Anthony Mancuso
ECE321
HW-8
19 OCT 2012

(5.2) $V_{IH} = 1.6V$
$V_{IL} = 0.3V$
$V_{OH} = 1.7V$
$V_{OL} = 0.2V$

(a) $NM_H = V_{OH} - V_{IH} = 1.7V - 1.6V = \boxed{0.1V}$

(b) $NM_L = V_{IL} - V_{OL} = 0.3V - 0.2V = \boxed{0.1V}$

(c) $V_{in} = 1.7V$, $V_{noise} = -50mV$

V_{in} spikes to $1.65V$ $\therefore$ $V_{in} > V_{IH}$ and the input remains high. Noise margin was reduced but circuit fidelity was not reduced by the 50mV spike

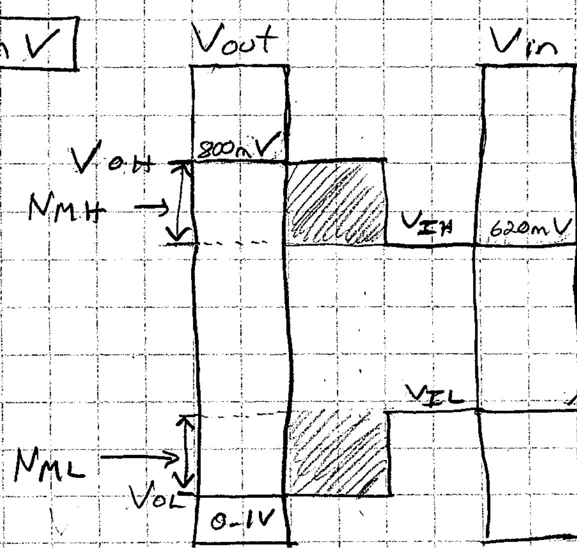
(d) $V_{in} = 1.7V$, $V_{noise} = -150mV$

$-150mV$ spike reduces V_{in} to value below V_{IH} and causes a weak logic voltage. Noise margin and gate driving voltage strengths are compromised, and circuit fidelity is reduced.

(5.4) $V_{DD} = 0.9V$
$V_{OH} = 0.8V$
$V_{OL} = 0.1V$
$NM_H = NM_L = (0.2)V_{DD} = \boxed{180mV}$

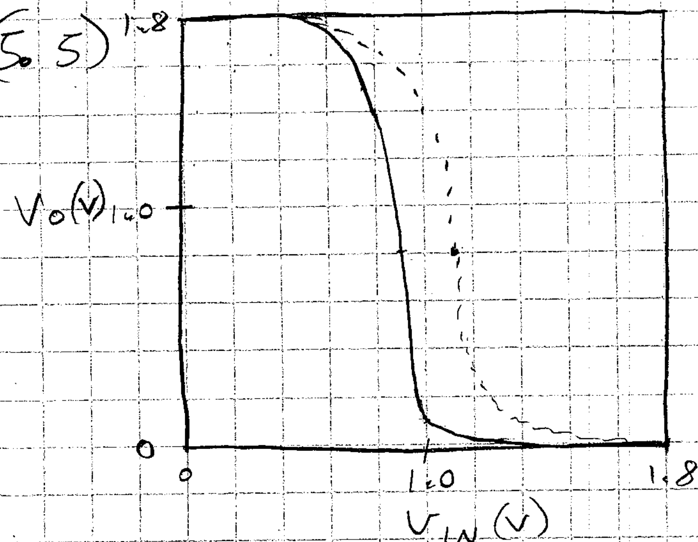
$V_{IL} = NM_L + V_{OL} = 280mV$

$V_{IH} = V_{OH} - NM_H = \boxed{620mV}$



Anthony Mancuso
ECE321
HW-8
19OCT2012

(5.5)

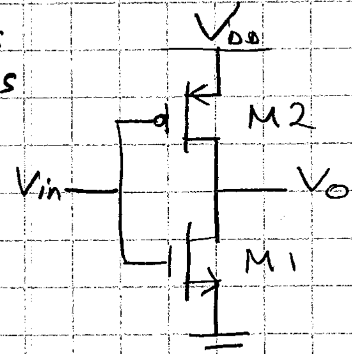


Logic threshold, $V_{IN} = V_M$ occurs at $V_o \approx V_{DD}/2$

Before shift $\Rightarrow V_M \approx 0.9V$

After shift $\Rightarrow V_M \approx 1.1V$

(5.6)
(a)
$\mu_n = 1400\ cm^2/V \cdot s$
$\mu_p = 500 cm^2/V \cdot s$
$V_{tn} = 0.35V$
$V_{tp} = -0.35V$
$V_{DD} = 1.3\ V$



For $V_M = V_{DD}/2$ and $V_{IN} = V_M$, M1 and M2 are in saturation.

