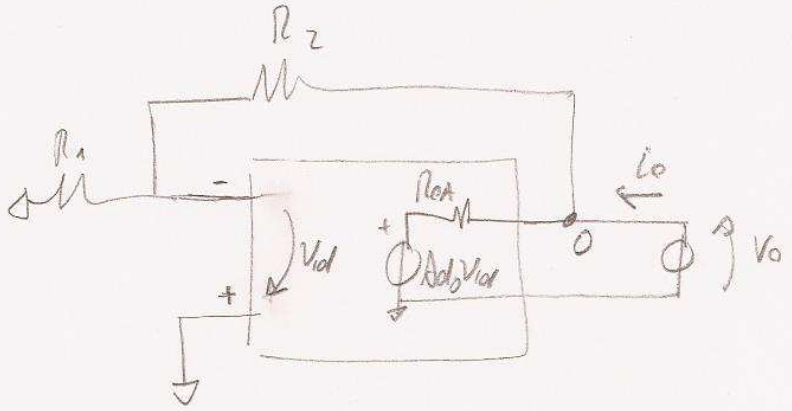
1)




BILANCIO Σ AL NODO 0

$$i_o = (v_o - A_{do} v_{id}) G_{OA} + v_o G_{12}$$

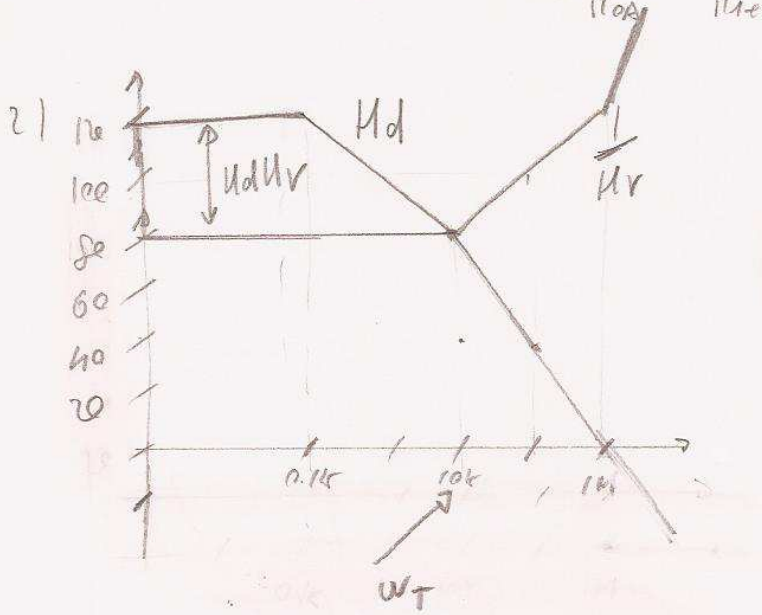
$$G_{12} = \frac{1}{R_1 + R_2}$$

$$H_r = \frac{R_1}{R_1 + R_2}$$

$$v_{id} = -v_o \cdot \frac{R_1}{R_1 + R_2} = -v_o H_r$$

$$R_o = \frac{v_o}{i_o} = \frac{1}{[1 + A_{do} H_r] \frac{1}{R_{OA}} + \frac{1}{R_1 + R_2}} \simeq 240\,\Omega$$

2)




Con $H_{r0} = -80\,dB$

$$|H_d H_r|_{\omega = 10k} = 0\,dB$$

$$\angle H_d H_r|_{\omega \simeq 10k} \simeq -135°$$

$$\Rightarrow PM \simeq 45°$$

$$H_{r\infty} = -80\,dB$$

3)

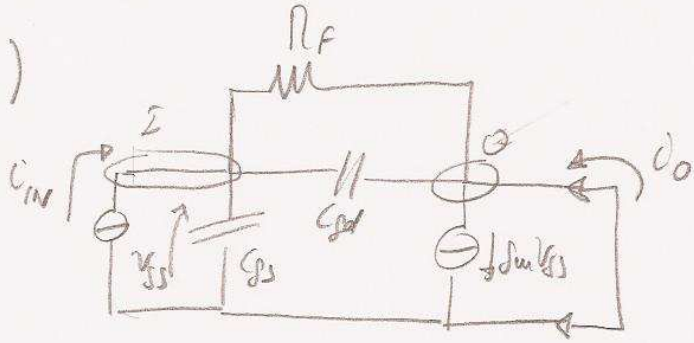
$V_{DS1} = V_{GS1} - I_{B1} R_1 \qquad I_{B1} R_1 < V_{TH} \Rightarrow M1$ SAT!

$V_{GS1} = V_{GS2}$, $\lambda \simeq 0$ per M1 e M2 $\Rightarrow$

$\Rightarrow I_{D2} = I_{D1} \cdot \frac{(W/L)_2}{(W/L)_1} \qquad I_{D1} = I_{B1}$

$I_O = I_{D2} - I_{B2} = 13\,\mu A$

4)




I: $C_{IN} = V_{gs} [s(C_{gs} + C_{gd}) + G_F]$

$G_F = \frac{1}{R_F}$

O: $C_O = g_m V_{gs} - V_{gs} (s C_{gd} + G_F)$

$A_I = \frac{C_O}{C_{IN}} = \frac{(g_m - G_F) - s C_{gd}}{G_F + s (C_{gd} + C_{gs})}$

$C_x = C_{gd} + C_{gs}$

$|A_I(\omega_t)| = 1 \longrightarrow$

$$\rightarrow \quad (g_m - G_F)^2 + \omega_T^2 C_{gd}^2 = G_F^2 + C_x^2 \omega_T^2$$

$$\Rightarrow \quad g_m^2 - 2 g_m G_F - \omega_T^2 (C^2 - C_{gd}^2) = 0$$

1 sola soluzione ammissibile ($g_m > 0$)

$$g_m = 143\ m$$

$$g_m = \sqrt{2 k' \frac{W}{L} I_B} \quad \rightarrow \quad I_B = 85.2\ mA$$

5)

