EE709 Problem Set.

Yobaji Pratik Sanjay 210070094

Q.1

a] M-stuck-at-0

for M-stuck-at-0 output $O = 1$ always independent input A, B.

So we can identify this fault By choosing the input A, B such that the output in good circuit is o/p $\Rightarrow O = 0$

$O = \overline{A.B}$ for $O = 0 \Rightarrow A = 1 \; B = 1$

Ans test vector $\boxed{A=1 \quad B=1}$

b] for Good circuit for Input $A = 1$ and $B = 1$ output $O = 0$ $P = 1$ $Q = 1$ $R = 1$

So in bad circuit (faulty circuit) we can detect the following faults.

		D-stuck-at-0
O-stuck-at 1	M-stuck-at-0	E-stuck-at-0
P-stuck-at 0	M-stuck-at-1	F stuck-at-1
Q-stuck-at 0	L-stuck-at-1	G-stuck-at-1
R-stuck-at 0	K-stuck-at-1	

c] for good circuit

$$O = \overline{A.B} = \bar{A} + \bar{B}$$
$$P = \overline{A.\bar{B}} = \bar{A} + B$$
$$Q = \overline{\bar{A}.B} = A + \bar{B}$$
$$R = \overline{\bar{A}.\bar{B}} = A + B$$

(A, B).

for O/0 Test vector - (0,0), (0,1), (1,0).
O/1 Test vector - (1,1)

for P/0 Test vector - (0,1), (0,0), (1,1).
P/1 Test vector - (1,0).

for Q/0 Test vector - (0,0), (1,0), (1,1).
Q/1 Test vector - (0,1).

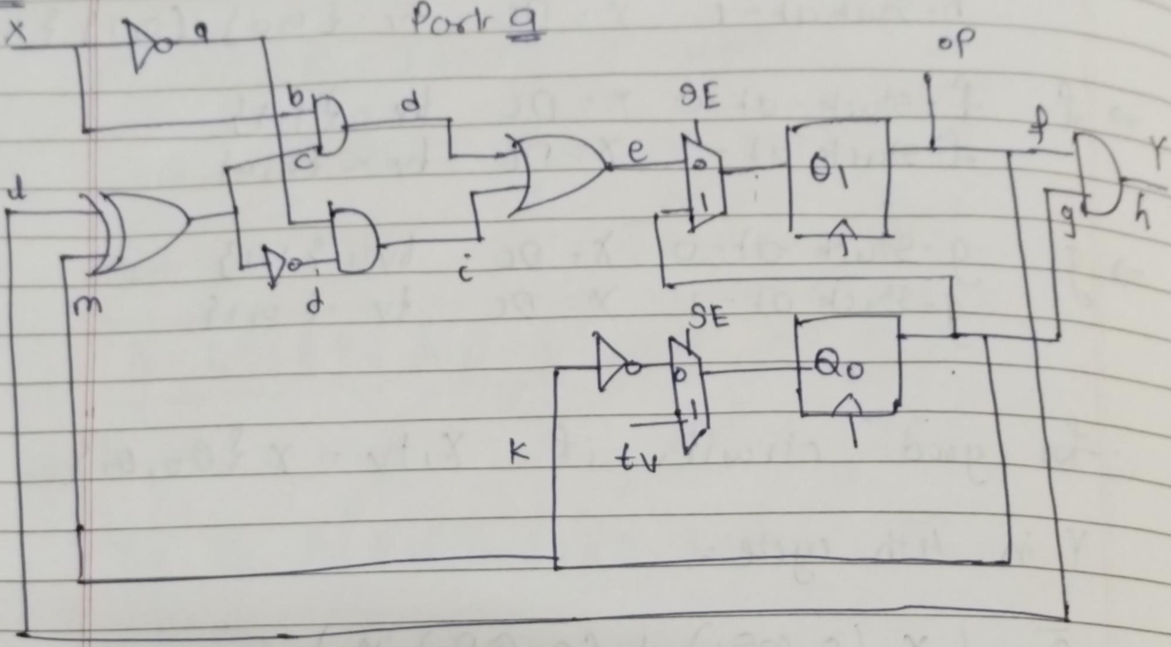
for R/0 Test vector - (0,1), (1,0), (1,1).
R/1 Test vector - (0,0)

As the maximum test set consits of this 4 ~~the~~ test vectors (0,0), (0,1), (1,0), (1,1) and this are the required test vectors to detect fault at O, P, Q, R.

Hence. With the help of $\boxed{(0,0), (1,0), (0,1), (1,1)}$ we can detect all the faults.

Q2

Part a



Part b $tv = \{Q_0, Q_1\}$.

