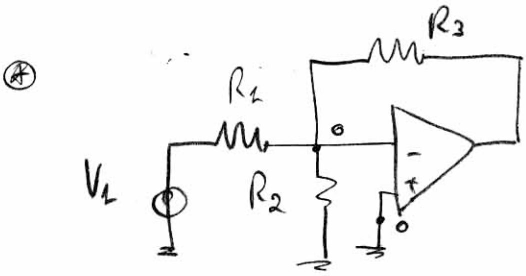
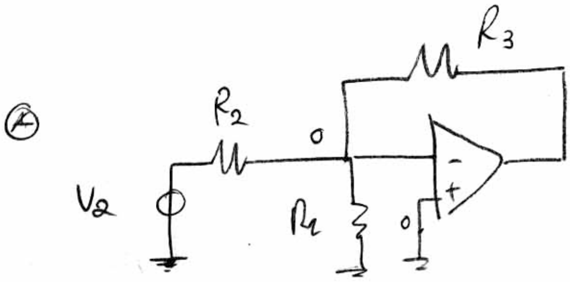
ESERCIZIO 1

1A PRINCIPIO di SOVRAPPOSIZIONE DEGLI EFFETTI

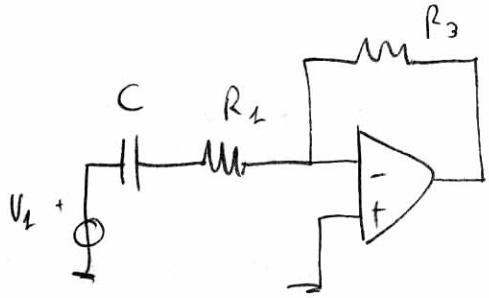


$$\boxed{G_1} = -\frac{R_3}{R_1} = -\frac{100\,k\Omega}{5\,k\Omega} = \boxed{-20}$$

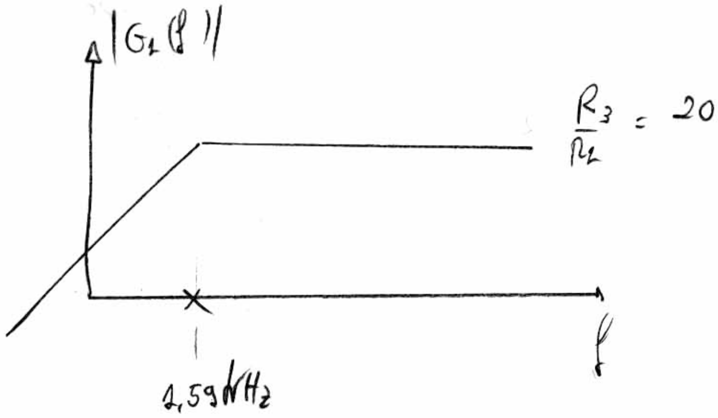


$$\boxed{G_2} = -\frac{R_3}{R_2} = -\frac{100\,k\Omega}{10\,k\Omega} = \boxed{-10}$$

1B



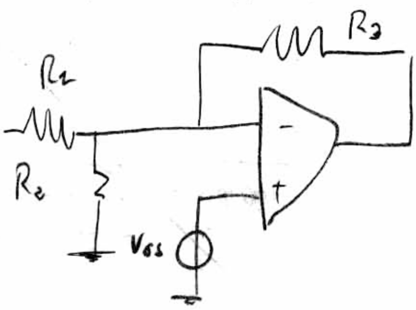
$$G_1(s) = \frac{R_3}{R_1 + \frac{1}{sC}} = \frac{sCR_3}{1 + sCR_1}$$



$$\tau_p = CR_1 = 5\,k\Omega \; 20\,nF = 100\,\mu s$$

$$f_p = \frac{1}{2\pi\tau_p} = 1{,}59\,kHz$$

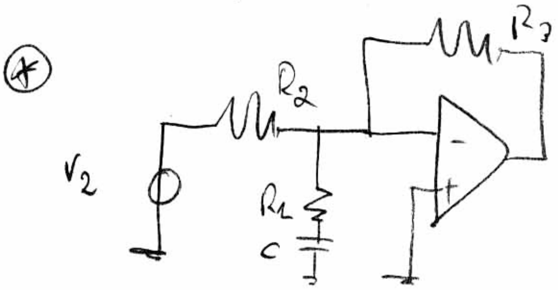
1C OFFSET COSTANTE → CONDENSATORE APERTO



