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EE 215D.
SPRING 2012.

Q. NO. 1

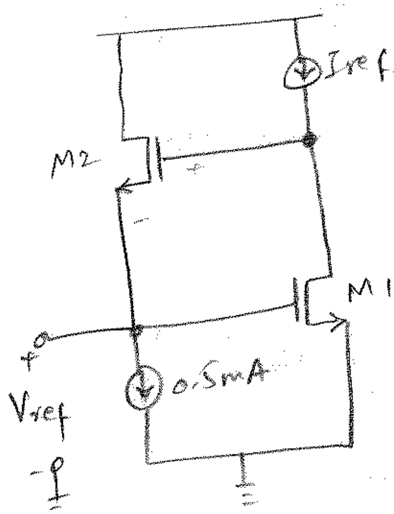
Part (a)

$0.5\,LSB = 0.5 \times \frac{0.9}{2^{10}} = 0.4394\,mV$

The worst case settling time occurs when $j = 4$
i.e. $D_1, D_2, D_3, D_4 = 1.8V$ and rest are at 0V.

$$\boxed{t_s = 418.8ps}$$ 5/5

Part (b)



$V_{GS_1} = V_{ref}$ $\Rightarrow$ $V_{GS_2} \geq V_{TH}$

Since M_2 is carrying 0.5mA and M_1 is in saturation.

$\therefore$ $V_{GD_1} < V_{TH}$

$I_{D_1} = I_{ref} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_{TH})^2$

$\mu_n = 310.25 \times 10^{-4}$, $C_{ox} = 8.42 \times 10^{-3}$

$V_{GS_1} = V_{ref} = 0.9$, $V_{TH} = 0.47$

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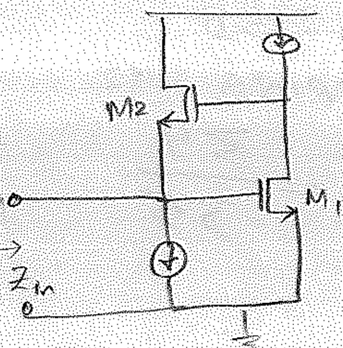
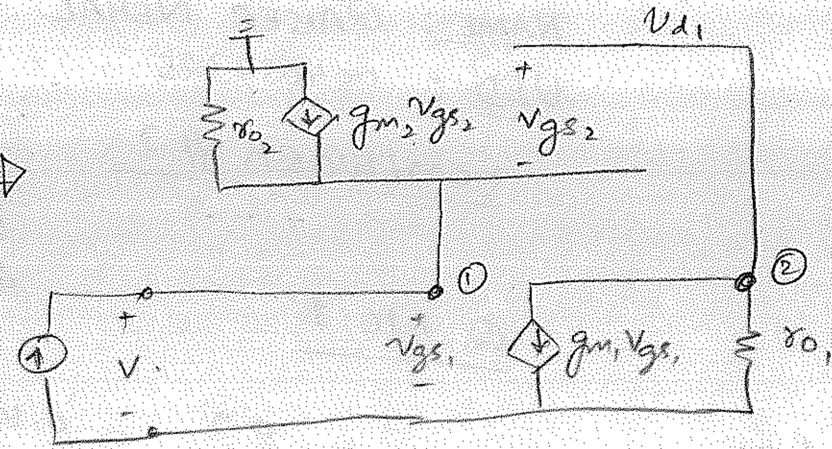
$$\Rightarrow \boxed{I_{ref} = 5.32\,mA}$$



