یا لطیف

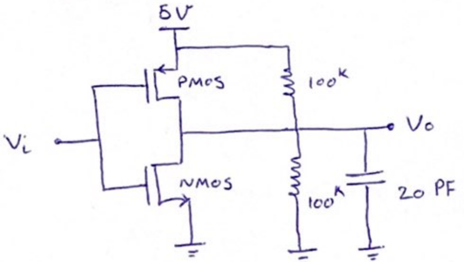
رضا ادیب پور

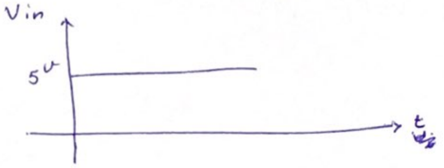
۹۸۱۴۳۰۳

ادامه تمرین سری ۲ تکنیک پالس

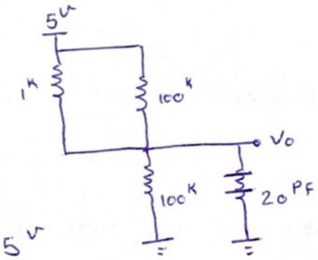
# #4-35

$$\begin{cases} R_{n\text{-}mos} = 200\Omega \\ R_{p\text{-}mos} = 1^{K} \\ K = 0.2\ \frac{mA}{V^2} \\ |V_t| = 1^{V} \end{cases}$$

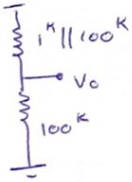




for $t<0 \longrightarrow \begin{cases} PMOS : ON \\ NMOS : off \end{cases} \Rightarrow$



$\Rightarrow$



$$V_{o}(t<0) = \frac{100^{K} \times 5}{100^{K} + (1^{K}||100^{K})} = 4.95^{V}$$

$$\Rightarrow V_{DS,PMOS} = 4.95 - 5 = -0.05 > \underbrace{V_{GS} - V_t}_{-5-1=-6V}$$

فرض اینکه PMOS در ناحیه ترایود است درست می‌باشد.

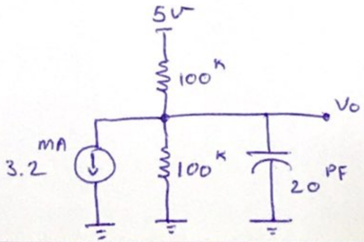
for $t = 0$ : $\begin{cases} PMOS : off \\ NMOS : ON \end{cases} \Rightarrow V_{DS,NMOS} = V_{D,PMOS} = 4.95^{V}$

$V_{GS,NMOS} = 5^{V} \Rightarrow V_{DS} \geq V_{gs} - V_t$

NMOS ابتدا اشباع می‌شود

$$i_D = k(V_{gs} - V_{th})^2 = 0.2(5-1)^2 = \boxed{3.2^{mA}}$$

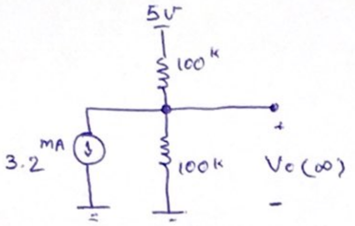
$\Rightarrow$



$V_o(0^-) = V_o(0^+) = 4.95^{V}$

$V_o(\infty) \longrightarrow C$ : open

$\Rightarrow$

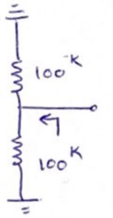


$$\text{KCL}: \frac{V_o(\infty)-0}{100^k} + \frac{V_o(\infty)-5}{100^k} + 3.2^{mA} = 0$$

$$\Rightarrow V_o(\infty)\cdot\left(\frac{1}{100^k}+\frac{1}{100^k}\right) = \frac{5}{100^k} - 3.2^{mA}$$

$$\Rightarrow V_o(\infty) = \frac{0.05^m - 3.2^m}{0.02^k} = \boxed{-157.5^v}$$

$\tau_1 = R_{TH} \cdot C_{TH}$ :



