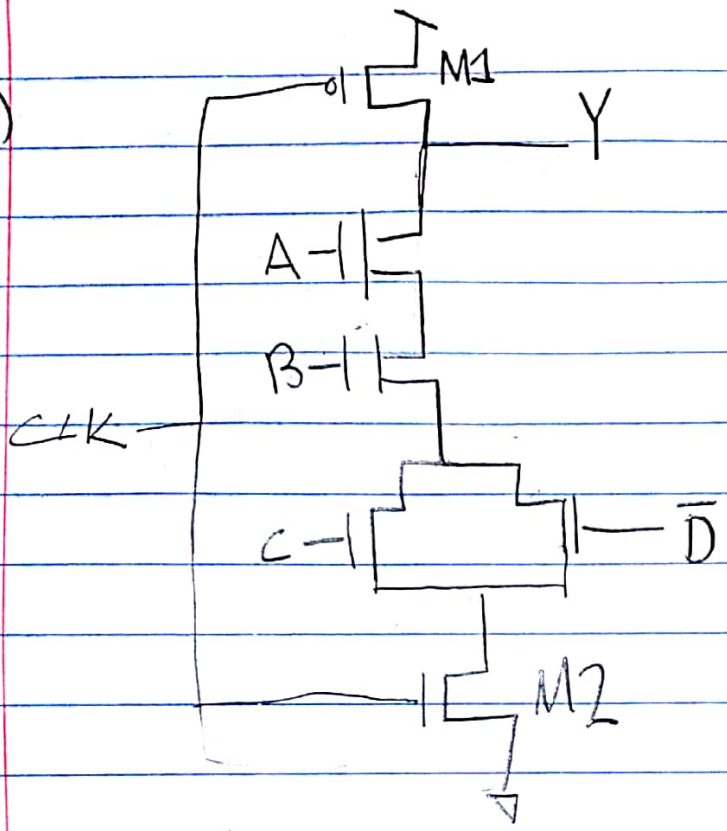
2a)



b) $\tau_{H\to L} = (4+3+2+1)\,RC = 10\,RC = 10 \times 145\Omega \times 15fF =$ 21.750 ps

$t_{p\,H\to L} = 0.69 \cdot \tau_{H\to L} = 15,008$ ps

$\tau_{L\to H} =$ 8.7 ns

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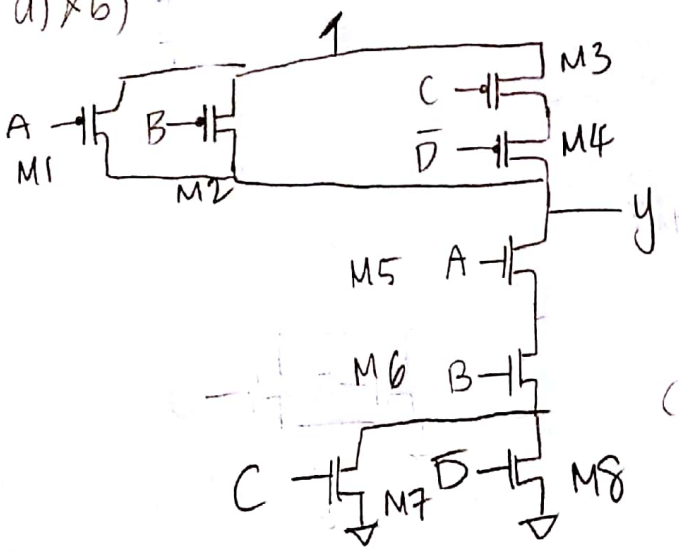
EE 307 HW 7
Mar 2, 2018
Collaborated w/
Jessie Folan

1. $Y = \overline{A \cdot B} + (\overline{C + D})$

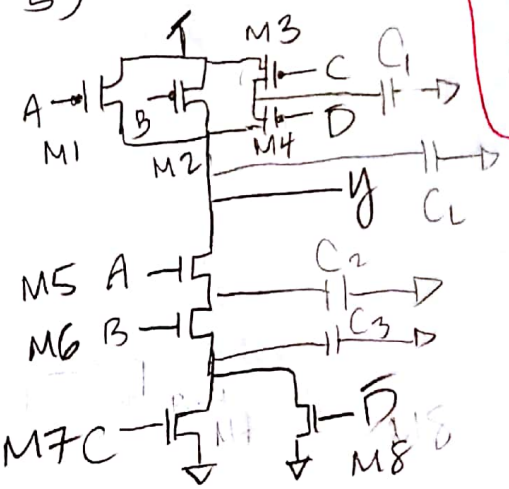
$= \overline{\overline{(A \cdot B)} + (\overline{C + D})}$

