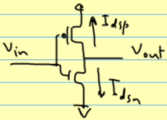
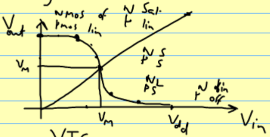
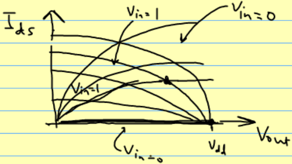
Inverter Analysis





VTC
(Voltage Transfer Curve)



V_M = switching threshold
(trip point)

$V_{in} = V_{out}$

V_M

$$I_{ds\,n} = -I_{ds\,p}$$

$$\overset{\left(\mu C_{ox}\frac{W}{L}\right)_n}{K_n}\left(V_M - V_{tn} - \frac{V_{dsat\,n}}{2}\right)\cdot V_{dsat\,n}$$

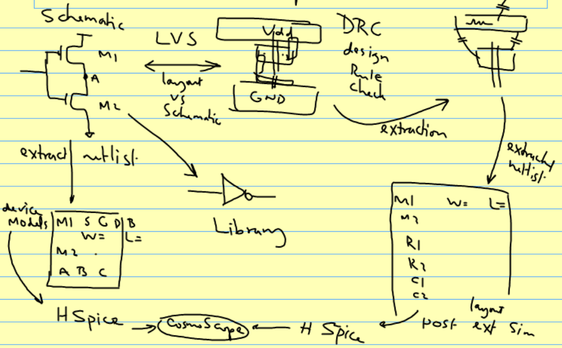
$$= -k_p\left(V_M - V_{dd} - V_{tp} - \frac{V_{dsat\,p}}{2}\right)\cdot V_{dsat\,p}$$

$$V_M - V_{tn} - \frac{V_{dsat\,n}}{2} = -\underbrace{\frac{k_p V_{dsat\,p}}{K_n V_{dsat\,n}}}_{=r}\cdot\left(V_M - \cdots\right)$$

$$\underline{\underline{V_M}} = \frac{V_{tn} + \frac{V_{dsat\,n}}{2} + r\left(V_{tp} + \frac{V_{dsat\,p}}{2} + V_{dd}\right)}{1+r}$$

$\underline{\underline{r \approx 1}}$ and V_{dd} large $\Rightarrow$ $\underline{\underline{V_M}} \approx \frac{r}{1+r} V_{dd}$

[Design Steps]

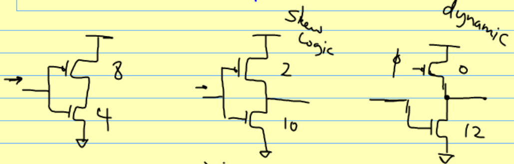


V_M and $r = 1$ (b/c want $V_M = \frac{1}{2} V_{dd}$)

$$r = \frac{k_p V_{dsat_p}}{k_n V_{dsat_n}} = \frac{\left(\mu \cancel{C_{ox}} \cancel{\frac{W}{L}}\right)_p}{\left(\mu \cancel{C_{ox}} \cancel{\frac{W}{L}}\right)_n} \cdot \frac{V_{dsat_p}}{V_{dsat_n}} = 1$$

$$\frac{W_p}{W_n} = \frac{\mu_n}{\mu_p} \cdot \cancel{\frac{V_{dsat_n}}{V_{dsat_p}}} \approx 2$$

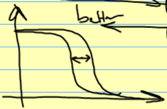
Noise vs Speed



better ← Noise

Speed → better

better ← power



$\text{delay} \propto \frac{1}{w}$