$R_{TH} = 100^k \,||\, 100^k = 50^k$

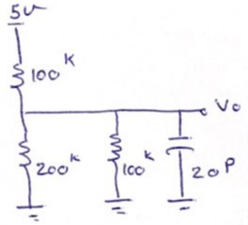
$C_{TH} = 20^{PF} \Rightarrow \tau = 50^k \times 20^p = 100^{ns}$

$= 1^{\mu s}$

$$V_o(t) = V_o(\infty) + \left(V_o(0^+) - V_o(\infty)\right) e^{-\frac{t}{\tau_1}} = -157.5 + \left(4.95 + 157.5\right) e^{-\frac{t}{1\mu s}}$$

$$= \cancel{157.5(} \quad -157.5 + 162.45\, e^{-\frac{t}{1\mu s}} \xrightarrow{V_{gs}-V_{th}=4} 4 = -157.5 + 162.45\, e^{-\frac{t}{1\mu s}}$$

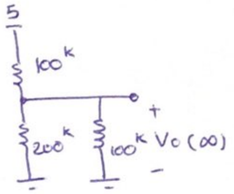
$\Rightarrow t = 5.86^{nsec} \longrightarrow$ پس از این زمان NMOS وارد ناحیه triod می شود $\Rightarrow$



$$V_o(t) = \cancel{\quad} V_o(\infty) + \left(V_o(t=5.86) - V_o(\infty)\right) e^{-\left(\frac{t-5.86}{\tau_2}\right)}$$

$$** : V_o(t) = -157.5 + (4.95 + 157.5)\, e^{-\frac{t}{1\mu}} \xrightarrow{t=5.86^{ns}} V_o(t=5.86^{ns}) = \boxed{4^v}$$

$V_o(\infty)$ :



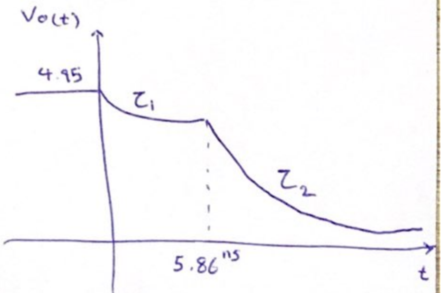
$$\text{KCL}: \frac{V_o(\infty)-5}{100^k} + \frac{V_o(\infty)-0}{200^k} + \frac{V_o(\infty)-0}{100^k} = 0$$

$$\Rightarrow V_o(\infty) = \frac{(200^k || 100^k) \times 5}{(200^k||100^k) + 100^k} = \boxed{0.01^v}$$

$$\tau_2 = \left[100^k || 100^k || 200^k\right] \times 20^{PF} = 3.98^{ns}$$

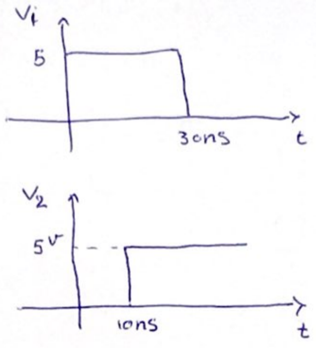
$$\Rightarrow V_o(t) = 0.01 + \left[4 - 0.01\right] e^{-\frac{t-5.86^{ns}}{3.98^{ns}}}$$

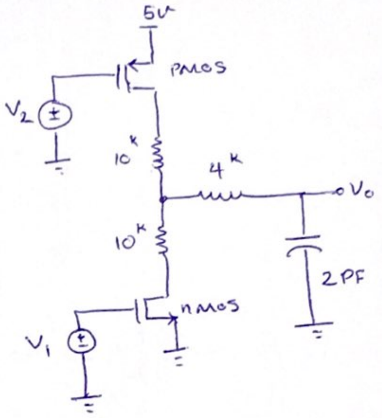
$$\Rightarrow V_o(t) = \begin{cases} 4.95 & t \le 0 \\ -157.5 + 162.45\, e^{-\frac{t}{1\mu s}} & 0 \le t \le 5.86^{ns} \\ 0.01 + 3.99\, e^{-\left(\frac{t-5.86^{ns}}{3.98^{ns}}\right)} & 5.86 \le t \le \infty \end{cases}$$