$\Rightarrow$



$Z_{in} = \frac{v}{i}$

$v_{gs_1} = v$

KCL @ 1 $\quad \boxed{i = \frac{v}{r_{o_2}} - g_m v_{gs_2}}$ — 1

KCL @ 2 $\quad 0 = g_{m_1} v + \frac{v_{d_1}}{r_{o_1}}$

$$\Rightarrow \boxed{v_{d_1} = -g_{m_1} r_{o_1} v}$$

$$v_{gs_2} = v_{d_1} - v$$

$$\boxed{v_{gs_2} = -v\,(1 + g_{m_1} r_{o_1})}$$

Substitute in eq 1

$$i = v\left[\frac{1}{r_{o_2}} + g_{m_2}(g_{m_1} r_{o_1} + 1)\right]$$

$$\Rightarrow Z_{in} = \frac{v}{i} = \frac{r_{o2}}{1 + g_{m_2} r_{o_2}(1 + g_{m_1} r_{o_1})}$$

$g_{m_1} r_{o_1} >> 1$

$g_{m_2} r_{o_2}\, g_{m_1} r_{o_1} >> 1$

$$Z_{in} \simeq \frac{1/g_{m2}}{g_{m_1} r_{o_1}}$$

Using $g_{m_2} = 7.9\,\text{mS}$

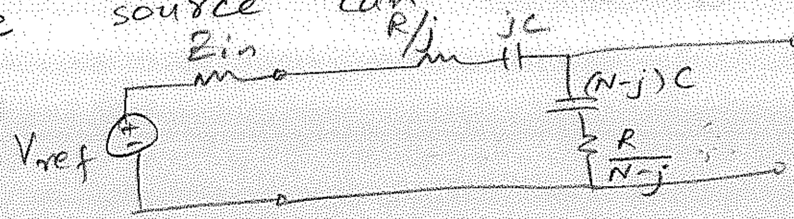
$g_{m_1} = 17.57\,\text{mS}$

$r_{o_1} = 1.4\,\text{k}\Omega$

$\Rightarrow \boxed{Z_{in} \simeq 5.15\,\Omega}$

↓ This is only the real part there is an imaginary part that affects the settling

The source can then be modelled as:



Due to the additional Z_{in} in the charging path, the settling should be increased.

Part (c)

The worst case settling time occurs when $j=3$

i.e. $D_1, D_2, D_3 = 1.8$, and rest are 0V.

$\boxed{t_s = 373.6ps}$ 5/5

This is lower than that of part (a) because V_{ref} is now no longer maintained at 0.9V. In fact V_{ref} jumps to 1V initially and then settles to 0.9V resulting in smaller worst case settling time.

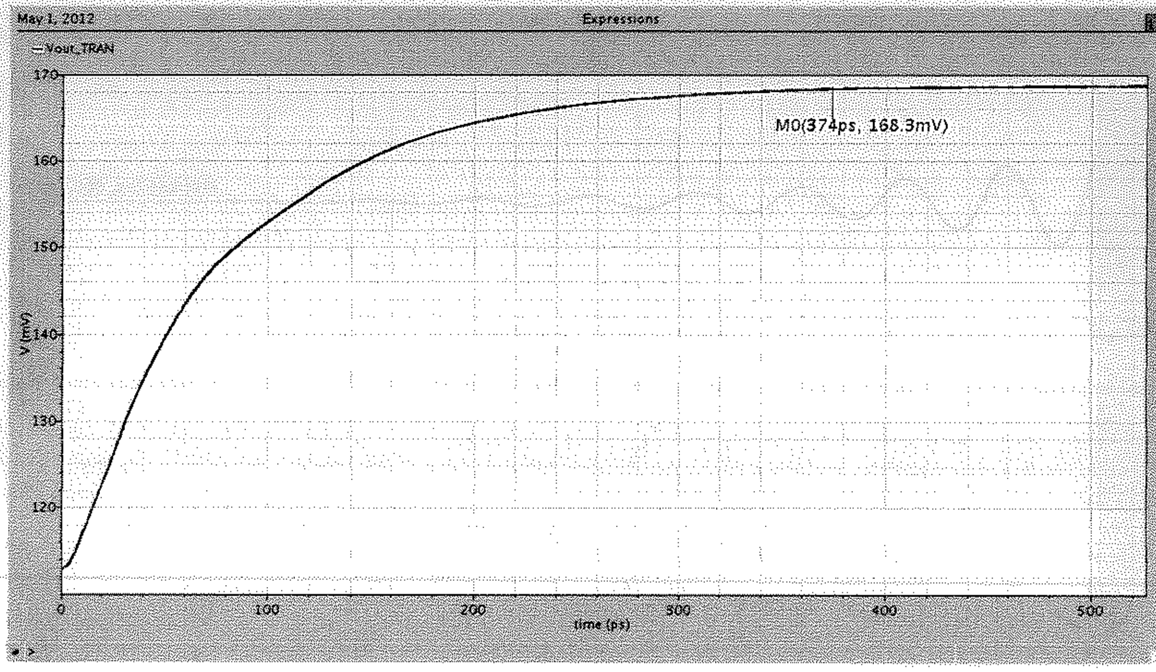
Part (d)

