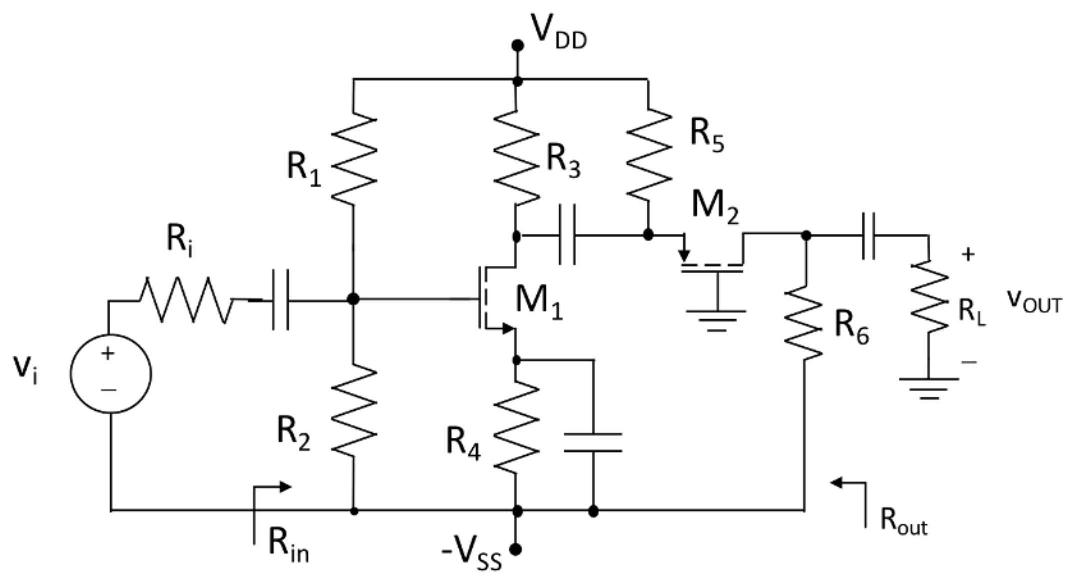
PROBLEMA P1

Dato il circuito riportato nella figura sottostante, determinare:

1) il valore delle resistenze R_3, R_4, R_5, R_6, in modo che le correnti di drain di M_1 M_2 valgano **$I_{D1} = 20$ mA, $V_{DS1} = 3$ V; $I_{D2} = 1$ mA, $V_{DS2} = -3$ V**
2) la potenza dissipata dai due MOSFETs M_1 e M_2 e la potenza dissipata dal circuito;
3) il guadagno di tensione ai piccoli segnali ac $A_v = v_o/v_i$;
4) le resistenze di ingresso e uscita ai piccoli segnali ac R_{in} e R_{out}.

