Lectures Covered: Lessons 24 to 27

Show all relevant steps. Don’t just write down the answers.

**Late HWs will not be accepted.** Lecture Students: turn in your HW in class. Recitation students: turn in your HW at the ECE Office Front Desk. **HWs turned-in anywhere else will not be accepted.**

Show your work on these pages, attach additional pages if necessary.

- Be sure to organize the pages in order and staple them all together, otherwise you will lose one point
- Fill out the following section. You will lose an additional point if you fail to provide these details

Your Last Name___________________________________________ Your First Name___________________________________________

1. Lecture Student __________ or Recitation Student__________ (check one)
2. If Recitation then fill out the following
   Name of recitation instruction___________________________ Date/time of recitation___________________________

Problem starts on next page. There is only one problem worth 10 points.
1) **10 Points:** Based on the problem solved in Screencast30, design a circuit using the State Machine Diagrams given below using four T-Flip Flops which implements the State Diagram given below. Go through the whole design process: i) Convert the State Diagram to a State Machine Diagram ii) Determine the State machine Table iii) Determine the Flip Flop input equations and the output equations and iv) finally draw the circuit. You do not have to simplify the equations so no need for K-maps.

Most of this problem was solved in the lecture (Screencast 23)
1) Continued ...
1) Continued ...

<table>
<thead>
<tr>
<th>State</th>
<th>State Code</th>
<th>TC</th>
<th>Next State</th>
<th>Next State Code</th>
<th>Non Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_0$</td>
<td>1000</td>
<td>X</td>
<td>$S_0^+$</td>
<td>1000</td>
<td>Z</td>
</tr>
<tr>
<td>$S_0$</td>
<td>1000</td>
<td>X</td>
<td>$S_1^+$</td>
<td>0100</td>
<td></td>
</tr>
<tr>
<td>$S_1$</td>
<td>0100</td>
<td>X</td>
<td>$S_0^+$</td>
<td>1000</td>
<td>Z</td>
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<tr>
<td>$S_1$</td>
<td>0100</td>
<td>X</td>
<td>$S_2^+$</td>
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<td>$S_2$</td>
<td>0010</td>
<td>X</td>
<td>$S_3^+$</td>
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<tr>
<td>$S_2$</td>
<td>0010</td>
<td>X</td>
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<td>$S_0^+$</td>
<td>1000</td>
<td>Z</td>
</tr>
</tbody>
</table>

$S_0^+ = S_0 \overline{X} + S_1 X + S_2 \overline{X} + S_3 \overline{X}$

$S_0^+ = (S_0 + S_1 + S_2 + S_3). \overline{X} = \overline{X}^3 \overline{X}^2 \overline{X}^{10}$

$S_1^+ = S_0 X$
1) Continued ...

\[
\begin{align*}
S_2^+ &= S_1 \cdot X \\
S_3^+ &= S_2 \cdot X + S_3 \cdot X = (S_2 + S_3)X
\end{align*}
\]

output

\[
Z = S_1 \cdot \overline{X} + S_2 \cdot \overline{X} + S_3 \cdot \overline{X} = (S_1 + S_2 + S_3) \cdot \overline{X}
\]

For a T flip flop

\[
Q^+ = Q \oplus T_a
\]

from \textit{Hub} we can get (as derived in the lecture)

\[
T_a = Q \oplus Q^+
\]
1) Continued ...

\[ T_{S_0} = S_0 \oplus S_{0}^{+} = S_0 \oplus \bar{S}_{b} \]

\[ T_{S_1} = S_1 \oplus S_{1}^{+} = S_1 \oplus (S_0 \cdot X) \]

\[ T_{S_2} = S_2 \oplus S_{2}^{+} = S_2 \oplus (S_1 \cdot X) \]

\[ T_{S_3} = S_3 \oplus S_{3}^{+} = S_3 \oplus (S_2 \cdot S_3 \cdot X) \]
1) Continued ...

Red shows what is different from Screencast 30