With $L_s = 2nH$ added, the settling time is $t_s = \underline{4.27ns}$ (when all caps are switched to V_{ref})

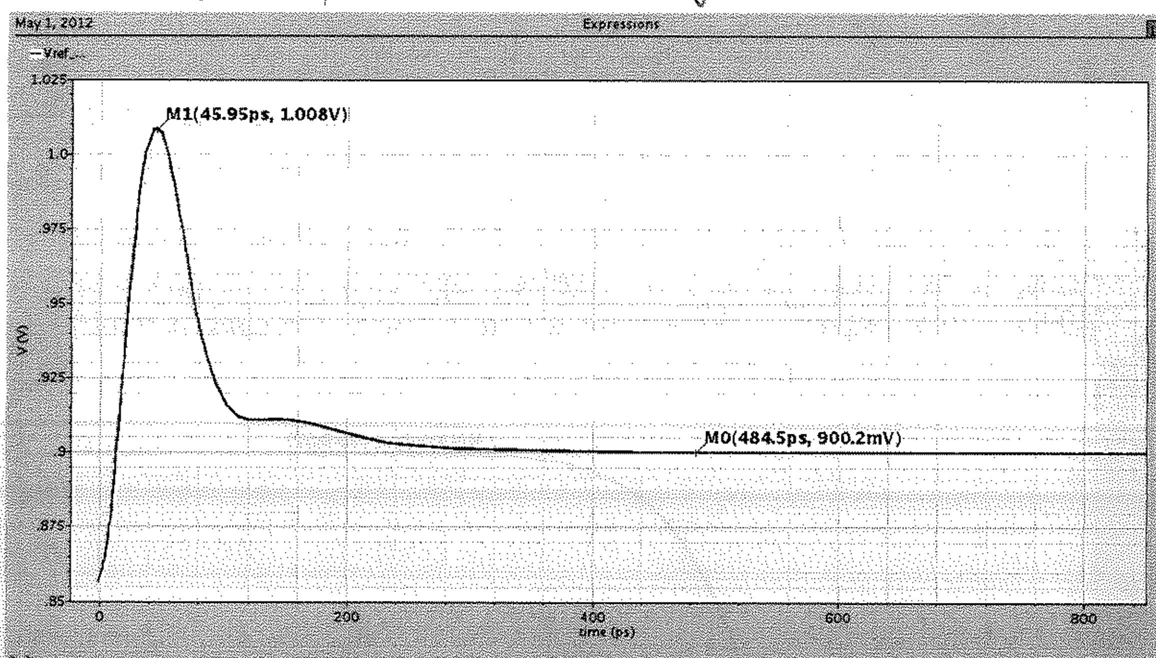
However using $R_s = 74\ \Omega$ in series with L_s gives $\boxed{t_s = 339.6ps}$ 5/5

