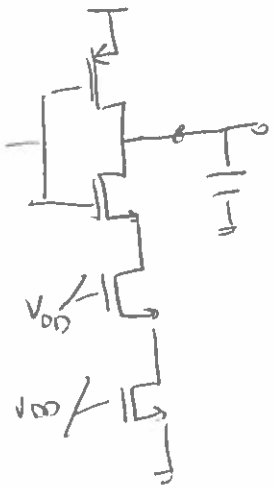
~~A~~ A

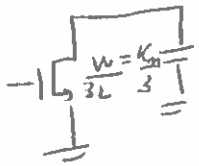
1)

| A | B | C | out |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1/2 |
| 1 | 1 | 1 | 0 |

2) B = C = 1



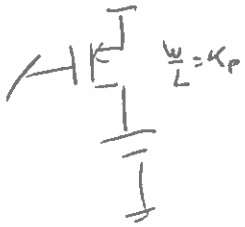

$\boxed{A = 0 \to 1}$




$I_{SAT} = \frac{K_n}{3}(V_{DD}-V_T)^2$

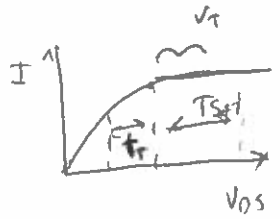
$T_{SAT} = \frac{I_{SAT}}{C} t = V_T$

$\boxed{A = 1 \to 0}$




$T_{SAT} = \frac{I_{SAT}}{C} t = V_T$

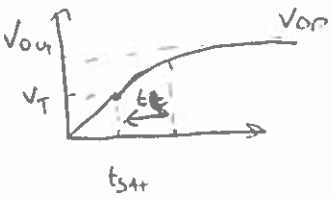
$I_{SAT} = K_p(V_{DD}-V_T)^2 = 676\,\mu A$




I due tempi di saturazione sono uguali e pari a 1,035 ms

Anche il $T_{Triode}$ è uguale e la resistenza equivalente è pari a $R = \frac{V_{DD}-V_T}{I_{SAT}} = 3{,}846\,K\Omega$ e $\tau = R \cdot C = 3{,}846\,ms$

carica




$$V_T + (V_{DD}-V_T)\left(1 - e^{-t/\tau}\right) = \frac{V_{DD}}{2}$$

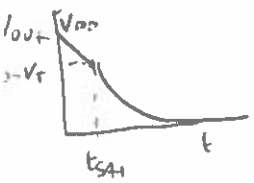
$$1 - e^{-t/\tau} = \frac{\frac{V_{DD}}{2} - V_T}{V_{DD}-V_T} \to 1 - \frac{\frac{V_{DD}}{2} - V_T}{V_{DD}-V_T} = e^{-t/\tau}$$

$$\ln\left(1 - \frac{\frac{V_{DD}}{2} - V_T}{V_{DD}-V_T}\right) = -t/\tau$$

$$t_t = \tau \ln\left(\frac{1}{1 - \frac{\frac{V_{DD}}{2} - V_T}{V_{DD}-V_T}}\right) = \tau \ln\left(\frac{V_{DD}-V_T}{V_{DD} - \cancel{V_T} + \cancel{V_T} - \frac{V_{DD}}{2}}\right) = \tau \ln\left(\frac{V_{DD}-V_T}{V_{DD}} \cdot 2\right)$$

$\simeq 1{,}75\,ms$

scarica

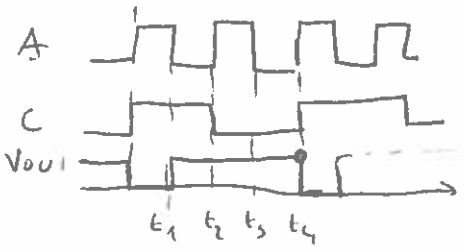



$$(V_{DD}-V_T)\, e^{-t/\tau} = \frac{V_{DD}}{2} \to \ln\left(\frac{\frac{V_{DD}}{2}}{V_{DD}-V_T}\right) = -t/\tau \Rightarrow t_t = \tau \ln\left(\frac{V_{DD}-V_T}{V_{DD}} \cdot 2\right)$$

