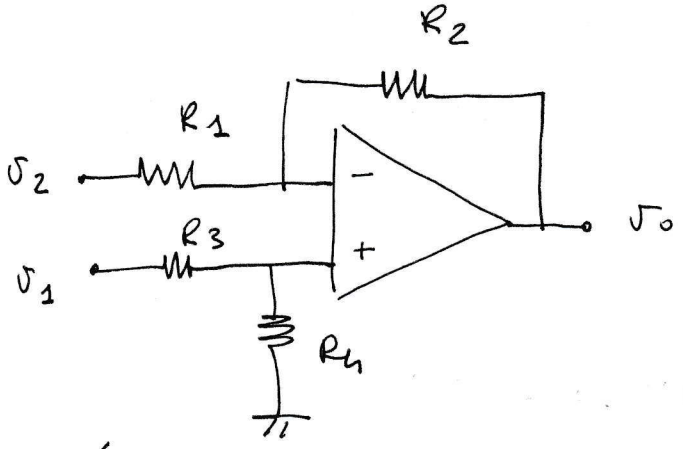
ES. 1

a) $v_o = 5 v_1 - 10 v_2$ con AO caratterizzato da

Guadagno asintotico

$$A_{OL} = \frac{10^5}{1 + j f/15}$$

$$I_{o_{MAX}} = 20 \text{ mA}$$



↳ con AO ideale $v_o = v_1 \frac{R_l}{R_3 + R_l}\left(1 + \frac{R_2}{R_1}\right) - v_2 \frac{R_2}{R_1}$

$$\boxed{\frac{R_2}{R_1} = 9} \Rightarrow \frac{R_l}{R_3 + R_l} \cdot \left(1 + \frac{R_2}{R_1}\right) = \frac{R_l}{R_3 + R_l} \cdot 10 = 5$$

$\frac{R_2}{R_1} = 9$

$$\Rightarrow \frac{R_l}{R_3 + R_l} = \frac{1}{2} \Rightarrow \boxed{R_3 = R_l}$$

Soluzione possibile $R_3 = R_l = R_1 = 1\,k\Omega$

$R_2 = 9\,k\Omega$

b) la larghezza di banda del fattore β

$$v_o = \left[\left(1-\frac{1}{\beta}\right)v_2 + \frac{v_1}{2}\cdot\frac{1}{\beta}\right]\frac{\beta A_0}{1+\beta A_0}\cdot\frac{1}{1+J\,f/f_H(1+\beta A_0)}$$

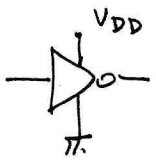
con $\beta = \frac{R_1}{R_1+R_2} = 10^{-1}$

$A_0 = 10^5$

$\rightarrow f_{Hf} = f_H(1+\beta A_0)$

$\simeq 15\cdot 10^4$ Hz

ES. 2

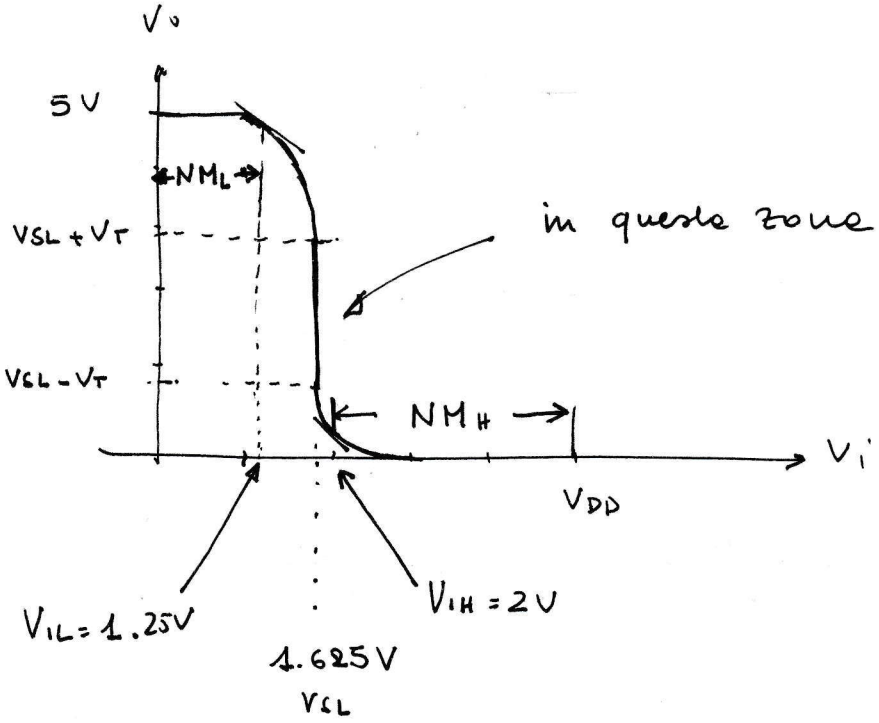


$V_{DD} = 5\,V$

$NM_H = 3\,V \quad NM_L = 1.25\,V$

$V_{SL} = 1.625\,V$

$V_{TN} = -V_{TP} = 1\,V$



in questa zona $I_{SAT_n} = |I_{SAT_p}|$ *

* $K_n (V_{SL} - V_T)^2 = K_p (V_{DD} - V_{SL} - V_T)^2$

$K_n (0.625)^2 = K_p (2.375)^2 \Rightarrow \frac{K_n}{K_p} = \frac{(2.375)^2}{(0.625)^2} = 14.44$

Quindi l'inverter, come risulta chiaro dai dati del problema, è fortemente dissimmetrico.

b) ricordando che

$$t_{PHL} = \frac{C_L \, V_{DD}/2}{K_n (V_{DD} - V_T)^2}, \qquad t_{PLH} = \frac{C_L \, V_{DD}/2}{K_p (V_{DD} - V_T)^2}$$

$$K_n t_{PHL} = K_p t_{PLH} \Rightarrow t_{PLH} = \frac{K_n}{K_p} t_{PHL} = 14.44 \, t_{PHL}$$