# EECS 150: Solution Set #11 by G. Moy

Fall 1999

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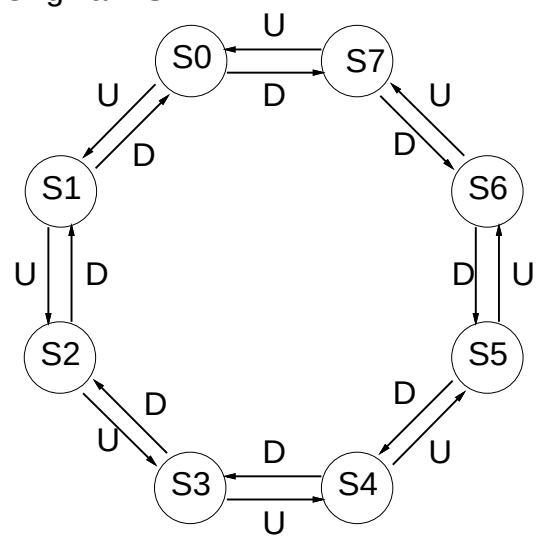
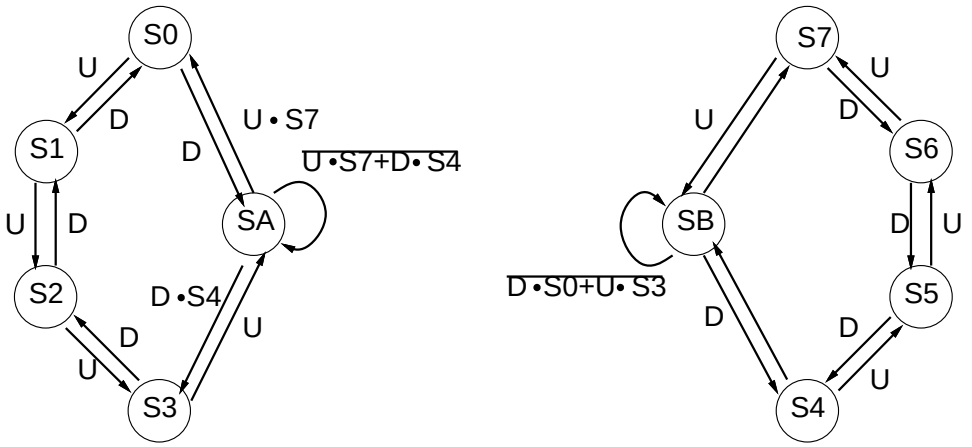
## Problem 1: State Partitioning

Katz 9.12.

Original FSM:

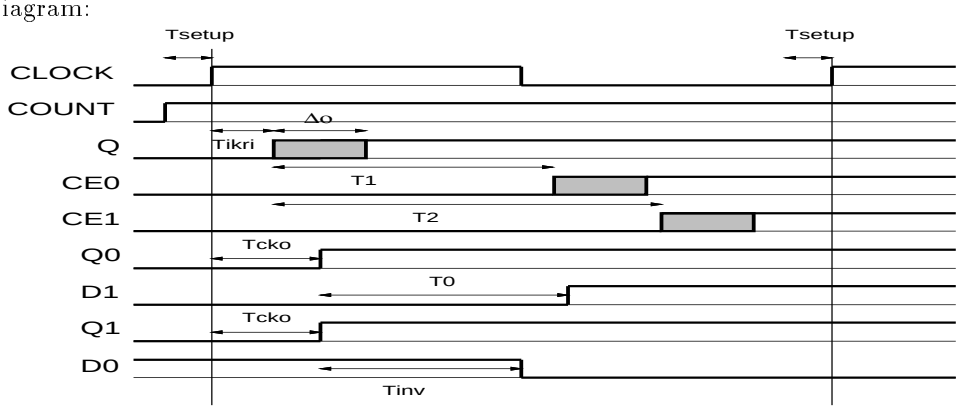



Partitioned FSM:



## Problem 2: Metastability

a) Timing Diagram:




