

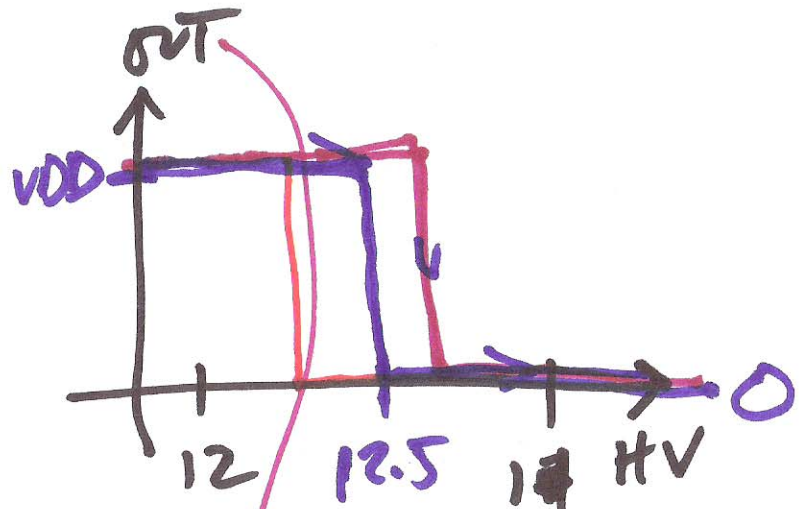
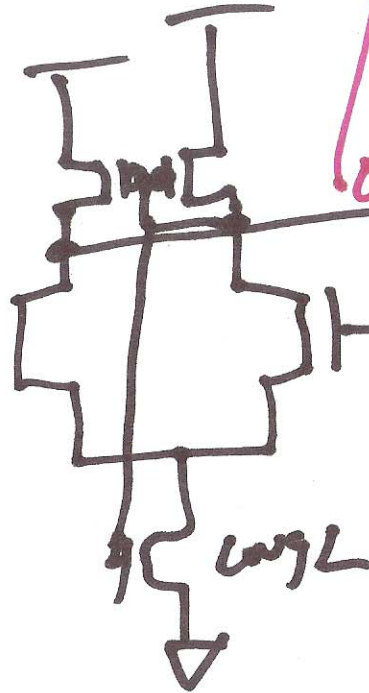
1)

