ECE 153A/253 CS 153A Homework 3

1. Consider the following FSM:
   States: a, b, c, d, e, f
   Transitions:
   0,a $->$ b,1
   1,a $->$ c,0
   0,b $->$ f,0
   1,b $->$ d,0
   0,c $->$ a,0
   1,c $->$ c,0
   0,d $->$ c,1
   1,d $->$ e,0
   0,e $->$ a,0
   1,e $->$ c,0
   0,f $->$ b,0
   1,f $->$ d,0
   Is this a minimal machine? If not, find the smallest equivalent machine.

2. Consider a quadrature encoder that senses the direction (clockwise or counter-clockwise) of a click based on the values on its two pins:

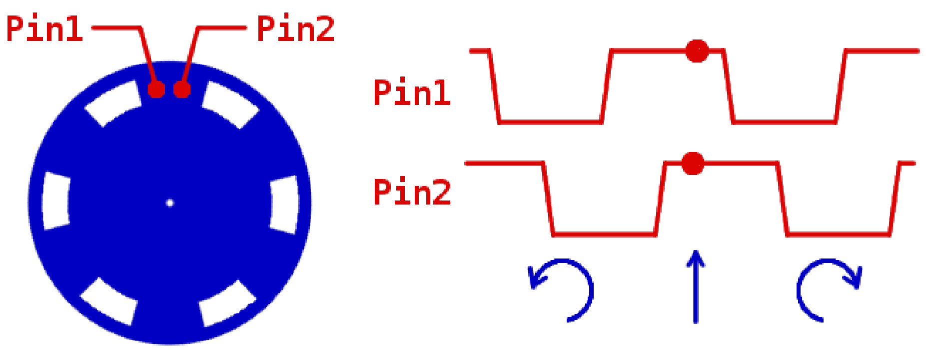

Figure 1

When at rest, both pins of the encoder read a logic high. For a clockwise click, Pin1 goes low first, then Pin2 goes low, then Pin1 one goes high, and finally Pin2 goes high. Whereas for a counter-clockwise click, the sequence is reversed: Pin2 goes low first, then Pin1 goes low, then Pin2 one goes high, and finally Pin1 goes high. The two pins never transition at the exact same time.

(a) Design a FSM that has two inputs (Pin1 and Pin2), is triggered on value changes on the inputs and produces two outputs (*CW* for a clockwise click and *CCW* for a counter-clockwise click). The outputs are produced on completion of the entire sequence described above. Draw a bubble chart for your design. Assume that the start-up state for the machine is (Pin1=1, Pin2=1).

(b) Mechanical switches (including quadrature encoders) are often bouncy. The pins undergo several transitions when they switch their state before they settle to a high or low value. The nature of a mechanical switch is that they usually bounce on closure – rather than on opening. This is because a small amplitude vibration in a closed level might cause it to leave the surface (causing a circuit open or bounce) while a similar small amplitude vibration in the open state does nothing. Encoders are usually wired with a pull-up resistor (the small black rectangle on the back of the encode pcb) so that open corresponds to logic high and closed to logic low. However, we won't assume any selectivity on rising or falling edges as we are building a generic machine. We do assume that the bounces stop before the next transition on the other pin. (This too might be a faulty assumption in a particularly noisy encoder). The model for this problem with bouncing pins during a clockwise click is shown below:

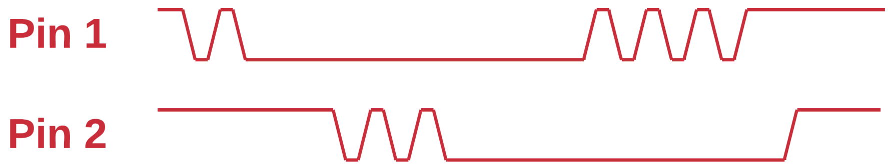

Figure 2

When one pin is bouncing, assume that the other pin does not change its state at all. Design a FSM that detects clockwise and counter-clockwise clicks correctly producing a CW output for a clockwise click and CCW output for a counter-clockwise click, given the bouncy behavior of the pins. The pins can bounce any number of times before settling, and the outputs should be produced on completion of the entire sequence of changes for a clock-wise or a counter-clockwise click. (Hint: you will need this machine design for the next lab...)