~~Q.NO 2~~

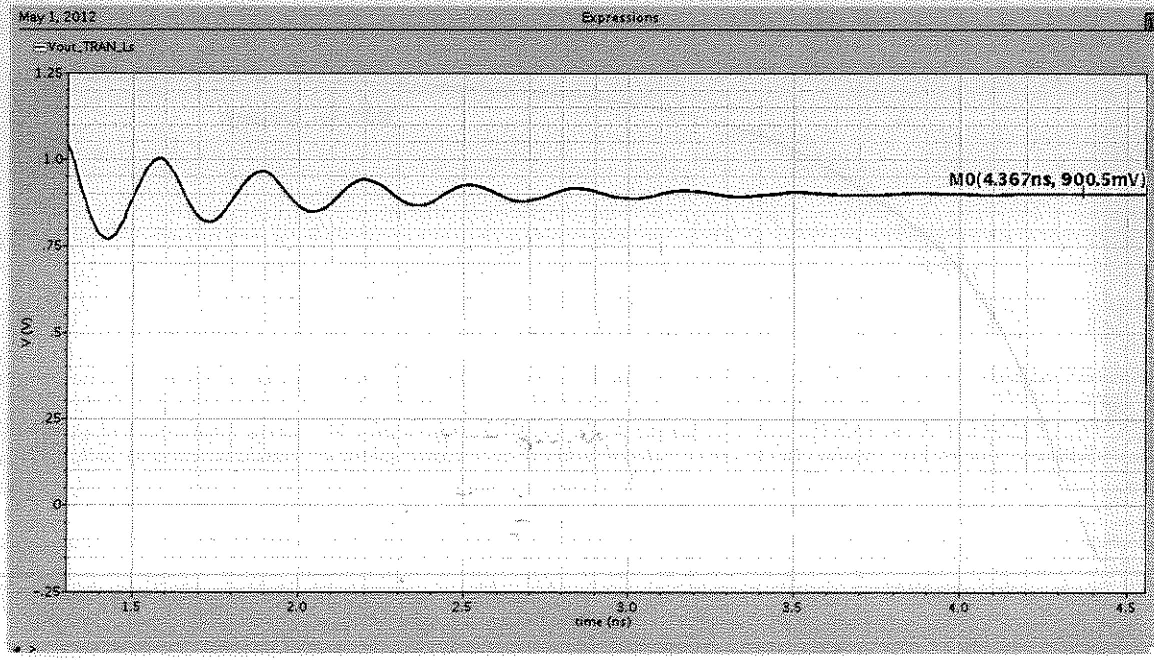
Part (c) Settling time.



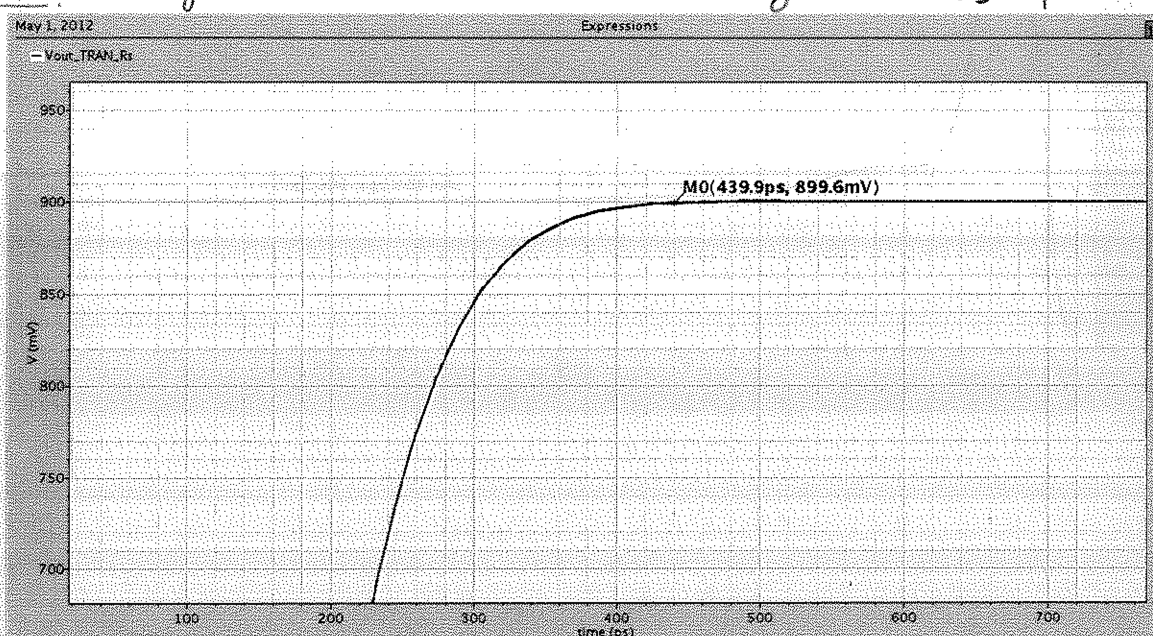
Part (c) Vref jumps to 1V initially.



