

Homework from Chapter 7

7.8

a. $V_i = V_L = 0V$, $V_o = V_H = 3.3V$

$\frac{M_N}{M_P}$ $V_{GS} = 0V$, $V_{DS} = 3.3V \Rightarrow M_N$ is off
 $\frac{M_P}{M_N}$ $V_{GS} = -3.3V$, $V_{DS} = 0V \Rightarrow V_{DS} > V_{GS} - V_{TP} \Rightarrow M_P$ is ~~saturated~~ ^{linear}

b. $V_i = V_H = 3.3V$, $V_o = V_L = 0V$

$\frac{M_N}{M_P}$ $V_{GS} = 3.3V$, $V_{DS} = 0V$, $V_{DS} < V_{GS} - V_{TN} \Rightarrow M_N$ is linear
 $\frac{M_P}{M_N}$ $V_{GS} = 0V$, $V_{DS} = -3.3V$, $V_{GS} > V_{TP} \Rightarrow M_P$ is off

c. $V_i = V_o = 1.65V$

$\frac{M_N}{M_P}$ $V_{GS} = 1.65V$, $V_{DS} = 1.65V$, $V_{DS} > V_{GS} - V_{TN} \Rightarrow M_N$ is saturated
 $\frac{M_P}{M_N}$ $V_{GS} = -1.65V$, $V_{DS} = -1.65V$, $V_{DS} < V_{GS} - V_{TP} \Rightarrow M_P$ is saturated

7.23

$$R_{onN} = \frac{1}{k_n (V_H - V_{TN})} = \frac{1}{(21/1)(25 \times 10^{-6})(3.3 - 0.75)} = 7843.14 \Omega$$

$$R_{onP} = \frac{1}{k_p (V_H + V_{TP})} = \frac{1}{(5/1)(10 \times 10^{-6})(3.3 - 0.75)} = 7843.14 \Omega$$

$$\tau_{PHL} = R_{onN} C \left\{ \ln \left[4 \left(\frac{V_H - V_{TN}}{V_H + V_L} \right) - 1 \right] + \frac{2V_{TN}}{V_H - V_{TN}} \right\} = 1.39 R_{onN} C = 2.18 \text{ ns}$$

$$\tau_{PLH} = 1.39 R_{onP} C = 2.18 \text{ ns}$$

Rise time $\tau_r = 2 \tau_{PLH} = 4.36 \text{ ns}$

Fall time $\tau_f = 2 \tau_{PHL} = 4.36 \text{ ns}$

Propagation delay $\tau_p = \frac{1}{2} (\tau_{PHL} + \tau_{PLH}) = 2.18 \text{ ns}$

7.24 (same as 7.23)

$$\tau_{PHL} = \tau_{PLH} = 1.35 R_{onN} C = 2.13 \text{ ns}$$

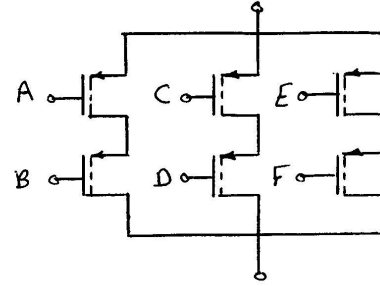
$$\tau_r = \tau_f = 4.26 \text{ ns} \quad \& \quad \tau_p = 2.13 \text{ ns}$$

7.58

a. $Y = \overline{(A+B)(C+D)(E+F)}$

b. NMOS $(\frac{W}{L})_N = 3(\frac{2}{1}) = \frac{6}{1}$

PMOS $(\frac{W}{L})_P = 2(\frac{5}{1}) = \frac{10}{1}$



7.60

a. $Y = \overline{F + G(C+E) + A(C+E)(B+D)}$

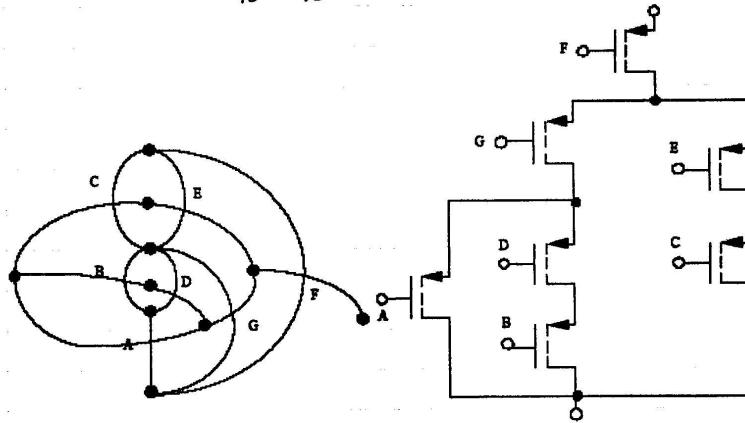
b. NMOS $(\frac{W}{L})_{A,B,C,D,E} = 3(2)(\frac{2}{1}) = \frac{12}{1}$

$(\frac{W}{L})_F = 2(\frac{2}{1}) = \frac{4}{1}$, $(\frac{W}{L})_G = \frac{1}{\frac{1}{4} - \frac{1}{12}} = \frac{6}{1}$

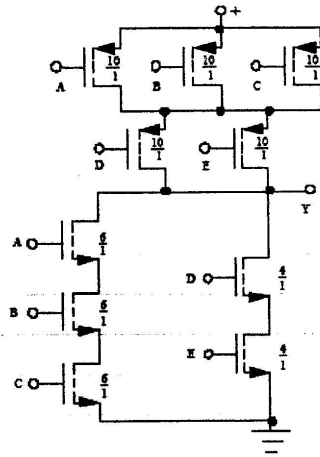
PMOS $(\frac{W}{L})_{F,G,B,D} = 4(2)(\frac{5}{1}) = \frac{40}{1}$

$(\frac{W}{L})_A = \frac{1}{\frac{1}{10} - \frac{2}{40}} = \frac{20}{1}$

$(\frac{W}{L})_{C,E} = 2 \frac{1}{\frac{1}{10} - \frac{1}{40}} = \frac{26.7}{1}$



7.63



7.63