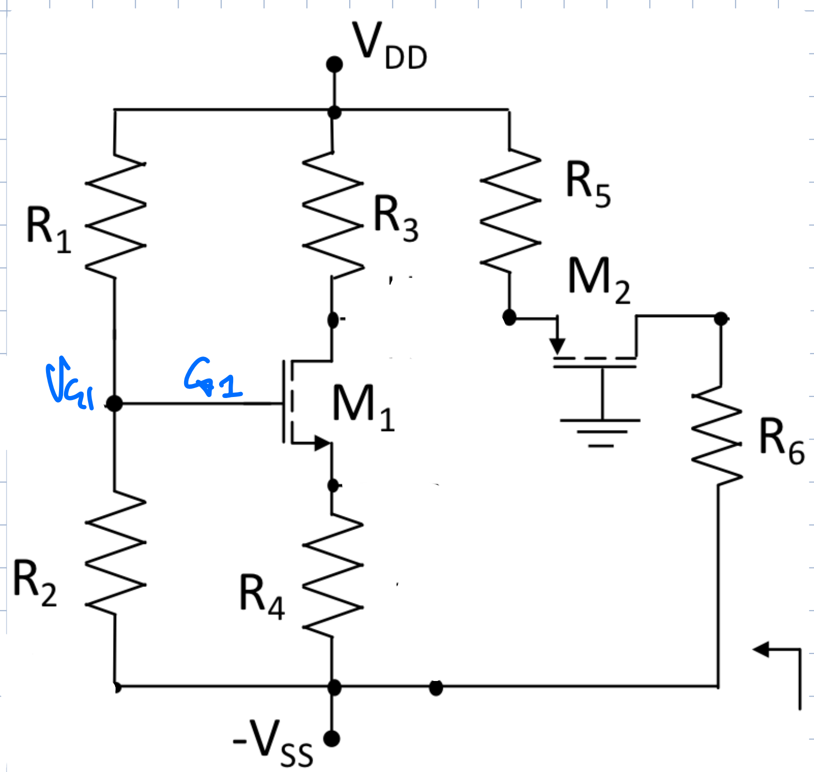


$V_{DD} = V_{SS} = 15$ V,
$R_1 = 600$ kΩ,
$R_2 = 400$ kΩ,
$R_L = 48$ kΩ,
$R_i = 500$ Ω,

***M_1*:**
$k_n = 10$ mA/V^2,
$V_{TN} = 3$ V,
$\lambda_p = 0$ V^{-1};

M_2:
$k_p = 2$ mA/V^2,
$V_{TP} = -3$ V,
$\lambda_p = 0$ V^{-1};

ANALISI DC



$$V_{G1} = V_{DD} \cdot \frac{R_2}{R_1+R_2} + (-V_{SS}) \cdot \frac{R_1}{R_1+R_2} = -3V$$

$$V_{GS1} = V_{TN} + \sqrt{\frac{2 I_{D1}}{K_{n1}}} = 5V$$

$$\Rightarrow V_{S1} = V_{G1} - V_{GS1} = -8V$$

$$\Rightarrow R_4 = \frac{V_{S1} - (-V_{SS})}{I_{D1}} = 350\ \Omega$$

$$V_{D1} = V_{S1} + V_{DS1} = -5V$$

$$\Rightarrow R_3 = \frac{V_{DD} - V_{D1}}{I_{D1}} = 1\,k\Omega$$

$V_{DS1} = 3V > V_{GS1} - V_{TN} = 2V$ OK M_1 IN SATURAZIONE

$$V_{GS2} = V_{TP} - \sqrt{\frac{2I_{D2}}{K_{P2}}} = -4V$$

$$\Rightarrow V_{S2} = -V_{GS2} = 4V$$

$$R_5 = \frac{V_{DD} - V_{S2}}{I_{D2}} = 11\,k\Omega$$

$$V_{D2} = V_{S2} + V_{DS2} = 1V$$

$$R_6 = \frac{V_{D2} - (-V_{SS})}{I_{D2}} = 16\,k\Omega$$

$V_{DS2} = -3V < V_{GS2} - V_{TP2} = -1V$

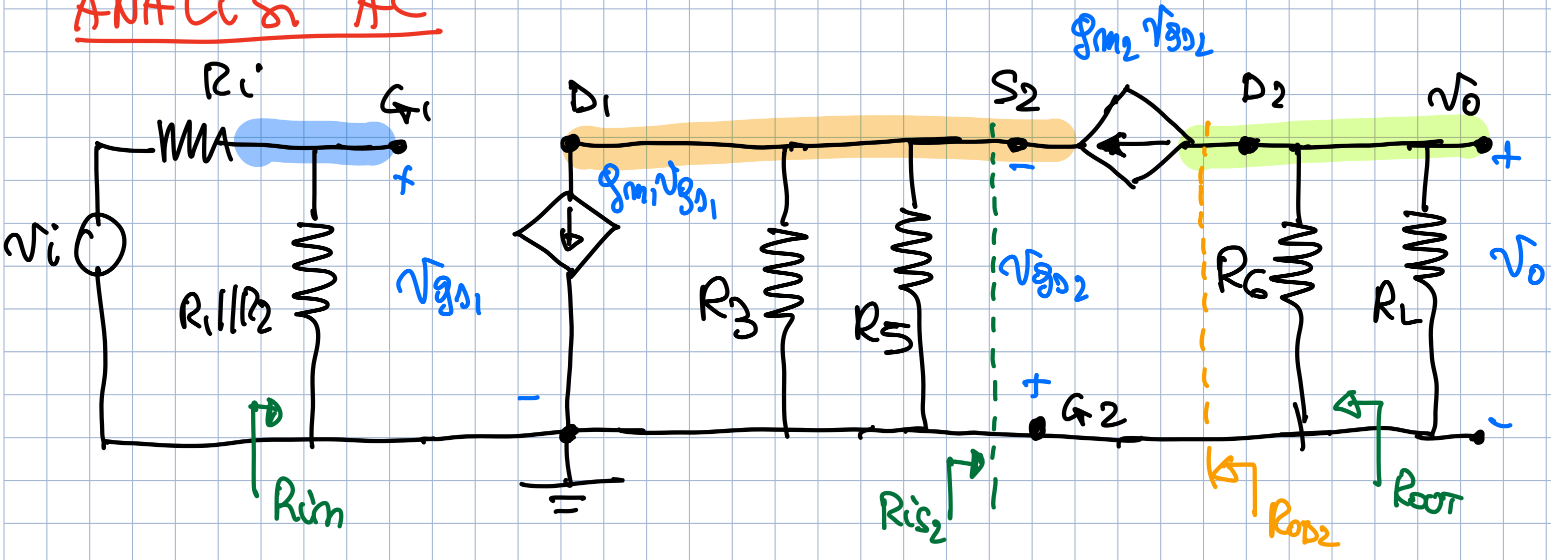
OK M_2 IN SAT.

