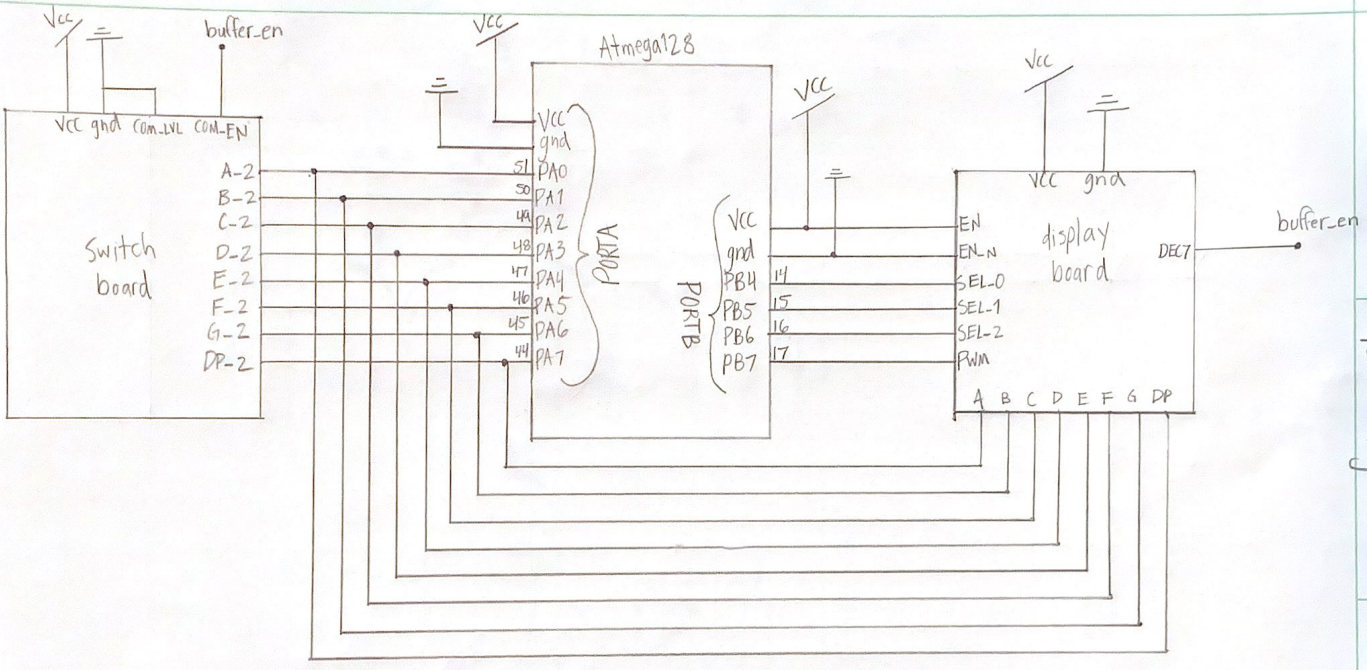
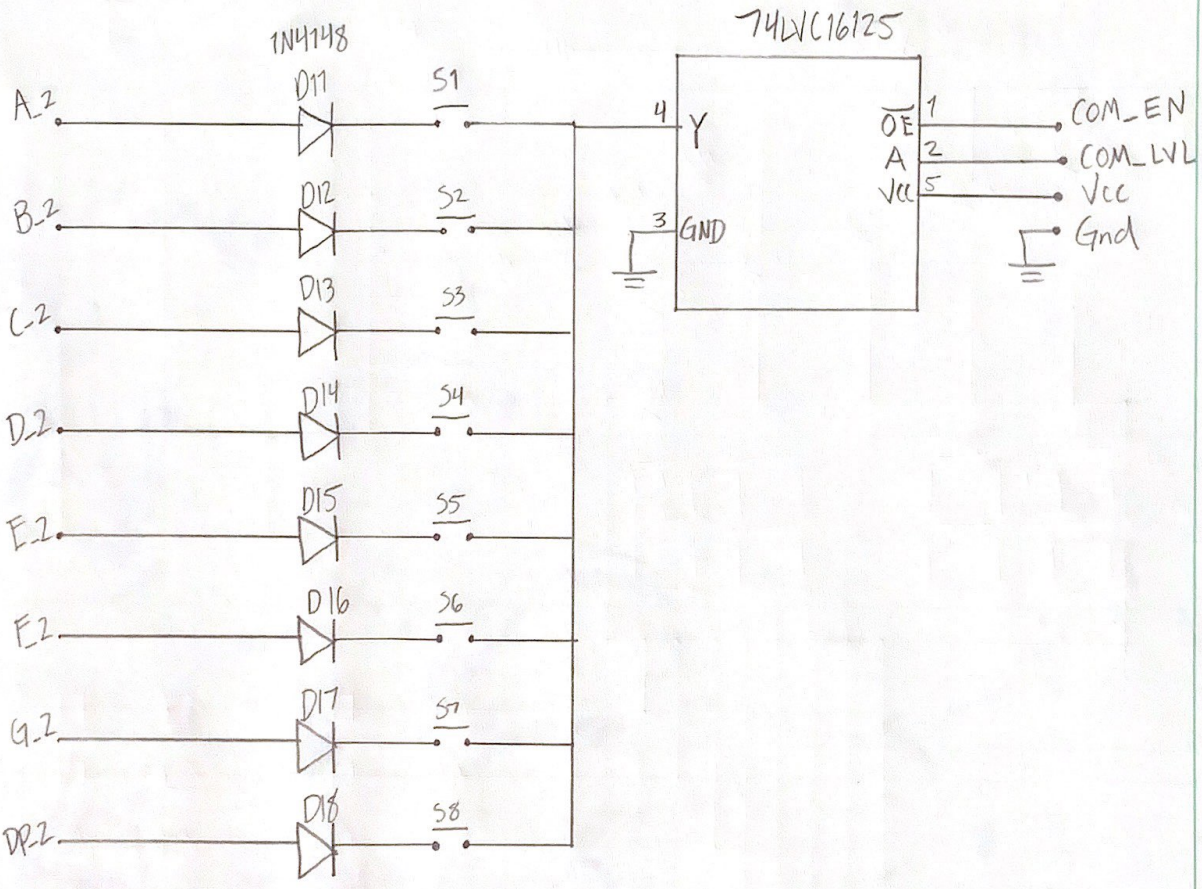
