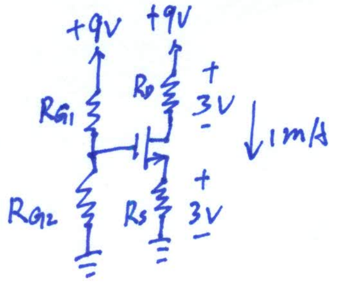
HW11 EE 20242

5.98



$$I_D = 1\,mA = \frac{1}{2} K_n V_{ov}^2 \Rightarrow V_{ov} = 1V$$

$$V_G - 3V - V_t = V_{ov} = 1V \Rightarrow V_G = 5V$$

$$\frac{5V}{9V} = \frac{R_{G2}}{R_{G1}+R_{G2}} = \frac{22\,M\Omega}{R_{G1}+22\,M\Omega} \Rightarrow R_{G1} = 17.6\,M\Omega\ (18\,M\Omega)$$

$$R_D = R_S = \frac{3V}{1mA} = 3\,K\Omega \qquad R_{G2} = 22\,M\Omega$$

$$V_G = \frac{\cancel{18}\,22}{18+22} \times 9V = 4.95V$$

$$I_D = \frac{1}{2} K_n V_{ov}^2 = \frac{1}{2} \times 2\,mA/V^2 \times (4.95V - I_D \cdot 3\,K\Omega - 1V)^2 \Rightarrow I_D = 0.985\,mA$$

$V_D = 9V - I_D R_D = 9V - 0.985\,mA \times 3\,K\Omega = 6.045V$, $V_{GD} = -1.09V$

At the edge of saturation. $V_{GD} = V_t = 1V$, so V_D is 2.09V from the edge of saturation.

5.111 (a) $A_{vo} = -\frac{2(V_{DD}-V_D)}{V_{ov}} = -\frac{2(10-2.5)}{1} = -15\,V/V$

(b) $I_D = \frac{1}{2}K_n V_{ov}^2 \Rightarrow I_D = \frac{0.5}{4} = 0.125\,mA$, $R_D = \frac{(10-2.5)V}{0.125} = 60\,K\Omega$,

$g_m = \frac{2 I_D}{V_{ov}} = 0.5\,mA/V$, $r_o = \frac{V_A}{I_D} \Rightarrow r_o = 4 \times \frac{75}{0.5} = 600\,K\Omega$

$A_{vo} = 2 \times (-15\,V/V) = -30\,V/V$

(c) $A_{vo} = -g_m (r_o \| R_D) = -0.5\,(600\,K\Omega \| 60K) = -27.3\,V/V$

$R_{out} = R_D \| R_o = 54.5\,K\Omega$

(d) $R_{in} = R_G = 4.7\,M\Omega$, $R_o = 54.5\,K\Omega$

$$G_v = \frac{R_{in}}{R_{in}+R_{sig}} A_{vo} \frac{R_L}{R_L+R_o} = \frac{4.7}{4.7+0.1} \times 27.3 \times \frac{15}{15+54.5} = 5.77\,V/V$$

(e) As we can see by reducing V_{ov} to half of its value or equivalently multiply drain current by 4. A_{vo} is almost doubled, while R_{out} is multiplied by 4. As a result, G_v which is proportional to both A_{vo} and R_{out} is only slightly reduced.

13.1 $NM_L = V_{IL} - V_{OL} = 1.2 - 0.2 = 1V$

$NM_H = V_{OH} - V_{IH} = 2.5 - 1.5 = 1V$

13.4 (a) Worse case

$NM_H = V_{OH,min} - V_{IH} = 2.4 - 2 = 0.4V$

$NM_L = V_{IL,max} - V_{OL} = 0.8 - 0.4 = 0.4V$

(b) $P_{Dav} = \frac{1}{2}[5 \times 3m + 5 \times 1m] = 10\,mW$

(c) Dynamic power dissipation $= fCV_{DD}^2 = 10^6 \times 45 \times 10^{12} \times 25 = 1.13\,mW$

(d) t_p (typical) $= \frac{1}{2}(t_{PHL} + t_{PLH}) = \frac{1}{2}(7n + 11n) = 9ns$