PARAMETRI AL PICCOLO SEGNALE

$$g_{m1} = \frac{2I_{D1}}{V_{GS1} - V_{TN}} = 20\,mS \qquad r_{01} = \infty$$

$$g_{m2} = \frac{2I_{D2}}{|V_{GS2} - V_{TP}|} = 2\,mS \qquad r_{02} = \infty$$

ANALISI AC

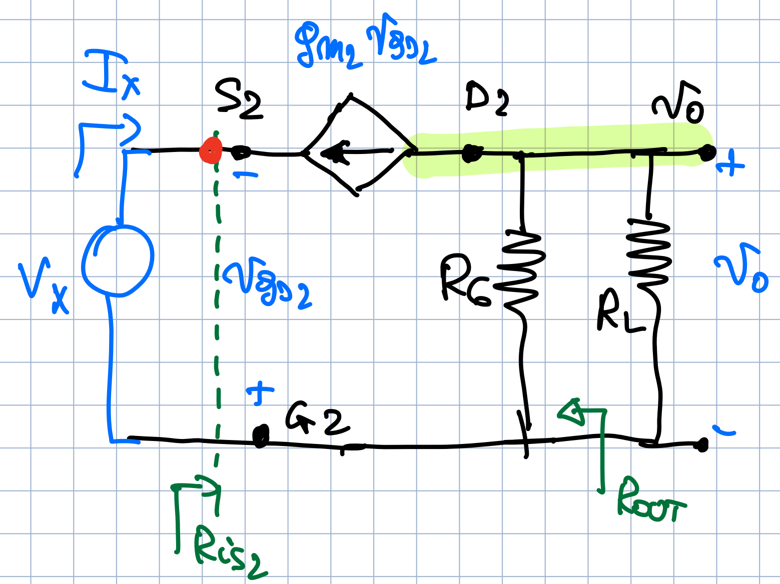


$R_{is_2} = ?$

$I_x = -g_{m_2} v_{gs_2}$

$V_x = -v_{gs_2}$

$\Rightarrow \boxed{R_{is_2} = \frac{V_x}{I_x} = \frac{1}{g_{m2}}}$



$R_{L1} = R_3 // R_5 // R_{is2} = R_3 // R_5 // \frac{1}{g_{m_2}} = 323,5\ \Omega$

$R_{L2} = R_6 // R_L = 12\ K\Omega$

N.B. $v_o \equiv v_{D2}$; $v_{D1} \equiv v_{S2}$

$$A_v = \frac{v_o}{v_i} = \frac{v_o}{v_{S2}} \cdot \frac{v_{S2}}{v_{G1}} \cdot \frac{v_{G1}}{v_i} = \frac{v_{D2}}{v_{S2}} \cdot \frac{v_{D1}}{v_{G1}} \cdot \frac{v_{G1}}{v_i} =$$

$$\Rightarrow A_v = A_{vt}^{CG} \cdot A_{vt}^{CS} \cdot \frac{v_{G1}}{v_i}$$

$A_{vt}^{CG} = g_{m2} R_{L2} = 24$

$\left(\begin{array}{l} v_{D2} = -g_{m_2} v_{gs_2} R_6 // R_L \\ v_{gs_2} = -v_{S2} \end{array} \right.$

$$A_{vt}^{CS} = -g_{m1} R_{L1} = -6,47 \quad \left\{ \begin{array}{l} v_{D1} = -g_{m1} v_{gs1} R_{L1} \\ v_{G1} = v_{gs1} \end{array} \right.$$