123 = HV
12 → 13

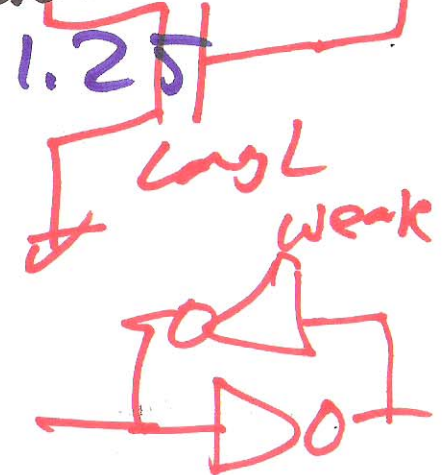


HV
10

OUT
12



OUT
10
off

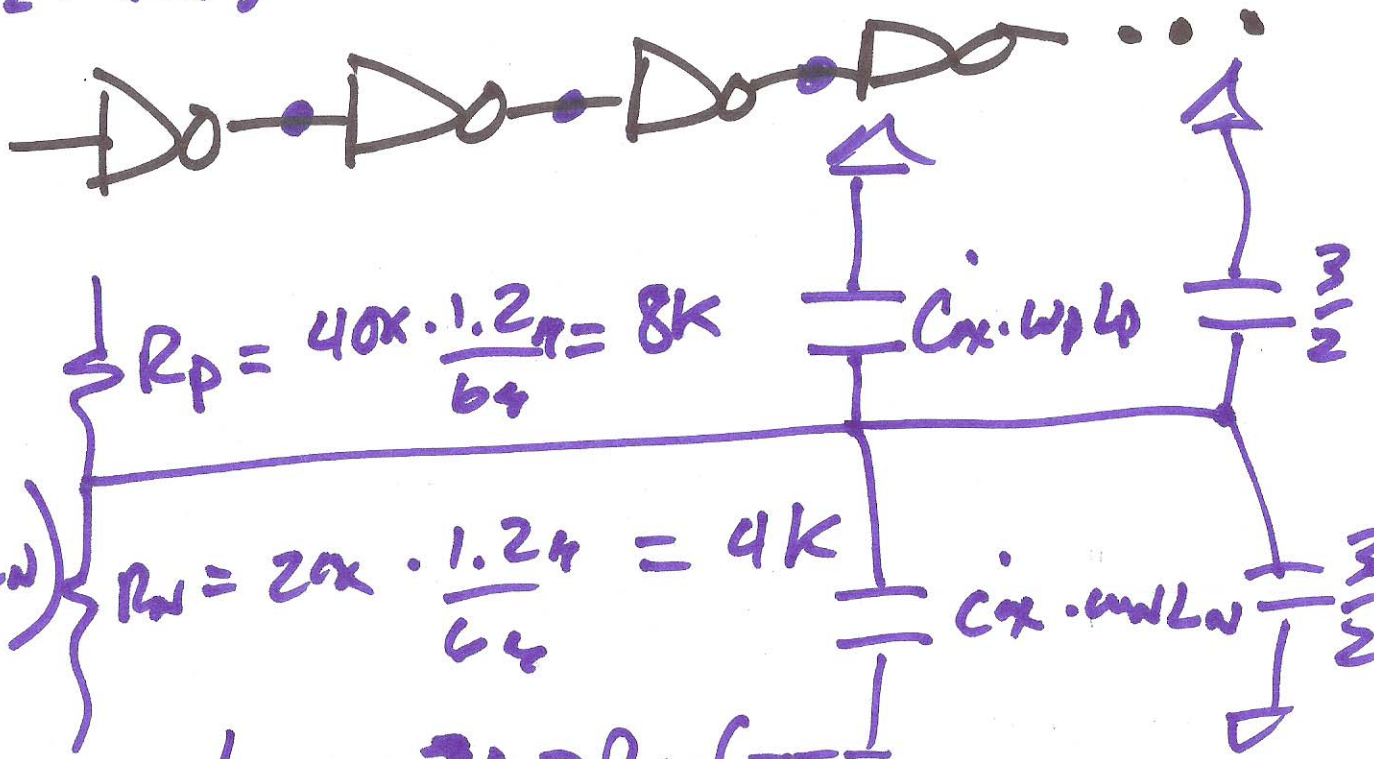


2)

Calculate the delay of an inverter in a N stage ring oscillator. $\omega_N = \omega_P = 64$, $L_N = L_P = 1.2\mu$

