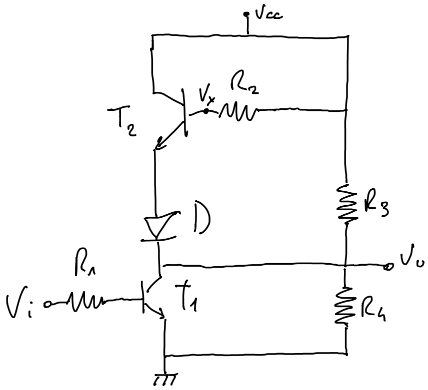
ES 1 15/01/2010



$V_{cc} = 5V$ $\quad R_2 = R_1 = 1.5\,k\Omega$

$V_{CE\,sat} = 0.2V$ $\quad R_3 = 100\,\Omega$

$V_\gamma = 0.75V$ $\quad R_4 = 5.5\,k\Omega$

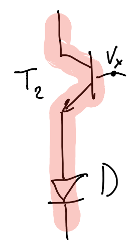
$\beta_F = 100$

→ trovare $V_u(V_i)$ per $0 < V_i < V_{cc}$

→ fare ipotesi, regioni funzionamento

→ si va a caso, spesso non si può sapere

→ diodo in cascata con transistor → entrambi accesi o spenti
→ serviranno $2V_\gamma$



→ se T_2 si accende andrà in AD (attiva diretta)

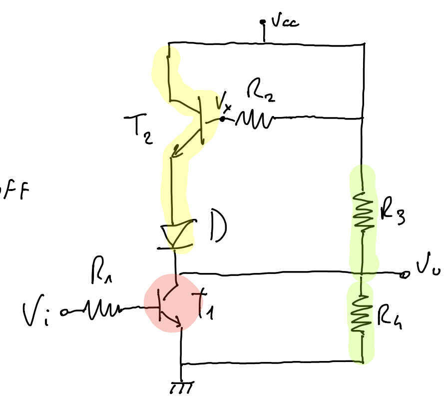
→ tensione ingresso nulla ⇒ T_1 OFF

→ studiare correnti di nodo

→ due possibilità: $T_2 + D$ ON/OFF

→ partire casuale

SUPPONGO SIA SPENTO, FACCIO PARTIZIONE, VERIFICO IPOTESI IN POCO TEMPO



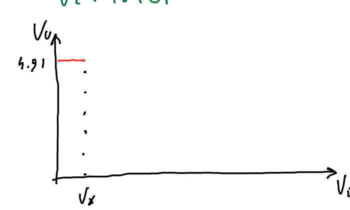
REG ① $V_i < V_\gamma \to T_1$ OFF

HP: T_2, D OFF

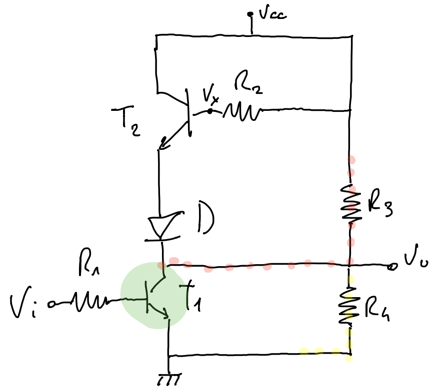
$$V_U = \frac{R_4}{R_3 + R_4} \cdot V_{cc} = 4.91V \to V_{cc} - V_U < 2V_\gamma \to$$ IPOTESI VERIFICATA

$$V_x - V_U < 2V_\gamma$$

$$V_x < 4.91 + 2V_\gamma$$



REG ② $V_i > V_\gamma$



$V_{CE} = 4.91V \to$ RN T_1

ATTIVA DIRETTA

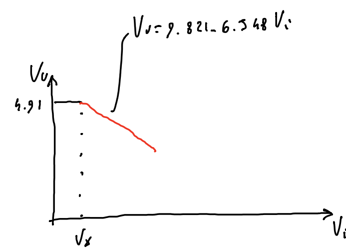
→ T_1 abbassa potenziale, corrente aumenta

$I_{R3} = I_{R4} + I_{C1}$ ← corrente nodo

corrente collettore

$$\frac{V_{CC} - V_{C1}}{R_3} = \frac{V_U}{R_4} + \beta_F I_{B1}$$

$$I_{B1} = \frac{V_i - V_\gamma}{R_1}$$



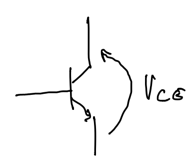
$V_U = 9.821 - 6.548\, V_i$ ← sta calando, ok

→ verificare che punto $V_i = V_\gamma$ le curve si intersechino

$V_U\big|_{V_i = V_\gamma} = 4.91\, V$ ok

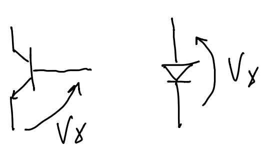
→ ed ora può succedere che
- $T_2 D$ si accendono
- T_1 SAT

T_1 SAT ?