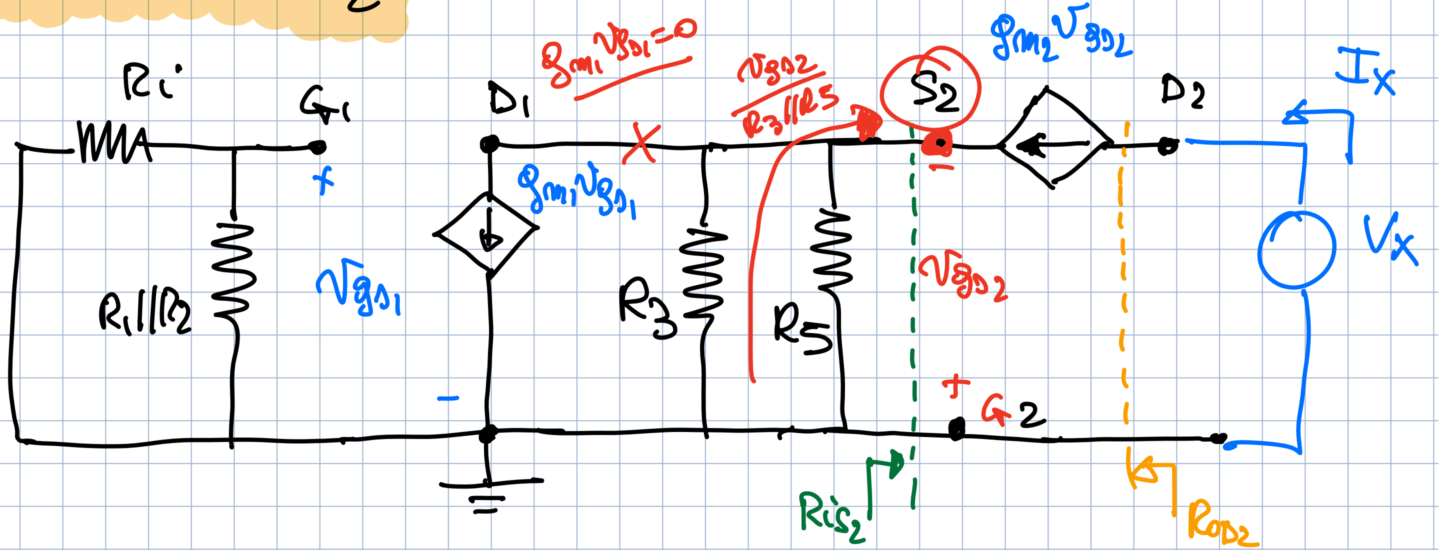
$$\frac{v_{G1}}{v_i} = \frac{R_1 \| R_2}{R_i + R_1 \| R_2} = 0,998$$

$$\Rightarrow \boxed{A_v = -154,97}$$

$R_{IN} = R_1 \| R_2 = 240\ k\Omega$ (OVVIO)

$R_{OUT} = R_6 = 16\ k\Omega$ (VEDI SOTTO)

$R_{OUT} = R_6 \,//\, R_{OD2}$



$v_{G1} = 0\ V \Rightarrow v_{gs1} = 0\ V$

$\Rightarrow g_{m1} v_{gs1} = 0\ A \Rightarrow$

AL NODO S_2:

$$\frac{v_{gs2}}{R_3 \| R_5} + g_{m2} v_{gs2} = 0$$

$\Rightarrow v_{gs2} = 0\ V$

$\Rightarrow g_{m2} v_{gs2} = 0$

$\Rightarrow I_x = 0$

$$R_{OD2} = \frac{V_x}{I_x} = \infty$$

$$R_{OUT} = R_6 \,//\, R_{OD2} = R_6$$

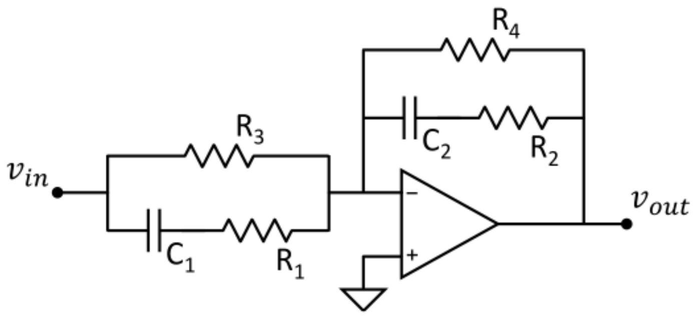
Esercizio 1

Sia dato il circuito in figura realizzato con un amplificatore operazionale ideale. Sappiamo che $C_1 = 1$ nF e $C_2 = 100$ nF, $R_1 = 1$ kΩ, $R_2 = 10$ kΩ, $R_3 = 99$ kΩ e $R_4 = 990$ kΩ

