上海交通大學

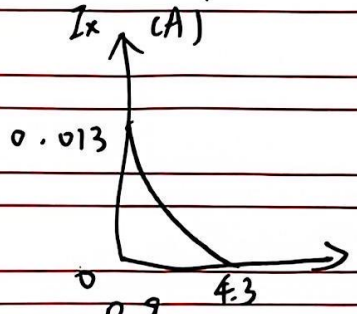
年 月 日

VE311 Homework 5. 严嘉成:

Question 1.

A). $V_{GS}-V_{th}=5-V_X-0.7$. Since $V_{DS}>V_{GS}-V_{th}$, it's in saturation region:

Apply the formula: $I_X=7.286\times10^{-4}\cdot(4.3-V_X)^2$



B). $V_{GS}-V_{th}=$ ~~1.8V~~ $-0.7V\geq$ ~~1V~~ $0.2V$.

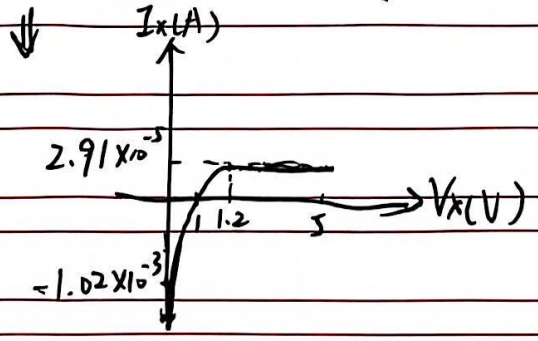
$V_{DS}=V_X-1V$ if $V_X\geq1.2V$ saturation if $0\leq V_X\leq1V$, $V_{DS}<V_{GS}-V_{th}$. (triode)

~~if $1.2V>V_X\geq1V$~~ triode.

for $V_X\geq1.2V$, $I_X=2.91\times10^{-5}A$.

for ~~$1V\leq V_X<1.2$~~ $I_X=-1.46\times10^{-3}\left(-\frac{V_X^2-2V_X+1}{2}+\frac{V_X-1}{5}\right)$

for $0\leq V_X<1V$: $I_X=-1.46\times10^{-3}\left(-\frac{1}{2}(1-V_X)^2+(1-V_X)\cdot(1.2-V_X)\right)$

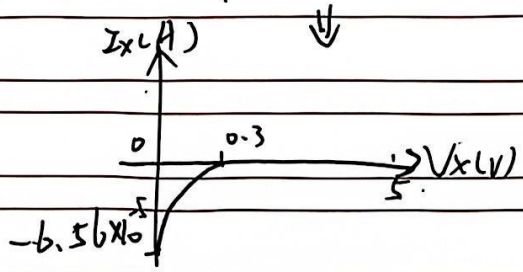


(C) $V_{DS}=V_X-1.9$, $V_{GS}-V_{th}=-1.6V<0$ $I_X=0$. cutoff. while not reverse,

when reverse: $V_{DS}=1.9-V_X$. $V_{GS}-V_{th}=0.3-V_X>0 \Rightarrow V_X<0.3V$.

also $V_{DS}>V_{GS}-V_{th}$: Saturation.

$\Rightarrow I_X=-7.29\times10^{-4}\cdot(0.3-V_X)^2$.



(D). ~~$V_{DS}=V_{SD}=1.9-V_X$~~ $V_{SD}=1.9-V_X$ while $V_X>1.9V$.

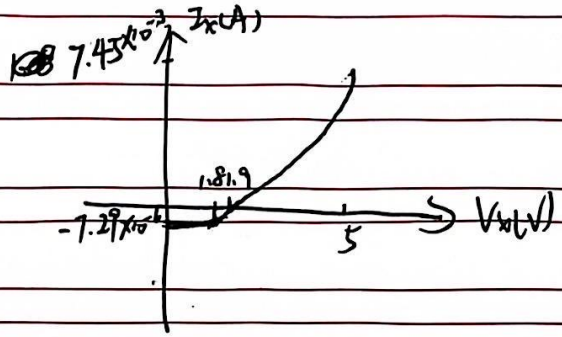
$V_{SG}-|V_{th}|=(V_X-1)-0.8=V_X-1.8V>V_{SD}$. (triode region)

~~$I_X=$~~ as $V_X<1.9V$: $V_{SD}=1.9-V_X$. $V_{SG}-|V_{th}|=0.1>0$.

$V_X>1.9V$: $I_X=-1.46\times10^{-3}\left(-\frac{1}{2}(1.9-V_X)^2+0.1(1.9-V_X)\right)$

$V_X\le1.9V$: when $V_X>1.8V$ (triode) $I_X=-7.29\times10^{-6}A$

when $V_X<1.8V$ (saturation). $I_X=-1.46\times10^{-3}\left(-\frac{1}{2}(1.9-V_X)^2+0.1(1.9-V_X)\right)$



Question 2:

For MOSFET 1: $V_{GS}-V_{th}= 2.5-V_1-0.9=1.6-V_1$

$V_{DS}=5-V_1 \Rightarrow$ In saturation area.

$I=\frac{1}{2}\mu_n C_{ox}\frac{W}{L_{eff}}[(V_{GS}-V_{th})\cdot V_{DS}-\frac{1}{2}V_{DS}^2](V_{GS}-V_{th})^2$.

For MOSFET 2: $V_{GS}-V_{th}=-5V-V_2-0.9$ $V_{DS}=V_1-V_2$.

Assume MOSFET 2 in ~~saturation~~ triode region. $\Rightarrow V_1 \leq -0.9V$.

$\frac{1}{2}(\frac{W}{L}-V_1)^2[(-5-V_1)\cdot(5-V_1)-\frac{1}{2}(5-V_1)^2] = (-V_2-0.9)(V_1-V_2)-\frac{1}{2}(V_1-V_2)^2=\frac{V_2+2.5V}{1000}\mu A$

$\Rightarrow V_{DS}<0$ Q_2 is off. X.

So MOSFET 2 in triode region $\Rightarrow V_1 \geq -0.9V$.

$\frac{V_2+2.5}{1000}=(V_{GS_1}-V_{th})^2=(V_{GS_2}-V_{th})^2 \Rightarrow V_1+V_2+2.5$.

$\Rightarrow \begin{cases} V_1=-0.66V \\ V_2=-1.84V. \end{cases}$