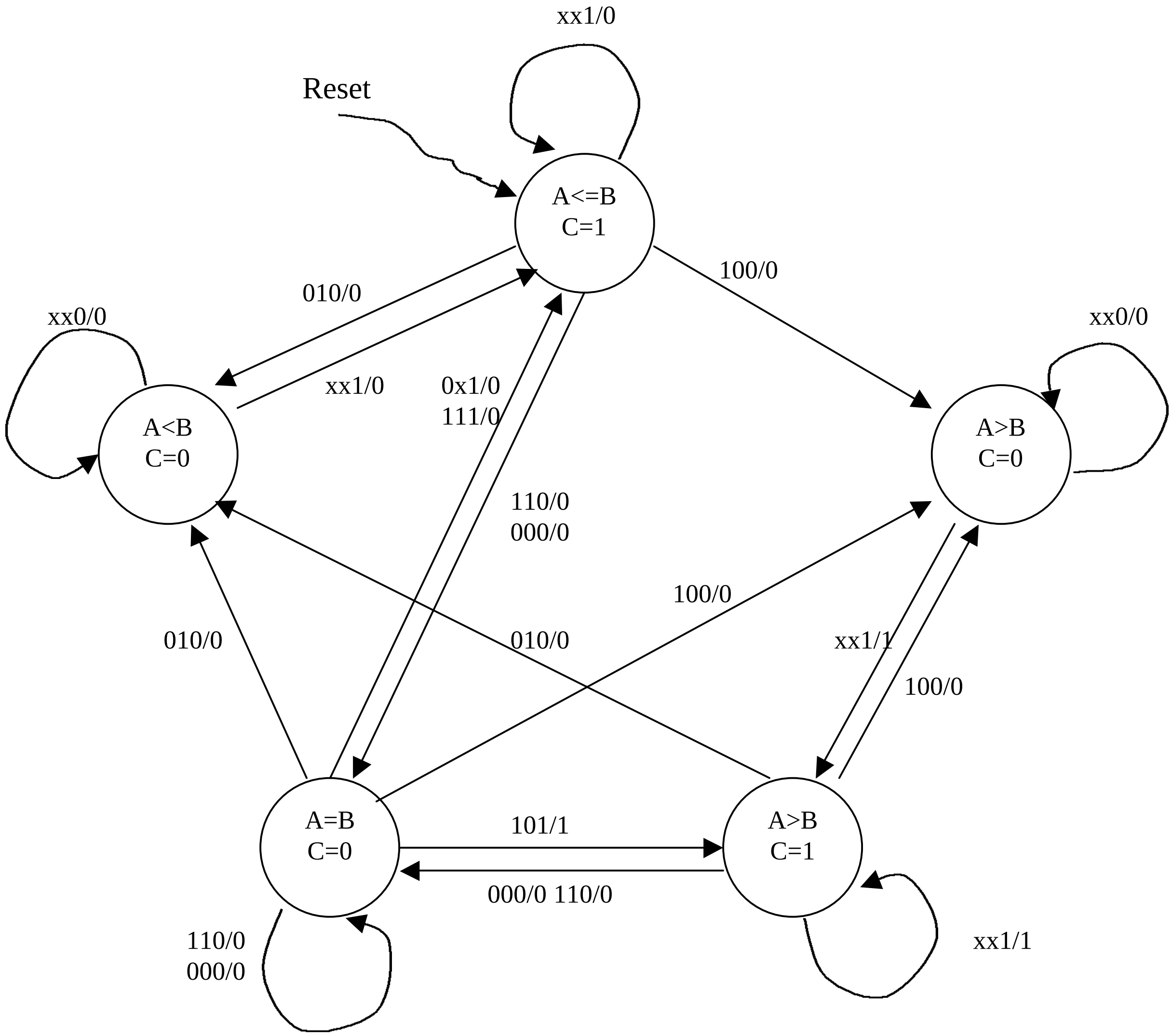
Solution of Sample Final

1. FSM Design



2. Timing Methodology
   Other parameter are as same as those in the HW6
   Margin = 1.1
   T_{skew} = 5ns
   Max($T_{p,FF}$) = 40ns
   Max($T_{p,Logic}$) = 20×2=40ns (NAND-NAND Implementation)
   T_{SU} = 20ns

Assume Φ_1 is the clock for the slave and Φ_2 for the master FFs

$T_{\Phi_1-\Phi_2}$ = margin[max($T_{p,FF}$) + T_{SU} + T_{Skew} + max($T_{p,Logic}$)]

= 1.1[40+20+5+40]

= 115.5 ns

$T_{\Phi_2-\Phi_1}$ = margin[max($T_{p,FF}$) + T_{SU} + T_{Skew}] < $T_{\Phi_1-\Phi_2}$

For Symmetric clock design, $T_{\Phi_1-\Phi_2}$ and $T_{\Phi_2-\Phi_1}$ have to be equal, so $T_{\Phi_2-\Phi_1}$ =115.5ns

$T_{CLK_1} = 2\max(T_{\Phi_1-\Phi_2}, T_{\Phi_2-\Phi_1})$ =2$T_{\Phi_1-\Phi_2}$ =2*115.5 = 231 ns

3. Moore Machine

(a) $2^{N_{FF}-1} < Ns \le 2^{N_{FF}}$

$N_{FF} = 4$

The minimum number of states in the state-transition diagram is $2^3 + 1 = 9$.

The maximum number of states in the state-transition diagram is $2^4 = 16$.

(b) 3 input bits

The minimum number of Transition arrows starting at a particular state is 1.

The maximum number of Transition arrows starting at a particular state is $2^3 = 8$.