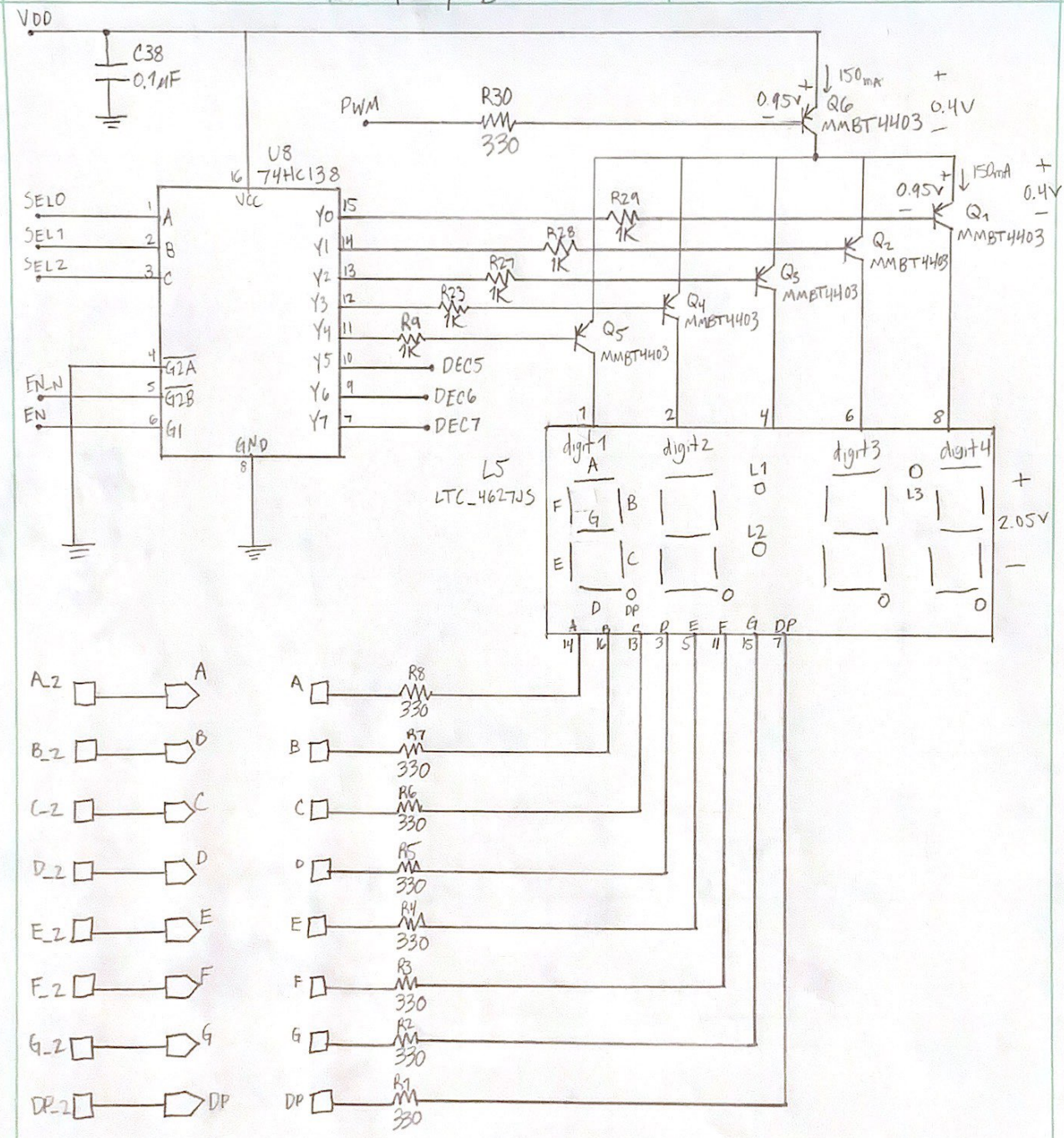