$V_{CE} = V_U = V_{CE\,sat} \to V_i = 1.469 \to$ allargare a prendere V_{CE} sat rispetto a massa

$T_2 D$ ON ?



$V_x - V_U = 2V_\gamma$

se transistor spento modello a soglia dice correnti nulle $\to V_x = V_{CC}$

$$I_{B2} = \frac{V_{CC} - V_x}{R_2} = 0$$

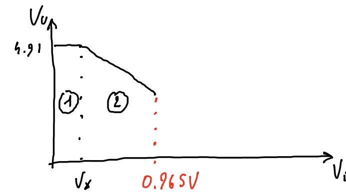
$V_{CC} - V_U = 2V_\gamma \longrightarrow V_{CC} - (9.821 - 6.548\, V_i) = 2V_\gamma$

T_2, D rimane off finché $V_x - V_u < 2V_\gamma$

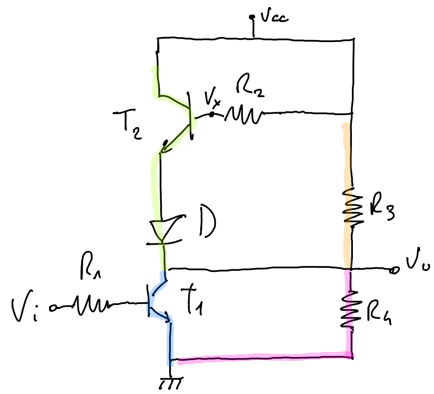
$V_i < 0.965\,V$

↳ poi si accendono

DELLE DUE CONDIZIONI QUESTA VIENE PER PRIMA



REG ③ T_1 AD T_2 AD D ON



bilancio di corrente

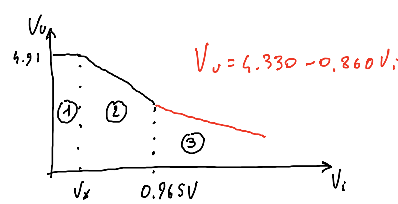
$$I_{E2} + I_{R3} = I_{C1} + I_{R4}$$

$$I_{B2} = \frac{V_{CC} - (V_U + 2V_\gamma)}{R_2}$$

$$(\beta_F + 1)\frac{V_{CC} - (V_U + 2V_\gamma)}{R_2} + \frac{V_{CC} - V_U}{R_3} = \beta_F \frac{V_i - V_\gamma}{R_1} + \frac{V_U}{R_4}$$

