

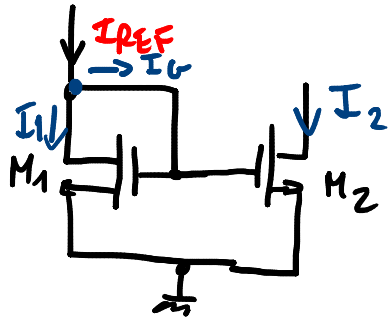
$$I_{D1} = I_{D2} = \frac{V_1 - V_2 - 2V_\gamma}{R_1 + R_2} = 3,3 \text{ mA} > 0$$

$$V_{A_{k3}} < V_\gamma? \quad V_{A_3} = V_3 = -15 \text{ V}$$

$$V_{k_3} = V_2 + V_\gamma + R_2 I_{D2} = 1 \text{ V}$$

$$V_{A_{k3}} = V_{A_3} - V_{k_3} = -16 \text{ V} < V_\gamma$$

SPECCHIO DI CORRENTE



$$I_{REF} = I_1 + I_G = I_1$$

$$V_{DS} \geq V_{GS} - V_T$$

$$V_D - V_S \geq V_G - V_S - V_T$$

$$V_D - V_G \geq -V_T$$

$$V_{GD} \leq V_T$$

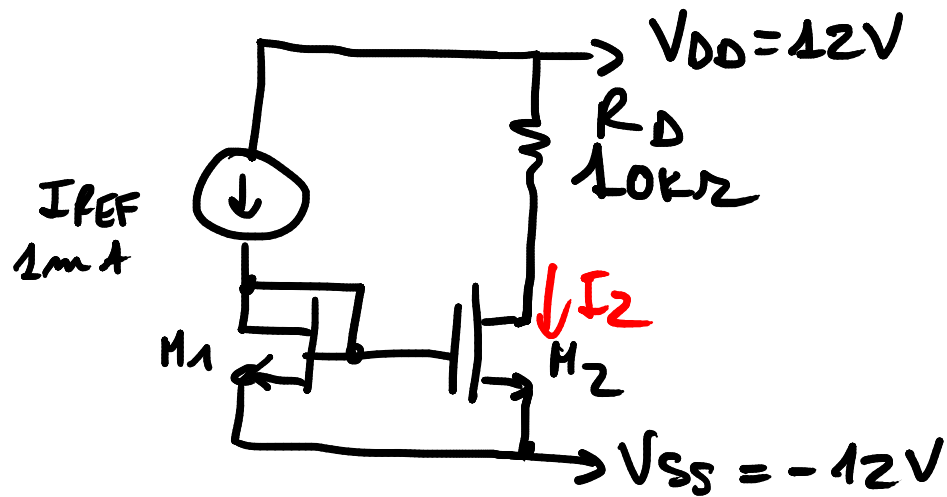
$V_{GD} = 0 \Rightarrow M_1$ è saturato

$$I_{DS} = \frac{\kappa}{2} (V_{GS1} - V_T)^2 = I_1 = I_{REF}$$

$$V_{GS} = \sqrt{\frac{2I_{REF}}{\kappa}} + V_T \geq V_T$$

$$V_{GS2} = V_{GS1}$$

$$I_2 = \frac{\kappa}{2} (V_{GS2} - V_T)^2 = \frac{\kappa}{2} (V_{GS1} - V_T)^2 = I_1$$



$$k = 2 \text{ mA/V}^2$$

$$V_T = 1 \text{ V}$$

$$I_1 = \frac{k}{2} (V_{GS} - V_T)^2$$

$$V_{GS1} = \sqrt{\frac{2I_1}{k}} + V_T = 2,414 \text{ V}$$

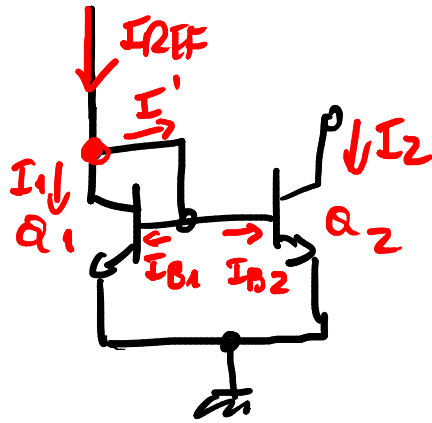
$$V_{DS1} = V_{GS1} = V_{GS2} = 2,414 \text{ V}$$

$$I_2 = I_{REF} = 1 \text{ mA}$$

$$V_{S2} = -12 \text{ V} \quad V_{D2} = V_{DD} - R_D I_2 = 2 \text{ V}$$

$$V_{DS2} = V_{D2} - V_{S2} = 14 \text{ V} \geq V_{GS2} - V_T = 1,414 \text{ V}$$

