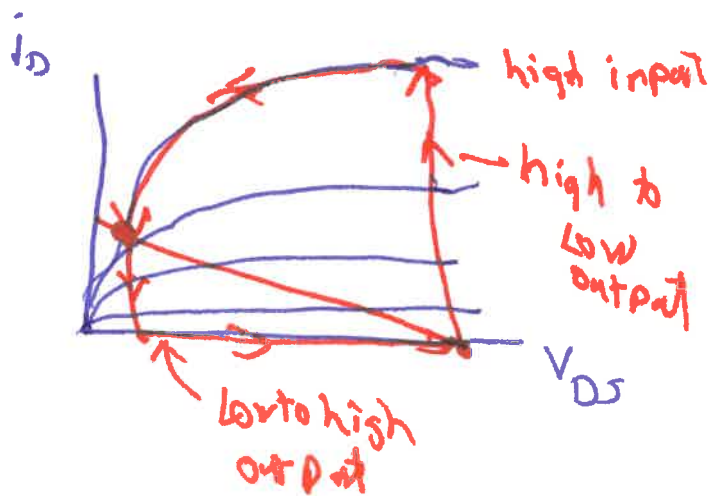




Low to High Output

$$V_o(t) = V_{DD} - (V_{DD} - V_{oh}) e^{-t/(R_o C_L)}$$

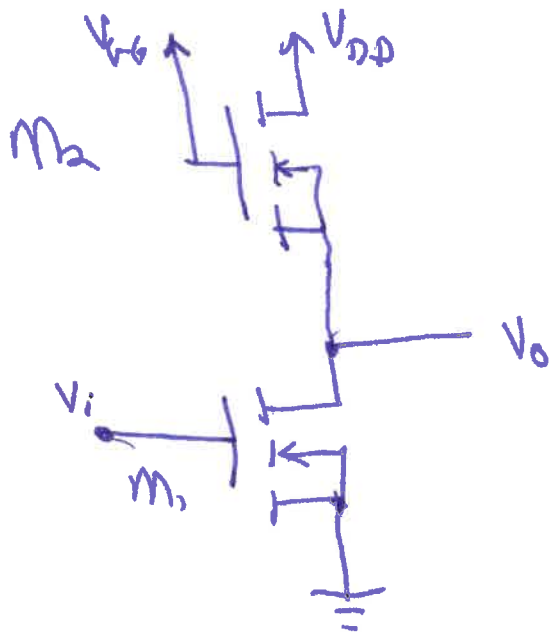
$$\left. \begin{array}{l} R_o \sim 10^5 \Omega \\ C_L \sim 10^{-12} \text{ F} \end{array} \right\} \text{Time constant} \sim 10^{-7} \text{ sec} \\ 100 \text{ ns}$$

High to Low output

$$V(t) \approx V_{DD} e^{-t/(R_{on} C_L)}$$

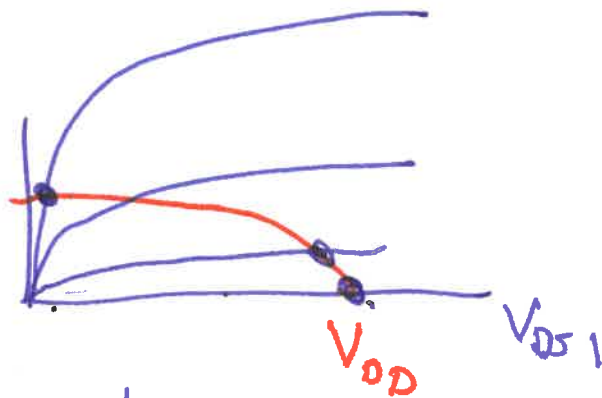
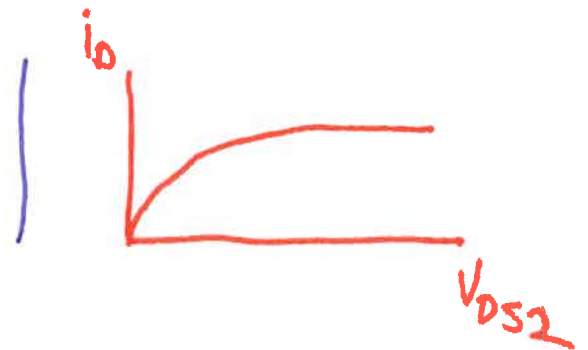
Bad News: $\left\{ \begin{array}{l} \text{Current (power) in Low Output state} \\ \text{Big Current in transition Down} \end{array} \right.$
 speed, size