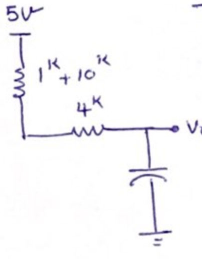
#4-36

$$\begin{cases} R_{nmos} = 200\,\Omega \\ R_{pmos} = 1^{k} \\ k = 0.2\ \frac{mA}{v^2} \\ |V_t| = 1^{v} \end{cases}$$





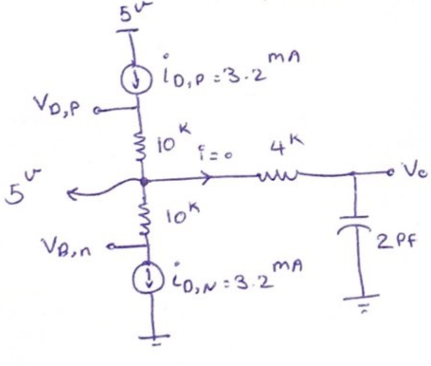
for $t<0$ : $\begin{cases} \text{PMOS : ON} \\ \text{nmos : off} \end{cases} \xrightarrow[\text{ترایود است}]{\text{با فرض اینکه PMOS در}}$



$\Rightarrow V_o(t<0) = 5^v \longrightarrow \begin{cases} V_{DS,\,PMOS} = -5^v \\ V_{GS} = -5^v \\ \Rightarrow V_{DS} \geq V_{gs} - V_{th} \end{cases} \longrightarrow$ فرض درست است

for $0 < t < 10^{ns}$ : $\begin{cases} \text{nmos : ON} \\ \text{PMOS : ON} \end{cases} \xrightarrow[\text{در ترایود هستند}]{\text{با فرض اینکه هردو}} \begin{cases} i_{D,P} = K(V_{gs}+V_{th})^2 = 0.2(-5+1)^2 = 3.2^{mA} \\ i_{D,N} = K(V_{gs}-V_{th})^2 = 0.2(5-1) = 3.2^{mA} \end{cases}$

$\Rightarrow$

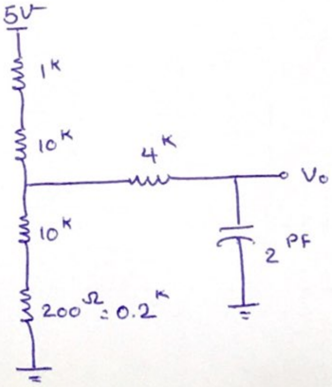


$\boxed{V_o(0^-) = V_o(0^+) = 5^v}$

$$\begin{cases} \frac{5 - V_{D,P}}{10^k} = -3.2 \Rightarrow V_{D,P} = 37^v \\ \frac{5 - V_{D,n}}{10^k} = 3.2 \Rightarrow V_{D,n} = -27^v \end{cases}$$

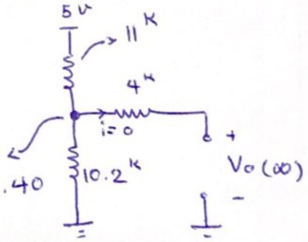
$\begin{cases} V_{DS,N} \ngeq V_{gs} - V_t \quad : \ -27 \ngeq 5-1 \quad \times \longrightarrow \text{فرض غلط بوده و nmos در ترایود است} \\ V_{DS,P} \leq V_{gs} - V_{th} \quad : \ 32 \leq 0+1 \quad \times \longrightarrow \text{" " " PMOS " " "} \end{cases}$

