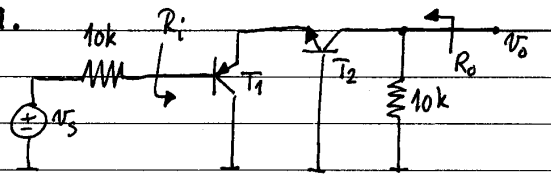
Resolução:

1a.



$R_i = r_{\pi 1} + (\beta+1) r_{e2} = 2 r_\pi$

$r_\pi = \frac{\beta V_T}{I_C} \cong \frac{100 \cdot 25m}{0,5m} = 5\,k\Omega$ logo $R_i = 10k\Omega$

Como $r_o \to \infty$ $R_o = 10\,k\Omega$

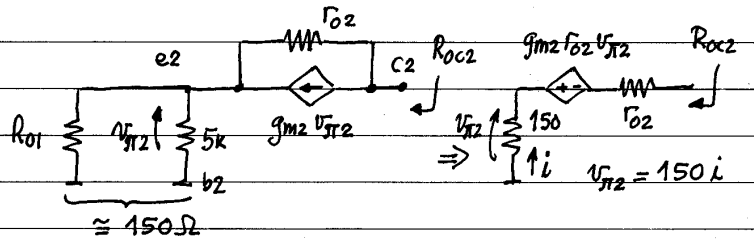
1b. $\frac{v_o}{v_s} = \frac{v_{b1}}{v_s} \cdot \frac{v_{e2}}{v_{b1}} \cdot \frac{v_o}{v_{e2}} = \frac{10k}{10k+10k} \cdot \frac{r_{e2}}{r_{e2}+r_{e1}} \cdot g_{m2} \cdot 10k = 50\ V/V$

$g_{m2} = \frac{I_C}{V_T} = \frac{0,5}{25} = 20mA/V$

1c.

$r_{o2} = \frac{100}{0,5m} = 200\,k\Omega$

$R_{o1} = \frac{10k + r_{\pi 1}}{\beta+1} \cong 150\,\Omega$



$R_{oc2} = 150 + 150\, g_{m2} r_{o2} + r_{o2} \cong r_{o2}(1+3) = 800\,k\Omega$ $R_o = 10k // R_{oc2} \cong 10k\Omega$

Não há, praticamente, alteração do valor de R_o. Era de prever dado o valor elevada da R_{oc} da montagem BC. Quer se admita r_{o2} real ou infinita, o valor de R_{oc2} é sempre $\gg 10k\Omega$.

2a.

$V_{G1} = \frac{133}{470+133} \times 15 = 3,31\ V$ De $3,31 = V_{GS1} + 10k \cdot I_1$

e $I_1 = 0,1m\,(V_{GS1} - 1)^2$

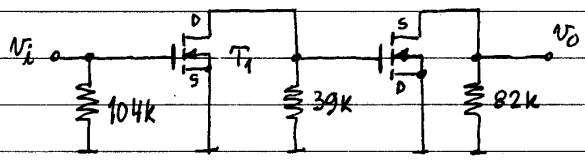
resulta $V_{GS1} \cong 2,10V$ e $I_1 \cong 120\mu A$. Então $V_{S1} = 10k\, I_1 = 1,21V$

$V_{D1} = 15 - 39k\, I_1 \cong 10,3\ V = V_{G2}$ $V_{D2} = 15V$

De $10,3 = V_{GS2} + 82k\, I_2$ e $I_2 = 0,1m\,(V_{GS2} - 1)^2$ vem $V_{GS2} \cong 2,00V$

e consequentemente $I_2 \cong 101\,\mu A$ e $V_{S2} = 8,3\ V$

2b.



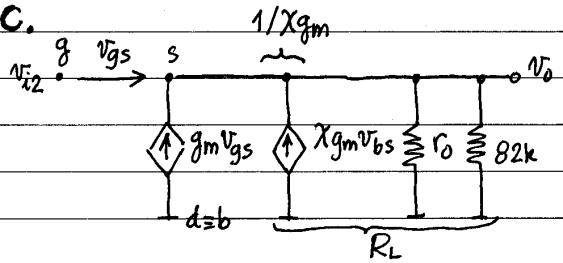
T_1 é um FC logo:

$A_{v1} = -g_{m1}(r_{o1} // 39k)$

$r_{o1} = \frac{50}{0,1m} = 500\,k\Omega$

$A_{v1} \cong -0,2 \times 39 = -7,8\ V/V$

2c.