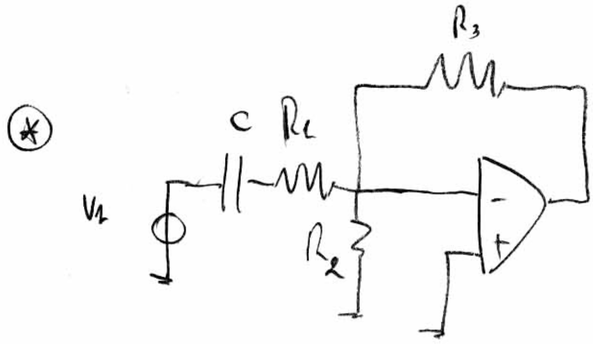
$$\boxed{V_{OUT}\big|_{OS}} = V_{OS}\left(1 + \frac{R_3}{R_2}\right) = 1\,mV\,(1 + 10) = \boxed{11\,mV}$$

NB: Non è noto a priori il segno della tensione di offset

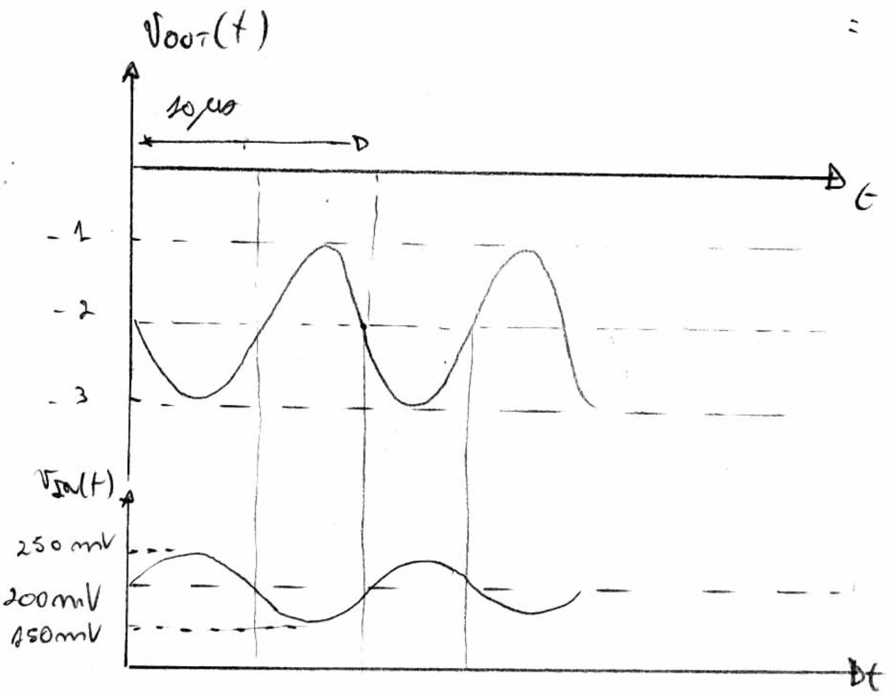
1D) PRINCIPIO di SOVRAPPOSIZIONE DEGLI EFFETTI



$$\boxed{|V_{OUT}|_2} = G_2 \times 200\,mV = \boxed{-2V}$$



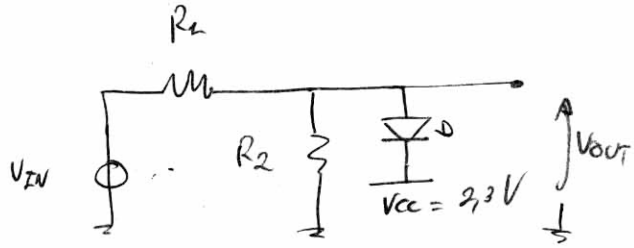
$$\boxed{|V_{OUT}|_1} = G_1(\bar f)\, A_1 \sin(2\pi \bar f t)$$
$$= (-20) \times 50\,mV \sin(2\pi \bar f t)$$
$$= (-1V) \times \sin(2\pi \bar f t)$$