1) Calcolare il guadagno per ω = 0.
2) Calcolare la funzione di trasferimento W(ω) e tracciare il diagramma di Bode asintotico del modulo e della fase
3) Dato il segnale di ingresso:

$$v_{i(t)} = V_{s1} \cdot \sin(\omega_1 t + \pi) + V_{s2} \cdot \sin\left(\omega_2 t + \frac{\pi}{2}\right)$$
$$V_{s1} = 10\,mV, \omega_1 = 10^4 rad/s, V_{s2} = 5\,mV, \omega_2 = 10^6 rad/s,$$

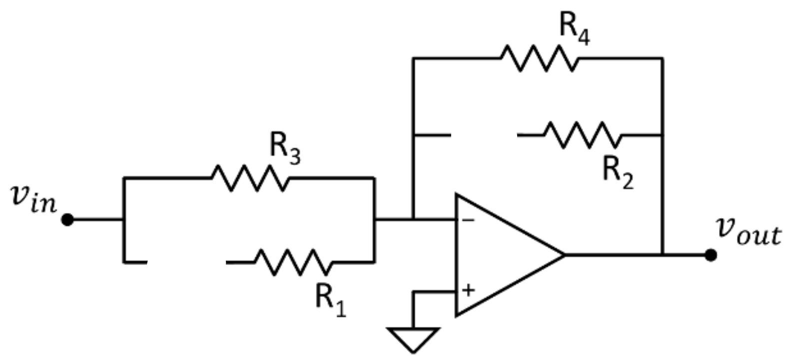
calcolare il segnale di uscita usando i diagrammi di Bode disegnati al punto 2).



1) GUADAGNO PER W = 0

$$V_{OUT} = V_{IN}\left(-\frac{R_4}{R_3}\right)$$

$$\Rightarrow A_v = \frac{V_{OUT}}{V_{IN}} = -\frac{R_4}{R_3} = -10$$



2) W(S)

$$Z_1 = R_1 + \frac{1}{SC_1} = \frac{1+SC_1R_1}{SC_1} \qquad Z_2 = \frac{1+SC_2R_2}{SC_2}$$

$$Z_{IN} = R_3 // Z_1 = \frac{R_3 \cdot \frac{1+SC_1R_1}{SC_1}}{R_3 + \frac{1+SC_1R_1}{SC_1}} = \frac{R_3(1+SC_1R_1)}{1+SC_1(R_1+R_3)}$$

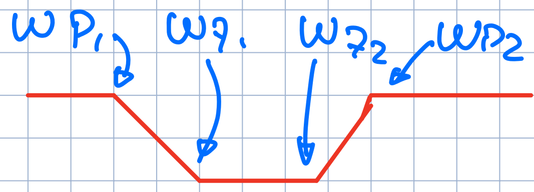
$$Z_F = R_4 // Z_2 = \frac{R_4(1+SC_2R_2)}{1+SC_2(R_2+R_4)}$$

$$W(S) = -\frac{Z_F}{Z_{IN}} = -\frac{R_4(1+SC_2R_2)}{1+SC_2(R_2+R_4)} \cdot \frac{1+SC_1(R_1+R_3)}{R_3(1+SC_1R_1)}$$