Part (d) Effect of $L_s = 2nH$ on settling time. (jump happens @ $t = 100ps$)

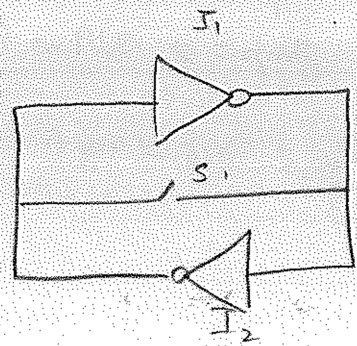


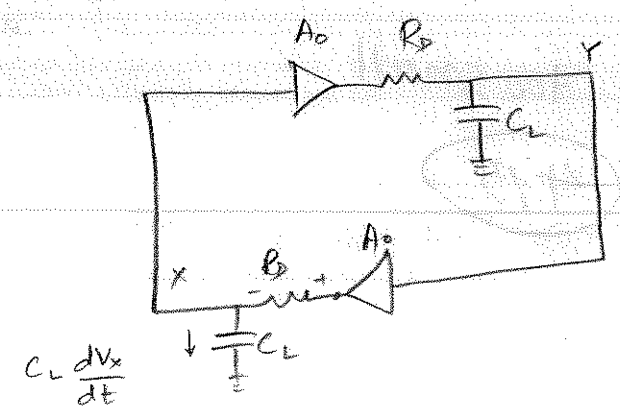
Part (d). Using $R_s = 74\Omega$ reduces settling time (jump occurs @ $t = 100ps$)



Q. NO. 2.

Part (a)





$$A_0 V_y = R_D C_L \frac{dV_x}{dt} + V_x$$

Similarly

$$A_0 V_x = R_D C_L \frac{dV_y}{dt} + V_y.$$

$$V_{xy} \triangleq V_x - V_y$$

$$-A_0 V_{xy} = R_D C_L \frac{dV_{xy}}{dt} + V_{xy}.$$

$$\Rightarrow \quad V_{xy}(1 + A_0) + R_D C_L \frac{dV_{xy}}{dt} = 0$$

$$\Rightarrow \quad V_{xy}(t) = V_{xy0} \, e^{t/\tau_R}$$

where V_{xy0} = Initial voltage difference between node X & Y.