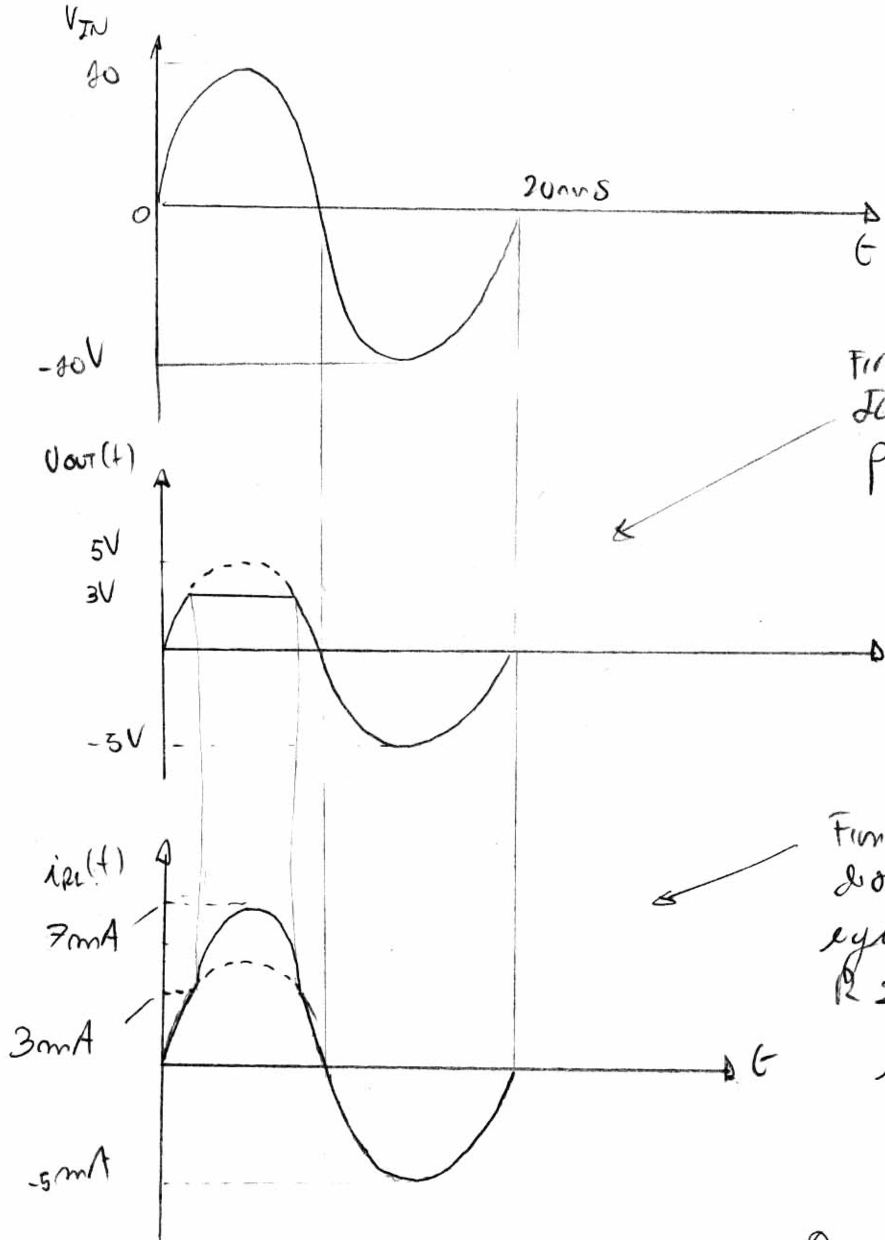
NB: $G(\bar f) = G(100kHz)$
$= -20$ come si deduce dal punto 1B

ESERCIZIO 2

2.A



D si accende solo quando $V_{OUT} \geq 3V$. In questo caso l'uscita viene bloccata a +3V



