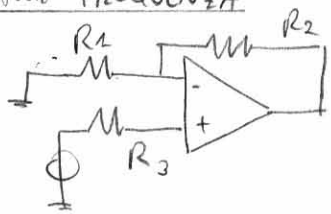
ESERCIZIO 1

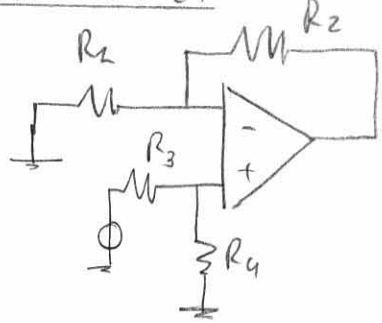
1A

BASSA FREQUENZA



$$G_{ID}(0) = \left(1 + \frac{R_2}{R_1}\right) = 7$$

MEDIA FREQUENZA

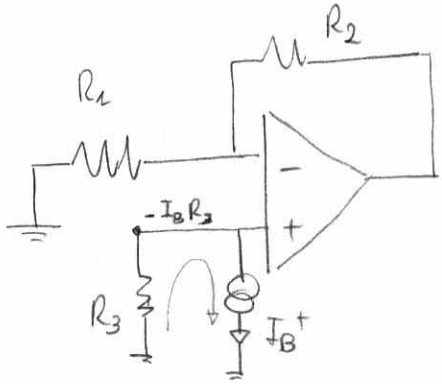


$$G_{ID}(MF) = \frac{R_4}{R_4+R_3}\left(1 + \frac{R_2}{R_1}\right) = \frac{7}{2}$$

1B

PRINCIPIO di SOVRAPPOSIZIONE degli EFFETTI → { SPENGO V_{IN} ; APPLICO le I_B UNA ALLA VOLTA

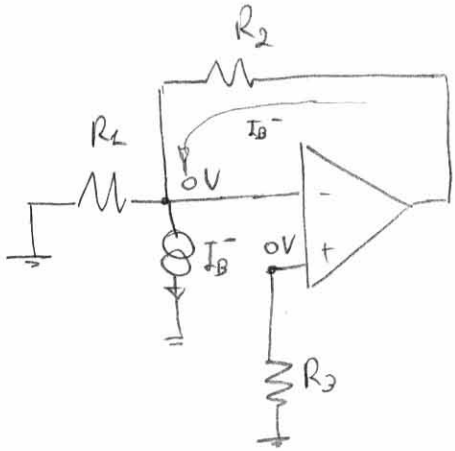
(*)



$$V_{OUT}\Big|_{I_B^+} = V^+\left(1 + \frac{R_2}{R_1}\right) =$$

$$= -I_B^+ R_3\left(1 + \frac{R_2}{R_1}\right) = -7mV$$

(*)

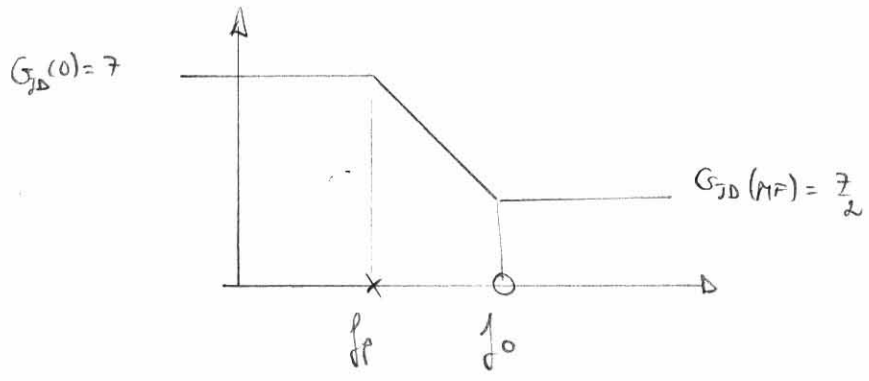


$$V_{OUT}\Big|_{I_B^-} = I_B^- R_2 = 1{,}2mV$$

NB: I_B costante ⇓ C aperto

$$\Rightarrow V_{OUT}\Big|_{I_B} = V_{OUT}\Big|_{I_B^+} + V_{OUT}\Big|_{I_B^-} = -5.8\,mV$$