$\simeq 1{,}75\,ms$

$t_{c_{HL}} = t_{c_{LH}} = t_{SAT} + t_t = 5,6\,ns$

3) $B = 1$




Si inizia con $A = C = 0$ e $B = 1$

$V_{OUT} = 1$

↳ $0 - t_1$ $A = B = C = 1$ $V_{OUT} = 0$

↳ $t_1 - t_2$ $A = 0$ $B = C = 1$ $V_{OUT} = 1$

↳ $t_2 - t_3$ $A = 1$ $B = 1$ $C = 0$ HZ rimane lo stesso valore di prima

↳ $t_3 - t$ $A = 0$ $B = 1$ $C = 0$ $V_{OUT} = 1$ come prima

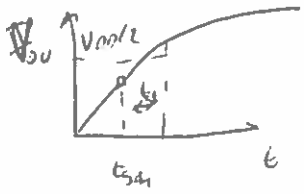
$P_D = C V_{DD}^2 \cdot f_c = 10,93\,W$

4)

$P_D$ è sempre uguale, ma i dissipati dai segnali applicati

Per i tempi di commutazione avrò una delle diverse temp tra H-L e L-H

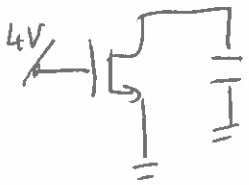
L-H

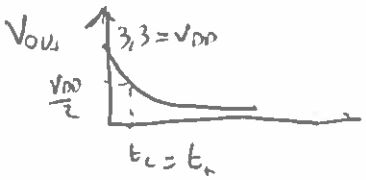



~~$t_{SAT} = \frac{I_{SAT} t_t}{C} = V_t \rightarrow t_{SAT} = \frac{V_t C}{I_{SAT}} = \frac{V_T \cdot C}{K_P (V_{DD} - V_T)^2} =$~~

è uguale al caso precedente

H-L




Porta già in triodo quindi $t_c = t_t$

$V_{DD} e^{-t/\tau} = \frac{V_{DD}}{2}$

$t = \tau \ln(2) = R C \ln(2)$

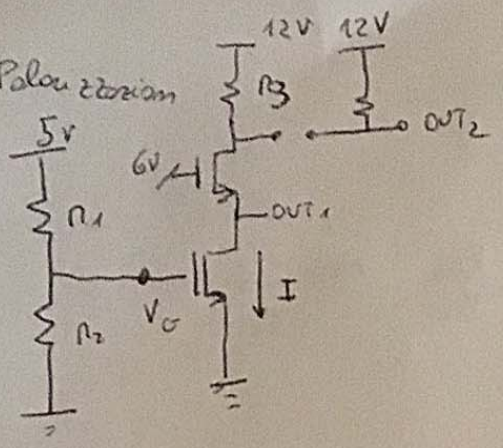
$I_{SAT} = \frac{K_n}{3} \cdot (V_{DD} - V_T)^2 = 1,08\,mA$

$R_T = \frac{V_{DS}}{I_{SAT}} = \frac{V_{DD}}{I_{SAT}} = 3,05\,K\Omega$

$= \frac{V_{DD} R_T}{I_{SAT}} \cdot C \ln(2) = 2,1\,n$

B

1) Polarizzazione




$V_{OUT2} = 12V$

$V_G = \frac{5V \cdot R_2}{R_1+R_2} = ?\ V$

$I = K(V_G - V_T)^2 = 1mA$

$I = K(6V - V_{OUT1} - V_T)^2 = K V_{ov}^2$

$\hookrightarrow V_{ov} = \sqrt{\frac{I}{K}} = 1V$

$6V - V_{OUT1} - V_T = 1V \rightarrow V_{OUT1} = 4V$

$g_m = \frac{2I}{V_{ov}} = 2\frac{mA}{V}$

2) $\frac{V_{OUT1}}{V_{IN}}$ ?

$\frac{V_{OUT1}}{V_{IN}} = -g_m \cdot \frac{1}{g_m} = -1$

3) $\frac{V_{OUT2}}{V_{IN}}(f)$ ?