FINO A CHE NON INTERVIENE IL DIODO V_{OUT} è data dalla partizione di V_{IN} su R_1 e R_2:

$$V_{OUT} = V_{IN}\frac{R_2}{R_1+R_2} = V_{IN}\frac{1}{2}$$

Fino a che non interviene il diodo la corrente in R_1 è uguale a quella che scorre in R_2 ed è pari a:

$$i_{R1} = \frac{V_{in}}{R_1+R_2} = \frac{10V\sin(2\pi f t)}{2k\Omega}$$

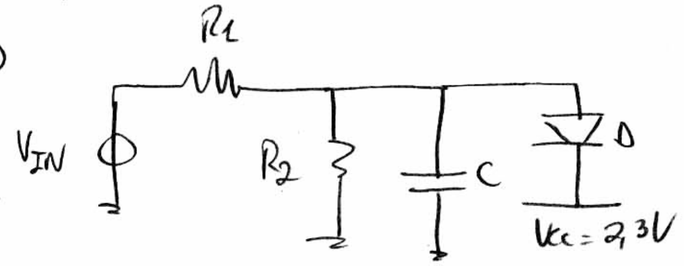
$$= 5mA\sin(2\pi f t)$$

Quando il diodo si accende:

$$i_{R1} = \frac{V_{IN}(t) - 3V}{R_1} =$$

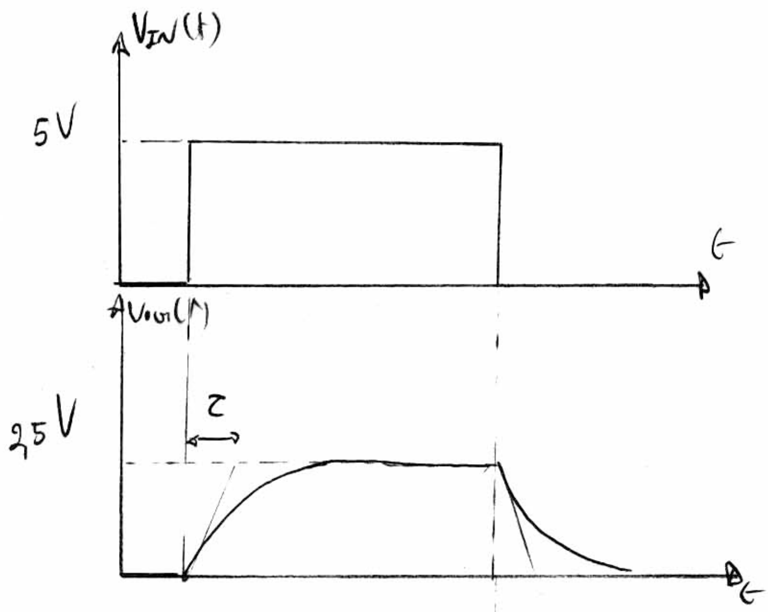
$$= \frac{10V\sin(2\pi f t) - 3V}{1k\Omega}$$

2B



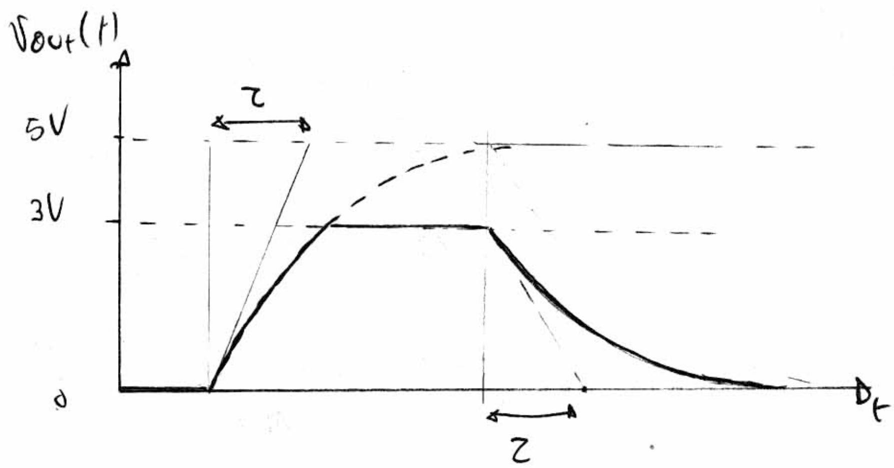
D si accende solo se $V_{OUT} > 3V$.
Inizialmente si può ipotizzare che D sia spento, salvo verificare a posteriori.