2C GUADAGNO IDEALE

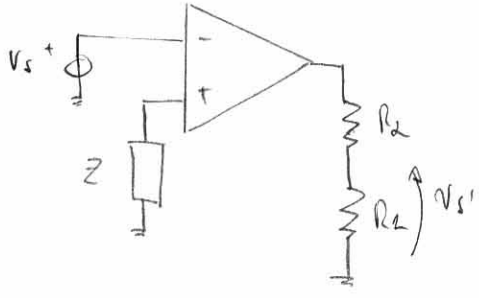


$$\tau_p = C(R_3 + R_4) = 9,4\ \mu sec$$

$$f_p = \frac{1}{2\pi\tau_p} = 16,9\ kHz$$

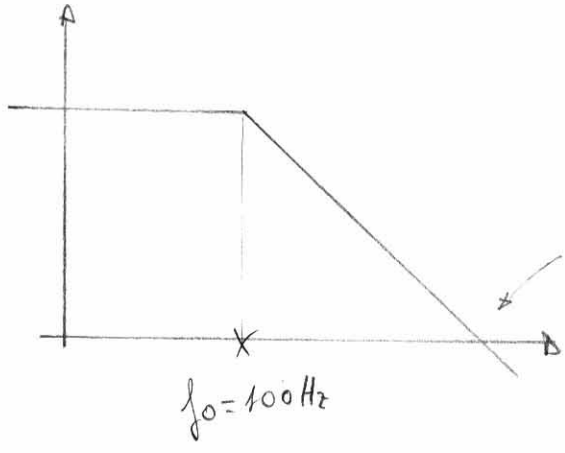
$$f_z = f_p \frac{G_{ID}(0)}{G_{ID}(MF)} = 33,9\ kHz$$

GUADAGNO D'ANELLO



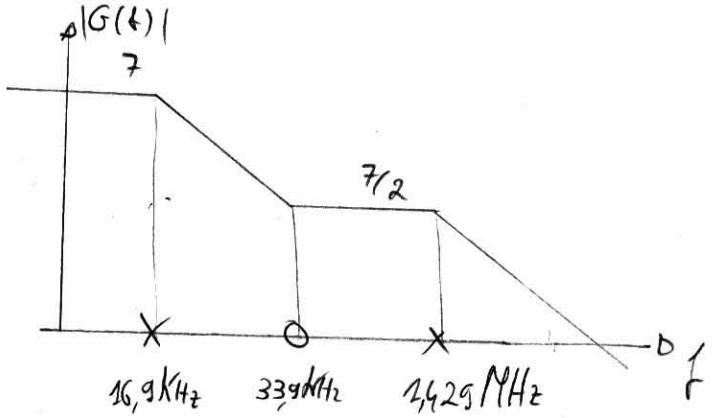
$$G_{Loop}(s) = \frac{R_1}{R_1+R_2}\left(-A(s)\right) = -\frac{A(s)}{1+\frac{R_2}{R_1}} = -\frac{A(s)}{G_{ID}(0)}$$

$$\frac{A_0}{G_{ID}(0)} = \frac{10^5}{7}$$



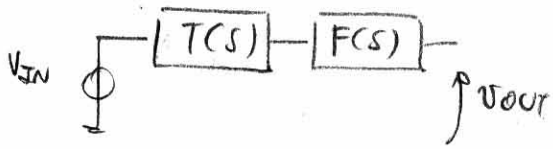
$$\bar{f} = \frac{10^5}{7} \times 10\,Hz = 1,429\,MHz$$

GUADAGNO REALE



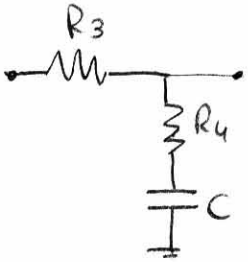
NB:

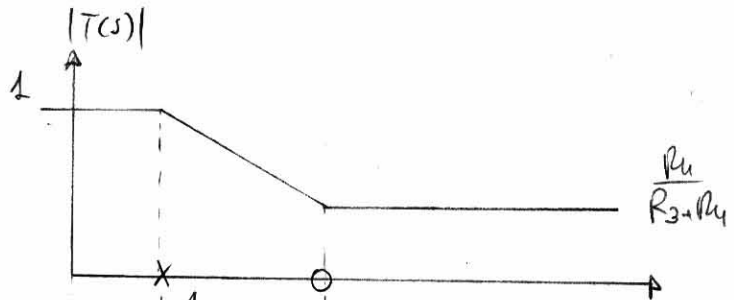
Il circuito poteva anche essere visto come la cascata di due stadi:



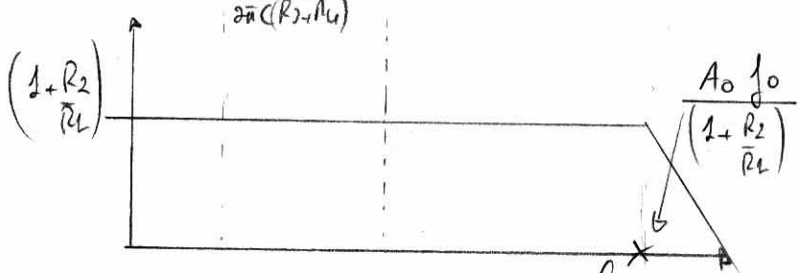
Dove:

T(S):

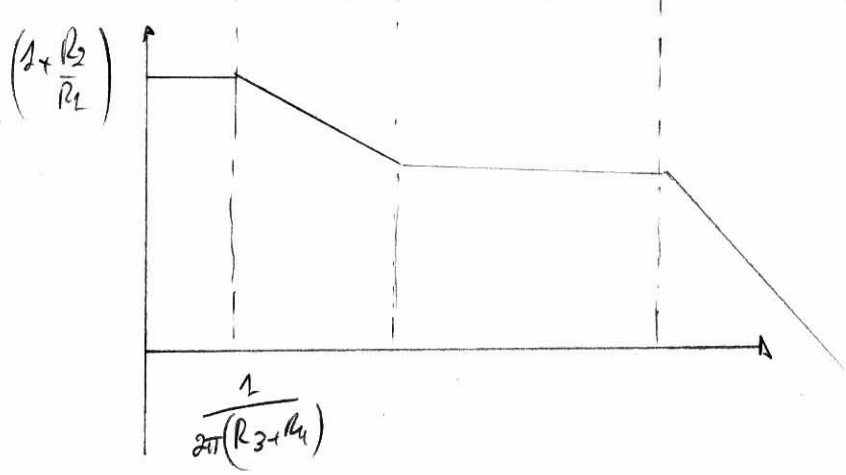




F(S)



La funzione di trasferimento è quindi il prodotto delle 2 funzioni di trasferimento:



1D

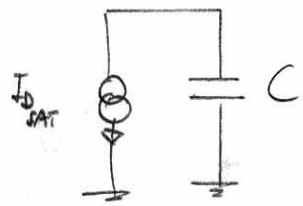
$$A|_{MAX} = \frac{SR}{G_{ID}(200kHz) \times 2\pi \times 200kHz} = 455\,mV$$

ESERCIZIO 2

2A $P = C V_{DD}^2 f = 2pF \times (3,3V)^2 \times 20MHz = \boxed{217,8\,\mu W}$

2B USCITA 1→0

FASE 1: MOS IN ZONA SATURA

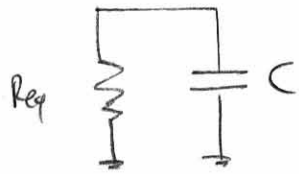


$$I_{DSAT} = k_n (V_{GS} - V_T)^2 = 2 \times 50 \frac{\mu A}{V^2} (3,3 - 0,8)^2 V^2$$

$$= 625\,\mu A$$

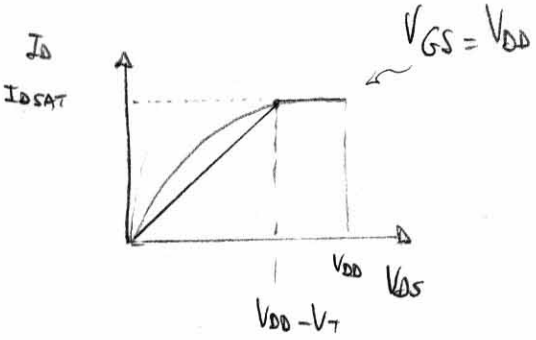
$$\Delta t_1 = \frac{C \Delta V}{I_{DSAT}} = \frac{C V_T}{I_{DSAT}} = 2,56\,ns$$

