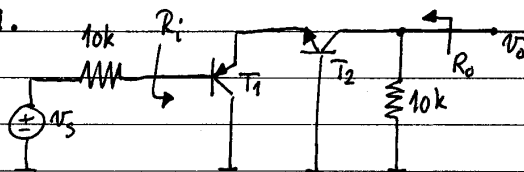


Resolução:

1a.



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

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

logo $R_i = 10 k\Omega$

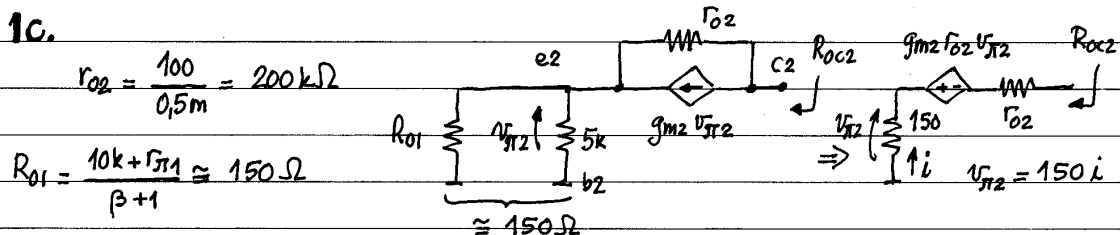
Como $r_o \rightarrow \infty$ $R_o = 10 k\Omega$

1b.

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

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

1c.



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

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

$R_{oc2} = 150 + 150 g_{m2} r_{o2} + r_{o2} \approx r_{o2} (1 + 3) = 800 k\Omega$ $R_o = 10k // R_{oc2} \approx 10k\Omega$
 Não há, praticamente, alteração de valor de R_o . Era de prever dado o valor elevada da R_{oc} da montagem BC. Over se admita r_{o2} real ou infinita, o valor de R_{oc2} é sempre $\gg 10k\Omega$.

2a.

$$V_{G1} = \frac{133}{470+133} \times 15 = 3,31 \text{ V}$$

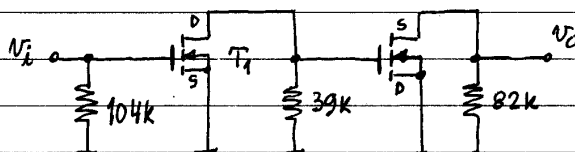
De $3,31 = V_{GS1} + 10k \cdot I_1$
 e $I_1 = 0,1m (V_{GS1} - 1)^2$

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

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

De $10,3 = V_{GS2} + 82k I_2$ e $I_2 = 0,1m (V_{GS2} - 1)^2$ vem $V_{GS2} \approx 2,00 \text{ V}$
 e consequentemente $I_2 \approx 101 \mu\text{A}$ e $V_{S2} = 8,3 \text{ V}$

2b.



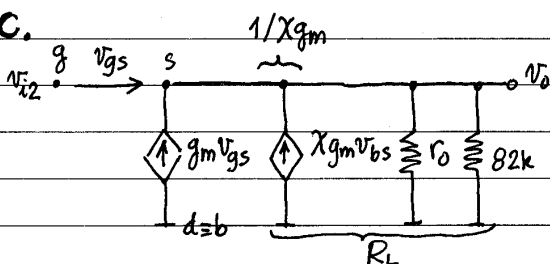
T_1 é um FC logo:

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

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

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

2c.



$$1/X_{gm} = 25 k\Omega$$

$$R_L = \frac{1}{X_{gm}} // r_o // 82k \approx 18,5 k\Omega$$

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

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 $\Rightarrow I_2 < 1\text{mA}$, isto é

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

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

Verifiquemos que D_1 está aceso.

Para $V_{bat} = V_1 = 6,1\text{V} \Rightarrow I_2 = 1\text{mA}$ e $I_1 = \frac{6,1 - 0,7}{2k\Omega} - 1\text{mA} = 1,45\text{mA} > 1\text{mA}$

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

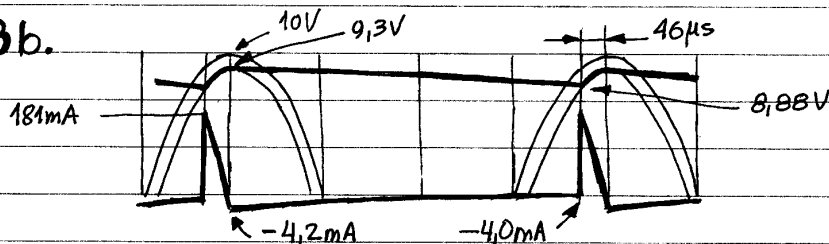
$$I_1 = \frac{V_{bat} - 0,7}{2k\Omega} - \frac{10 - 0,7 - V_{bat} + 0,7}{3k\Omega} < 1\text{mA}$$

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

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

$$I_2 = \frac{10 - 0,7 - (5,46 - 0,7)}{3k\Omega} \approx 1,16\text{mA}$$

3b.



$$f = 1\text{kHz} \Rightarrow T = 1\text{ms} \rightarrow \tau = RC = 2k\Omega \times 10\mu\text{F} = 22\text{ms}$$

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

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

Na carga

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

donde $\Delta t \approx 46\mu\text{s}$

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

$$\text{logo } i_{\text{máx}} = -10 \omega C \text{sen}(\omega \Delta t) \approx 181\text{mA}$$

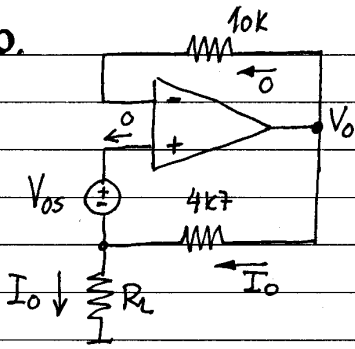
$$4a. Z = [10k \parallel 10nF] = \frac{10k}{1 + s 100\mu} = \frac{10k}{1 + s/10^4}$$

$$V^- - V_0 = Z I_i \quad \text{e} \quad V^+ - V_0 = -4k\Omega I_0$$

Como $V^- = V^+$ resulta $Z I_i = -4k\Omega I_0$ donde

$$A_I(s) = \frac{I_0}{I_i} = -\frac{Z}{4k\Omega} = -\frac{10/4i7}{1 + s/10^4}$$

4b.



$$V^- = V^+ = V_o$$

$$V_{os} - 4\text{k}\Omega I_o = 0$$

logo:

$$I_o = \frac{V_{os}}{4\text{k}\Omega} = \frac{\pm 10\text{mV}}{4\text{k}\Omega} = \pm 2,1\mu\text{A}$$