EGR 680
Fall 2018
Laboratory #3

State Machine Design

Due Date: By beginning of next lab section

Objectives

- To become familiar with using state machines to implement synchronous sequential network

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Part I – A Vending Machine

Words of Wisdom

Design of sequential circuits is quite a bit more involved than that of combinational circuits. There are many opportunities for things to go wrong, and debugging a malfunctioning circuit can be tedious at best and downright frustrating at worst. Fortunately, by adopting a structured approach to the design and debug of sequential circuits, and by carefully documenting the design, many of these problems become manageable. The analogy to software development here is quite apt; if you write "spaghetti" code you are more likely to be frustrated when things don't work, and won't get much sympathy when you seek help. The reward for discipline, on the other hand, is that you'll spend less time chasing after hard-to-find bugs and more enjoying the fruits of your creativity. Design *can* be fun!

Design Specifications

The design should be implemented on the PYNQ board using two Pmod 7-segment displays. ***VENDMACH*** is a vending machine that accepts nickels, and dimes, and dispenses gum, apple, or yogurt. A gum pack costs 10¢, an apple is 15¢, and yogurt is 20¢. The machine is only allowed to accept up to 20¢. Any coins inserted that pushes the value beyond 20¢ should be ignored.

The top-level schematic of ***VENDMACH*** is shown in figure below. The machine has the following 1-bit inputs:

- **NICKEL** a signal that becomes 1 when a nickel is deposited in the coin slot.
- **DIME** a signal that becomes 1 when a dime is deposited in the coin slot.
- **GUM** a signal that becomes 1 when the gum selection button is pressed.
- **APPLE** a signal that becomes 1 when the apple selection button is pressed.
- **YOGURT** a signal that becomes 1 when the yogurt selection button is pressed.

In addition to these "user" inputs, the machine has two control inputs:

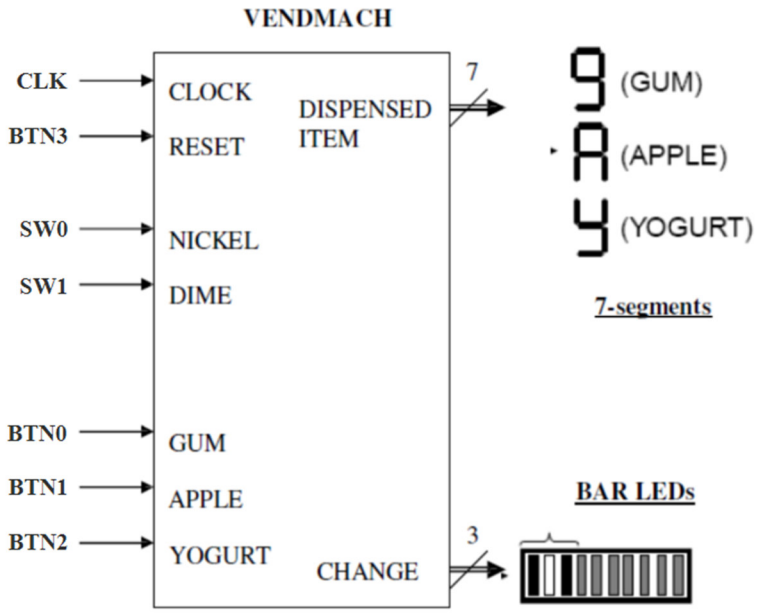
- **CLOCK** a timing signal that sequences the state transitions of the machine.
- **RST** an initialization signal that resets the machine to a suitable starting state.

The machine has three outputs:

- **MONEY ENTERED** The amount of money inserted into the machine should be displayed on one of the 7-segment Pmod displays. This should update every time a coin is inserted (i.e. 5¢ should read **05**). Upon startup or reset, the display should read **VEND**.

- **DISPENSED ITEM** The item that was just purchased should be displayed on the 7-segment: **g** for gum, **A** for apple, and **y** for yogurt, as indicated in figure below.

- **CHANGE** The amount of money returned in change. The machine returns change using only cents; the number of cents returned should be displayed as a binary number using the on-board LEDs.



Design Behavior

The machine should behave in accordance with the following specifications:

1. A customer needs to deposit a sufficient amount of money *before or at the same time* that he or she is selecting an item for purchase. If the item costs less than the deposited amount, the item is dispensed and the correct change is returned. If the item costs more than the deposited amount, the machine waits for more coins to be inserted or for a cheaper item to be selected.

2. The maximum amount that the user can enter is 20¢, after which the selection has to be made. Once the product has been dispatched, the vending machine goes back to the initial state and waits for user to enter the coins.

3. The machine should "time-out" after exactly 3 seconds and perform a self-reset back to the **IDLE** state.

Extra Credit – 5%

When an item is dispensed, utilize the on-board RGB LEDs to provide a visual output of the item.

1. Use green for **GUM**, red for **APPLE**, and white for **YOGURT**.
2. The two RGB LEDs should flash 3 times before the machine performs the self-reset.
3. The RGB LEDs should turn off after the self-reset.

Laboratory Deliverables

You are required to turn in a hard copy of the report. Report should have the following items:

- Cover page with one page description of your design
- State Transition Diagram (depicting the flow of your state machine)
- Simulation printouts (highlighting various conditions that you have tested)

You also have to demonstrate your design and turn in a compressed version of the project.