- set Q_0, Q_1 using tv and set $SE = 1$ for initial 2 cycles
- 1 cycle for compution. $SE = 0$
- set $SE = 1$ again for next 2 cycles in order to read Q_0, Q_1

We can detect fault by cheking Y, op [last 2 cycles]

SE

$\Rightarrow$ h   h-stuck at-0 $X = DC$ $tv = \{1,1\}$
h-stuck at-1 $X = DC$ $tv = \{0,0\}, \{0,1\}, \{1,0\}$

$\Rightarrow$ f   f-stuck-at-0 $X = DC$ $tv = \{1,1\}$
f-stuck at-1 $X = DC$ $tv = \{1,0\}$.

$\Rightarrow$ g   g-stuck at-0 $X = DC$ $tv = \{1,1\}$
g-stuck at-1 $X = DC$ $tv = \{0,1\}$.

for good circuit. if $X, tv = X\{\theta_0, \theta_1\}$.

Y in 4th cycle =

$\overline{\theta_0} \cdot (X \cdot (\theta_0 \oplus \theta_1) + \overline{(\theta_0 \oplus \theta_1)} \cdot \overline{X})$.

op in 4th cycle.

$op_4 = X \cdot (\theta_0 \oplus \theta_1) + \overline{X} \cdot \overline{(\theta_0 \oplus \theta_1)}$

op_5 = op in 5th cycle $= \overline{\theta_0}$

$\Rightarrow$ a   a-stuck-at 0

$Y = \overline{\theta_0} \cdot X \cdot (\theta_0 \oplus \theta_1)$. $op_4 = X \cdot (\theta_0 \oplus \theta_1)$
$op_5 = \overline{\theta_0}$

$\boxed{X = 0 \quad \theta_0, \theta_1 = \{0,0\} \; \{1,1\}}$

$\Rightarrow$ a - stuck - at - 1

$Y = \overline{\theta_0} \cdot \left(X \cdot (\theta_0 \oplus \theta_1) + \overline{(\theta_0 \oplus \theta_1)} \right)$.

$op_4 = X \cdot (\theta_0 \oplus \theta_1) + \overline{(\theta_0 \oplus \theta_1)}$

$op_5 = \overline{\theta_0}$

$\boxed{X = 1 \quad (\theta_0, \theta_1) = \{0,0\}, \{1,1\}.}$

$\Rightarrow$ b - stuck at - 0

$Y = \overline{\theta_0} \cdot \left(\overline{\theta_0 \oplus \theta_1} \right) \cdot \overline{X}$ $\quad op_5 = \overline{\theta_0}$

$op_4 = \overline{X} \cdot \left(\overline{\theta_0 \oplus \theta_1} \right)$.

$\boxed{X = 1 \quad \cancel{\theta_0 = 0} \quad (\theta_0, \theta_1) = \{0,1\} \{1,0\}.}$

$\Rightarrow$ b = stuck - at - 1

$Y = \overline{\theta_0} \cdot \left((\theta_0 \oplus \theta_1) + \overline{(\theta_0 \oplus \theta_1)} \cdot \overline{X} \right)$.

$op_4 = (\theta_0 \oplus \theta_1) + \overline{X} \cdot \left(\overline{\theta_0 \oplus \theta_1} \right)$. $\quad op_5 = \overline{\theta_0}$

$\boxed{X = 0 \quad (\theta_0, \theta_1) = \{0,1\} \{1,0\}.}$

$\Rightarrow$ c - stuck - at - 0

$Y = \overline{\theta_0} \cdot \left(\overline{\theta_0 \oplus \theta_1} \right) \overline{X}$ $\quad op_5 = \overline{\theta_0}$

$op_4 = \overline{X} \cdot \left(\overline{\theta_0 \oplus \theta_1} \right)$. $\quad \boxed{X = 1 \quad \theta_0, \theta_1 = \{0,1\} \{1,0\}.}$

⇒ c-stuck-at-1

~~$Y = \overline{\theta_0}$ $op_4 = 1$ $op_5 = \overline{\theta_0}$~~

$Y = \overline{\theta_0}\,(X + \overline{(\theta_0 \oplus \theta_1)}.\overline{X})$.

$Op_4 = X + \overline{(\theta_0 \oplus \theta_1)}.\overline{X}$ $Op_5 = \theta_0$.

$\boxed{X = 1 \quad \theta_0, \theta_1 = \{0,0\}\ \{1,1\}}$.

⇒ d-stuck-at-0

$Y = \overline{\theta_0}.\,(0 + \overline{X}.\overline{(\theta_0 \oplus \theta_1)})$.

$OP_4 = \overline{X}.\overline{(\theta_0 \oplus \theta_1)}$ $OP_5 = \overline{\theta_0}$

$\boxed{X = 1 \quad \theta_0, \theta_1 = \{1,0\}\ \{0,1\}}$.