BILANCIO AL NODO B (BASE)

$$I_X = I_{R_B} + I_B$$

MAGLIA

$$I_E R_E + V_\gamma + R_B (I_B + I_X) = V_{DD}$$

$$I_C = \frac{V_{DD} - V_\gamma - R_B I_X}{(\beta+1) R_E + R_B} \cdot \beta = 336\ \mu A$$

6)

Sovrapposizione degli effetti

a) $V_{cj} = 0$, $I_B = 0$

$$V_{o_d} = -\left(\frac{9R_1}{R_1}\right) V_{IN} = -9\, V_{IN}$$

b) $V_{IN} = 0$, $I_B = 0$

$$V_{o_b} = V_{os}\left(\frac{9R_1}{R_1}\right) + V_{cj} = 10 \cdot V_{cj}$$

c) $V_{IN} = e$, $V_{cj} = 0$

$$V_{o_c} = 9R_1 \cdot I_B$$

$$V_o = V_{o_a} + V_{o_b} + V_{o_c} = -110\,mV$$

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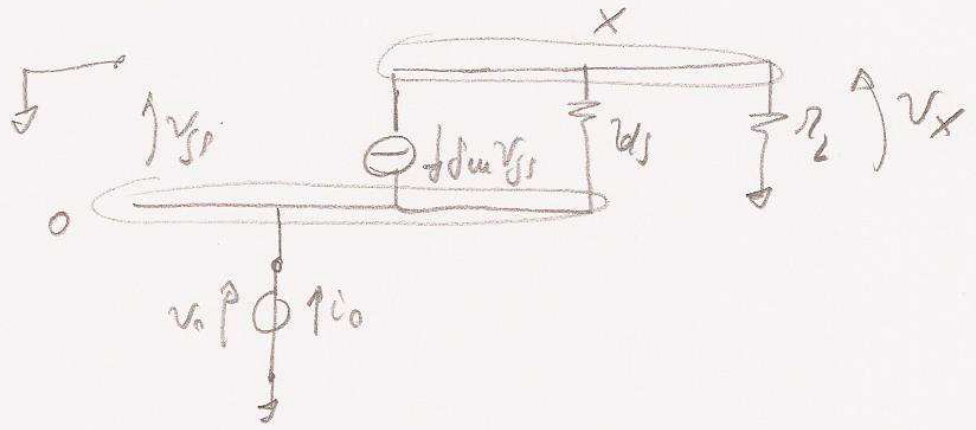



$$g_L = \frac{1}{r_L}$$

$(v_{gs} - v_o)$

0: $\quad i_o = g_m v_o + (v_o - v_x) g_{ds}$

x: $\quad v_x g_L - g_m v_o + g_{ds}(v_x - v_o) = 0$

$$R_o \triangleq \left.\frac{v_o}{i_o}\right|_{v_{in}=0} = \frac{g_x + g_{ds}}{g_m g_L + g_{ds} g_L} = \frac{r_{ds} + R_L}{r_{ds} g_m + 1} = 5.4\,k\Omega$$

8)

CHECK MΦ SATURATION

$$I_{B\Phi} = I_{D1} = I_{DC}$$

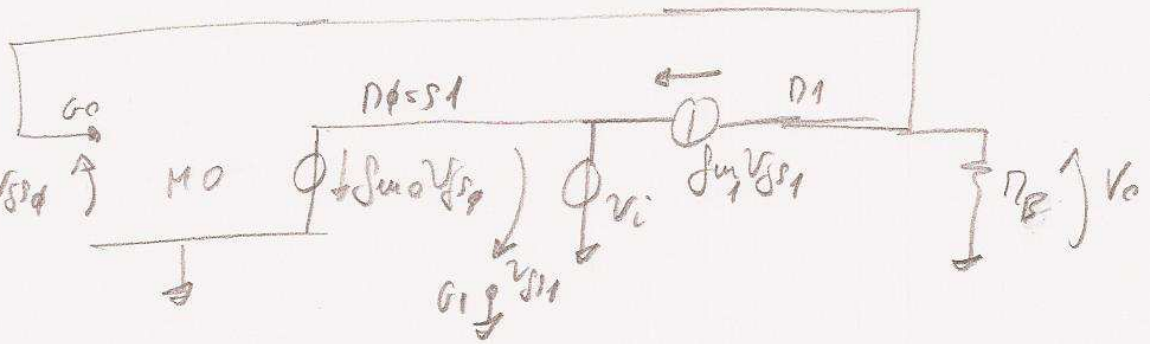
$$V_{GS\Phi} = V_T + \sqrt{\frac{2I_{B\Phi}}{k'\left(\frac{W}{L}\right)_0}} \cong 0.55V$$

$$V_{GS1} \cong V_T + \sqrt{\frac{2I_{B\Phi}}{k'\left(\frac{W}{L}\right)_1}} \cong 0.7V$$

$$V_{D\Phi} = V_{B\Phi} - V_{GS1} = 0.6V > V_{G\Phi} - V_T = 0.4V \Rightarrow M\Phi SAT.!$$

CHECK M1

$$V_{D1} = V_{GS\Phi} > V_{G1} - V_T \Rightarrow M1\ SAT!$$




$$V_{C1} - g_{m_1} V_{GS1} R_L = -g_{m_1}(-V_i) R_L$$

$$\rightarrow A_V = g_{m_1} R_L = 200$$