Final Exam

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<tr>
<th>Last name of student</th>
<th>Student ID number</th>
<th>Section</th>
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<tbody>
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<td>SOLUTIONS</td>
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<table>
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<th>First name of student</th>
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Exam Rules:

- This is a 2 hour and 50 minutes exam
- The syllabus includes all material covered during this semester
- This is an Open Book and Notes Exam
- You are not allowed to consult any other student
- You may NOT use a calculator, laptop, palmtop, PDA, or such other computer
- If you need more space, continue on the back sides of pages, but make sure to indicate a continuation

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<td>Boolean</td>
<td>Building Blocks</td>
<td>Word Problem</td>
<td>Reverse Engineering</td>
<td>Stacks &amp; Subroutines</td>
<td>Interrupts</td>
<td>Bus Interfacing</td>
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ECSE-2610 Computer Components and Operations, Fall 2000

a. (3 points) Consider the following un-minimized circuit for function F. Use Boolean algebra to minimize the function F, and then draw the circuit corresponding to the minimized circuit implementing the same function, F.

\[ F = (X + Y) \cdot \overline{YZ} \rightarrow 1 \text{ pt} \]
\[ = (X + Y) + \overline{YZ} \rightarrow 1 \text{ pt} \]
\[ = X + Y \rightarrow 1 \text{ pt} \]

b. (3 points) Using Boolean algebra theorems, show that \( x + (x + z)(x + y + z) = x + yz \)

\[ x + [ (x + z) + (x + y + z) ] \]
\[ x + [ x + y + z ] \rightarrow 1 \text{ pt} \]
\[ x + (x + y + z) \]
\[ x + (x + y + z) \cdot z \rightarrow 1 \text{ pt} \]
\[ x + (x + y + z) \cdot z + \overline{x + y + z} = x + yz \rightarrow 1 \text{ pt} \]

c. (2 points) Consider the function \( f(A,B,C,D) = \Sigma m(0,2,4,5,6,8,9,10,13) \). Rewrite the expression in canonical Maxterm form.

Partial:

\[ \overline{A} \cdot M(1, 3, 7, 11, 12, 13, 15) \]
\[ \overline{A} + (A + B + C + D) + (A + B + C + \overline{D}) + (A + \overline{B} + C + \overline{D}) \]
\[ + (A + B + C + \overline{D}) \cdot \overline{A} + \overline{B} + C + \overline{D} \cdot (A + \overline{B} + C + D) \]
\[ + (\overline{A} + \overline{B} + C + \overline{D}) \cdot \overline{A} + \overline{B} + C + \overline{D} \]
d. (5 points) Consider the function \( f(A,B,C,D) = \sum m(0,2,4,5,6,8,9,10,13) \). Use the following K-map to minimize the function and write the result in SOP form.

\[
\begin{align*}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + BD + A\bar{D}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + BD + A\bar{B}\bar{C}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + \bar{B}\bar{C}D + A\bar{B}\bar{C}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + \bar{B}\bar{C}D + A\bar{B}\bar{C}
&Correct entries in K-Map = 2.
&Correct Simplification = 3.
&LO partial: 1 or 2.
\end{align*}
\]

e. (3 points) Does the above function have a static 1-hazard? If so, use the K-map to identify terms you need to add to the function to remove the hazard. Write the SOP form of the revised function below. An extra K-map template is given below for your convenience.

\[
\begin{align*}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + BD + A\bar{D}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + BD + A\bar{B}\bar{C}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + \bar{B}\bar{C}D + A\bar{B}\bar{C}
&\bar{B}\bar{D} + \bar{A}\bar{B}D + \bar{B}\bar{C}D + A\bar{B}\bar{C}
&Yes.
&\bar{B}\bar{D} + \bar{A}\bar{B}D + BD + A\bar{D}
&+ A\bar{B}\bar{C} + A\bar{B}\bar{C}
&There are two extra terms.
&Only one term correct: 2.
&No term correct: 0.
\end{align*}
\]
3. (10 points) Word Problem Sequential Circuit Synthesis

Draw the Mealy state diagram for a sequence recognizer with a single input $x$, and a single output $z$. It produces an output of $z = 1$ whenever the sequence 0101 is detected, and 0 at all other times. For example:

Input: $x \ldots 0 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ldots$
Output: $z \ldots 0 \ 0 \ 0 \ 1 \ 0 \ 1 \ldots$

Your state diagram should not have more than four states.

Correct States: 3 pts. — Partial: 2 pts
Correct Transitions: 7 pts. — 1
If the Main Transition is correct
i.e. $0 \rightarrow 1 \rightarrow 0 \rightarrow 1$ is correct
- 4 pts. — Partial: 1
Other Transitions — 3 pts.
Partial: 2
4. (15 points) Reverse Engineering

Your goal is to reverse engineer the following mystery Mealy machine using the functional analysis method. The parts of this question will help you do this in steps.

(a) (1 point) What are the input variables, state variables and output variables of this circuit?

(b) (2 points) Fill up the following tables for the T- and D- flip flops and write out the characteristic equation (Q+ in terms of Q and T (or D)) in each case.

<table>
<thead>
<tr>
<th>Q</th>
<th>T</th>
<th>Q+</th>
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<tbody>
<tr>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
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\[ Q^+ = Q \oplus T \]

<table>
<thead>
<tr>
<th>Q</th>
<th>D</th>
<th>Q+</th>
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<tbody>
<tr>
<td>0</td>
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\[ Q^+ = D \]

c. (6 points) Using the characteristic equations above, write equations for the outputs and next states in terms of the inputs and previous states. Substitute equations for the inputs to the T and D flip flops. (For example, the input to the D flip flop is \( \bar{A} \), which will be substituted into its characteristic equation to get the equation for the output B+)

\[ Z = \left( \left( \bar{T} . B \right) \cdot \left( B + A \right) \right) = T \cdot B + (B . \bar{A}) = B \left( \bar{T} + \bar{A} \right) \quad (2) \]

\[ A^+ = \left( B \oplus \bar{T} \right) \oplus A = \left( B \oplus \bar{T} \right) \oplus A \quad (2) \]

\[ B^+ = \bar{A} \quad (2) \]
d. (2 points) Fill up the next-state (state transition) table and output table below based upon the above equations.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>I</th>
<th>A⁺</th>
<th>B⁺</th>
<th>Z</th>
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e. (3 points) Draw the state machine corresponding to the above state transition table. Remember that this is a Mealy Machine with 4 states (corresponding to the bit combinations of A and B, the state bits).

Correct state diagram - 3
Consistent but wrong - 2
Correct truth table, wrong state diagram - 2
Not consistent - 0