$$V_U = 4.330 - 0.860\,V_i$$

$$V_U\Big|_{V_i = 0.965\,V} = 3.5\,V$$



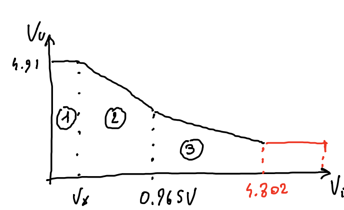
→ guardo quando T_1 SAT

$V_{CE1} = V_{CEsat}$

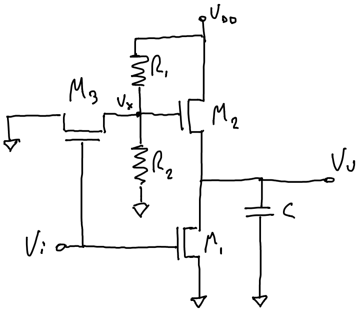
T_1 SAT

⇑

$V_{CE1} = V_U = 4.330 - 0.860\,V_i = V_{CEsat} \rightarrow V_i = 4.802\,V$



ES. 1 31/01/2008



$t<0 \quad V_i = V_{DD}$

$t>0 \quad V_i = 0$

t_{RISE} ← tempo salita 10-90% escursione

$V_{DD} = 3.5V$

$V_{TN} = 0.6V$

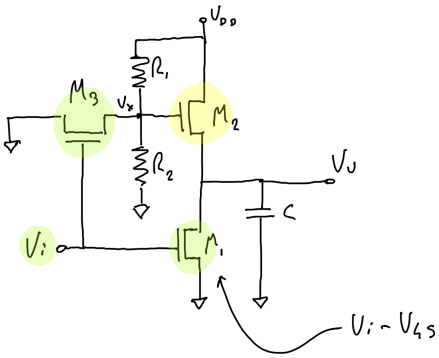
$\beta_n = 1 \ mA/V^2$

$R_1 = 500\,\Omega$

$R_2 = 10k\Omega$

$C = 5\ pF$

STUDIO QUALITATIVO $t<0$



→ $V_i = V_{CC}$

M_1 ON, M_3 ON

M_2 potrebbe essere acceso

→ V_u parte da 0 oppure da valore basso

→ per M_2 viene controllato da V_x

→ corrente al nodo, trovo tensione

$I_{R1} = I_{R2} + I_{M3}$ ← cercare di capire circuito prima di M_2

M_3 ON → $V_{GS} = V_{DD} > V_{TN}$

M_3 SAT ⟷ $V_{GS} < V_{DS} + V_{TN}$

$V_{DD} < V_x + V_{TN}$

$V_x > V_{DD} - V_{TN}$

M_3 LIN ⟷ $V_x < V_{DD} < V_{TN}$

$I_{R1} = I_{R2} + I_{DM3\,LIN}$

$$\frac{V_{DD}-V_x}{R_1} = \frac{V_x}{R_2} + \beta_n\left[\left(V_{DD}-V_{TN}\right)V_x - \frac{V_x^2}{2}\right]$$

↳ $\begin{cases} V_x = 1.683V \\ \cancel{V_x = 8.312V} \end{cases}$ → verifica se rispetta condizioni → ✓

NON ACCETT.

M_2 ON $\iff V_x - V_U > V_{TN}$

$\iff V_U < V_x - V_{TN} = 1.083V$

M_2 SAT $\iff V_{GS} < V_{DS} + V_{TN}$

$V_x - \cancel{V_U} < V_{DD} - \cancel{V_U} + V_{TN}$

$1.683V < V_{DD} + V_{TN}$

M_2 SAT QUANDO ON

$\rightarrow M_1$: $V_{GS} = V_{DD} > V_{TN}$ ON

M_1 SAT $\iff V_{GS} < V_{DS} + V_{TN}$

$V_{DD} < V_U + V_{TN}$

$V_U > V_{DD} - V_{TN} = 2.9V$

$I_{M2\,SAT} = I_{M1\,LIN}$

$$\frac{\beta_n}{2}\left[V_x - V_U - V_{TN}\right]^2 = \beta_n\left[(V_{DD} - V_{TN})V_U - \frac{V_U^2}{2}\right]$$

$\hookrightarrow \begin{cases} V_U = 0.153V & < 1.083 \\ \cancel{V_U = 2.33V} & < 2.9 \end{cases}$

$\rightarrow M_1$ LIN M_2 SAT

$\rightarrow$ per condensatore $\dashv\vdash$

$V_U(0^-) = V_U(0^+)$

$\rightarrow$ quando si spegne M_3 V_x si porta a nuovo valore istantaneamente

tensione per accendere FET

$\rightarrow M_2$ carica capacità, si ferma quando $V_x - V_U = V_{TN}$

① $t<0$ $V_i = V_{DD} \Rightarrow V_U = 0.153V$

② $t \to +\infty$ $V_x - V_U(+\infty) = V_{TN}$

$V_U(+\infty) = V_x - V_{TN}$

@ $t = 0^+$ M_3 OFF $\rightarrow V_x$ cambia

$$V_x(0^+) = V_{DD} \cdot \frac{R_2}{R_1 + R_2} = 3.333V$$

$$V_U(+\infty) = (3.333 - 0.6) = 2.733V$$

$\left.\begin{cases} V_U(0^-) = 0.153V \\ V_U(\infty) = 2.733V \end{cases}\right\} \Delta V_U$

$\rightarrow T_{RISE}$ $\rightarrow$ tempo da 10% a 90% escursione

escursione da coprire $\rightarrow \Delta V_U = 2.58V$

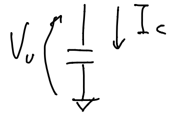
$V_{U\,INIZ} = V_U(0^-) + \underbrace{0.1 \cdot \Delta V_U}_{10\%}$

$= 0.411V$

$V_{U\,FIN} = V_U(0^-) + 0.9 \cdot \Delta V_U$

$= 2.473V$

→ da fare integrale



$$I_c = C \cdot \frac{dV_U}{dt} = I_{M2}$$

M_2: $V_{GS} < V_{DS} + V_{TN}$

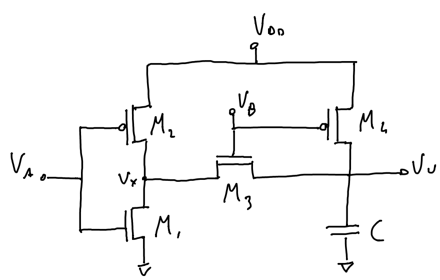
$$V_x(0^+) - \cancel{V_U} < V_{DD} - \cancel{V_U} + V_{TN}$$

