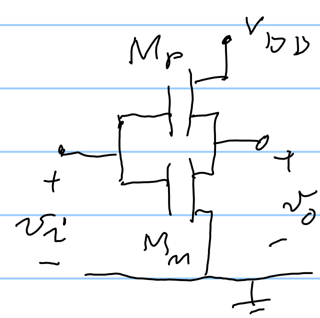
Note Title 10/22/2015

EE303H
10/22/15

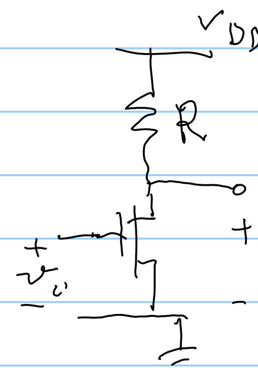
Exam next Th = open book open notes (old exams on web)
current mirrors, differential pair
small signal equivalents, gain

ALD = advanced linear devices
NMOS ALD 1101
PMOS ALD 1102

Inverter

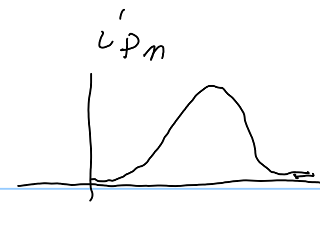


CMOS
uses no power when in a given state



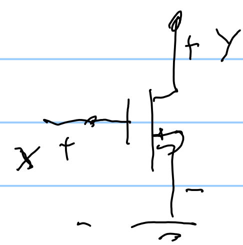
uses power

i_D during a transition

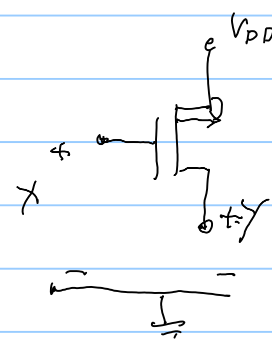


M_n called pull down, M_p is called pull up

$1 = V_{DD}$, $0 = \text{gnd}$



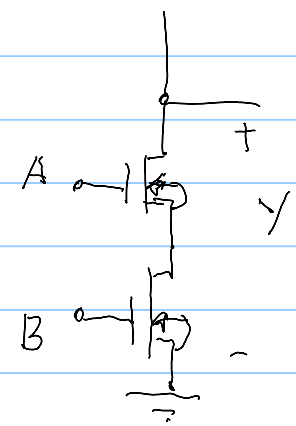
$\tilde{Y} = X$ as binary $\bar{\ } =$ complement



$Y = \bar{X} \Rightarrow \tilde{Y} = X$

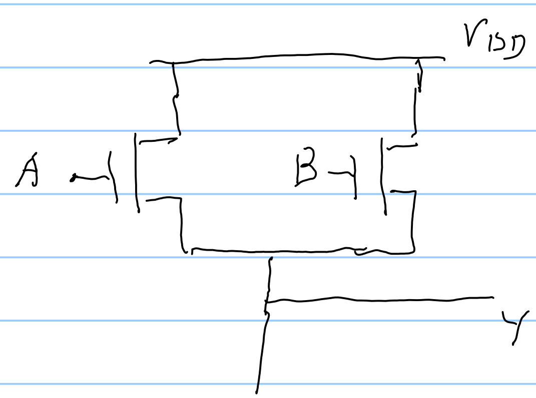
if connect $X_n = X_p$, $Y_n = Y_p \Rightarrow Y = \bar{X}$

for other binary laws, see p. 1112 of Ed. 6



$\overline{Y} = A \cdot B$ $\qquad$ $\cdot$ = and, + = or, $\bar{\ }$ = complement

a pull down for $Y = \overline{A \cdot B}$

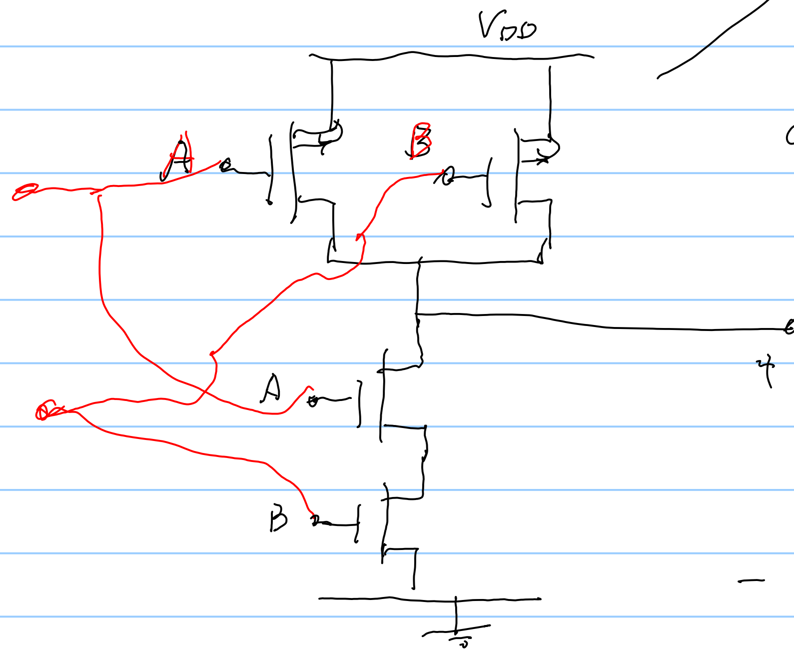


$Y = \overline{A} + \overline{B} \Rightarrow \overline{Y} = \overline{A} \cdot \overline{B}$

pullup

to get a nand $Y = \overline{A \cdot B} = \bar{A} + \bar{B} \Rightarrow Y = \text{Not And}$

