Digital Design

(a) Consider the following combinational circuit implementing the parity check on 8 inputs x1, ..., x8

- What is the total number of tests to detect stuck-at-1 logic fault on input line x1?
- What is the total number of tests to detect stuck-at-1 logic fault on input line x8?
- Consider the following ‘complex’ fault model: single stuck-at-1 fault can occur either on line x1 or on line x8. What is the total number of tests to detect this ‘complex’ logic fault?
- Consider the following ‘complex’ fault model: single stuck-at-1 fault can occur on both lines x1 and x8. What is the total number of tests to detect this ‘complex’ logic fault?

SOLUTION
(i) input x1 should be set to x1= 0 and all other inputs can assume 2**7 different values \( \rightarrow \) total number of tests is 2**7
(ii) input x8 should be set to x8= 0 and all other inputs can assume 2**7 different values \( \rightarrow \) total number of tests is 2**7
(iii) inputs x1 and x8 should be set to x1x8= 00 and all other inputs can assume 2**6 different values \( \rightarrow \) total number of tests is 2**6
(iv) there are no tests to detect this fault.

Grading: 0.5 pts for each part (i) – (iv)

(b) Consider the ripple counter shown below. Assume that all flip-flops are positive edge-triggered. Show the transition diagram for this counter, and clearly show the transition states. Determine the counting sequence for this ripple counter assuming the initial state 000. Is this counter self-starting?

Note: the counter is self-starting if the states in the counting sequence can be reached from any other state in the transition diagram.
SOLUTION

Operation table:
- A is toggled when CP goes positive and C=0.
- B is toggled when A goes from 1 to 0.
- C is clocked when CP goes positive;
  it is set when ABC=11-, cleared when ABC=0-, and unchanged when ABC=01-.

The complete transition diagram is shown below:

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101 --> 100 --> 000,010 --> 110 --> 011,001 --> 000

111

011
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Assuming the initial state 000, the counting sequence (of stable states) is:

000 → 100 → 010 → 110 → 001 → back to 000

Transition states are indicated in red color:

000 → 100 → 000 → 010 → 110 → 011 → 001 → back to 000

The counter is NOT self-starting.

Grading: 2 pts total.
Points Breakdown:
- Transition diagram + operation table ~ 1.5 pts
- counting sequence ~ 0.25 pts
- self-starting question ~ 0.25 pts