$$\tau = C(R_1 // R_2) = 2\mu F \times \frac{1}{2} k\Omega =$$
$$= 1 ms$$



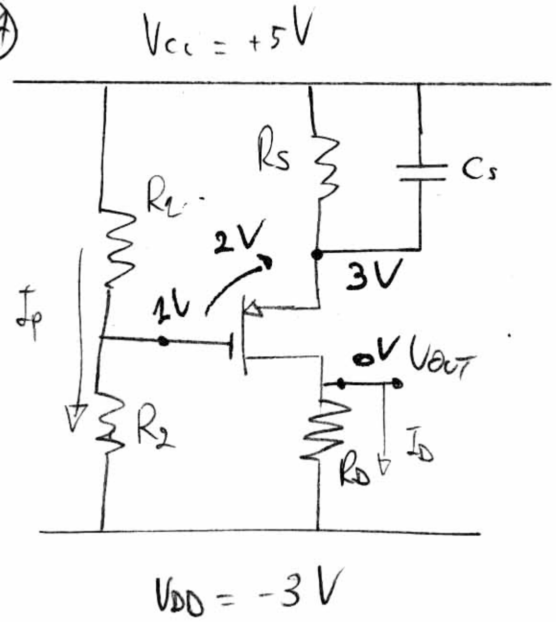
L'uscita non supera mai i 3V → è corretta l'ipotesi che il diodo sia sempre spento

2C Come nel caso precedente, ma l'uscita tenderebbe ad andare a +5V → quando supera i 3V interviene il diodo che la blocca:



ESERCIZIO 3

(3.A)



$$I_P = \frac{V_{CC} - V_{DD}}{R_1 + R_2} \Rightarrow$$

$$\boxed{(R_1 + R_2)} = \frac{V_{CC} - V_{DD}}{I_P} = \frac{8V}{80\mu A} = \boxed{100\,k\Omega}$$

⊛ $I_D = k(V_{GS} - V_T)^2 \rightarrow (V_{GS} - V_T) = \sqrt{\frac{I_D}{k}} = \sqrt{\frac{500\,\mu A}{2\,mA/V^2}} = 0{,}5\,V \rightarrow$

$\rightarrow V_{GS} = (0{,}5 + 1{,}5)V = 2V$

⊛ $V_S = V_{CC} - I_D R_S = 5V - 500\,\mu A \times 4\,k\Omega = 3V$

$\Downarrow$

⊛ $V_G = 3V - 2V = 1V$

ma:

$$V_G = (V_{CC} - V_{DD}) \frac{R_2}{R_2 + R_1} + V_{DD} \iff$$

$$\boxed{R_2} = \frac{(V_G - V_{DD})(R_2 + R_1)}{V_{CC} - V_{DD}} = \frac{(1V + 3V)(100\,k\Omega)}{8V} = \boxed{50\,k\Omega}$$

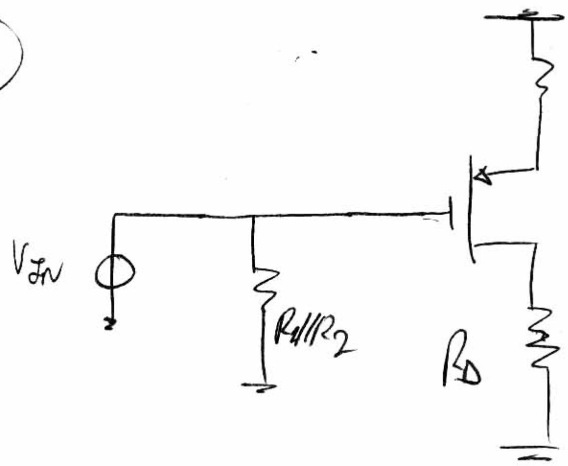
$\Rightarrow \boxed{R_1 = 50\,k\Omega}$

$\boxed{V_{OUT}} = V_{DD} + V_{R_D} = -3V + 0{,}5\,mA \times 6\,k\Omega = \boxed{0V}$

$$\boxed{g_m} = \frac{2I_D}{V_{ov}} = \frac{1\,mA}{0{,}5\,V} = \boxed{\frac{2\,mA}{V}}$$

