Embedded Real-Time Systems (AME 3623)
Homework 2 Solutions

February 25, 2009

Question 1

1. (5pts) Given the binary number: 010111010. What is the decimal equivalent? What is the hexadecimal equivalent? Show your work.
\[ 2 + 8 + 16 + 32 + 128 = 186 \]
0xBA

2. (5pts) Given the binary number: 110110111. What is the decimal equivalent? What is the hexadecimal equivalent? Show your work.
\[ 1 + 2 + 4 + 16 + 32 + 128 + 256 = 439 \]
0x1B7
3. (5pts) Given the decimal number: 486. What is the binary equivalent? Show your work (all of the steps of the algorithm that we discussed in class).

<table>
<thead>
<tr>
<th>value</th>
<th>binary</th>
<th>$i$</th>
<th>$2^i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>486</td>
<td>0000000000</td>
<td>8</td>
<td>256</td>
</tr>
<tr>
<td>230</td>
<td>1000000000</td>
<td>7</td>
<td>128</td>
</tr>
<tr>
<td>102</td>
<td>1100000000</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>38</td>
<td>1110000000</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>1111000000</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>111100100</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>111100110</td>
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<td></td>
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</tbody>
</table>

4. (5pts) Given the decimal number: 524. What is the binary equivalent? Show your work.

<table>
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<th>value</th>
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<th>$i$</th>
<th>$2^i$</th>
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<tr>
<td>4</td>
<td>1000001000</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>1000001100</td>
<td></td>
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</table>
Question 2

Consider the following circuit with input $CLK$:

1. (10pts) Assume that the initial state is: $Q_0 = 0, Q_1 = 0, Q_2 = 0$ Show the timing diagram for $Q_0, Q_1$ and $Q_2$ as the clock ($CLK$) is pulsed (show 6 transitions).

2. (10pts) Interpreting $Q_2, Q_1, Q_0$ as a 3-bit binary number (with $Q_0$ as the 1’s digit), what is the sequence of values that this circuit produces?

$Q_2, Q_1, Q_0 = 000, 010, 100, 110, 000, 010, 100, ...$

or:

$0, 2, 4, 6, 0, 2, 4, ...$
3. (10pts) Assume that the initial state is: $Q_0 = 1, Q_1 = 0, Q_2 = 1$ Show the timing diagram for $Q_0, Q_1$ and $Q_2$ as the clock ($CLK$) is pulsed (show 6 transitions).

4. (10pts) Interpreting $Q_2, Q_1, Q_0$ as a 3-bit binary number (with $Q_0$ as the 1’s digit), what is the sequence of values that this circuit produces? $Q_2, Q_1, Q_0 = 101, 111, 001, 011, 101, 111, 001, ...$

or:

5, 7, 1, 3, 5, 7, 1, ...

5. (10pts) What is the mathematical function of this circuit?

The circuit counts by two on each clock cycle.

(modulo 8 = after the counter reaches 7, it starts over again).
Question 3

Consider the following circuit with inputs $CLK$ and $X$:

1. (10pts) Assume that the initial state is: $Q_0 = 1$ and $Q_1 = 0$. Assume also that $X = 0$. Show the timing diagram for $Q_0$ and $Q_1$ as the clock ($CLK$) is pulsed.

2. (10pts) Interpreting $Q_1$, $Q_0$ as a 2-bit binary number (with $Q_0$ as the 1’s digit), what is the sequence of values that this circuit produces?
   $Q_1, Q_0 = 01, 10, 11, 00, 01, 10, 11, ...$

3. (10pts) What is the mathematical function of this circuit when $X = 0$?
   Counts by 1 on each clock tick (modulus 4).
4. (10pts) Assume the same initial state as above, and assume that $X = 1$. Show the timing diagram for $Q0$ and $Q1$ as the clock ($CLK$) is pulsed. Note: $A \oplus 1 = \bar{A}$.

5. (10pts) What is the sequence of values that this circuit produces?
$Q_1 \ Q_0 = 01, 00, 11, 10, 01, 00, 11, ...$

6. (10pts) What is the function of this circuit when $X = 1$?
Downward counting, modulus 4.