$R_N = 20k$ $R_P = 40k$
 $C_{ox} = 2.5 fF/\mu m^2$

$$f_{osc} = \frac{1}{N(t_{PHL} + t_{PLH})}$$



$$C_{TOT} = \frac{5}{2} C_{ox}'$$

$$(W_P L_P + W_N L_N)$$

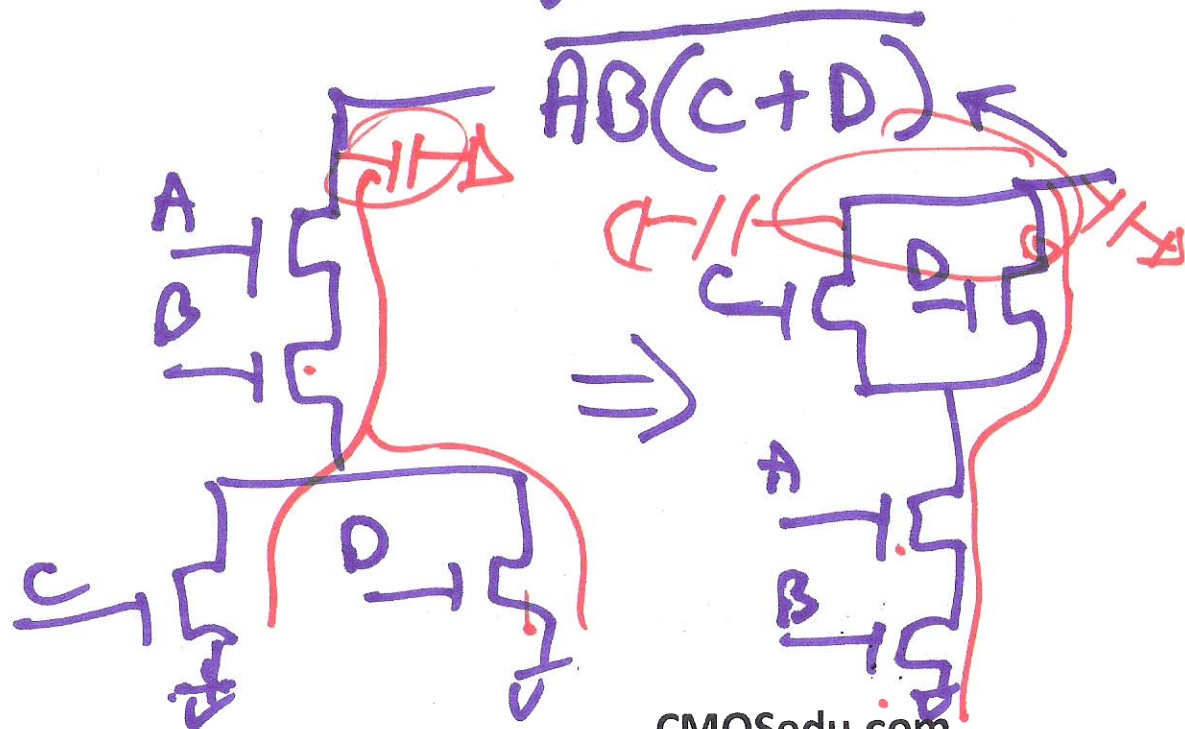
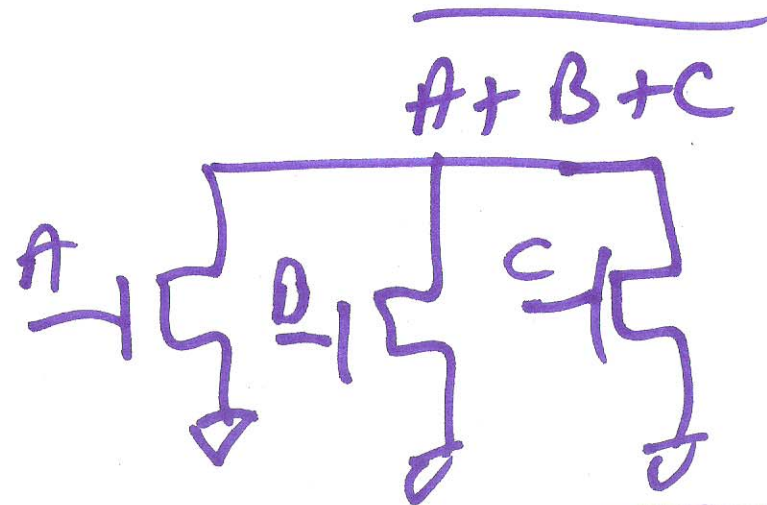
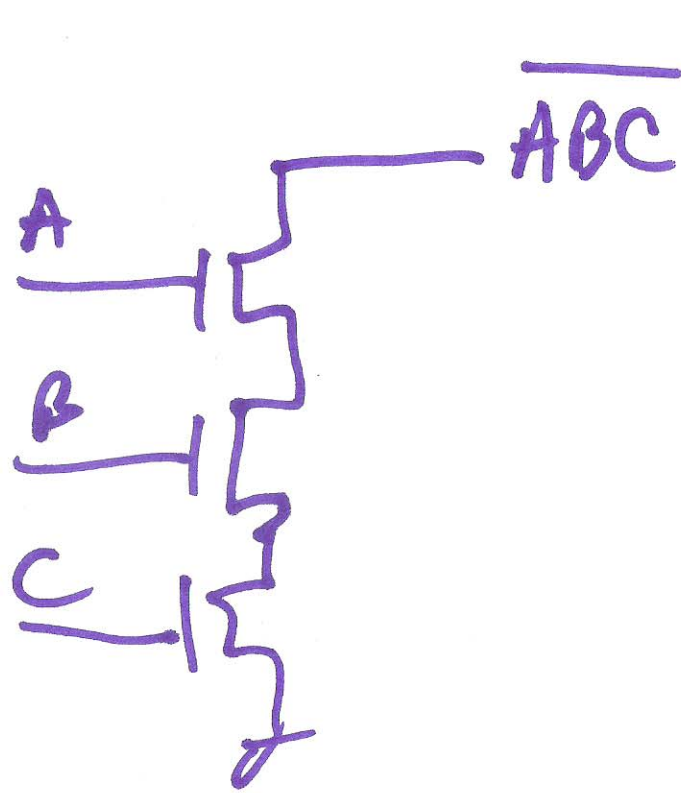
$$R_P = 40k \cdot \frac{1.2\mu}{64} = 8k$$