FASE 2: MOS IN ZONA OHMICA



$$R_{eq} = \frac{V_{DD} - V_T}{I_{DSAT}} = 4k\Omega$$

$$\tau = R_{eq} C = 8ns$$



$$v(t) = [v(0) - v(\infty)]\, e^{-t/\tau} + v(\infty)$$

$$\Downarrow$$

$$\Delta t_2 = \bar{t} = -\tau \ln \left[\frac{v(\bar{t}) - v(\infty)}{v(0) - v(\infty)} \right] =$$

NB: $v(\bar{t}) = 10\%\, V_{DD} = 0,33V$

$$= -8ns \times \ln \left[\frac{0,33V - 0V}{2,5V - 0V} \right]$$

$$= 16,2\,ns$$

$$t_{H \to L} = \Delta t_1 + \Delta t_2 = 2,56\,ns + 16,2\,ns = \boxed{18,8\,ns}$$

USCITA 0 → 1

$$I_{DSAT}\big|_p = I_{DSAT}\big|_n \frac{k_p}{k_n} = \frac{2}{5} I_{DSAT}\big|_n$$

$$R_{eq}\big|_p = \frac{5}{2} R_{eq}\big|_n$$

$$\boxed{t_{L\to H} = 5/2\, t_{H\to L} = 46{,}9\ ns}$$

2c

$$t_p = \frac{t_{L\to H} + t_{H\to L}}{2} = 32{,}8\ ns$$

$$\downarrow$$

$$f_{MAX} \approx \frac{1}{t_p} \approx 30\ MHz$$

$$\downarrow$$

Con un segnale a 1 GHz la porta non commuta →

$$\boxed{P_{DISS} = 0}$$

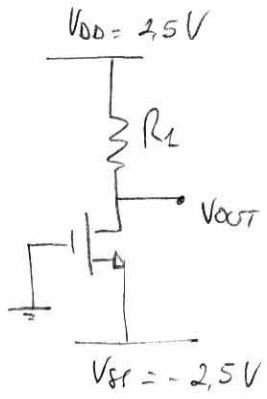
ESERCIZIO 3

3A $V_T = 1V$

$$I_D = K \cdot (V_{GS} - V_T)^2 \iff$$

$$K = \frac{I_D}{(V_{GS} - V_T)^2} = \frac{2700\,\mu A}{(4V - 1V)^2} = 0{,}3\,\frac{mA}{V^2}$$

3B



IN POLARIZZAZIONE:

- V_{IN} SPENTO
- C APERTO

$$I_D = K(V_{GS} - V_T)^2 = 0{,}3\,\frac{mA}{V^2}\,(2{,}5V - 1V)^2 =$$

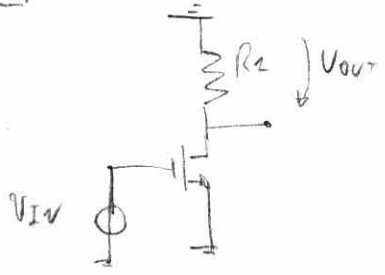
$$= 675\,\mu A$$

$$V_{OUT} = V_{DD} - I_D R_L = -0{,}2V$$

VERIFICO MOS IN SATURAZIONE

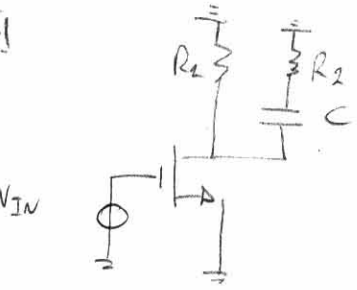
$$V_{GD} \overset{?}{<} V_T \rightarrow 0{,}2V < 1V \quad OK!$$

