EE 231

Final Exam

December 16, 2009

Name: _____

Show all work. Partial credit will be given. No credit will be given if an answer appears with no supporting work. No calculators allowed. You may use one page of notes.

1. Consider the following Verilog code:

```
reg [3:0] R1, R2, R3;

always @(posedge clock)
    R1 = R1 - 4'h3;
    R2 = R1 + 4'h1;
    R3 = R1 - R2;
```

`R1 = 4'h6`, `R2 = 4'h2`, and `R3 = 4'h3` before the clock edge. What is the value of `R3` after the clock edge?

2. Consider the following Verilog code:

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reg [3:0] R1, R2, R3;

always @(posedge clock)
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`R1 = 4'h6`, `R2 = 4'h2`, and `R3 = 4'h3` before the clock edge. What is the value of `R3` after the clock edge?

3. Simplify the following Boolean equation using Boolean algebra:
   $(x'y' + z)' + z + xy + wz$

4. Represent the following numbers in 8-bit two's complement form:

   (a) +43

   (b) -29

5. A RAM chip has 16 address lines and 32 data lines.

   (a) How many words (unique address locations) does the RAM hold?

   (b) How many bytes does the RAM hold?

6. The following two problems deal with the Hamming code for error detection and correction. The numbers are of the form $P_0\ P_1\ P_2\ D_3\ P_4\ D_5\ D_6\ D_7\ P_8\ D_9\ D_{10}\ D_{11}\ D_{12}$, where P_0 is the overall parity bit.

   (a) Consider the binary number 10010010_2. Generate the Hamming code for the number which will allow you to correct one-bit errors and detect two-bit errors.

   (b) You read the number $0\ 0011\ 0010\ 0101$ from a memory which uses error detection and correction. What was the original 8-bit data word which was written to memory?

7. Answer the following questions about combinational logic functions:

   (a) Consider the function $F(w, x, y, z) = \sum(2, 3, 4, 6, 7, 8, 12, 13, 15)$

      i. Draw a Karnaugh map for the function.

      ii. Identify the prime implicants, and indicate which ones are essential.

      iii. Write down a minimum sum of products for the function.

      iv. Write down a minimum product of sums for the function.

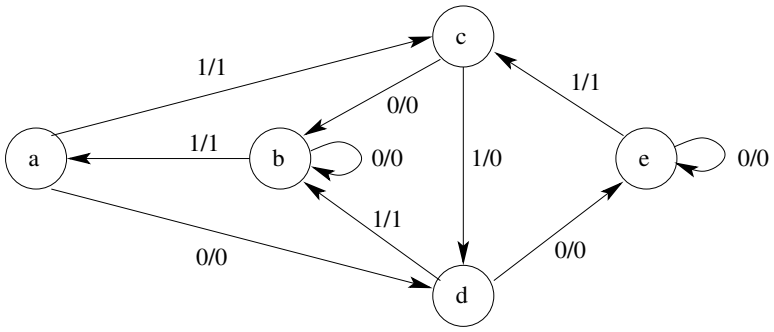
(b) Design a three input, one output combinational circuit which tests the operation of a traffic light. The three inputs are R, Y and G. The R input is high if the red light is on, the Y input is high if the yellow light is on and the G input is high if the green light is on, The output Y will be high if the traffic light control system fails, and an invalid combination of lights is displayed. (The only valid combination is one and only one light on.)

i. What is the truth table for the circuit?

ii. Write a Boolean expression for Y as a minimum sum of products.

(c) Consider the Boolean function $F(w, x, y, z) = \sum(1, 2, 3, 10, 11, 12)$. Implement this function using an 8x1 multiplexer and an inverter.

8. The figure below shows a state diagram for a digital circuit. The state is held in three D flip-flops $Q_2Q_1Q_0$, the input to the system is x, and the output is y.

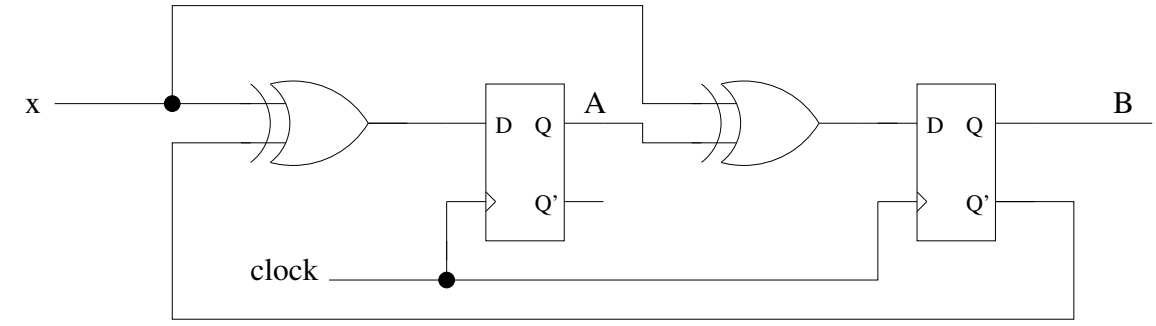


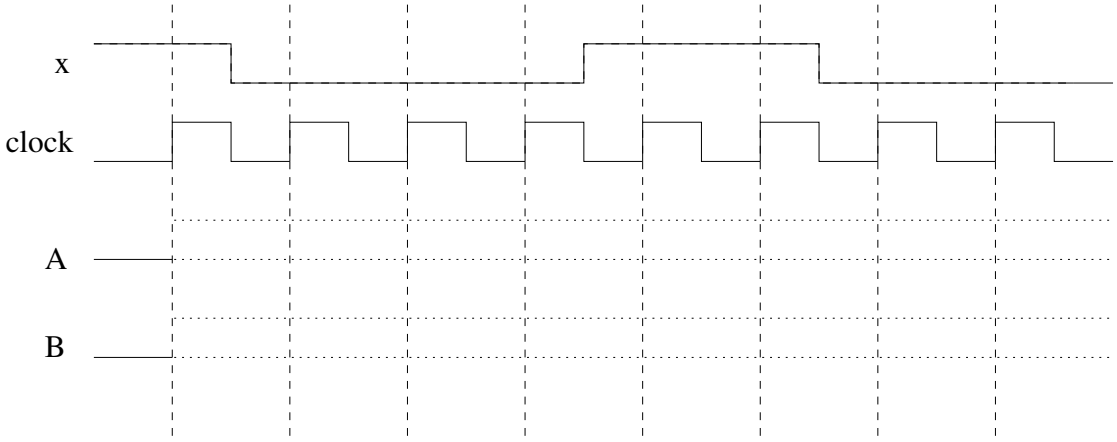
(a) Is this a Moore machine or a Mealy machine? Explain.

(b) Tabulate the state transition table for this circuit, showing the next states and output based on the current states and input to the controller.

(c) Write down the equations for the next state (the inputs $D_2D_1D_0$ to the three D flip-flops) and output (y).

9. Draw the timing diagram for the circuit shown below.





10. The equation for a combinational circuit is $Y = x'z' + yz + xy'$.

    (a) Does this circuit have any static hazards? Explain.

    (b) If the circuit does have static hazards, show how to eliminate the hazards. Write a Boolean equation with implements Y without any hazards.