Typical CMOS Transistor Parameters (Table 7.1, p. 361)

Parameter	NMOS	PMOS
V_{T0}	0.6V	-0.6V
γ	$0.5\,V^{1/2}$	$0.75\,V^{1/2}$
$2\phi_F$	0.6V	0.7V
K'	$100\mu A/V^2$	$40\mu A/V^2$

note: $V_{TN} = V_{TON} + \gamma_N\left(\sqrt{V_{SBN} + 2\phi_{FN}} - \sqrt{2\phi_{FN}}\right)$

$V_{TP} = V_{TOP} - \gamma_P\left(\sqrt{V_{SBP} + 2\phi_{FP}} - \sqrt{2\phi_{FP}}\right)$ } Body effect

if $V_{SB} = 0$ → PMOS S & B → V_{DD}, NMOS S & B → gnd

then $V_{TN} = V_{TON}$

$V_{TP} = V_{TOP}$

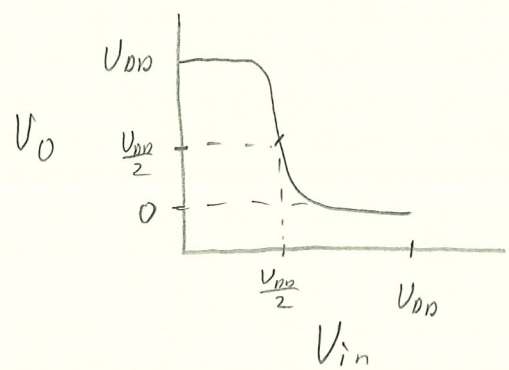
note: $K'_n \approx 2.5K'_p$

$K_n = \mu_n C''_{ox}$ and $K'_p = \mu_p C''_{ox}$

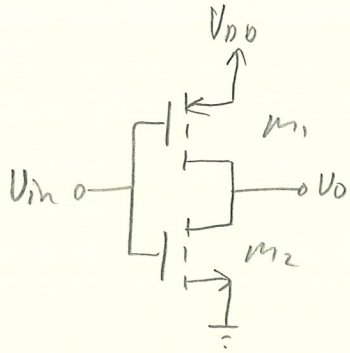
$\mu_n \approx 2.5\mu_p$

because e^- mobility > hole mobility

For a symmetrical inverter : $V_{Trip} = \frac{V_{DD}}{2}$



at V_{trip} : $V_{in} = V_O$



$K_n' = 2.5 K_p'$

$|V_{TP}| = V_{TN}$

$\lambda = 0 V^{-1}$

for symmetrical device: $V_{Trip} = \frac{V_{DD}}{2}$

at $V_{in} = V_O \rightarrow V_{GS} = V_{DS}$

$|V_{DS}| \geq |V_{GS} - V_T| \geq 0 \rightarrow$ saturation at V_{Trip}

$I_D = 0.5 K'(\frac{W}{L})(V_{GS} - V_T)^2$

$m_1 : I_D = 0.5 K_p'(\frac{W}{L})_p (V_{GS_1} - V_{TP})^2$

$m_2 : I_D = 0.5 K_n'(\frac{W}{L})_n (V_{GS2} - V_{TN})^2$

<u>note</u>: $(V_{GS1} - V_{TP})^2 = (V_{GS2} - V_{TN})^2$

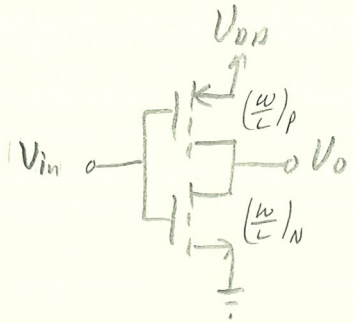
$I_{Dm_1} = I_{Dm2}$

$\therefore K_p'(\frac{W}{L})_p = K_n'(\frac{W}{L})_n$

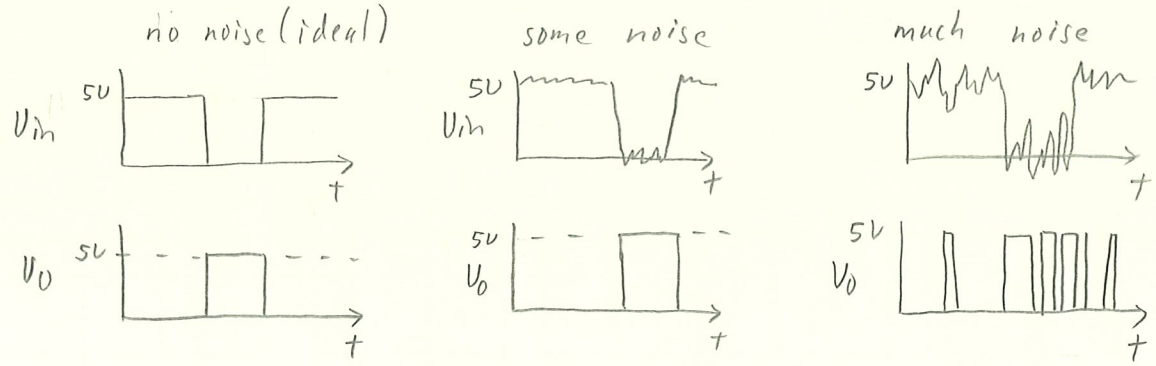
$$\frac{(\frac{W}{L})_p}{(\frac{W}{L})_n} = \frac{K_n'}{K_p'} = \frac{2.5}{1}$$

ex: select $W_n = 1\mu m$, $L_n = 1\mu m$
$W_p = 5\mu m$, $L_p = 2\mu m$ } results in a symmetrical inverter

More on the Symmetrical CMOS inverter

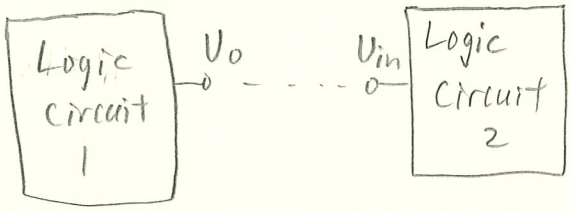


1) Noise margins in CMOS logic devices



Noise margin → acceptable range of voltage variation on V_{in} while still getting to correct V_o

Definition:



$NM_H = V_{OH_1} - V_{IH_2}$

V_{OH_1}: min high output voltage

V_{IH_2}: min high input voltage

$NM_L = V_{IL_2} - V_{OL_1}$

V_{IL_2}: max input low voltage

V_{OL_1}: max low output voltage

Noise → adds to our "desired" electrical signal

a. Sources : ① internal

→ noise inherent in electronics devices : thermal noise, shot noise, 1/f noise

→ interference from other circuitry in same system

② exteral

→ Near by electronics

i. noise on power supply lines (power and ground lines)

ii. electromagnetic interference

→ Mechanical vibrations

→ RF : nearly by radio/TV stations, cell phones TVset, etc.

* Dynetics RF power meter story 200kHz to 2GHz

→ solar/cosmic radiation

→ stray cap from nearby motion

* HMX2000 high R testing story

* Dump truck story

b. characteristics

→ voltage or current noise sources

→ at specific frequencies or wide bandwidth

→ random or nonrandom

→ temporary or always present