System diagram

Button Board



Display Board



Calculations

Max Current through PA0-PA7: 40 mA

Current through each segment: 20 mA @ $V_F = 2.05$ (typ.)

$\therefore |I_{Q_6}| = 20\text{mA}(8)$

$= 160\text{mA}$

need about 160 mA through Q_6 to light up all segments

From data sheet: $V_{CE_{sat}} = -0.4\text{V}$ @ $I_C = -150\text{mA}$, $I_B = -15\text{mA}$

$$R_{1\text{-}8} = \frac{5\text{V} - 0.8\text{V} - 2.05\text{V}}{150\text{mA}/8} \cong 115\Omega$$

$V_{BE_{sat}} = -0.95\text{V}$ @ $I_C = -150\text{mA}$, $I_B = -15\text{mA}$

$$R_{9\text{-}29} = \frac{5\text{V} - 0.4\text{V} - 0.95\text{V}}{15\text{mA}} \cong 243\Omega$$

$$R_{30} = \frac{5\text{V} - 0.95\text{V}}{15\text{mA}} \cong 270\Omega$$

Worst case analysis: One segment on

From data sheet: $V_{CE_{sat}} \cong -0.05\text{V}$ @ $I_C = -20\text{mA}$

$$I_{R_{1\text{-}8}} = \frac{5\text{V} - 0.1\text{V} - 2.05\text{V}}{115\Omega} \cong 24.78\text{mA} < 40\text{mA}$$

(Max current through Atmega I/O pins)

$V_{BE_{sat}} \cong -0.75\text{V}$ @ $I_C = -20\text{mA}$

$$I_{R_{9\text{-}29}} = \frac{5\text{V} - 0.05\text{V} - 0.75\text{V}}{243\Omega} \cong 17.28\text{mA} < 25\text{mA}$$

(Max current through 74HC138 output pins)