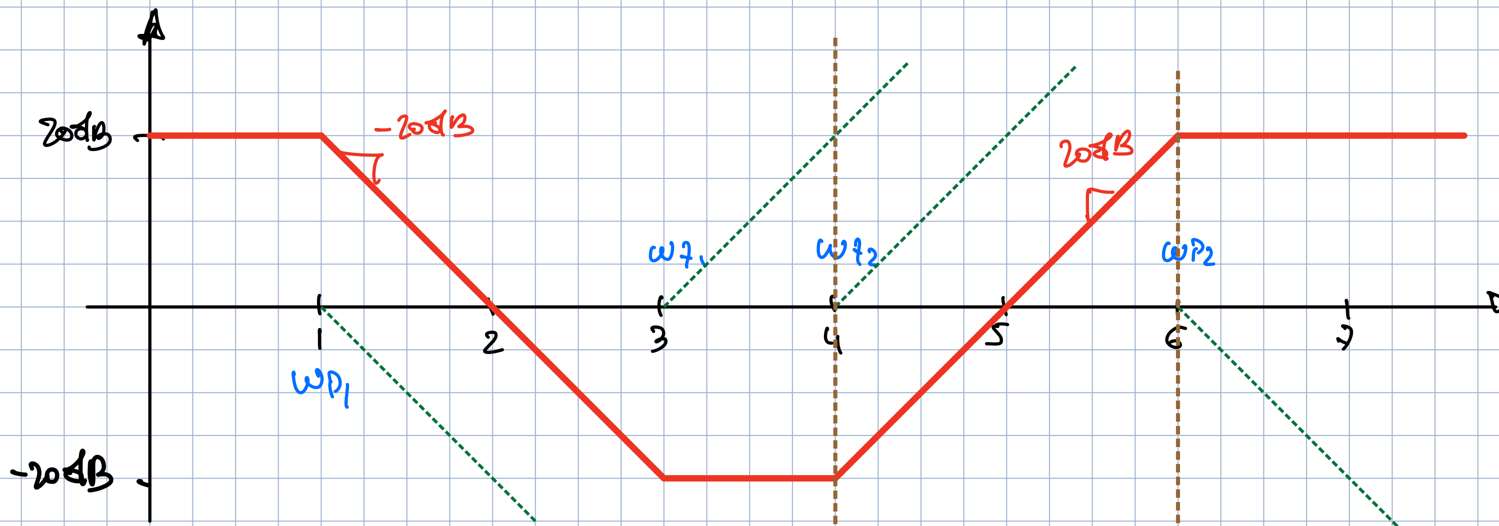
$$= -\frac{R_4}{R_3} \cdot \frac{(1+SC_2R_2)[1+SC_1(R_1+R_3)]}{(1+SC_1R_1)[1+SC_2(R_2+R_4)]}$$

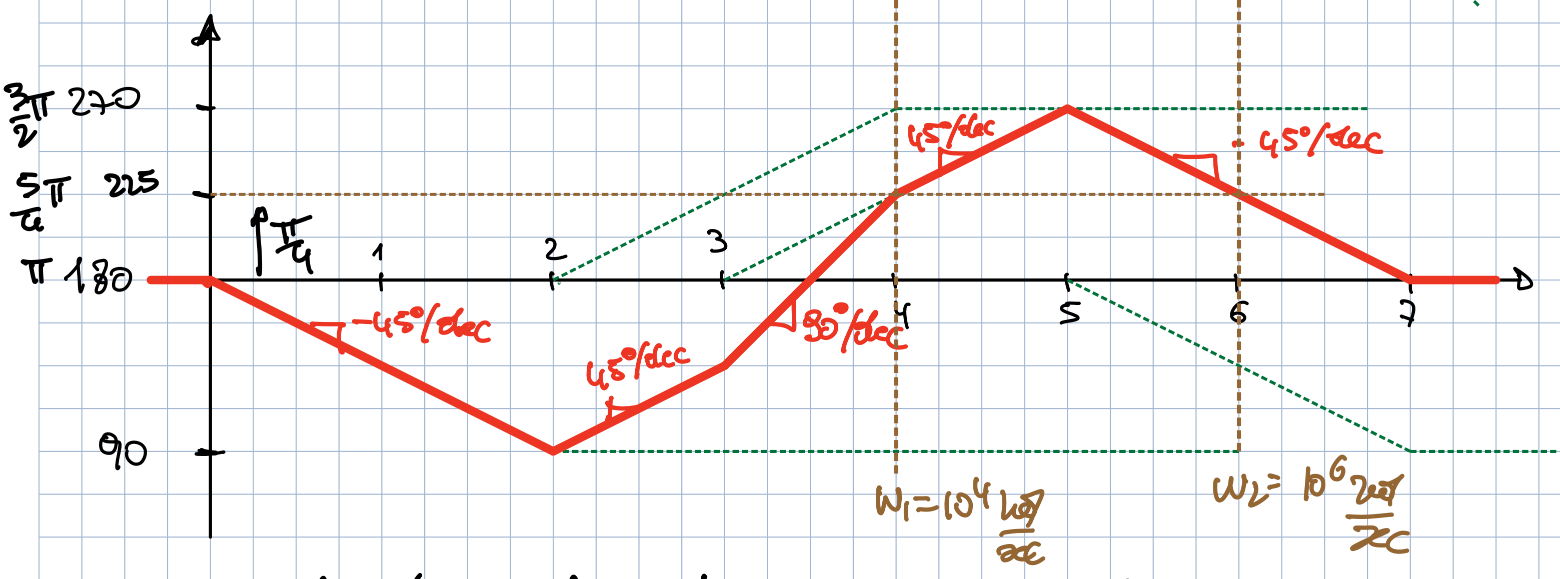
$$\omega_{z_1} = \frac{1}{C_2 R_2} = 10^3 \ rad/sec \qquad \omega_{P_1} = \frac{1}{C_2(R_2+R_4)} = 10^1 \ rad/sec$$