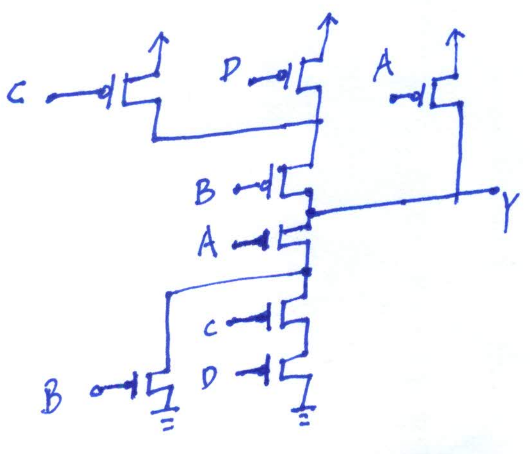
t_p (maximum) $= \frac{1}{2}(15n + 22n) = 18.5ns$

13.35. $t_{PHL} = 0.69 R_N C$ $\quad t_{PLH} = 0.69 R_P C$

$(\frac{W}{L})_n = (\frac{W}{L})_p = 1$ $\quad R_N = \frac{12.5}{(\frac{W}{L})_N} = 12.5\,K\Omega$ $\quad R_P = \frac{30}{(\frac{W}{L})_P} = 30\,K\Omega$

$\Rightarrow t_p = \frac{1}{2}(t_{PLH} + t_{PHL}) = \frac{0.69 \times 10 \times 10^{-15}}{2}(30 \times 10^3 + 12.5 \times 10^3) = 146.6\,ps$

13.45. For $Y = \overline{A + B(C+D)}$, the PDN can be drawn directly, then we can drawn PUN as direct dual:



13.46. $Y = \bar{A}BC + A\bar{B}C + AB\bar{C}$

$2(3\times3)=18$ MOS for the gate itself, $3\times2=6$ for the required inverters. which needs 24 transistors in total.

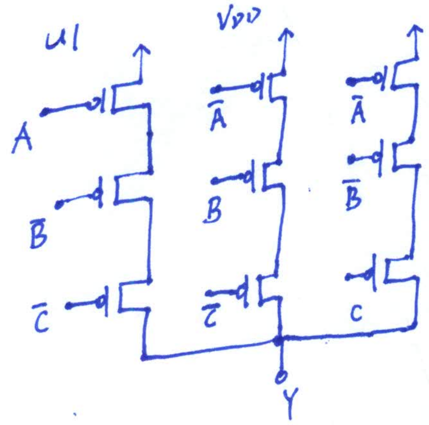
For PUN directly: (Inverting variables)

For PDN, $Y = \bar{A}BC + A\bar{B}C + AB\bar{C}$. Correspondingly:

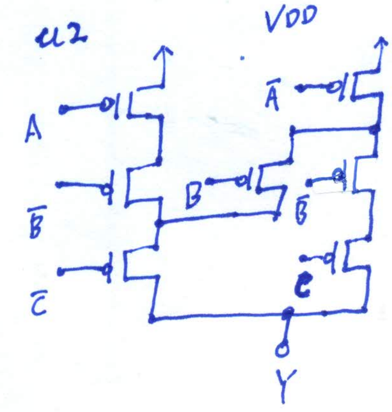
$$\bar{Y} = \overline{\bar{A}BC + A\bar{B}C + AB\bar{C}} = \overline{\bar{A}BC}\cdot\overline{A\bar{B}C}\cdot\overline{AB\bar{C}}$$

$$= (A+\bar{B}+\bar{C})(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+C) = ABC + A\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}\bar{B}\bar{C} + \bar{A}BC,$$

and replicating $\bar{A}\bar{B}\bar{C}$



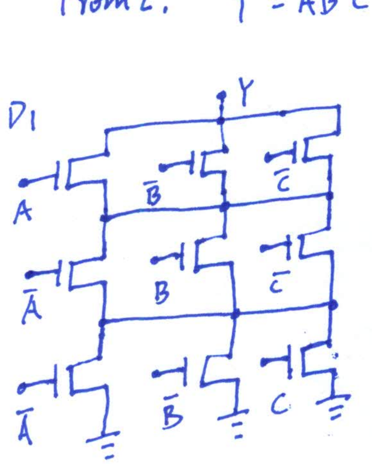
path merging

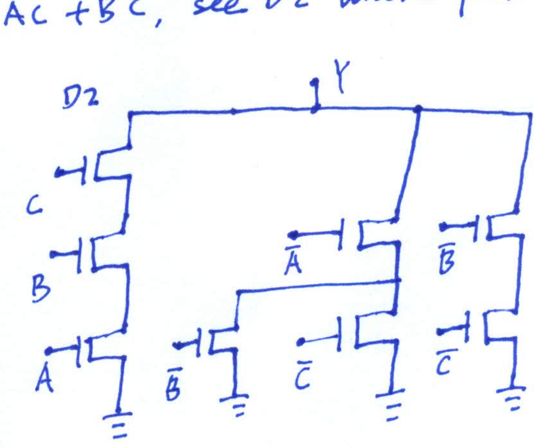


For the PDN directly:

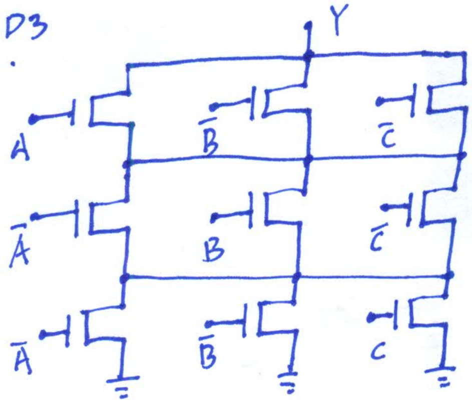
From 1, $\bar{Y} = (A+\bar{B}+\bar{C})(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+C)$

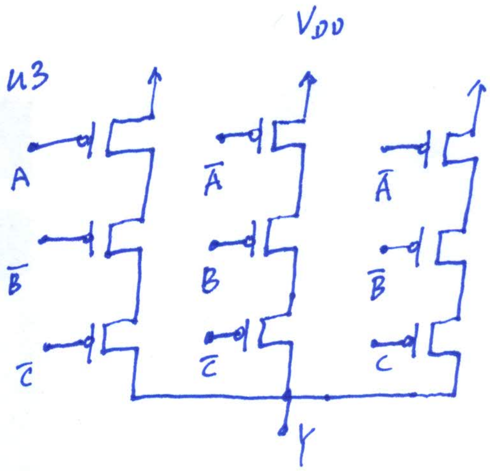
From 2, $\bar{Y} = ABC + \bar{A}\bar{B} + \bar{A}\bar{C} + \bar{B}\bar{C}$, see D2 where path merging is included.





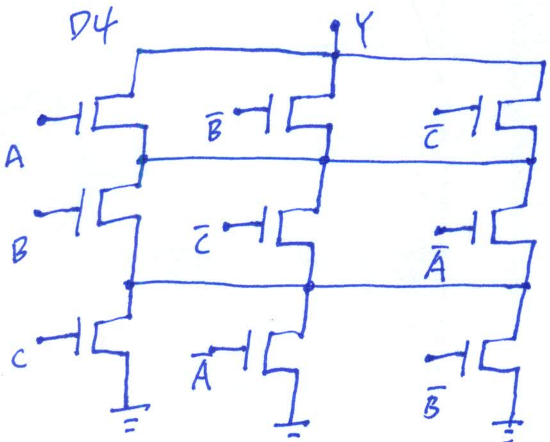
Simply, replacing series connections with paralled connections.

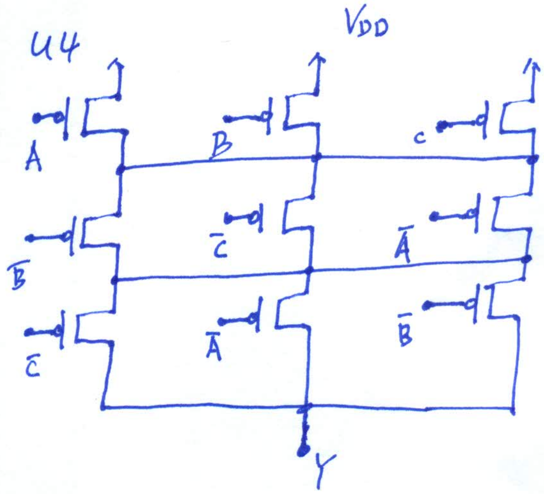




see that D3 is identical to D1 in detail.

For the PUN from PND. See that both parallel and series connections can be identified for transformation, but that the series one contain variables and their complements are therefore always open. Thus, converting parallel paths to serial ones. See this the same as U1





See that U4, while note the same as U1, is highly related, having some variable exchange in the middle and right columns. Clearly, there are lots of variations of the completely-connected array.