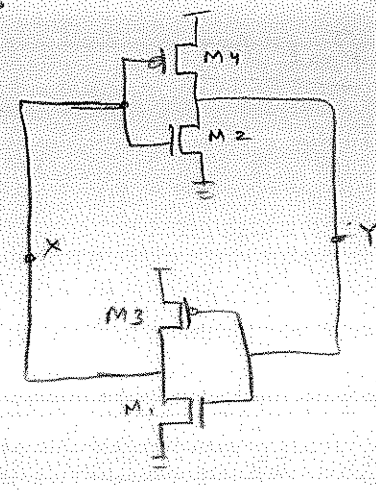
$$\tau_R = \frac{R_D C_L}{-A_0 - 1} \qquad R_D = r_{ON} \| r_{OP}$$

where $A_0 = -(g_{m_N} + g_{mp})(r_{ON} \| r_{OP})$

$r_{oN} = 5.52\,k\Omega$, $r_{op} = 6.13k$

$g_{mN} = 4.712m$, $g_{mp} = 2.319m$ S

$C_L = C_{db_1} + C_{db_3} + C_{gs_2} + C_{gs_4} \simeq 40fF$



$R_D = r_{oN} \| r_{op} = 2.9k\Omega$

$C_L = 40fF$

$\boxed{A_o = -20.39}$

$\boxed{\tau_R \simeq 6ps} \rightarrow$ too small

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(b) $\underline{V_{xy}(t=0)} = 2mV$

$V_x = 1.6V$ @ $t = 164.03ps$

$V_Y = 0.2V$ @ $t = 136.28ps.$

$\underline{\tau_R =?}$ $t/\tau_R = \ln\left(\frac{V_{xy}}{V_{xy0}}\right)$

Plot $\ln\left(\frac{V_{xy}}{V_{xy0}}\right)$ using Cadence @ $t = 5ps, 10ps, 15ps$

find $t/\tau_R = \ln\left(\frac{V_{xy}}{V_{xy0}}\right)$

From this data we can find out τ_R.

@ $t = 5ps$ $\ln\left(\frac{V_{xy}}{V_{xy0}}\right) = \frac{t}{\tau_R} = 2.57mV$

$\Rightarrow \boxed{\tau_R = \frac{5ps}{2.57mV} = 20.1ps}$

(average) $\tau_R = 20.39ps.$

$\underline{V_{xy}(t=0) = 4mV}$

$V_x = 1.6V$ @ $t = 149.713ps$

$V_Y = 0.2V$ @ $t = 121.94ps$

$\boxed{\tau_R = 20.44}$

5/5 Power dissipation $= 2.8746mW$.

(c) when $\left(\frac{W}{L}\right) = \frac{24\mu m}{0.18\mu m}$

$\underline{V_{xy}\ (t=0) = 2mV}$

$V_x = 1.6V$ @ $t = 163.848ps$

$V_Y = 0.2V$ @ $t = 136.22ps$.

$\boxed{\tau_R = 20.1}$

$\underline{V_{xy}\ (t=0) = 4mV}$

$V_x = 1.6V$ @ $t = 149.53ps$

$V_Y = 0.2V$ @ $t = 121.88ps$

$\boxed{\tau_R = 20.1}$

Power dissipation $= 5.74mW$.

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Percentage change in $\tau_R = 1.66\%$