$$\therefore \frac{k'_n}{2}\left(\frac{W}{L}\right)_n\left(V_{DD}/2 - V_{tn}\right)^2 = \frac{k'_p}{2}\left(\frac{W}{L}\right)_p\left(|V_{DD}/2| - |V_{tp}|\right)^2, \text{ where } L_1 = L_2$$

$$\frac{W_p}{W_n} = \frac{\frac{k'_n}{2}\left(V_{DD}/2 - V_{tn}\right)^2}{\frac{k'_p}{2}\left(|V_{DD}/2| - |V_{tp}|\right)^2} = \frac{\frac{\mu_n C_{ox}}{2}\left(V_{DD}/2 - V_{tn}\right)^2}{\frac{\mu_p C_{ox}}{2}\left(|V_{DD}/2| - |V_{tp}|\right)^2} = \frac{\mu_n\left(V_{DD}/2 - V_{tn}\right)^2}{\mu_p\left(V_{DD}/2 - V_{tp}\right)^2}$$

$$\frac{W_p}{W_n} = \frac{(1400 cm^2/V \cdot s)(0.65 - 0.35)^2}{(500 cm^2/V \cdot s)(0.65 - 0.35)^2} = \boxed{2.8}$$

(b) For $V_{tp} = -0.45V$: $\frac{W_p}{W_n} = \frac{(1400 cm^2/V \cdot s)(0.65 - 0.35)^2}{(500 cm^2/V \cdot s)(0.65 - 0.45)^2} = \boxed{6.3}$

Anthony Mancuso
ECE321
HW-8
19 Oct 2012

(5.8) $K'_n\left(\frac{W}{L}\right)_n = 100\mu A/V^2$
$K'_p\left(\frac{W}{L}\right)_p = 300\mu A/V^2$
$V_{tn} = 0.7V$
$V_{tp} = -0.75V$
$V_{DD} = 2.5V$

$$\frac{K'_n}{2}\left(\frac{W}{L}\right)_n\left(V_{GS}-V_{tn}\right)^2 = \frac{K'_p}{2}\left(\frac{W}{L}\right)_p\left(V_{GS}-V_{tp}\right)^2$$

For <u>nmos</u> in saturation: $V_{DS} = V_{GS} - V_{tp}$

$V_{GS} = V_{IN}$, $V_{IN} = V_O + V_{tn}$, $V_{DS} = V_O$

sub: $\frac{K'_n}{2}\left(\frac{W}{L}\right)_n\left(V_{IN}-V_{tn}\right)^2 = \frac{K'_p}{2}\left(\frac{W}{L}\right)_p\left[\left(V_{IN}-V_{DD}\right)-V_{tp}\right]^2$

sub: $\frac{K'_n}{2}\left(\frac{W}{L}\right)_n\left(V_O\right)^2 = \frac{K'_p}{2}\left(\frac{W}{L}\right)_p\left[\left(V_O+V_{tn}-V_{DD}\right)-V_{tp}\right]^2$

$$\left(100\mu A/V^2/2\right)V_O^2 = \left(300\mu A/V^2/2\right)\left(V_O+0.7V-2.5V+0.75V\right)^2$$

$$V_O^2 = 3\left(V_O - 1.05\right)^2 = 3V_O^2 - 6.3V_O + 3.3075$$

$$2V_O^2 - 6.3V_O + 3.3075 = 0$$

$$V_O = 0.665V \Rightarrow \frac{V_{DD}-V_O}{V_{DD}} = 0.734 = \boxed{73.4\%}$$

(5.9) nMOS - nonsat ; pMOS - sat
$K'_n = 50\mu A/V^2$, $\left(\frac{W}{L}\right)_n = 2$
$K'_p = 25\mu A/V^2$, $\left(\frac{W}{L}\right)_p = 4$
$V_{tn} = 0.5V$, $I_{DD} = 11\mu A$
$V_{tp} = -0.6V$, $V_{DD} = 2V$

$V_{GS}(n) = V_{IN}$
$V_{DS}(n) = V_O$
$V_{GS}(p) = V_{IN} - V_{DD}$

$$K'_n\left(\frac{W}{L}\right)_n\left[\left(V_{IN}-V_{tn}\right)V_O - \frac{V_O^2}{2}\right] = \frac{K'_p}{2}\left(\frac{W}{L}\right)_p\left(V_{IN}-V_{DD}-V_{tp}\right)^2$$

$$I_{DD} = \frac{K'_p}{2}\left(\frac{W}{L}\right)_p\left(V_{IN}-V_{DD}-V_{tp}\right)^2 \Rightarrow V_{IN} = 0.931V$$

$$I_{DD} = K'_n\left(\frac{W}{L}\right)_n\left[\left(V_{IN}-V_{tn}\right)V_O - \frac{V_O^2}{2}\right] \Rightarrow V_O =$$