Experiment 12

Aquarium Controller

As chief engineer of $\overline{\text{AQUA}}$ (Pronounced "AquaNot") Aquarium Maintenance Engineering, Inc., you have decided to develop an automatic device to control the acidity (pH) and Calcium content of the water in fish aquariums. You also want to use this device to automatically feed the fish on a regular basis.

You have decided to purchase devices that measure the pH and Calcium content and use them as inputs to your system. The pH measuring device has an output pH which is asserted as (1) when the pH is too high requiring the introduction of a measured amount of buffering agent into the aquarium to lower the pH. The Calcium measuring device has an output (pC) which is asserted as (0) when the calcium level is too low requiring the introduction of a measured amount of Calcium into the aquarium. You will use these two measurement devices as inputs to your design to determine whether to actuate the output devices.

The first of the three output devices introduces a measured amount of buffering solution (B) into aquarium to lower the pH of the water. The second output device introduces a measured amount of calcium (C) into the water to raise Calcium levels. The simultaneous introduction of the buffering solution and calcium cannot be allowed since they may cancel the effects of each other. You have decided that pH control is more important than Calcium control, so that if both pH and pC sensors indicated that the buffer and calcium must be introduced at the same time, you will only introduce the buffer into the water during that cycle.

There is, of course, a third (output) device (F) which dumps food into the aquarium. Through experience you have found that you cannot put fish food into the tank at the same time that you put in any chemicals. Experience has also shown that, if possible, it is more important to control pH and pC than to feed the fish. it is well known that the breed of fish you have in the tank cannot miss more than two feeding cycles before they are adversely affected.

Remembering that this type of problem can be reasonably solved using a synchronous finite state machine of the Mealy type, it further seems reasonable that this can be done in three states where the first one (01) indicates that the fish were fed on the last cycle, the second (10) indicates that the fish have missed one feed cycle and the third (11) state which indicates that the fish have missed a second feed cycle.

With reference to the above word problem do the following:

1. Draw a properly labeled and complete state diagram of the Mealy machine to implement the aquarium controller.
2. Fill in a State/Output table for the Mealy machine.

3. Write a VHDL Behavioral Description which implements the finite state machine, including the following
    a. Entity declaration
    b. Behavioral architecture body
    c. An appropriate testbench
4. Simulate and print the resulting waveform for all possible inputs and state transitions.
5. Determine whether the FSM is self-starting and verify this by starting the FSM in state 0.