Percentage Change in Power dissipation when S_1 is ON $= 100\%$

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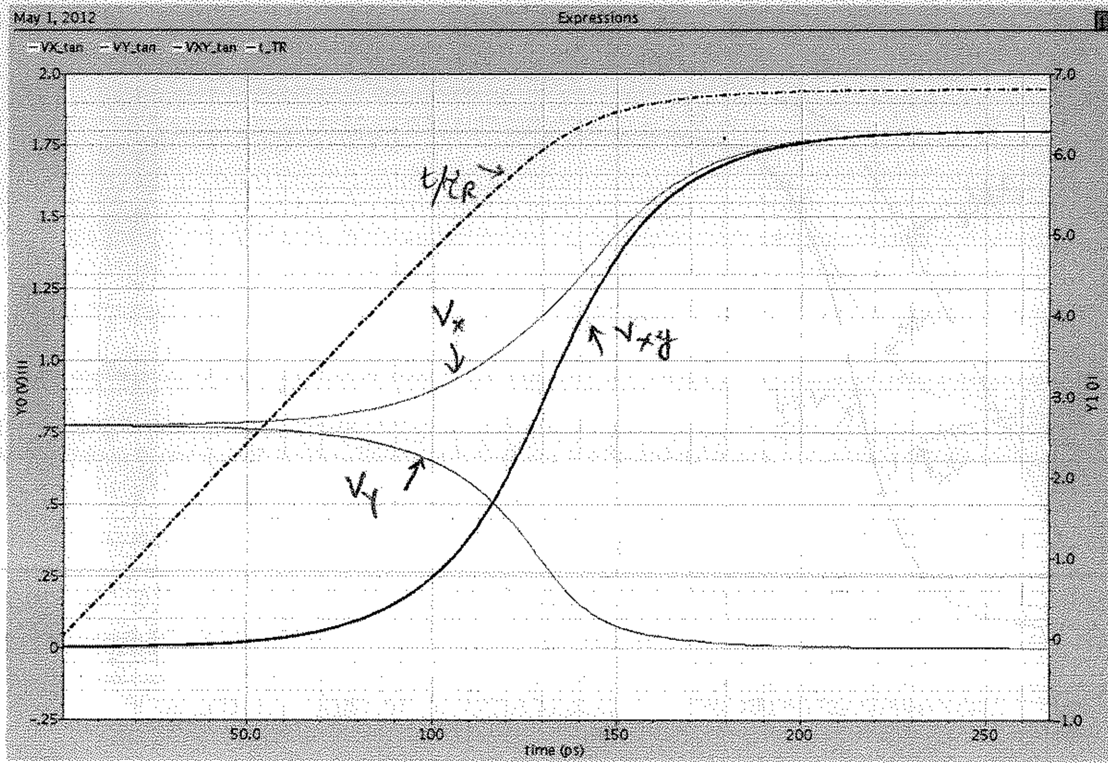
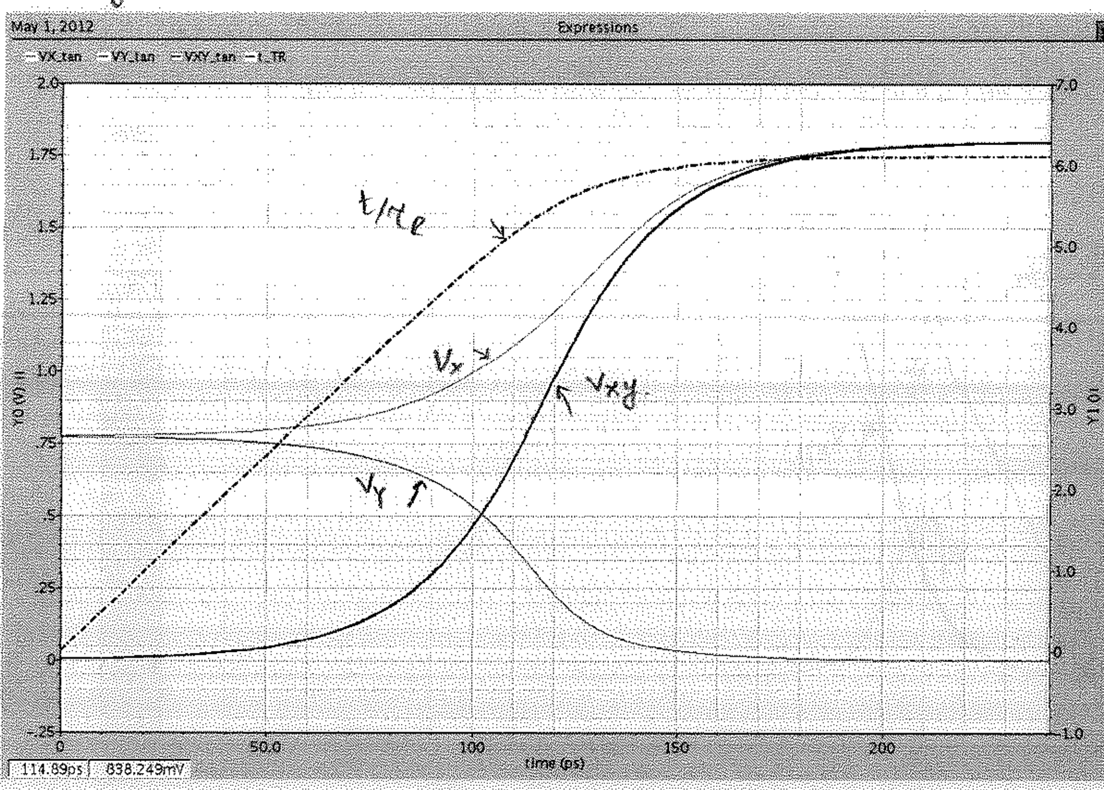
Q.NO.2