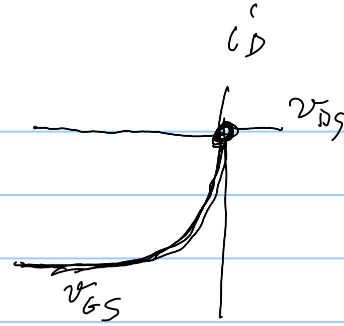
pulldown   pull up

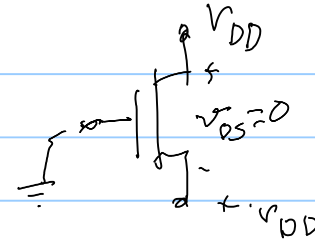


$Y = \overline{A \cdot B}$

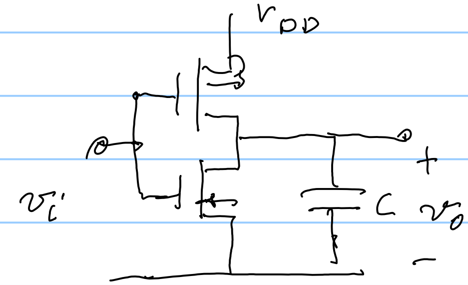
Fig 13.32

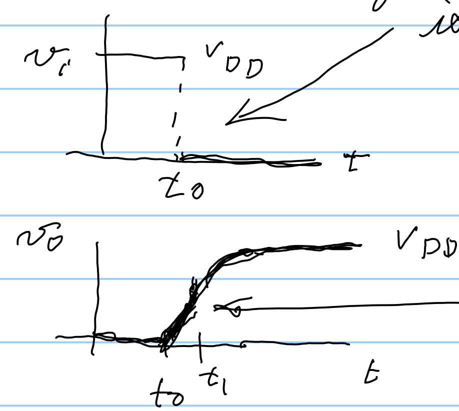
a CMOS NAND





if $v_{GS} = 0$





after t_0 M_n is off so C is fed by i_{Dp}

$v_0 \approx 0$ for $t = t_{0-}$

slope $= \dfrac{i_D(t_{0+})}{C} = \dfrac{k_p(V_{DD}-V_{th})^2}{C}$

$i_C = C\dfrac{dv}{dt}$ if i_C = constant

t_0 = initially M_p is in saturation

when M_p changes to ohmic (= Triode) then

$$-i_{D_p} = i_C = k_p\left(2(V_{DD}-V_{T0})\cdot v_{SD} - v_{SD}^2\right) \qquad \text{but } v_{SD} = V_{DD} - v_O(t)$$

$$C\frac{dv_O}{dt} = k_p\left(2(V_{DD}-V_{T0})(V_{DD}-v_O) - (V_{DD}-v_O)^2\right)$$

$$C\left(-\frac{d[V_{DD}-v_O]}{dt}\right) =$$

$$x = V_{DD} - v_O$$

$$a = \frac{k_p}{C}\cdot 2(V_{DD}-V_{T0})$$

$$b = \frac{k_p}{C}$$

$$\frac{dx}{dt} = -ax + bx^2$$

not a single time constant system

$$\frac{dx}{ax+bx^2} = dt \qquad \int_{x(t_1)}^{x(t)} \frac{-dx}{x(a-bx)} = \int_{t_1}^{t} d\tau = (t-t_1)$$

$$\frac{1}{x(a-bx)} = \frac{c_1}{x} + \frac{c_2}{x-a/b} \implies \text{partial fraction expansion}$$

$$= \frac{1/a}{x} + \frac{-1/a}{x-a/b} \qquad c_1 = \frac{1}{a} \implies \left.\frac{x}{x(a-bx)}\right|_{x=0} = \left. c_1 + \frac{c_2 x}{x-a/b}\right|_{x=0}$$

$$\int_{x(t_1)}^{x(t)} \frac{1}{a}\frac{dx}{x} \mp \int_{x(t_1)}^{x(t)} \frac{c_2}{x - a/b}\, d(x - a/b) = \frac{1}{a}\ln\left(\frac{x(t)}{x(t_1)}\right) + c_2 \ln\left(\frac{x(t) - a/b}{x(t_1) - a/b}\right)$$

$$e^{\frac{1}{a}\ln\left(\frac{x(t)}{x(t_1)}\right) + c_2 \ln\left(\frac{x(t) - a/b}{x(t_1) - a/b}\right)} = e^{t - t_1}$$

$$x = V_{DD} - v_0$$

allows an analytic solution for charging C from a gate versus time.