NB: $V_{OUT} < V_G \Rightarrow$ IL MOS È CERTAMENTE IN SATURAZIONE

(3B)



$$\begin{cases} v_{gs} = -v_{IN} \dfrac{\frac{1}{g_m}}{\frac{1}{g_m} + R_S} \\ i_d = g_m v_{gs} \\ v_{OUT} = R_D\, i_D \end{cases} \Rightarrow$$

$$v_{OUT} = -R_D\, g_m \frac{\frac{1}{g_m}}{\frac{1}{g_m} + R_S} = \frac{-g_m R_D}{1 + g_m R_S} v_{IN} \Rightarrow$$

$$\boxed{G(MF)} = \boxed{-\frac{g_m R_D}{1+g_m R_S}} = -\frac{2\,mA/V\; 6\,k\Omega}{1 + \frac{2\,mA}{V}\, 4\,k\Omega} = -\frac{12}{9}$$

$$= \boxed{-\frac{4}{3}} = -1{,}3$$

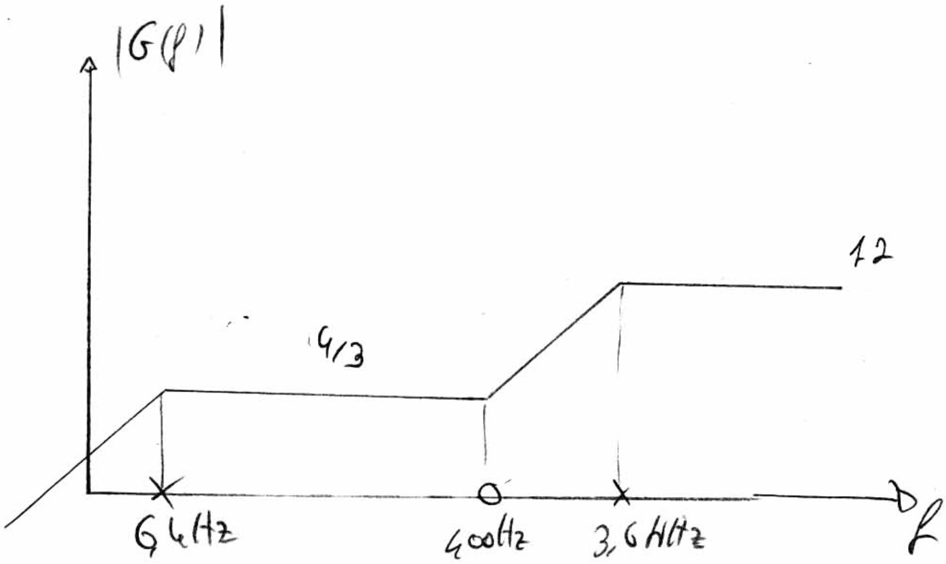
(3C)

METODO 1

$$G(0) = 0$$

$$G(MF) = \frac{-g_m R_D}{1+g_m R_S} = -\frac{4}{3}$$

$$G(\infty) = -g_m R_D = -12$$ ← ENTRAMBI I CONDENSATORI SONO IN CORTO → LO STADIO SI RIDUCE AD UN AMPLIFICATORE "SOURCE A MASSA"



Il guadagno presenta quindi 2 poli e 1 zero, che possono essere così calcolati:

$$\tau_{pL} = C_{IN}(R_1//R_2) = 1\,\mu F \times (5k\Omega//5k\Omega) = 2{,}5\ ms$$

$$\boxed{f_{pL}} = \frac{1}{2\pi\tau_{pL}} = \boxed{6{,}4\ Hz}$$

$$\tau_{pH} = C_S\left(R_S // \frac{1}{g_m}\right) = 100\ nF \times (4k\Omega // 500\Omega) = 44\,\mu s$$

$$\boxed{f_{pH}} = \frac{1}{2\pi\tau_{pH}} = \boxed{3{,}6\ kHz}$$

$$\boxed{|f_z|} = \frac{4/3}{12} f_p = \frac{\cancel{4}}{3}\cdot\frac{1}{\cancel{12}_3} f_{pH} = \frac{f_{pH}}{9} = \boxed{400\ Hz}$$

