TSEI03 Homework 2: Solution

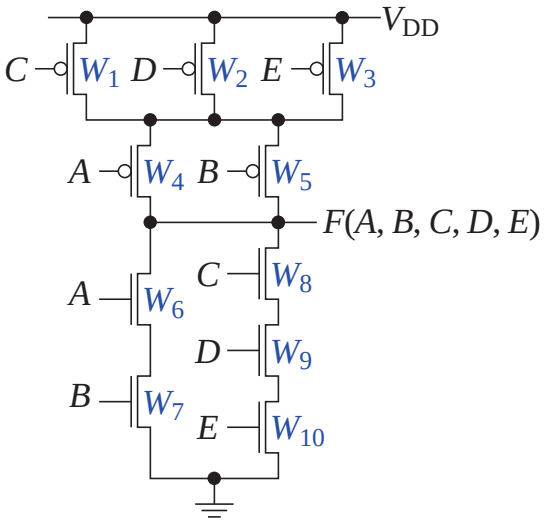
Identify logic function from gate schematic

$$F\left(A,B,C,D,E\right)=\overline{\overline{\left(\overline{A\cdot B}\right)+\left(\overline{C\cdot D}\right)+\overline{E}}}=\overline{A\cdot B+C\cdot D\cdot E}$$

Switch nets

$$\begin{cases}S_{\mathrm{p}}=F\left(\overline{A},\overline{B},\overline{C},\overline{D},\overline{E}\right)=\overline{\overline{A}\cdot\overline{B}+\overline{C}\cdot\overline{D}\cdot\overline{E}}=\left(A+B\right)\left(C+D+E\right)\\ S_{\mathrm{n}}=\overline{F\left(A,B,C,D,E\right)}=\overline{\overline{A\cdot B+C\cdot D\cdot E}}=A\cdot B+C\cdot D\cdot E\end{cases}$$

Transistor schematic with annotated widths, W_k



Select all channel lengths to minimum, L_{min}, and express the widths in units of L_{min}. Worst case resistance occurs when a single path conducts. Design the widths of a single conduction path to be equal. Using $R\propto 1/W$, we should design the six pull-up paths to have an equivalent resistance of $W_{\mathrm{p}}=5L_{\mathrm{min}}$:

$$\begin{cases}W_1^{-1}+W_4^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\\ W_1^{-1}+W_5^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\\ W_2^{-1}+W_4^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\\ W_2^{-1}+W_5^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\\ W_3^{-1}+W_4^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\\ W_3^{-1}+W_5^{-1}=\left(5L_{\mathrm{min}}\right)^{-1}\end{cases}\overset{\text{equal widths in path}}{\Rightarrow}\begin{cases}W_1=W_4=10L_{\mathrm{min}}\\ W_1=W_5=10L_{\mathrm{min}}\\ W_2=W_4=10L_{\mathrm{min}}\\ W_2=W_5=10L_{\mathrm{min}}\\ W_3=W_4=10L_{\mathrm{min}}\\ W_3=W_5=10L_{\mathrm{min}}\end{cases}$$

Design the two pull-down paths to have an equivalent resistance of $W_{\mathrm{n}}=1.5L_{\mathrm{min}}$:

$$\begin{cases}W_6^{-1}+W_7^{-1}=\left(1.5L_{\mathrm{min}}\right)^{-1}\\ W_8^{-1}+W_9^{-1}+W_{10}^{-1}=\left(1.5L_{\mathrm{min}}\right)^{-1}\end{cases}\overset{\text{equal widths in path}}{\Rightarrow}\begin{cases}W_6=W_7=3L_{\mathrm{min}}\\ W_8=W_9=W_{10}=4.5L_{\mathrm{min}}\end{cases}$$

Hence $W_1=W_2=W_3=W_4=W_5=10L_{\mathrm{min}}$, $W_6=W_7=3L_{\mathrm{min}}$, and $W_8=W_9=W_{10}=4.5L_{\mathrm{min}}$.