$(W/L) = \frac{12\,\mu m}{0.18\,\mu m}$

Part (b) $V_{XY}(t=0) = 2mV$



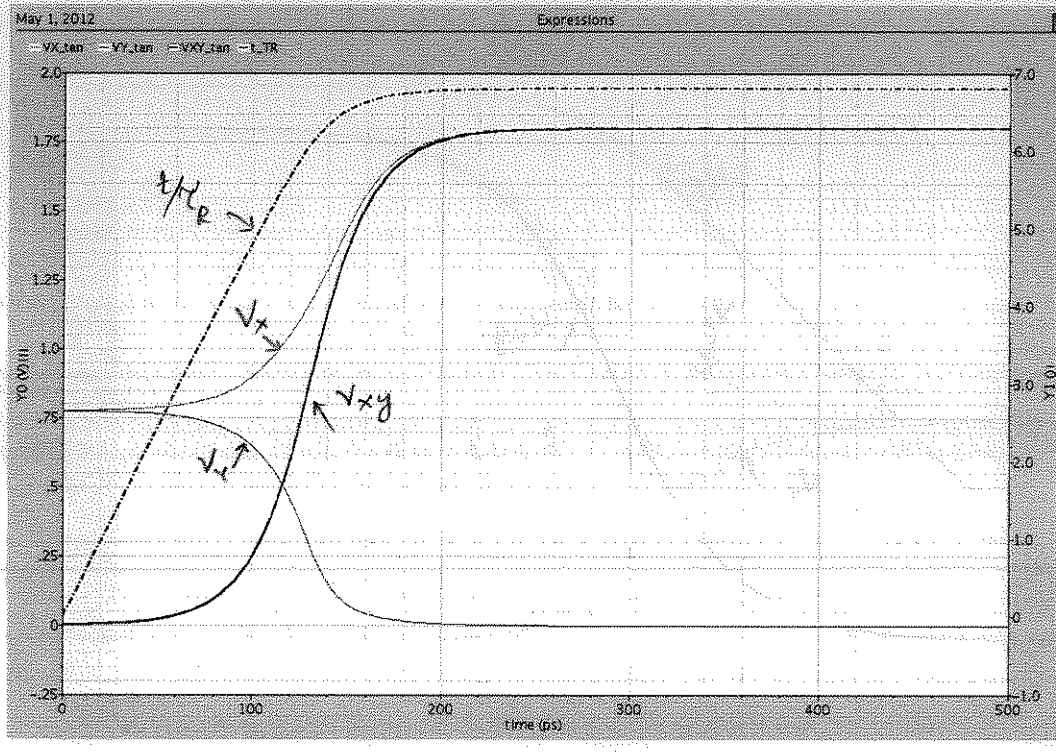
$V_{xy}(t=0) = 4mV$



$(W/L) = \frac{24\,\mu m}{0.18\,\mu m}$

Part (k)

$V_{xy}(t=0) = 2\,mV$



$V_{xy}(t=0) = 4\,mV$