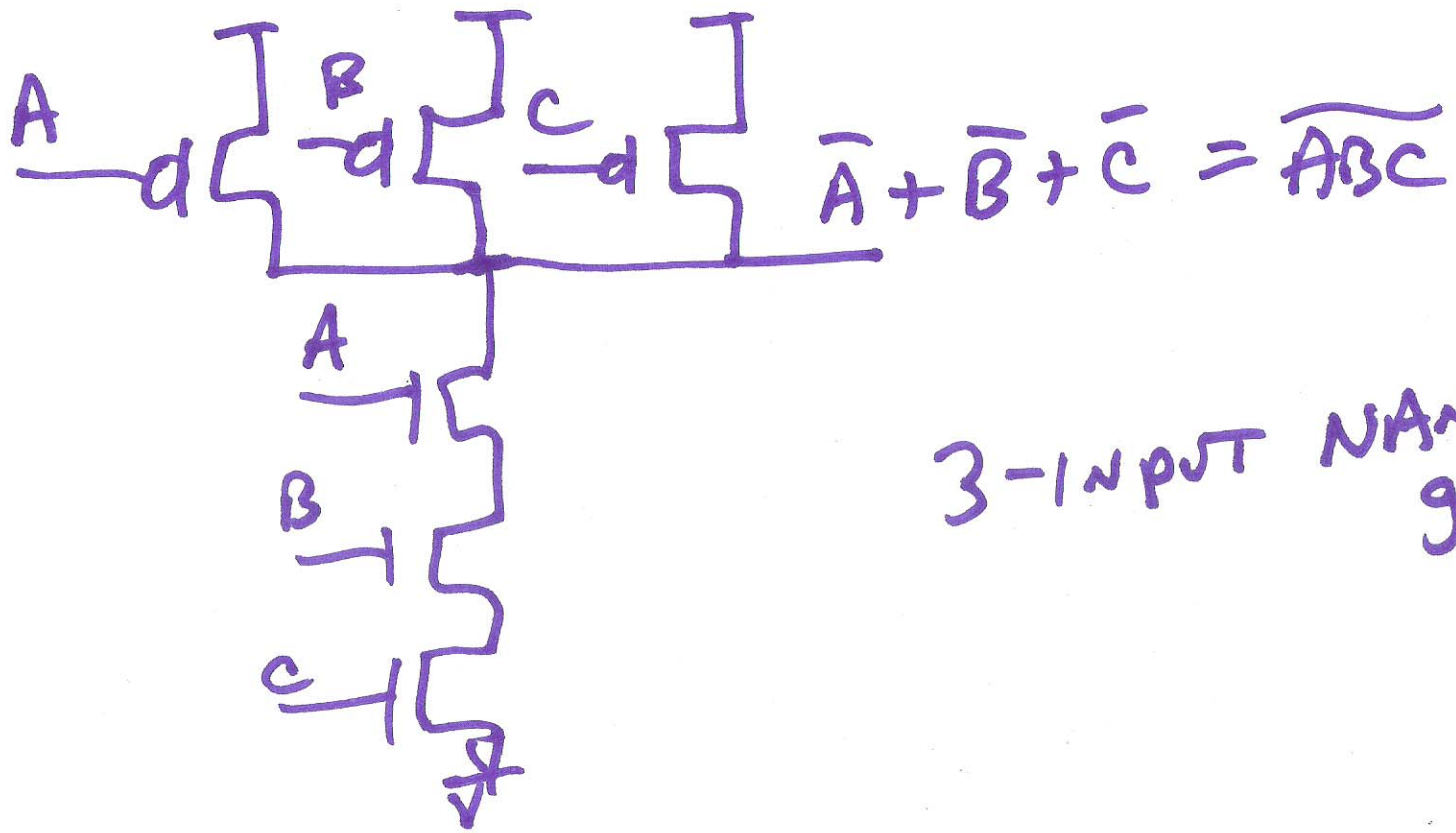
$$R_N = 20k \cdot \frac{1.2\mu}{64} = 4k$$