$\Rightarrow$



$V_o(0^-) = V_o(0^+) = 5^v$

$V_o(\infty)$ :

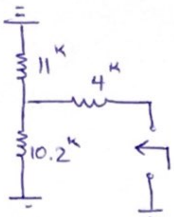


$\bar{V} = \frac{10.2 \times 5}{10.2 + 11} = 2.40$

$\Rightarrow \boxed{\bar{V} = V_o(\infty) = 2.40\ v}$

$$\Rightarrow V_o(t) = V_o(\infty) + \left[V_o(t=0^+) - V_o(\infty)\right] e^{-\frac{t}{\tau}}$$

$\tau_1 = RC$ :



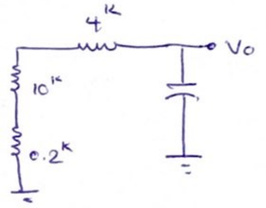
$$R_{TH} = 4^k + 11^k \| 10.2^k = 9.3^k$$

$$\tau_1 = 2^{pF} \times 9.3^k = 18.6^{ns}$$

$$\Rightarrow V_o(t) = 2.40 + \left[5 - 2.40\right] e^{\frac{-t}{18.6^{ns}}} = 2.40 + 2.6 e^{\frac{-t}{18.6^{ns}}} \quad \text{for} \quad 0 < t < 10^{ns}$$

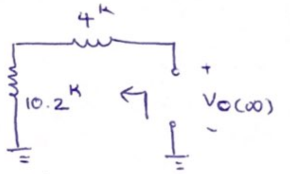
$$\Rightarrow V_o(t = 10^{ns}) = 2.40 + 2.6 e^{\frac{-10^{ns}}{18.6^{ns}}} = \underline{3.9\,v}$$

for $10^{ns} < t < 30^{ns}$ : $\begin{cases} \text{PMOS: off} \\ \text{nMOS: ON} \end{cases} \Rightarrow$



$$V_o(10^{ns}_-) = V_o(10^{ns}_+) = 3.9^v$$

$\Rightarrow V_o(\infty)$ :

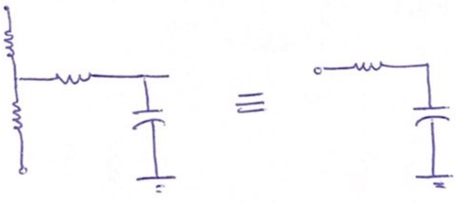


$\Rightarrow V_o(\infty) = 0$

$$\tau_2 = \left[4^k + 10.2^k\right] \times 2^{pF} = 28.4^{ns}$$

$$\Rightarrow V_o(t) = 0 + \left[3.9 - 0\right] e^{-\left(\frac{t-10^{ns}}{28.4^{n}}\right)} = 3.9 e^{-\left(\frac{t-10^{ns}}{2,8.4^{ns}}\right)} \quad \text{for} \quad 10^{ns} < t < 30^{ns}$$

for $t > 30^{ns}$ : $\begin{cases} \text{PMOS : off} \\ \text{nmos : off} \end{cases} \Rightarrow$



$$\Rightarrow V_o(t = 30^{ns}) = 3.9 e^{-\left(\frac{30^n - 10^n}{28.4^n}\right)} = 1.92\,v$$

$$\Rightarrow V_o(t) = \begin{cases} 5\,v & ; \ t<0 \ \cancel{0<t<10^{ns}} \\ 2.4 + 2.6 e^{\frac{-t}{18.6^{ns}}} & ; \ 0 < t < 10^{ns} \\ 3.9 e^{-\left(\frac{t-10^{ns}}{28.4^{ns}}\right)} & ; \ 10^{ns} < t < 30^{ns} \\ 1.92 & ; \ t > 30^{ns} \end{cases}$$