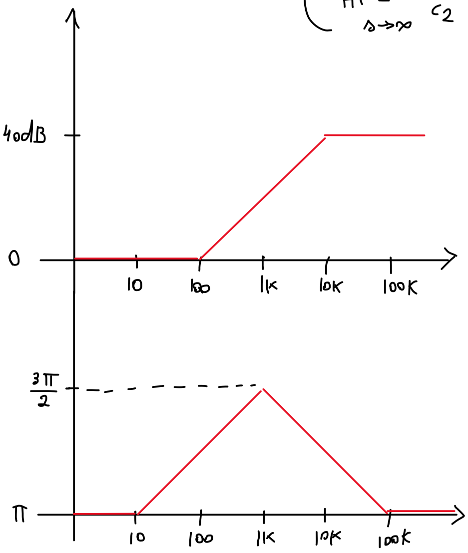
$$\begin{cases} \dfrac{V_o}{V_i} = -\dfrac{Z_2}{Z_1} \\[2ex] Z_2 = R_2 // \dfrac{1}{j\omega C_2} = \dfrac{1}{\frac{1}{R_2} + j\omega C_2} = \dfrac{R_2}{1+j\omega C_2 R_2} \\[2ex] Z_1 = R_1 // \dfrac{1}{j\omega C_1} = \dfrac{R_1}{1+j\omega C_1 R_1} \end{cases} \Rightarrow \frac{V_o}{V_i} = -\frac{R_2}{R_1}\cdot\frac{1+j\omega C_1 R_1}{1+j\omega C_2 R_2} = -\frac{C_1}{C_2}\cdot\frac{\frac{1}{C_1R_1}+s}{\frac{1}{C_2R_2}+s} \Rightarrow \begin{cases} \omega_z = \dfrac{1}{C_1R_1} \\[1ex] \omega_p = \dfrac{1}{C_2R_2} \\[1ex] \underset{s\to 0}{DC} = -\dfrac{R_2}{R_1} \\[1ex] \underset{s\to\infty}{HF} = -\dfrac{C_1}{C_2} \end{cases}$$

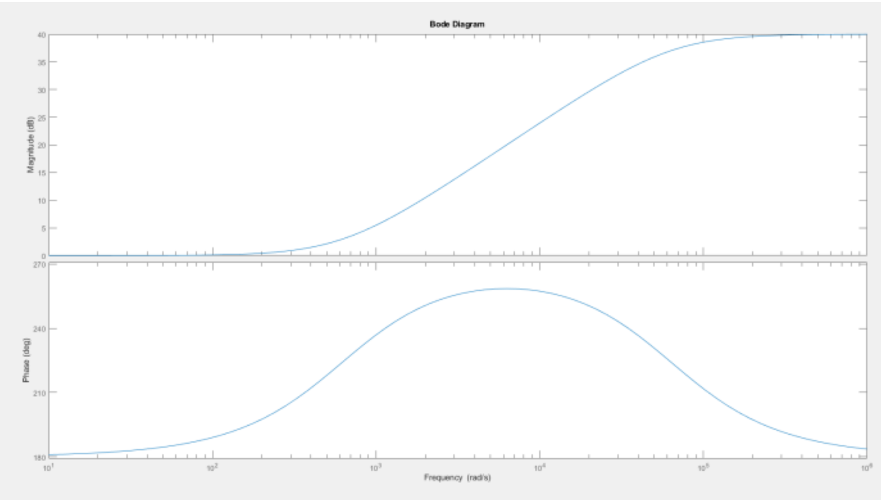
b) $\omega_z = 2\pi\cdot 100 \Rightarrow C_1 = \dfrac{1}{R_1\omega_z} = 160\ nF$

$\omega_p = 2\pi\cdot 10\cdot 10^3 \Rightarrow C_2 = \dfrac{1}{R_2\omega_p} = 1.60\ nF$ $\Rightarrow |HF| = 100$

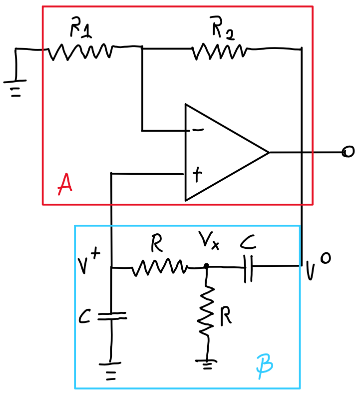
$|DC| = 1 \Rightarrow R_2 = 10k\Omega$

$R_{in} = 10k\Omega \Rightarrow R_1 = 10k\Omega$





4.



A: Montagem não inversora

$A = 1 + \dfrac{R_2}{R_1}$

B: $\beta = \dfrac{V^+}{V_o} = \dfrac{sCR}{s^2C^2R^2 + 3sCR + 1}$

$$V^+ = \frac{\frac{1}{sC}}{\frac{1}{sC} + R}\cdot V_x = \frac{1}{1+sRC} V_x$$

$$(R+C)//R = \left[\left(R + \frac{1}{sC}\right)^{-1} + R^{-1}\right]^{-1} = \left[\frac{sC}{sCR+1} + \frac{1}{R}\right]^{-1} = \frac{1}{\frac{sC}{sCR+1} + \frac{1}{R}} = \frac{R(sCR+1)}{sCR + sCR + 1} = \frac{sCR^2 + R}{2sCR + 1}$$

$$V_x = \frac{(R+C)//R}{(R+C)//R + C} V_o = \frac{\frac{sCR^2+R}{2sCR+1}}{\frac{sCR^2+R}{2sCR+1} + \frac{1}{sC}} V_o = \frac{s^2C^2R^2 + sCR}{s^2C^2R^2 + 3sCR + 1} V_o$$

$$L(s) = A\beta = \left(1 + \frac{R_2}{R_1}\right)\cdot\frac{sCR}{s^2C^2R^2 + 3sCR + 1}$$