Note: $T_{cko}$ and $T_{inv}$ don't affect metastability calculation
$\Delta_0 = (clock\ period) - T_{setup} - T_{IKRI} - T_2 = 40ns - 3ns - 2.8ns - 30ns = 4.2ns.$

b)

$$\begin{aligned}
\frac{1}{MTBF(sec)} &= f_1 f_2 K_1 e^{-K_2 t} \\
&= (25 \times 10^6)(2 \times 10^6)(1.5 \times 10^{-10}) e^{-(16\times10^9)(4.2\times10^{-9})}\ per\ second \\
&= 4.90 \times 10^{-26}/s \times \frac{365\ days}{year} \times \frac{24\ hours}{day} \times \frac{60\ minutes}{hour} \times \frac{60\ seconds}{minute} \\
&= 1.55 \times 10^{-18}\ per\ year
\end{aligned}$$

c)

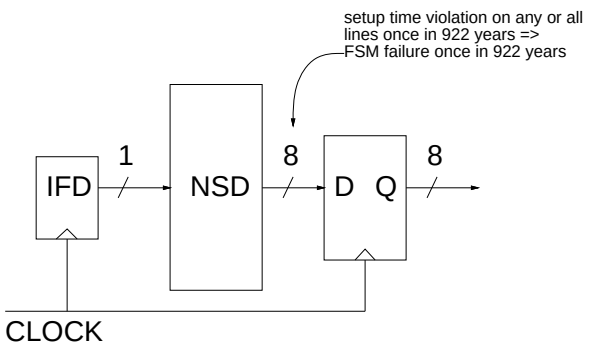
$\Delta_0 = (clock\ period) - T_{setup} - T_{IKRI} - T_2 = 40ns - 3ns - 2.8ns - 33ns = 1.2ns.$

$$\begin{aligned}
\frac{1}{MTBF(sec)} &= f_1 f_2 K_1 e^{-K_2 t} \\
&= (25 \times 10^6)(2 \times 10^6)(1.5 \times 10^{-10}) e^{-(16\times10^9)(1.2\times10^{-9})}\ per\ second \\
&= 3.44 \times 10^{-5}/s \times \frac{365\ days}{year} \times \frac{24\ hours}{day} \times \frac{60\ minutes}{hour} \times \frac{60\ seconds}{minute} \\
&= 1085\ per\ year
\end{aligned}$$

d)

$$\begin{aligned}
MTBF\ per\ year &= 1/(365 \times 24 \times 60 \times 60 \times (25 \times 10^6)(2)(1.5 \times 10^{-10}) e^{-(16\times10^9)(1.2\times10^{-9})} \\
&= 922\ years
\end{aligned}$$

1 million units / 922 years = 1085 lawsuits




Alternatively, a more complex statistical anaylsis can be used but is beyond the scope of this course.

## Problem 2: Testability

| | fault type | A | B | C | Y(proper) | Y(improper) | |
|---|---|---|---|---|---|---|---|
| node1 | sa0 | 0 | 1 | 0 | 1 | 0 | |
| | sa1 | 1 | 1 | 0 | 0 | 0 | can't detect |
| node2 | sa0 | 0 | 1 | 0 | 0 | 1 | |
| | sa1 | 0 | 0 | 0 | 1 | 0 | |
| node3 | sa0 | 0 | 0 | 1 | 1 | 1 | can't detect |
| | sa1 | 0 | 0 | 0 | 1 | 1 | can't detect |
| node4 | sa0 | 0 | 1 | 0 | 0 | 1 | |
| | sa1 | 0 | 0 | x | 1 | 0 | |
| node5 | sa0 | 0 | 1 | 1 | 0 | 0 | can't detect |
| | sa1 | 0 | 0 | x | 1 | 0 | |
| node6 | sa0 | 1 | 0 | 0 | 0 | 1 | |
| | sa1 | 0 | 0 | x | 1 | 0 | |

Nodes 1, 3, and 5 are not completely testable. This is expected since the circuit is not minimized.
Node 1 unobservable fault is SA1.
Node 3 unobservable faults are SA0 and SA1.
Node 5 unobservable fault is SA0.