INFATTI IN UN TRATTO CON PENDENZA +20 dB/dec SI MANTIENE COSTANTE IL RAPPORTO GUADAGNO-BANDA

METODO 2

$$\boxed{G(s) =} \frac{R_1//R_2}{R_2//R_1 + \frac{1}{sC_{IN}}} \times \frac{-g_m R_D}{1 + g_m\left(R_S // \frac{1}{sC_S}\right)} =$$

$$= \frac{(R_1//R_2)\, s\, C_{IN}}{1 + s\, C_{IN}(R_1//R_2)} \cdot \frac{-g_m R_D}{1 + \frac{g_m R_S}{(1 + s\, C_S R_S)}} =$$

$$= \frac{s(C_{IN}\, R_1//R_2)}{1 + s\, C_{IN}(R_1//R_2)} \cdot \frac{(-g_m R_D)(1 + s\, C_S R_S)}{1 + g_m R_S + s C_S R_S} =$$

$$= -\frac{g_m R_D}{1+g_m R_S} \cdot \frac{1+sC_SR_S}{1+sC_S\left(\frac{R_S \cdot 1/g_m}{R_S+1/g_m}\right)} \cdot \frac{\quad}{\quad}$$

$$= \boxed{-\frac{g_m R_D}{1+g_m R_S} \cdot \frac{1+sC_SR_S}{1+sC_S\left(R_S // \frac{1}{g_m}\right)} \cdot \frac{sC_{IN}(R_1//R_2)}{1+sC_{IN}(R_1//R_2)}}$$