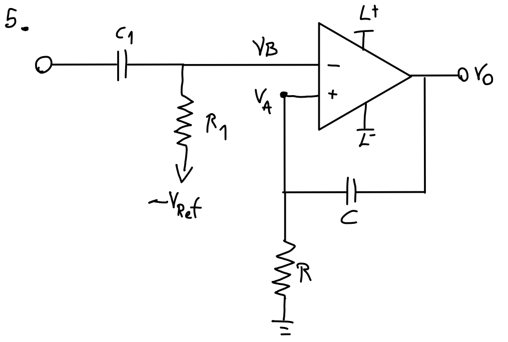
$$V^+ = \frac{1}{\cancel{1+sRC}}\cdot\frac{sCR(\cancel{1+sCR})}{s^2C^2R^2 + 3sCR + 1} V_o = \frac{sCR}{s^2C^2R^2 + 3sCR + 1} V_o$$

$$L(s)=A\beta=\left(1+\frac{R_2}{R_1}\right)\cdot\frac{sCR}{s^2C^2R^2+3sCR+1}=1$$

$$\left(1+\frac{R_2}{R_1}\right)\cdot\frac{j\omega CR}{-\omega^2C^2R^2+3j\omega CR+1}=1$$

$$\left(1+\frac{R_2}{R_1}\right)\cdot\frac{\omega CR}{-\frac{1}{j}\omega^2C^2R^2+3\omega CR+\frac{1}{j}}=1 \Rightarrow \begin{cases}-\frac{1}{j}\omega^2C^2R^2+\frac{1}{j}=0 \Leftrightarrow \omega^2C^2R^2=1 \Rightarrow \omega=\frac{1}{CR}\\ \frac{\left(1+\frac{R_2}{R_1}\right)\cancel{\omega}CR}{3\cancel{\omega}CR}=1 \Rightarrow \frac{R_2}{R_1}=2\end{cases}$$

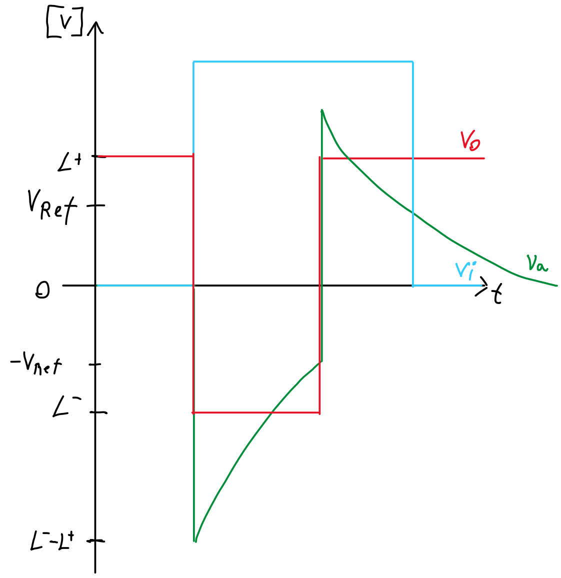
5.



$V_o=L^+$

$V_A=0$

$V_B=-V_{Ref}$



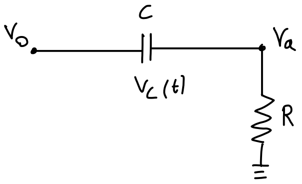
$V_i>V_{Ref} \Rightarrow V_B>0 \Rightarrow V_o \to L^-$

$V_c=L^+$ (Não muda instantaneamente!)

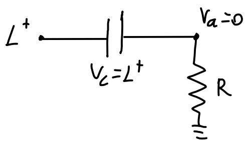
$V_a=V_o-V_c=L^--L^+ \Rightarrow C$ vai descarregar até atingir $V_a=-V_{Ref}$

Como V_B é novamente $V_B=V_{Ref}$, V_o passa de L^- para L^+

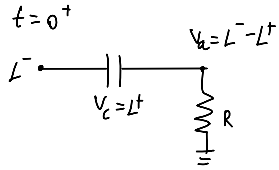
$V_a=V_o-V_C=L^+-(L^--V_{Ref})=L^+-L^--V_{Ref}$



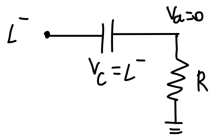
$t=0^-$



$t=0^+$



$t=\infty$



$$V_a=RC\frac{dV_C}{dt} \qquad \begin{matrix}V_a(0^+)=L^--L^+\\ V_a(\infty)=0\end{matrix} \Rightarrow \begin{matrix}K_2=L^--L^+\\ K_1=0\end{matrix}$$

$$V_a(t)=K_1+K_2e^{-\frac{t}{RC}} \Rightarrow V_a(t)=(L^--L^+)e^{-\frac{t}{RC}} \Rightarrow -V_{Ref}=(L^--L^+)e^{-\frac{t}{RC}}$$

$$\hookrightarrow t=RC\ln\left(\frac{L^+-L^-}{V_{Ref}}\right)$$