Professor Fearing EECS150/Problem Set 11 Fall 1999

Due at 10 am, Fri. Dec. 3 in box outside 218 Cory Hall

(This problem set may be done individually or by a group of two people maximum.)

1. State Partitioning (30 pts)

Katz 9.12.

2. Metastability (50 pts)

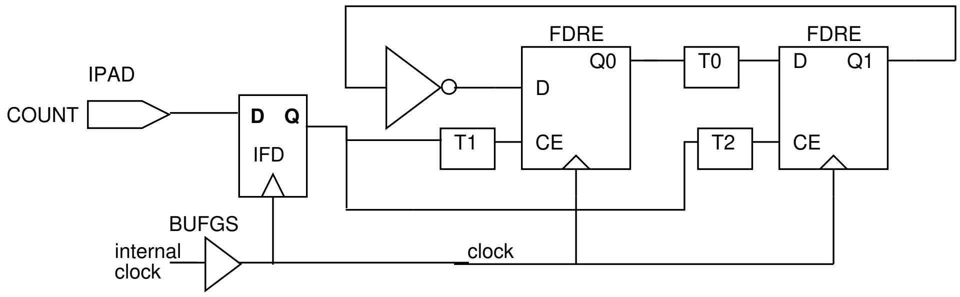
This question considers the problem of a synchronizer FF going metastable and causing an FSM to have an incorrect next state. Consider a FSM as shown in the block diagram below, using the Xilinx 4005E-3. Assume COUNT (an unsynchronized input) is at 2.0 MHz and Clock is at 25.0 MHz. For this problem consider the parameters of the XC4005E-3 $T_{ICK} = T_{setup} = 3.0$ ns min, $T_{hold} = T_{CKI} = 0$ ns. Delays are $T_0 = 15$ ns, $T_1 = 20$ ns, and $T_2 = 30$ ns. The input FF has propagation delay $T_{IKRI} = 2.8ns$. (Assume parameters for IFD $K_1 = 1.5 \times 10^{-10} sec$ and $K_2 = 16 \times 10^9 sec^{-1}$.)

a. Draw a detailed timing diagram for the FSM. What is the maximum metastable time Δ_O which can be tolerated without effecting proper FSM operation?

b. What is the Mean Time Between Failure for this clock and data rate? (in years)

c. Now assume that there is an additional 3 ns delay, so that T_2 now equals 33 ns. Now what would the MTBF be?

d. Your pacemaker company uses an FSM based on the XC4005E-3 with 8 FF running at 25 MHz, and a 33 ns delay from the synchronizing IFD through the NSD to the CLB inputs. Your customer's heart provides an asynchronous input with maximum frequency of 2 Hz. Unfortunately, the FSM is not self-starting, so if any FF makes an incorrect transition, a service call is required. If you had 1 million customers, how many lawsuits per year could you expect?



3. Testability (20 pts)

Which nodes in the circuit below can not be completely tested for functionality by setting inputs ABC and observing output Y? Is the unobservable fault(s) stuck-at-one or stuck-at-zero?