CSC270 Midterm Exam – Spring 2019

The exam is a closed-book, closed-notes, closed computers, closed phones, in-class exam given under the rules of the Smith College honor code. You are not allowed to discuss any details or exchange information with anybody except the instructor. You have 80 minutes to answer all the questions. Please answer the questions on the exam itself.

Solutions
Problem 1 (10 points)

There are several arduinos stations around, next to oscilloscopes.

Each arduino is programmed to output a particular waveform on Pin # 52.

Pick one of the stations, measure the waveform with the scope, and draw it on the timing diagram below. Measure the period of the signal, and report it below, with the appropriate units. Indicate on the waveform you have drawn where you put the cursors to measure the period.
Problem 2 (10 points)

What is the minterm canonical form of the function $f$, below? What is its maxterm canonical form?
Problem 3 (10 points)

Draw the state diagram of the circuit below.

When \( \text{cmd} \) is 0, D is always 1 and output of FF stays stuck at 1 = \( \text{cmd} = 0 \) when \( \text{cmd} = 0 \) and \( Q = 1 \).

When \( \text{cmd} \) is 1, D is \( \overline{Q} \), and we have \( \text{cmd} = 1 \) when \( Q = 0 \).

Putting the 2 together:

\[ S_0 \rightarrow A/0 \rightarrow S_1 \rightarrow D \]
Problem 4 (10 points)

Implement the circuit below with a 4-to-1 multiplexer.
Problem 5 (10 points)

Express $g$ as a Boolean function of $a$ and $b$. The circuit is an 8-to-1 multiplexer. $c_2$ is the most-significant bit (MSB), $c_0$ is the least-significant bit (LSB). For example, when $c_2, c_1, c_0$ are 1, 1, 0, then $I_6$ is connected to $g$.

Express $g$ as simply as possible, i.e. in a way that would require the fewest 2- or 3-input gates to implement it.

\[ g = \overline{a}b + a\overline{b} + ab = a \]
Problem 6 (10 or 20 points)

Implement the FSM with the state diagram shown below with D- or JK-flipflops. The question is worth 10 points if using D-flipflops, and 20 points if using JK flipflops.

\[
\begin{array}{c|c|c}
\text{cmd} & S^0 & S^1 \\
\hline
0 & S_0 & S_1 \\
1 & S_1 & S_0 \\
\end{array}
\]

4 states => 2 FFs

\[
\begin{array}{c|cc|c}
\text{cmd} & Q_2 & Q_1 & GYR \\
\hline
0 & 0 & 0 & 000 \\
0 & 1 & 1 & 100 \\
1 & 0 & 1 & 010 \\
1 & 1 & 0 & 001 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c}
\text{cmd} & Q_2 & Q_1 & Q_2^r & Q_1^r & J_1 & K_1 \\
\hline
0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 1 & 0 & 0 & 1 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 \\
\end{array}
\]

\[
G = \overline{Q_2} \overline{Q_1}, \quad T = Q_1 Q_2, \quad R = Q_2 \overline{Q_1}
\]

\[
J_1 = \overline{\text{cmd}(Q_1 \overline{Q_2})}, \quad J_2 = \overline{\text{cmd} \overline{Q_1} Q_2}
\]

\[
k_1 = J_1, \quad k_2 = J_2
\]
Problem 7 (10 points)

The circuit below uses ANDs with one input inverted. The output of the top AND, for example, is $S.Q2'$. Is this circuit a latch? Why or why not?

Yes, because if we move the inversion circles to the outputs of the AND circuits we get equivalent circuits:

\[
\begin{align*}
S & \rightarrow Q1 \\
R & \rightarrow Q2
\end{align*}
\]
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