$1/\chi g_m = 25\,k\Omega$

$R_L = \frac{1}{\chi g_m} // r_o // 82k \cong 18,5\,k\Omega$

$A_{v2} = \frac{v_o}{v_{i2}} = \frac{R_L}{1/g_m + R_L} \cong 0,79\ V/V$

3a. Desejamos: $V_{bat} > V_1$ D_1 aceso D_2 apagado

$V_2 < V_{bat} < V_1$ " D_2 aceso

$V_{bat} < V_2$ D_1 apagado "

Para D_2 apagado $\Rightarrow I_2 < 1mA$, isto é

$$I_2 = \frac{10 - 0,7 - (V_{bat} - 0,7)}{3k9} < 1mA$$

donde $V_{bat} > 6,1\,V$ logo $V_1 = 6,1\,V$

Verifiquemos que D_1 está aceso.

Para $V_{bat} = V_1 = 6,1\,V \Rightarrow I_2 = 1mA$ e $I_1 = \frac{6,1 - 0,7}{2k2} - 1mA = 1,45mA$ O.K

Para D_1 apagado $\Rightarrow I_1 < 1mA$, logo

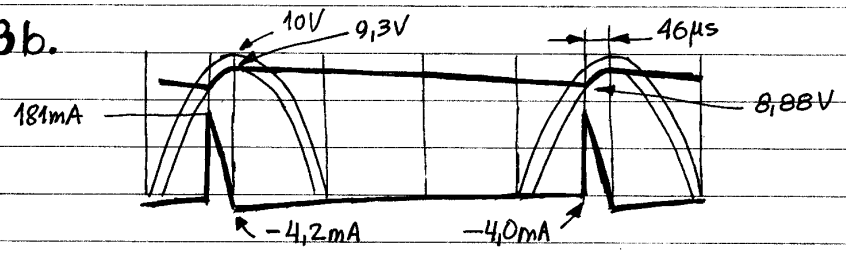
$$I_1 = \frac{V_{bat} - 0,7}{2k2} - \frac{10 - 0,7 - V_{bat} + 0,7}{3k9} < 1mA$$

donde $V_{bat} < 5,46\,V$ logo $V_2 = 5,46\,V$

Para $V_{bat} = V_2 = 5,46V$ D_2 está aceso pois:

$$I_2 = \frac{10 - 0,7 - (5,46 - 0,7)}{3k9} \cong 1,16mA$$

3b.



$f = 1kHz \Rightarrow T = 1ms \rightarrow \tau = RC = 2k2 \times 10\mu = 22\,ms$

Na descarga $v_C = 9,3\,e^{-t/\tau}$

Para $t \cong T$ $9,3 - V_r \cong 9,3\left(1 - \frac{T}{\tau}\right) \Rightarrow V_r = 9,3\,\frac{T}{\tau} = 0,42\,V$

Na carga

$$v_C = 10\cos\omega t - 0,7 \rightarrow 8,88 = 10\cos(\omega \Delta t) - 0,7$$

donde $\Delta t \cong 46\mu s$

A corrente no condensador $i = C\frac{dv_C}{dt} \Rightarrow i = -\omega C 10\,\text{sen}\,\omega t$

logo $i_{max} = -10\,\omega C\,\text{Sen}(\omega \Delta t) \cong 181\,mA$

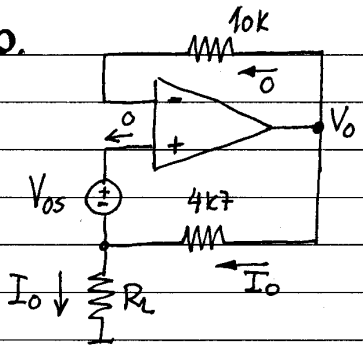
4a. $Z = [10k \,//\, 10nF] = \frac{10k}{1 + s\,100\mu} = \frac{10k}{1 + s/10^4}$

$V^- - V_o = Z I_i$ e $V^+ - V_o = -4k7\,I_o$

Como $V^- = V^+$ resulta $Z I_i = -4k7\,I_o$ donde

$$A_I(s) = \frac{I_o}{I_i} = -\frac{Z}{4k7} = -\frac{10/4,7}{1 + s/10^4}$$

4b.



$V^- = V^+ = V_0$

$V_{os} - 4k7\ I_0 = 0$

logo:

$$I_0 = \frac{V_{os}}{4k7} = \frac{\pm 10mV}{4k7} = \pm 2{,}1\mu A$$