$$t_{PHL} = \frac{3}{5} 0.7 R_N \cdot C_{TOT}$$

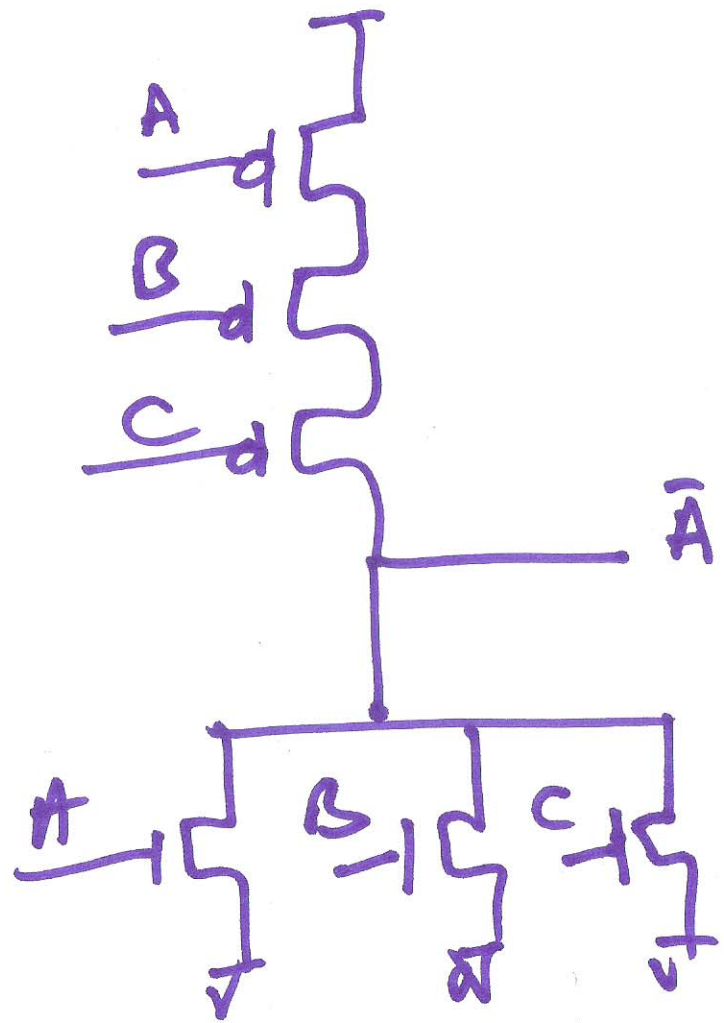
$$t_{PLH} = 0.7 R_P \cdot C_{TOT}$$

Complex Cmos logic





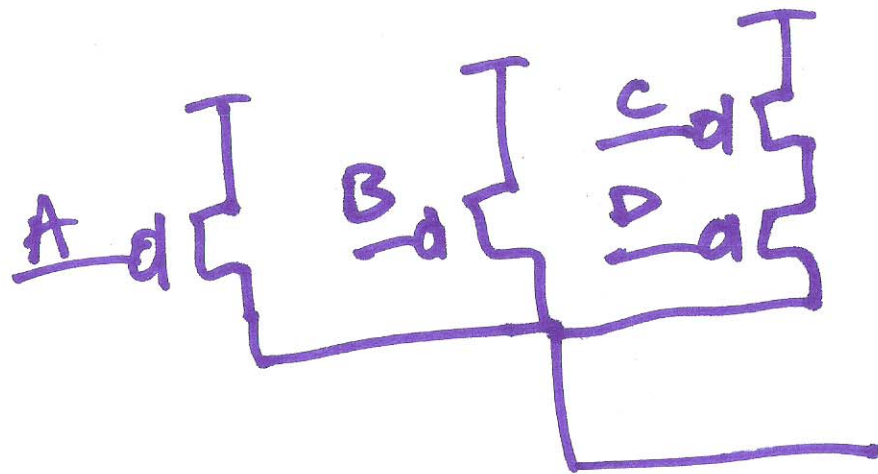
6)



$$\bar{A} \bar{B} \bar{C} = \overline{A+B+C}$$

3-input NOR

6)