(c) The minimum number of Transition arrows that can end at a particular state is 1, because no state is isolated.

All possible transition arrows are 16 (# of max states)×8 (# of max input) = 128. And since no state is isolated, every state needs at least 1 input. So the maximum number of transition arrow that can end at a particular state is 16×8-15 =113**.**

(d) 7 output bits

The minimum number of different binary patterns that can be displayed on the outputs is **2**, otherwise if only 1 output, the machine does not do anything useful.

Since this is a Moore machine, one output is associated with each state. The max # of different output = min(2^7, max # of states) = (2^7, 16) = 16.

4. State Minimization

X

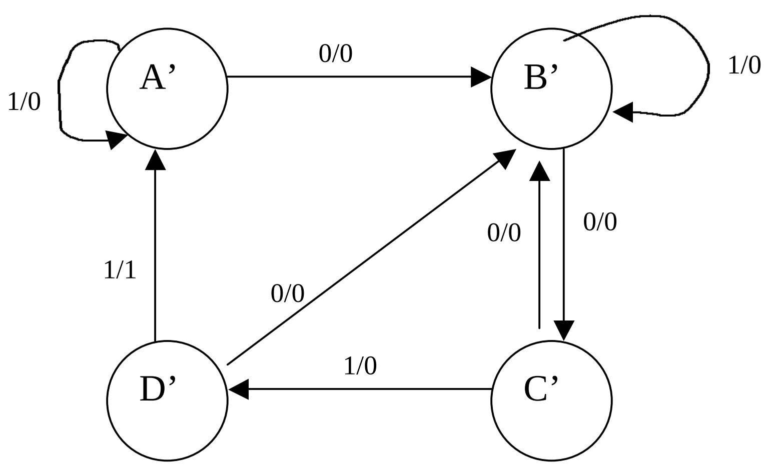
	0	1
S_0	S_1/0	S_4/0
S_1	S_2/0	S_1/0
S_2	S_1/0	S_6/0
S_3	S_1/0	S_3/0
S_4	S_5/0	S_4/0
S_5	S_2/0	S_1/0
S_6	S_5/0	S_3/1

	S_0	S_1	S_2	S_3	S_4	S_5
S_1	~~S_1S_2 S_1S_4~~					
S_2	~~S_4S_6~~	~~S_1S_6~~				
S_3	S_4S_3 ✓	~~S_1S_2~~	~~S_3S_6~~			
S_4	S_1S_5 ✓	~~S_2S_6~~	~~S_1S_5 S_4S_6~~	S_1S_5 ✓		
S_5	~~S_1S_4 S_1S_2~~	✓	~~S_1S_2 S_1S_6~~	~~S_1S_2 S_1S_3~~	~~S_1S_4 S_2S_5~~	
S_6	X	X	X	X	X	X

From above table, we get the reduced state as following,

($S_0S_3S_4$) (S_1S_5)(S_2) (S_6)
A’ B’ C’ D’

	X = 0	X = 1
A’	B’/0	A’/0
B’	C’/0	B’/0
C’	B’/0	D’/0
D’	B’/0	A’/1



5. Testing

$F^{p/d} = f^{p/d} \oplus f = 0$

$F^{p/d}$ represents all tests for fault *p/d*

a). $F^{p/d} = 0$. No test is available for the fault $f^{p/d}$. $f^{p/d}$ is untestable

b). $F^{p/d} = 1$. Any input combination can be used as a test for fault $f^{p/d}$

3). No

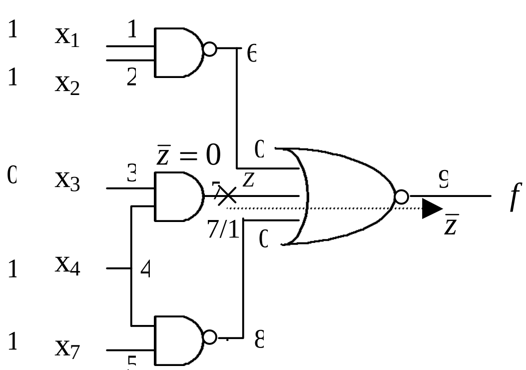
6. Testing

$$f = \overline{\overline{x_1x_2} + x_3x_4 + \overline{x_5x_6}} = x_1x_2 \cdot \overline{x_3x_4} \cdot x_4x_5 = x_1x_2(\overline{x_3} + \overline{x_4})x_4x_5$$
$$= x_1x_2\overline{x_3}x_4x_5$$
$$f^{8/0} = \overline{\overline{x_1x_2} + x_3x_4} = x_1x_2 \cdot \overline{x_3x_4} = x_1x_2(\overline{x_3} + \overline{x_4})$$

$$F^{8/0} = x_1x_2\overline{x_3}x_4x_5 \oplus (x_1x_2\overline{x_3} + x_1x_2\overline{x_4})$$
$$= x_1x_2\overline{x_3}x_4x_5 \cdot \overline{(x_1x_2\overline{x_3} + x_1x_2\overline{x_4})} + \overline{x_1x_2\overline{x_3}x_4x_5} \cdot (x_1x_2\overline{x_3} + x_1x_2\overline{x_4})$$
$$= x_1x_2x_3\overline{x_4} + x_1\overline{x_3}x_2\overline{x_4} + x_1x_2\overline{x_4} + x_1\overline{x_3}x_2\overline{x_5} + x_1\overline{x_5}x_2\overline{x_4}$$
$$= x_1x_2\overline{x_4} + x_1\overline{x_3}x_2\overline{x_5}$$

The tests are 11000, 11100, 11001,11101 and 11010

2) Let us use z to denote the fault



The test is 11011