

# CSE435 Introduction to EDA & Testing - Spring 2022

## Homework Assignment #4

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1. (25%)

- (a) (10%) For state transition fault model, explain why there are  $M(N-1)$  faults for a  $M$ -transition  $N$ -state machine. Similarly explain why there are  $N^M-1$  multiple state transition faults.

**Solution:** Denote  $M$  and  $N$  as the number of transitions and states, respectively.

**Single-state-transition (SST) fault** For each transition, the possible destination could be either one of the states, so there are  $(N-1)$  faulty cases and 1 faultless case. The SST could occur at either one of the transitions, producing  $M(N-1)$  distinguishable faults.

**Multiple-state-transition (MST) fault** For each transition, the possible destination could be either one of the states, so there are  $N$  cases. Since each transition is independent to other transitions, there are  $N^M$  distinguishable state-transition diagrams. Disregarding 1 faultless diagram, the number of faults in MST is thus  $N^M-1$ .

- (b) (10%) For stuck-at fault model, explain why there are  $2K$  single stuck-at faults. Similarly explain why there are  $3^K-1$  multiple stuck-at faults.

**Solution:** Denote  $K$  as the number of lines in the circuit.

**Single-stuck-at (SSA) fault** The SSA fault would occur at either one of the lines, and in the SSA faults, there will be the case of stuck-at-0 and stuck-at-1. So the number of distinguishable SSA faults would be  $2K$ .

**Multiple-stuck-at (MSA) fault** For each lines, there are three possible cases: no-error, stuck-at-0 or stuck-at-1. With  $K$  lines, there would be  $3^K$  possible circuits, including  $3^K-1$  faulty ones and 1 faultless one.

- (c) (5%) Please show the similarity and differences of (single, multiple) fault numbers between the state transition fault model and the stuck-at fault model.

**Solution:**

**Single** Both the numbers of faults of SST and SSA fault are multiples of the numbers of transitions and lines, respectively. However, the multiplier of the SST fault depends on the number of states, while the one of the SSA is fixed to 2 (sa0, sa1).

**Multiple** In the power of both the numbers of faults of SST and SSA fault. The exponents are the numbers of transitions and lines, respectively. However, the base of the SST fault depends on the number of states, while the one of the SSA is fixed to 3 (no-error, sa0, sa1).

2. (20%) Prove that for combinational circuits **faults dominance is a transitive relation**, i.e. if  $f$  dominates  $g$  and  $g$  dominates  $h$ , then  $f$  dominates  $h$ .

**Solution:**

3. (55%) In the circuit shown in Figure 1,

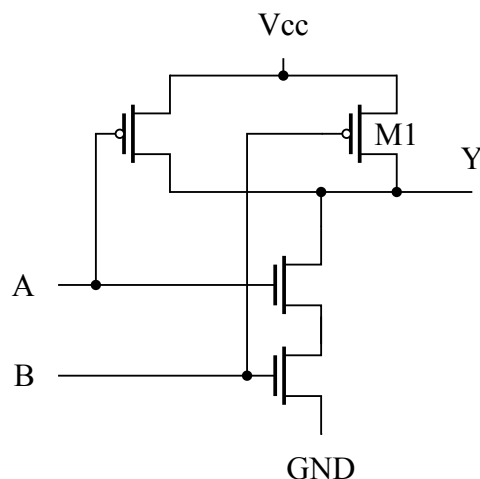


Figure 1

- (a) (5%) How many single stuck-at faults needed to be considered initially?

**Solution:**

- (b) (25%) Applying the **check point theorem (incl. fault dominance)**, how many check point faults needed to be considered?

**Solution:**

- (c) (25%) Using **fault dominance** and **fault equivalence** relations to further reduce the number of stuck-at faults? How many remaining faults needed to be considered?

**Solution:**