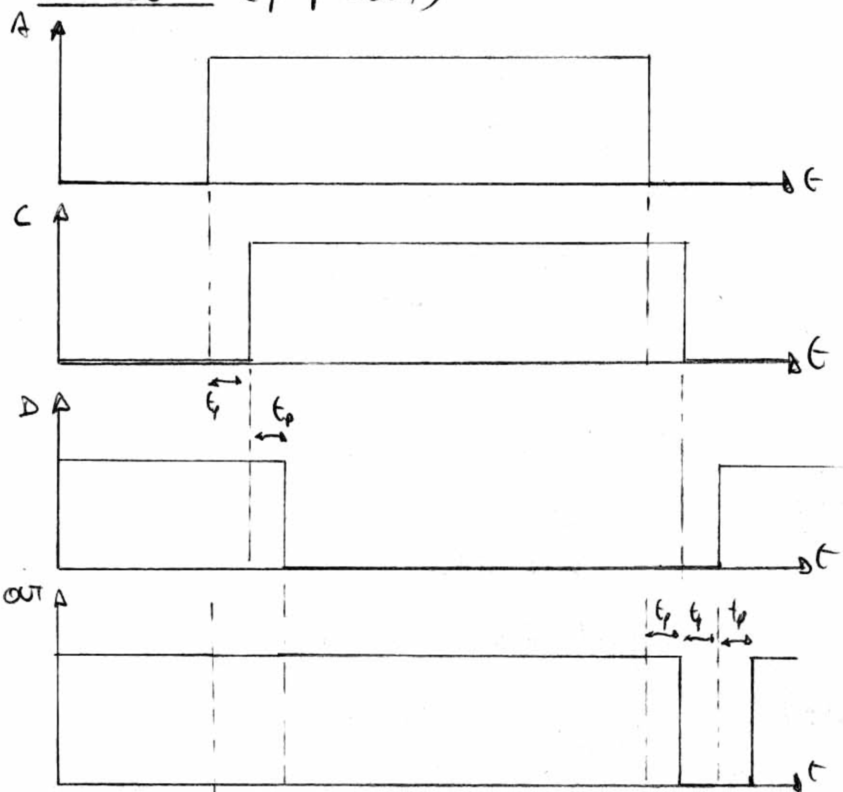
ESERCIZIO 4

4.A

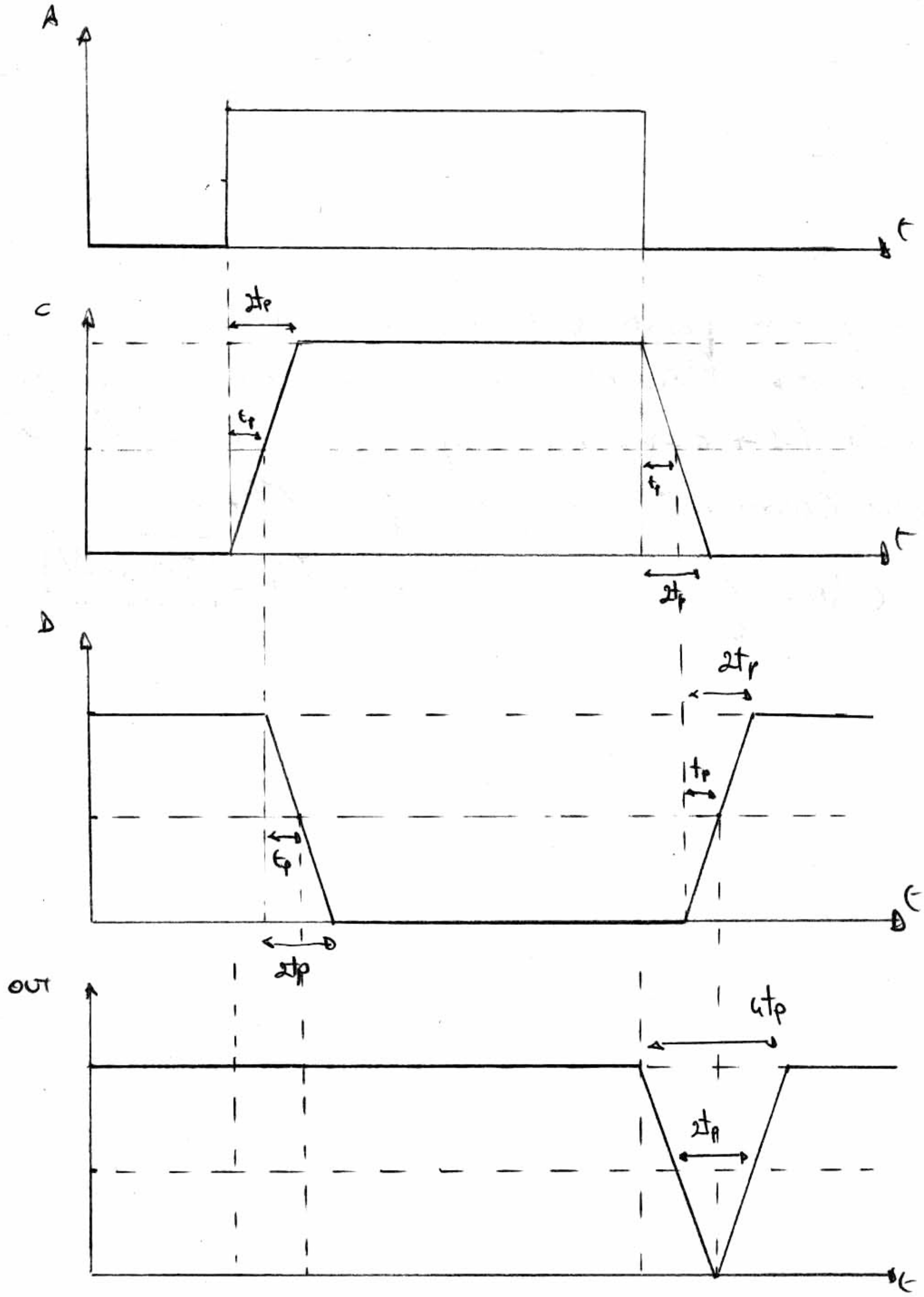
A \ B	0	1
0	1	0
1	1	1

4.B

METODO 1 (prof. COVA)



METODO 2 (prof.ssa GUAZZONI)



4.C

CASO 1: $t_p = 0$

In assenza di ritardi propagazione la OR-3 non commuta →
→ $\boxed{P_{DISS} = 0}$

CASO 2: $t_p = 10 ns$

Come visto nel punto 4.B i ritardi di propagazione fanno sì che l'uscita dobbia una commutazione completa ($1 \to 0 \to 1$) per ogni periodo di A. Quindi l'uscita commuta con freq. $f = 1MHz$:

$$\boxed{P_{DISS}} = C V_{CC}^2 f = 2pF \times (5V)^2 \times 1MHz = \boxed{50 \mu W}$$