TTL



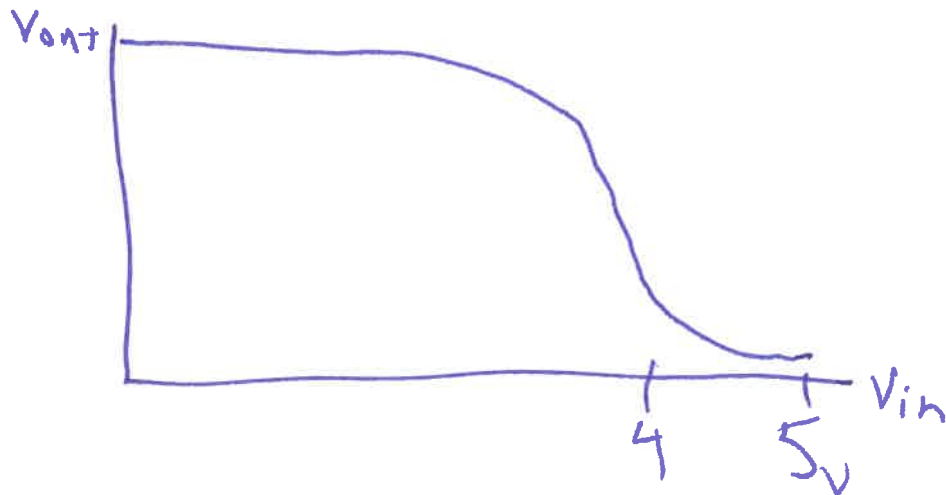
and variation

$$V_{GG} = V_{DD}$$

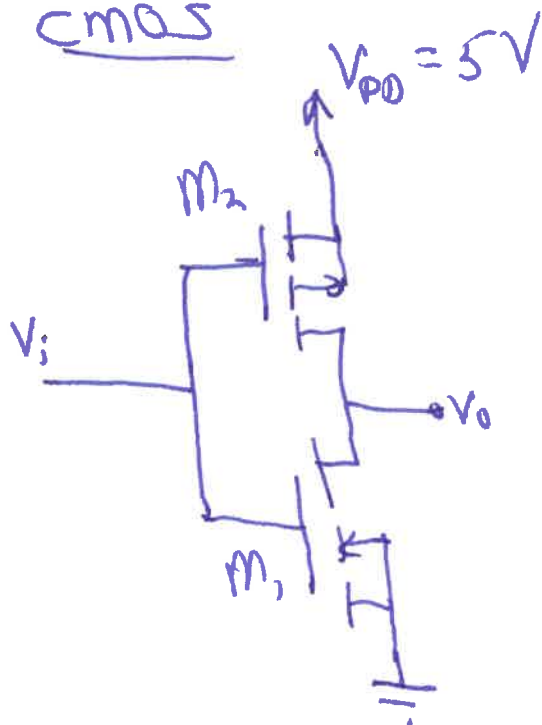
M₂ depletion NFET

$$V_{DS2} + V_{DS1} = V_{DD}$$

After a lot of math



CMOS



input 0 5