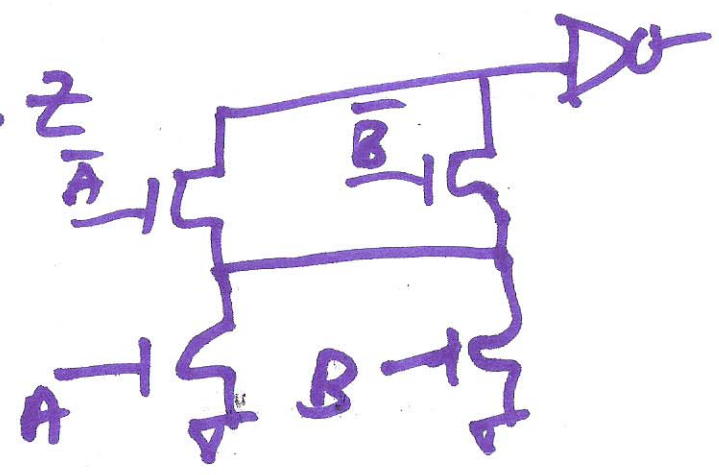
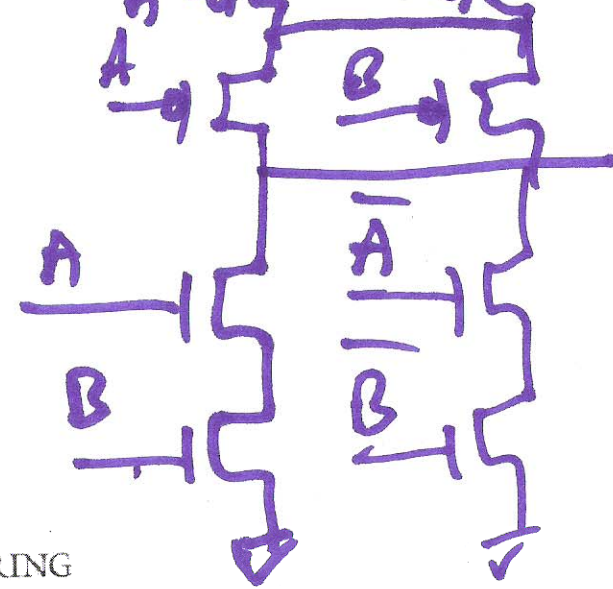


$$\frac{\bar{A} + \bar{B} + \bar{C} \bar{D}}{AB(C+D)}$$

A	B	XOR (Z)
0	0	0
0	1	1
1	0	1
1	1	0

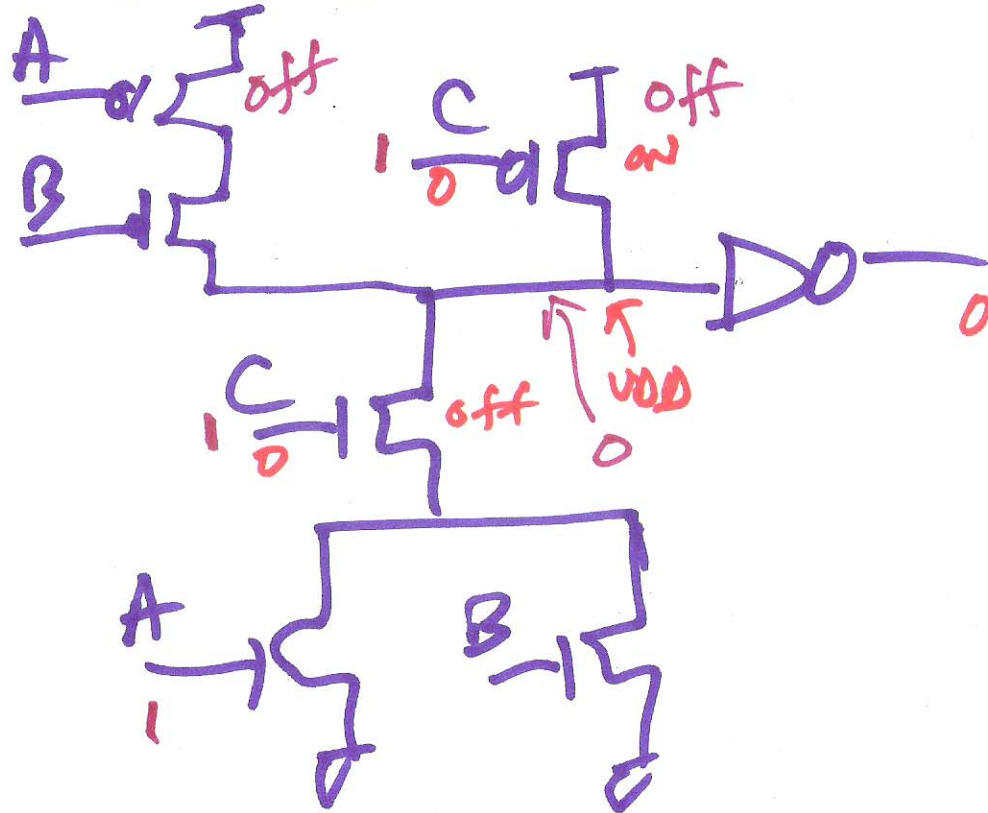
$$Z = \bar{A} \bar{B} + \bar{A} B$$

$$\rightarrow (A+B)(\bar{A}+\bar{B})$$



7)

$$z = (A + B)C$$



8)