

Assignment #4

**Instructions:** The assignment is due on the date shown above. Tips to remember: give the assignments to your TA in section, remember your name, section number, TA name, and assignment number (5 points). Also, make sure your assignment is neat, stapled, and is entirely **your own work**.

1. Implement a 4-bit adder using only the following components: a single 1-bit adder, and no more than seven master-slave flip-flops (built with two D-latches and an inverter each). Note that this is called a **bit-serial adder**. Assume that the input signals are A (1 bit) and B (1 bit) and a clock. On each rising edge of the clock, the next bit of the four bit input for A and B arrives on the A and B wires (at the start of cycle 0, A[0] arrives on the A wire, at the next cycle rising edge, A[1] appears on the wire, then A[2] on the next cycle, and finally A[3]. Your four-bit adder should end up with each of the sum bits S[0] through S[3] in a separate flip-flop. You may assume that the values of all the flip-flops are initially zero.
2. Design a state machine that will determine the parity of a sequence of input bits. There are two inputs, DATA and RESET. The sequence arrives on the DATA input. RESET moves the machine to its initial state from any other state if it is set to 1. There is a single output line, PARITY. This contains a 1 if the machine has seen an odd number of 1's on the input line since the last time the machine was reset. Otherwise PARITY is 0.
  - (a) Draw a finite state diagram describing the behavior of this machine.
  - (b) How many flip-flops will it take to implement this controller?
  - (c) Provide a state encoding and name the outputs of the flip-flops. Using these names and the state encoding, draw a truth table for the operation of the machine.
  - (d) Give minimal sum-of-products expressions for the state transition function and the output.
  - (e) Draw a circuit diagram of the machine.
3. Design a controller for a soda machine that operates as follows. The price of a soda is 40 cents. The machine takes three inputs: nickel, dime, and quarter. Once at least 40 cents is deposited, the machine dispenses a soda and appropriate change. States can be used to record the amount of money put into the machine. Output functions should be defined that cause a soda to be delivered and the proper change, i.e. one output function for nickels, one for dimes, and one for quarters so that an appropriate combination of them will give correct change for any given input. Once a soda has been delivered, the next coin put in will restart the process. You may assume that clock signals are generated by the arrival of a coin so that input is synchronized with the clock.
  - (a) Draw a finite state diagram describing the behavior of this controller.
  - (b) How many flip-flops will it take to implement this controller?
4. P&P 3.34
5. P&P 3.40
6. P&P 3.43