V_{GS1} 0 5

V_{GS2} 5 0

V_G 5 0

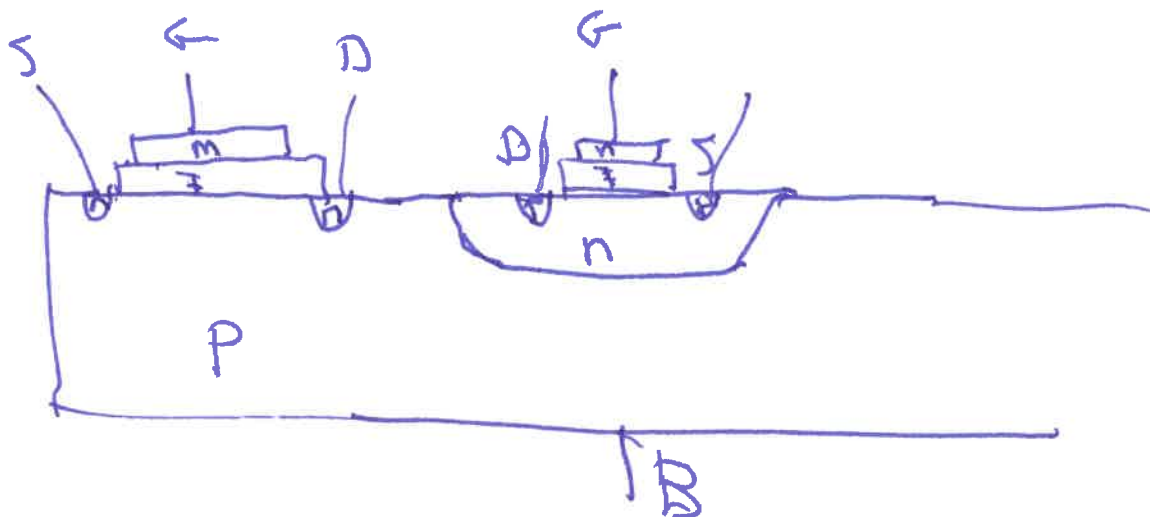
Cutoff

Little detail

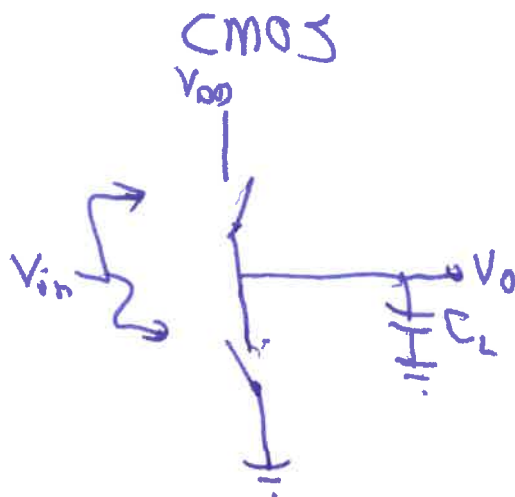
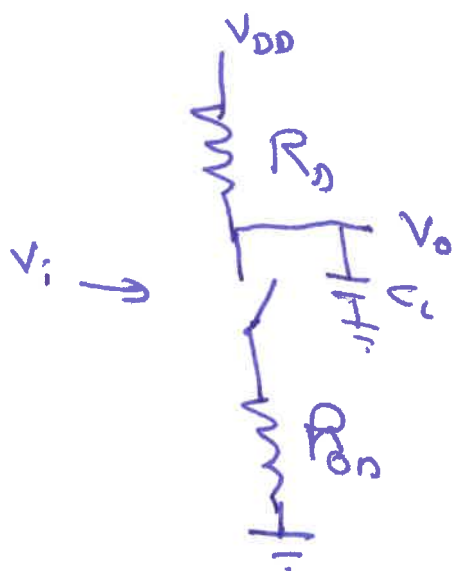
$$K_{p(p)} = \frac{K_{p(n)}}{2}$$

