TSTE86 Homework 2: Solution

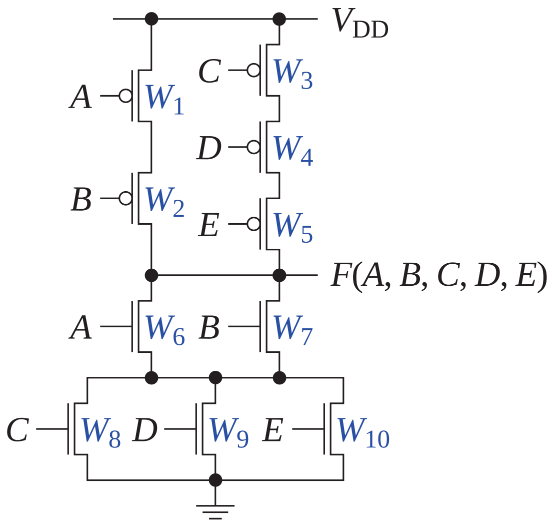
Identify logic function from gate schematic

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

Switch nets

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

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 two pull-up paths to have an equivalent resistance of $W_{\mathrm{p}} = 5L_{\mathrm{min}}$:

$$\begin{cases} \frac{1}{W_1}+\frac{1}{W_2}=\frac{1}{5} \\ \frac{1}{W_3}+\frac{1}{W_4}+\frac{1}{W_5}=\frac{1}{5} \end{cases} \overset{\text{equal widths in path}}{\Rightarrow} \begin{cases} W_1=W_2=10 \\ W_3=W_4=W_5=15 \end{cases}$$

Design the six pull-down paths to have an equivalent resistance of $W_{\mathrm{n}} = 3L_{\mathrm{min}}$:

$$\begin{cases} W_6^{-1}+W_8^{-1}=3^{-1} \\ W_6^{-1}+W_9^{-1}=3^{-1} \\ W_6^{-1}+W_{10}^{-1}=3^{-1} \\ W_7^{-1}+W_8^{-1}=3^{-1} \\ W_7^{-1}+W_9^{-1}=3^{-1} \\ W_7^{-1}+W_{10}^{-1}=3^{-1} \end{cases} \overset{\text{equal widths in path}}{\Rightarrow} \begin{cases} W_6=W_8=6 \\ W_6=W_9=6 \\ W_6=W_{10}=6 \\ W_7=W_8=6 \\ W_8=W_9=6 \\ W_9=W_{10}=6 \end{cases}$$

Hence $W_1 = W_2 = 10\ L_{\mathrm{min}}$, $W_3 = W_4 = W_5 = 15\ L_{\mathrm{min}}$, and $W_6 = W_7 = W_8 = W_9 = W_{10} = 6\ L_{\mathrm{min}}$.