CSE 140 Fall 2012: Final, Due 6PM Friday 12/14/2012

The exam contains six problems of which we are free to choose four to answer. This is an open book final. Web searches are encouraged. If there is any uncertainty about the problems, make and state your assumptions. Each person is supposed to work by oneself. Thus, no discussion is allowed.

1. State the difference between Boolean algebra and switching algebra. Use an example to demonstrate your point.

2. State and prove the Shannon’s expansion theorem of switching algebra.

3. Inverter chains:
   3.1. Given a loop of three inverters, we have the first inverter output to the second, the second to the third and the third to the first. Suppose that the delay of each inverter is 20 picoseconds. Draw the timing diagram of the outputs of the three inverters in a time interval of 200 picoseconds.
   3.2. Given a loop of four inverters, suppose that the delay of each inverter is 20 picoseconds. Draw the timing diagram of the outputs of the four inverters in a time interval of 200 picoseconds.

4. The logic diagram below shows a 3-bit Johnson counter. Derive the function behavior of the counter.
   4.1. Suppose that the flip-flops are reset initially, list all possible states \((Q_2, Q_1, Q_0)\) generated by the counter.
   4.2. Suppose that the flip-flops are not reset initially. Instead, the initial state is \((Q_2, Q_1, Q_0) = (0, 1, 0)\). List all possible states generated by the counter.

![Figure 1: A 3-bit Johnson counter.](image-url)
5. Consider the ROM (Read Only Memory) circuit below. For each row, can the circuit in column I be replaced by an equivalent circuit in column II by proper programming of the latter’s ROM? Explain your answer.

6. Design a divisor that divides a dividend with a divisor and produces the quotient and remainder with all inputs and outputs in binary numbers. Use a binary subtractor to implement the design.
6.1. Describe the program.
6.2. Describe the data subsystem with a schematic diagram.
6.3. Draw the state diagram of the control subsystem and list the control signals.