$$\left(\frac{W}{L}\right)_p = 2 \left(\frac{W}{L}\right)_n$$

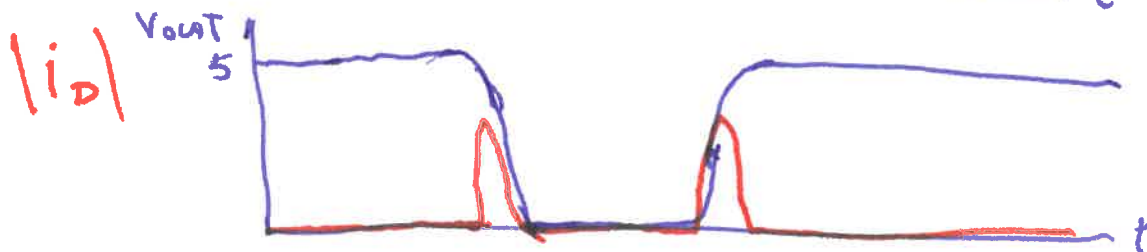
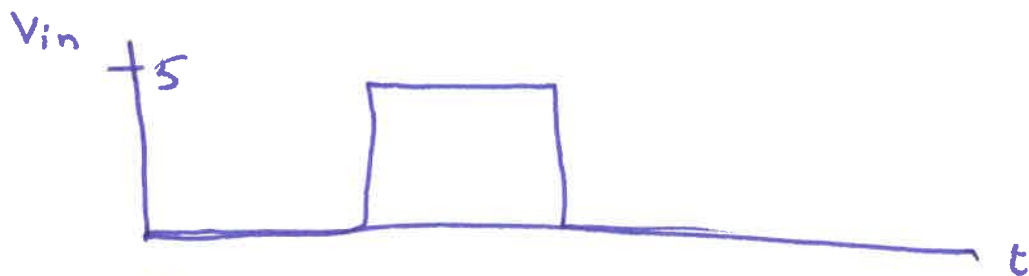
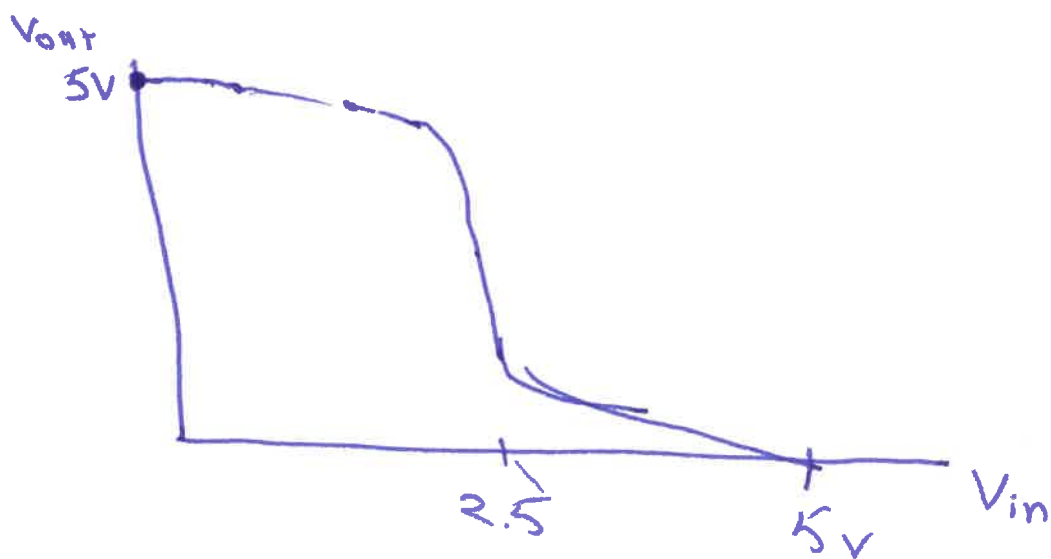
$$K_{(p)} = K_{(n)}$$



RTL (Remember)



Transfer function



(14)

$$i_{D(N)} = k (V_{DD} - V_{T0(N)})^2$$

$$\Delta t = \frac{\Delta Q}{i_D} = \frac{C_L \Delta V}{i_D}$$

$$T_{PHL} = \frac{C_L V_{DD}}{k (V_{DD} - V_{T0(N)})^2}$$

$$T_{PLH} = \frac{C_L V_{DD}}{k (V_{DD} - V_{T0(P)})^2}$$

$$\sim \frac{10^{-12} \text{ F } 1 \text{ V}}{10^{-3} \frac{\text{A}}{\text{V}^2} (1 \text{ V})^2} \approx 10^{-9} \text{ Sec}$$

1 nSec.