$$\omega_{z_2} = \frac{1}{C_1(R_1+R_3)} = 10^4 \ rad/sec \qquad \omega_{P_2} = \frac{1}{R_1 C_1} = 10^6 \ rad/sec$$



$$A_0 = -\frac{R_4}{R_3} = 10 = 20 \ dB$$





$\omega_1 = 10^4 \ rad/sec \qquad |W(j\omega_1)| = -20dB \cdot \sqrt{2} = 0{,}1 \cdot 1{,}414 = 0{,}1414$

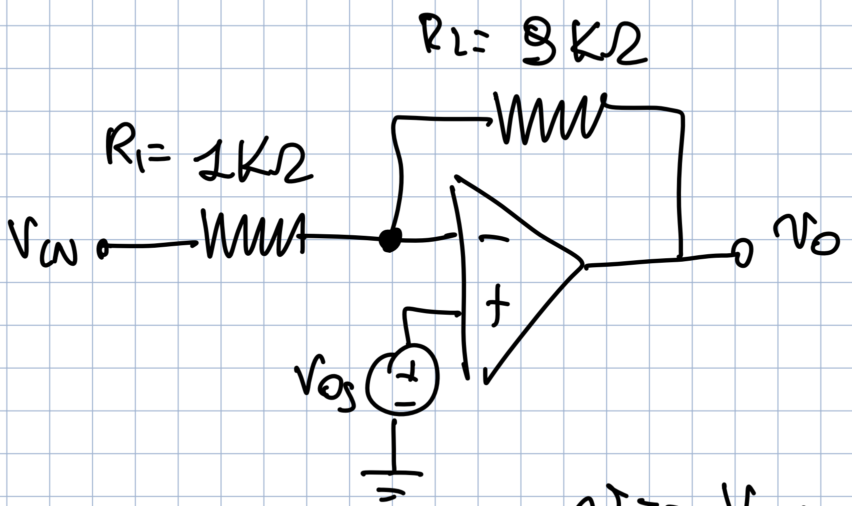
$\angle W(j\omega_1) = 225^\circ$

$\omega_2 = 10^6 \ rad/sec \qquad |W(j\omega_1)| = +20dB / \sqrt{2} = \frac{10}{1{,}414} = 7{,}05$

$\angle W(j\omega_2) = 225^\circ$

$$v_0(t) = 1{,}414 \, mV \cdot \sin\left(\omega_1 t + \frac{\pi}{4}\right) + 35{,}35 \, mV \left(\sin \omega_2 t - \frac{\pi}{4}\right)$$

PROBLEMA Q1



$V_{OS} = 10mV$

$V_{IN} = 2V$

V_{OUT} ?

$$v_o = -V_{IN} \cdot \frac{R_2}{R_1} + V_{OS}\left(1 + \frac{R_2}{R_1}\right)$$

$$-18V + 0{,}1V = -17{,}9V$$

PROBLEMA Q2

Data la seguente tabella della verità

1) Ricavare la mappa di Karnaugh corrispondente;
2) Trovare una F minimizzata
3) Disegnare la rete logica minimizzata tramite porte logiche fondamentali.

A	B	C	D	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	X
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	X
1	1	1	1	X

AB \ CD	00	01	11	10
00	1	1	1	
01	1			1
11	1		X	X
10	X	1	1	

$\bar{B} \cdot D + \bar{C} \cdot \bar{D} + B \cdot \bar{D}$