$M_2 \bar{e}$ saturation



$$I_c = \beta I_B$$

$$V_{BE1} = V_{BE2}$$

$$I_c \approx I_{sc} \left(e^{\frac{V_{BE}}{V_T}} - 1 \right)$$

$$I_{c1} = I_{c2}$$

$$I_{B1} = I_{B2} = \frac{I_1}{\beta}$$

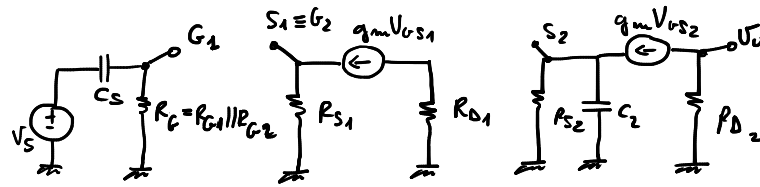
$$I' = I_{B1} + I_{B2} = \frac{2}{\beta} I_1$$

$$\frac{I_2}{I_{REF}} = ?$$

$$I_{REF} = I' + I_1$$

$$I_{REF} = \frac{2}{\beta} I_1 + I_1 = \frac{2 + \beta}{\beta} I_1 = \frac{2 + \beta}{\beta} I_2$$

$$\frac{I_2}{I_{REF}} = \frac{\beta}{2 + \beta}$$



$$R_G = 50k\Omega$$

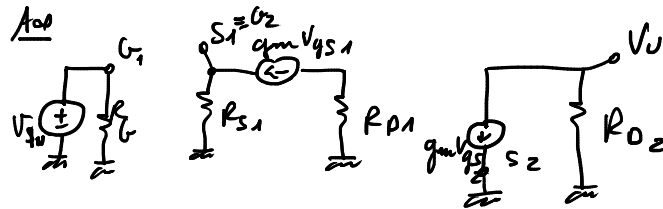
$$A_V(s) = \frac{A_{V0} S (S + \omega_0)}{(S + \omega_{p1})(S + \omega_{p2})}$$

$$\omega_{p1} = \frac{1}{C_S R_G} = 20 \text{ rad/sec}$$

$$\omega_{p2} = \frac{1}{C_2 R_{V_{C2}}} = 3 \text{ Mrad/sec}$$

$$R_{V_{C2}} = R_{S2} \parallel \frac{1}{g_m} = 339.3 \Omega$$

$$\omega_0 = \frac{1}{C_S R_S} = 2 \text{ Mrad/sec}$$



$$V_O = -R_{D2} g_m V_{GS2}$$

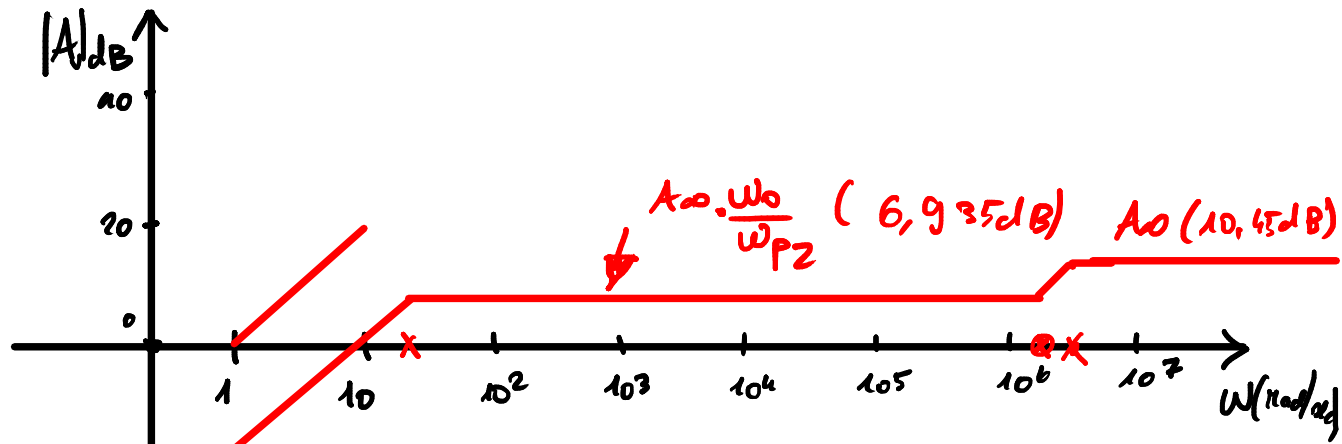
$$V_{GS2} = V_{O1} - V_{S2} = V_{O1} = V_{S1} = R_{S1} g_m V_{GS1}$$

$$V_{GS1} = V_{O1} - V_{S1} = V_{i0} - R_{S1} g_m V_{GS1}$$

$$V_{GS1} = \frac{V_{i0}}{1 + g_m R_{S1}}$$

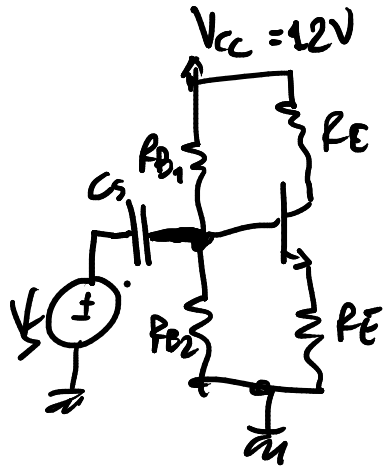
$$V_{S1} = \frac{g_m R_{S1} V_{i0}}{g_m R_{S1} + 1}$$

$$A_{V0} = \underbrace{-R_{D2} g_m}_{\text{Stage 2 Gain}} \cdot \underbrace{\frac{g_m R_{S1}}{1 + g_m R_{S1}}}_{\text{Stage 1 Gain}} =$$



$$\lim_{s \rightarrow 0} A_0 \frac{(s + \omega_0)}{(s + \omega_{p2})} = \frac{A_0 \omega_0}{\omega_{p2}}$$

$$A_{\infty} = -3,333 \quad (10,45dB)$$



LEZIONI DA RECUPERARE:

- 1) 15/5 2+1
- 2) 17/5 3
- 3) 22/5 2