3C



$$G_f = -g_m R_L = -0{,}9\,\frac{mA}{V}\,4k\Omega = \boxed{-3.6}$$

3D

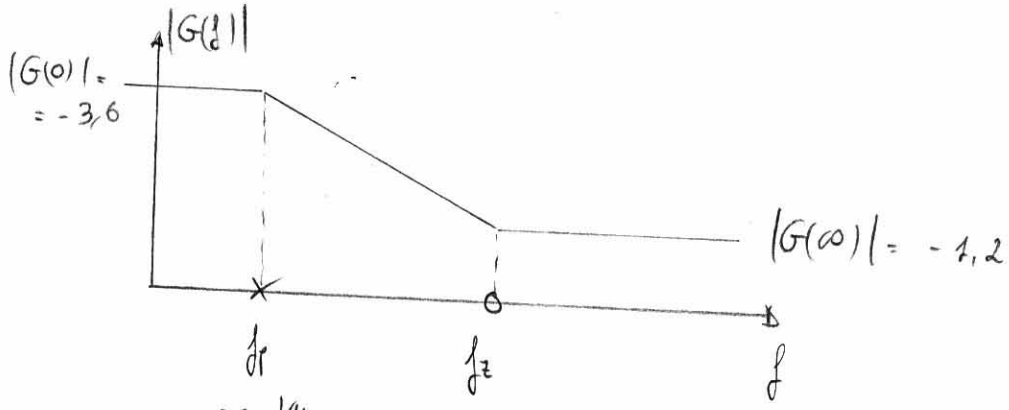


$$G(0) = -g_m R_L = -3{,}6$$

$$G(\infty) = -g_m (R_L // R_2) = -1{,}2$$

polo: $\tau_p = C(R_1 + R_2) = 1mF \times 6k\Omega = 6\mu s$

$$\boxed{f_p} = \frac{1}{2\pi \tau_p} = \boxed{26{,}5\,kHz}$$



$$\boxed{f_z} = f_p \frac{|G(0)|}{|G(\infty)|} = \boxed{79{,}5\,KHz}$$

METODO 2

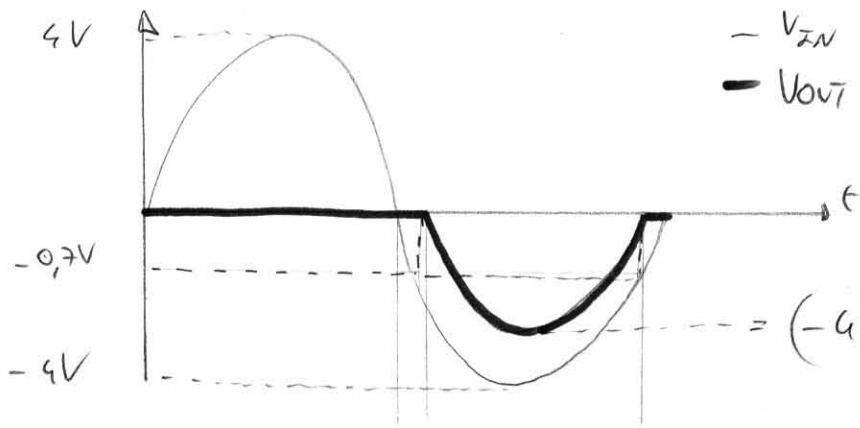
$$\boxed{G(s)} = -g_m Z_c(s) = -g_m \left[R_1 // \left(R_2 + \frac{1}{sC}\right)\right] = \ldots$$

$$= \boxed{-g_m R_1 \frac{1 + sCR_2}{1 + sC(R_1 + R_2)}}$$

ESERCIZIO 4

4A D2 SI ACCENDE SOLO SE $V_{OUT} > 1,5 + 0,7 = 2,3V$

D1 SI ACCENDE SOLO SULLA SEMIONDA NEGATIVA, per $V_{IN} < -0,7V$



$$= (-4V + 0,7V)\frac{R_2}{R_1 + R_2} = -1,32V$$

4B D2 VA IN BREAKDOWN QUANDO $V_{OUT} < 1,5V - 2V = -0,5V$