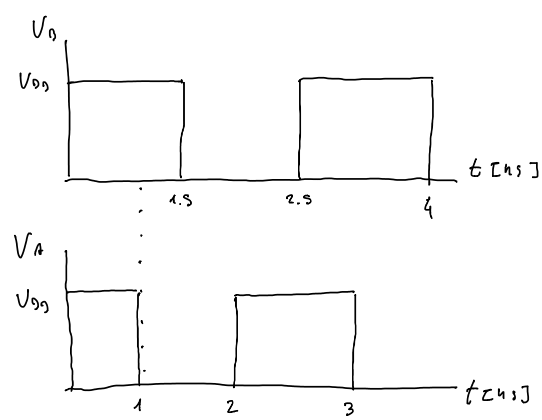
$$3.333 < (3.5 + 0.6)V = 4.1V$$

$$I_c = \ldots = \frac{\beta_n}{2}\left(V_x(0^+) - V_U - V_{TN}\right)^2$$

$$\int_0^{t_{fase}} dt = \int_{V_U(ini) = 0.466V}^{V_U(fin) = 2.433V} \frac{C\, dV_U}{I_{M2\,SAT}}\, dt = \underline{\underline{34.4\,ms}}$$

ES. 2 10/06/2010





$V_{DD} = 3.3\,V$ $\beta_n = \beta_p = 1$

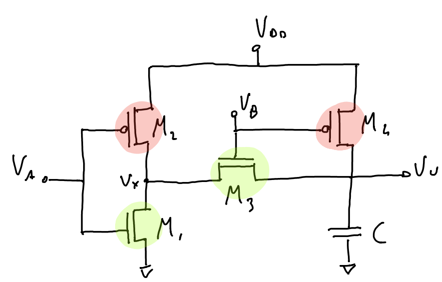
$V_T = 0.4\,V$ $C = 50\,fF$

→ determinare V_U, calcolare tempo prop. T_{PHL}

① $0 < t < 1$

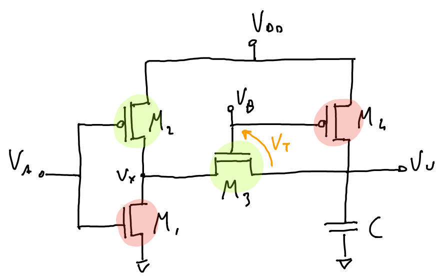
$V_A = V_{DD}$ $V_B = V_{DD}$

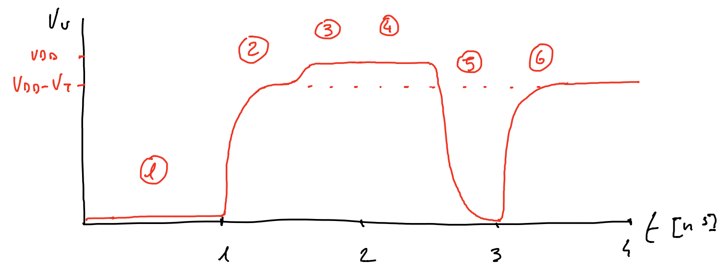
→ $V_x = 0$ $V_U = 0$



② $1 < t < 1.5$

$V_A = 0$ $\quad V_B = V_{DD}$



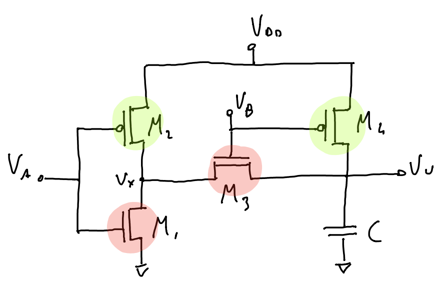


$\rightarrow V_U = V_{DD} - \boxed{V_T}$

$V_B - V_U = V_T \rightarrow M_3$ OFF

③ $V_A = 0$ $\quad V_B = 0$

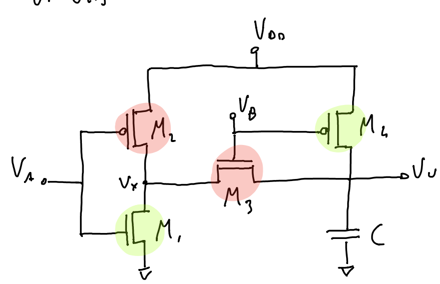
PMOS NON PERDE SOGLIE



④ $2 < t < 2.5$ . . .

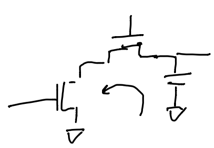
$V_B = 0$

$V_A = V_{DD}$

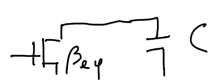


→ cercare dove possibile calcolare TPHL

→ SOLO DA REGIONE ④ A REGIONE ⑤



⇒



β_{eq} che scarica capacità C

$$\beta_{eq} = \frac{\beta_1 \beta_3}{\beta_1 + \beta_3} = \frac{\beta_n}{2}$$

→ calcolare transitorio

→ si usa formula, altrimenti calcolare transitorio