$= \overline{(A \cdot B) \cdot (C + \bar{D})}$

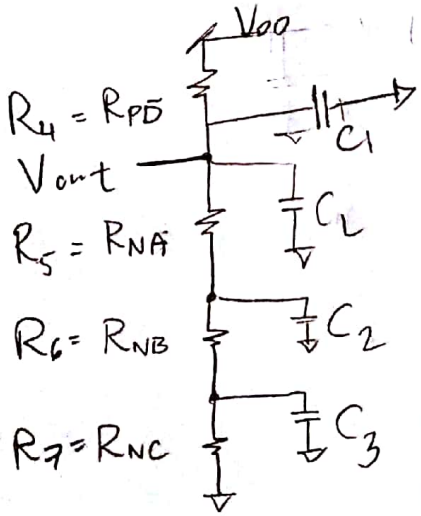
a) & b)



b)

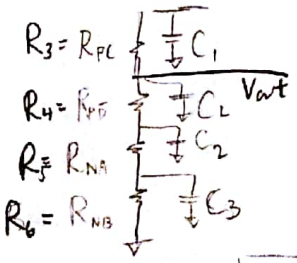


c) $A = B = D = 1$ & $C = 0$
to $A = B = D = C = 1$



d) $T = (R_{N7} \cdot C_3) + (R_{16} + R_{17}) \cdot C_2$
$+ (R_7 + R_6 + R_5) \cdot C_L$
$+ (R_7 + R_6 + R_5 + \ldots) \cdot C_1$

e) when $A = B = C = D = 1 \Rightarrow A = B = D = 1$ & $C = 0$
$\Rightarrow R_{PC} \cdot C_1$ turns on



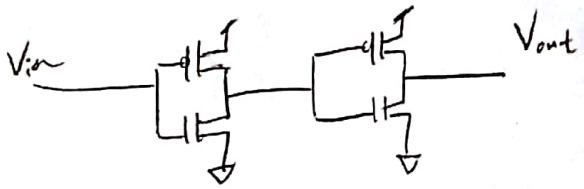
$T = (R_3 \cdot C_1) + (R_3 + R_4) C_L$
$+ (R_3 + R_4 + R_5) C_2 +$
$(R_3 + R_4 + R + R) C_3$

$\frac{1}{T} =$

3. $R_{ONN} = 145\Omega$ $R_{ONP} = 325\ \&\ C$, $C_{out} = 20.2fF$

C on the input 26.82F, wire is in N+

wire 2 μm long & 0.05μm wide



$R_{wire} = \frac{L}{W}\frac{\Omega}{sq}$

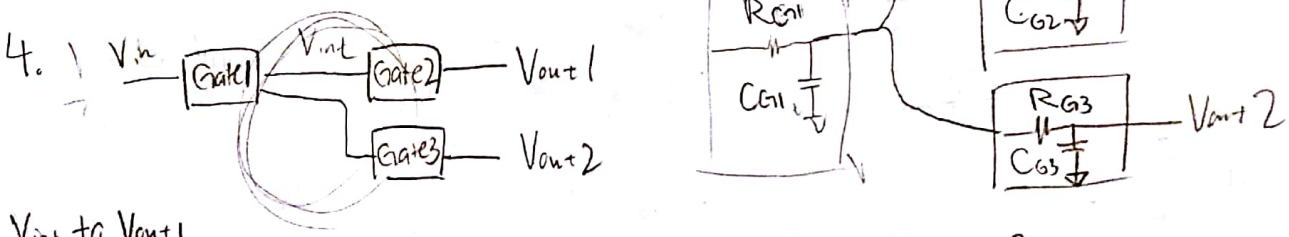
$= (6.2\frac{\Omega}{sq})(\frac{2}{0.05}\frac{\mu m}{\mu m}) = 248\Omega$

$\tau = (145\Omega \times 20.2fF) + (145 + 248\Omega) \times 26.82fF = 13.47ps$

$t_{p_{0\text{to}VDD}} = (0.69)(13.47ps)$

$t_{p\text{to}VDD} = 9.2943ps$

4.