Basse f

$\frac{V_{OUT2}}{V_{IN}} = 0$

$\tau_{C1} = C_1 \cdot R_1 // R_2 = 120\ \mu s \rightarrow f_{P1} = 1,327\ kHz$

$\tau_{C2} = C_2 \cdot (R_3 + R_4) = 4\ \mu s \rightarrow f_{P2} = 39,8\ kHz$

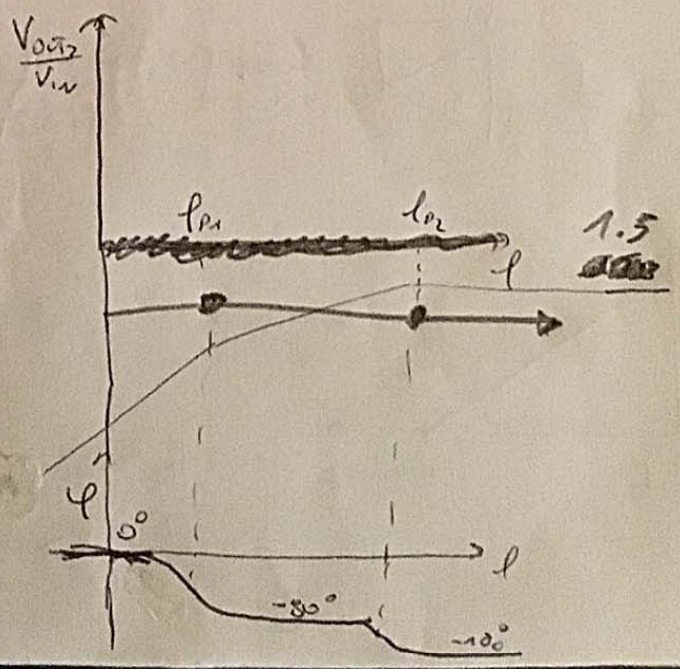
C1 si chiude prima di C2

Media f

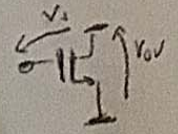
$\frac{V_{OUT2}}{V_{IN}} = 0$

Alte f

$\frac{V_{OUT2}}{V_{IN}} = -g_m \cdot R_3 // R_4 = -1.5$




4) OUT2 può solo andare sotto i 12V quando $V_{IN} > 0$




$6 - V_T = V_{IN} \cdot G_{HF}$

$\hookrightarrow V_{IN} = \frac{6 - V_T}{G_{HF}} = \frac{6-1}{0,75} = 6,66V$

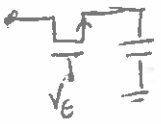
Es e

1) $I_{m}\big|_{max} \cdot R_l = V_{DD} \rightarrow R_l = \dfrac{V_{DD}}{I_m\big|_{max}} = \dfrac{5\,V}{10\,mA} = 500\,\Omega$

2) $I_{min} R_l = V_{LSB} = 5\,mV$ $\qquad V_{LSB} = \dfrac{V_{DD}}{2^n} \rightarrow 2^n = \dfrac{V_{DD}}{V_{LSB}} = 1000 \rightarrow n = 10$ bit

3)

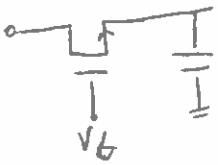
ON



Caso peggiore $V_{IN}\big|_{ADC\ max} = 5V$

$$R_{DS}\big|_{ON} = \frac{1}{2k\,(V_{GS}-V_T)} = 200\,\Omega \rightarrow \frac{1}{R_{DS}\big|_{ON}\cdot 2k} + V_T + V_S = V_G = \frac{1}{2k\,R_{DS}\big|_{ON}} + V_T + V_{IN}\big|_{ADC\ max} = 7{,}66\,V$$

OFF

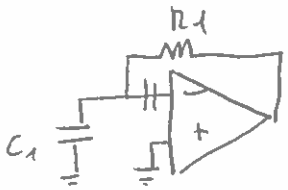


Caso peggiore $V_{IN}\big|_{ADC\ min} = 0V$

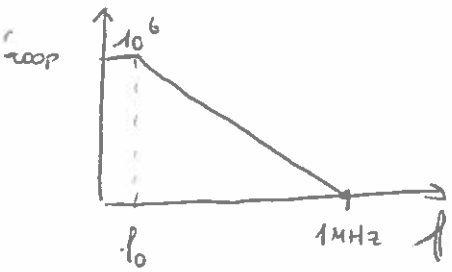
$$V_{GS} < V_T \rightarrow V_G < V_T - V_S = V_T - \overset{=0}{V_{IN}\big|_{ADC\ min}} = V_T$$

$$V_G < 1V$$

4)



$$G_{loop}(s) = -\frac{A_0}{1+sz_0} \cdot \frac{\frac{1}{sC_1}}{R_l + \frac{1}{sC_1}} = -\frac{A_0}{1+sz_0} \cdot \frac{1}{1+sC_1R_l}$$




$$f_0 = \frac{GBWP}{A_0} = 1\,Hz$$

$f_{P_2} > GBWP$

$$\frac{1}{2\pi C_1 R_l} > GBWP \rightarrow C_1 < \frac{1}{2\pi R_l\, GBWP} = 318{,}5\,pF$$