V_{int} to V_{out1}

$\tau_{int} = R_{G1}C_{G1} + (R_{G1}+R_{G2})C_{G2} + (R_{G1}+R_{G3})C_{G3}$

$\tau_1 = R_{G1}C_{G1} + R_{G1}C_{G3} + (R_{G1}+R_{wire})C_{G2}$

$t_{p1} = t_{pG1} + 0.69(\tau_1)$

$\tau_2 = R_{G2}C_{G2}$

$t_{p2} = t_{pG2} + 0.69(R_{G2}C_{G2})$

$t_{p\,total} = t_{p1} + t_2$

$= t_{pG1} + 0.69(R_{G1}C_{G1} + R_{G1}C_{G3} + (R_{G1}+R_{wire})C_{G2} + t_{pG2} + 0.69R_{G2}C_{G2}$

V_{in} to V_{out2}

$\tau_3 = R_{G1}C_{G1} + R_{G1}C_{G2} + (R_{G1}+R_{wire})C_{G3}$

$t_{p3} = t_{pG1} + 0.69(R_{G1}\cdot C_{G1} + R_{G1}C_{G2} + (R_{G1}+R_{wire})C_{G3})$

$\tau_4 = R_{G2}C_{G2}$

$t_{p4} = t_{pG3} + 0.69R_{G3}C_{G3}$

$t_{p\,total} = t_{pG1} + 0.69(R_{G1}C_{G1} + R_{G1}C_{G2} + (R_{G1}+R_{wire})C_{G3} + t_{pG2} + 0.69R_{G3}C_{G3}$

5.

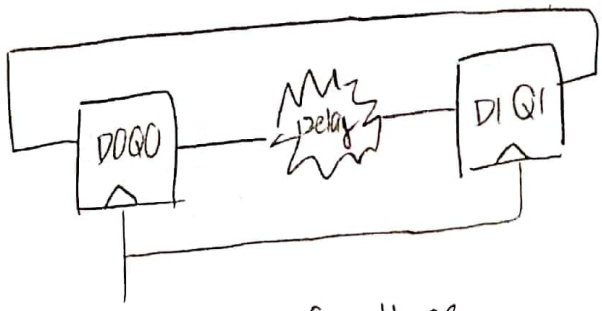
a) $t_{pINV_b} = t_{pNANDC} + t_{pNANDE} + t_{pNANDF}$ or $t_{pNANDD} + t_{pNANDE} + t_{pNANDF}$

b) $t_{phold} = t_{pINVb}$

c) $t_{CLK \to a} = t_{INV3} + t_{pNANDd} + t_{pNANDC} + t_{pNANDE} + t_{pNANDF}$

d) $t_{setup} = t_{INVA}$

*e)



i) There is a violation for these

Hold time violation

$t_{clkQ0} + t_{delay} = 2ns + 3ns = 5ns < t_{hold1} = 8ns$

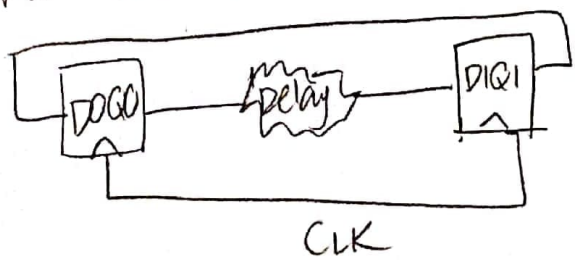
Setup time violation

$t_{clkQ0} + t_{delay} = 8ns + 6ns = 14ns < t_{setup1} = 20ns$

ii) The setup violation can be fixed w/ adjusted clock speed. The hold violation cannot.

iii) The setup violation ... hold time violation ... can be solved by adding inverters to increase the transition time. However this will increase the power consumption.

iii)



iv) $f = \frac{1}{T} = \frac{1}{20ns + 14ns} = 29\,MHz$

The hold time shouldn't be affected by the clock speed.

v) The setup violation can be fixed by slowing the clock