⇒ d-stuck-at = 1

$Y = \overline{\theta_0}$ $OP_4 = 1$ $OP_5 = \overline{\theta_0}$

$X = 0 \quad \theta_0, \theta_1 = \{0,1\}\ \{1,0\}$
$X = 1 \quad \theta_0, \theta_1 = \{0,0\}\ \{1,1\}$,

⇒ j-stuck-at = 0

$Y = \overline{\theta_0}.\,(\theta_0 \oplus \theta_1).X$ $OP_5 = \overline{\theta_0}$

$OP_4 = X,\,(\theta_0 \oplus \theta_1)$

$\boxed{X = 0 \quad \theta_0, \theta_1 = \{0,1\}\ \{1,0\}}$.

⇒ j-stuck-at = 1

$Y = \overline{\theta_0} \cdot (X \cdot (\theta_0 \oplus \theta_1) + \overline{X})$.

$OP_4 = X \cdot (\theta_0 \oplus \theta_1) + \overline{X}$ $\quad$ $OP_5 = \overline{\theta_0}$

$\boxed{X = 0 \quad \theta_0, \theta_1 = \{1,1\}\ \{0,0\}}$

⇒ i = stuck - at - 0

$Y = \overline{\theta_0} \cdot (X \cdot (\theta_0 \oplus \theta_1))$. $\quad$ $OP_4 = X \cdot (\theta_0 \oplus \theta_1)$.

$OP_5 = \overline{\theta_0}$

$\boxed{X = 0 \quad \theta_0, \theta_1 = \{0,0\}\ \{1,0\}}$

⇒ i - stuck - at - 1

$Y = \overline{\theta_0}$ $\quad$ $OP_4 = 1$ $\quad$ $OP_5 = \overline{\theta_0}$

$$\boxed{\begin{array}{ll} X = 0 & \theta_0, \theta_1 = \{0,1\}\ \{1,0\} \\ X = 1 & \theta_0, \theta_1 = \{0,0\}\ \{1,1\} \end{array}}$$

⇒ e - stuck - at - 0

$Y = 0$ $\quad$ $OP_4 = 0$ $\quad$ $OP_5 = \overline{\theta_0}$

$$\boxed{\begin{array}{ll} X = 0 & \theta_0, \theta_1 = \{0,0\}\ \{1,0\} \\ X = 1 & \theta_0, \theta_1 = \{0,1\}\ \{1,0\} \end{array}}$$

⇒ e - stuck - at - 1

$Y = \overline{\theta_0}$ $\quad OP_4 = 1$ $\quad OP_5 = \overline{\theta_0}$

$$\boxed{\begin{array}{ll} X = 0 & \theta_0, \theta_1 = \{0,1\} \ \{1,0\} \\ X = 1 & \theta_0, \theta_1 = \{0,0\} \ \{1,1\} \end{array}}$$

⇒ b - stuck - at - 0

$OP_5 = 1 \quad OP_4 = X(\theta_0 \oplus \theta_1) + \overline{X}.(\overline{\theta_0 \oplus \theta_1}) = Y$

$$\boxed{X = DC \quad \theta_1 = DC \quad \theta_0 = 1}$$

⇒ b - stuck at - 1

$OP_5 = 0$

$$\boxed{X = DC \quad \theta_1 = DC \quad \theta_0 = 0}$$

⇒ d - stuck - at = 0

$Y = \overline{\theta_0}.(X.\theta_0 + \overline{\theta_0}.\overline{X})$.

$OP_4 = X.\theta_0 + \overline{\theta_0}.\overline{X} \quad OP_5 = \overline{\theta_0}$

$$\boxed{X = 0 \quad (\theta_0, \theta_1) = \{0, 1\}}$$

⇒ d - stuck - at = 1

$Y = \overline{\theta_0}.(X.\overline{\theta_0} + \theta_0.\overline{X})$. $\quad OP_4 = X.\overline{\theta_0} + \theta_0.\overline{X}$

$$\boxed{X = 0 \quad \{\theta_0, \theta_1\} = \{1, 0\}}$$

$\Rightarrow$ m-stuck-at-0

$Y = \overline{\theta_0} . (X . \theta_1 + \overline{\theta_1} . \overline{X})$

$Op_4 = X . \theta_1 + \overline{\theta_1} . \overline{X}$ $\quad\quad\quad Op_5 = \overline{\theta_0}$

$\boxed{X = 0 \quad\quad (\theta_0, \theta_1) = \{1, 0\}.}$

$\Rightarrow$ m-stuck at-1

$Y = \overline{\theta_0} . (X . \overline{\theta_1} + \theta_1 . X)$ $\quad\quad\quad Op_5 = \overline{\theta_0}$

$Op_4 = X . \overline{\theta_1} + \theta_1 . \overline{X}$

$\boxed{X = 0 \quad\quad (\theta_0, \theta_1) = \{0, 1\}}$

So with the help of this test cases we can detect all the wire faults.

We can find solution using SAT solver. by finding solution which satisfies.

$Y_{good} \oplus Y_{bad}$ or $Op_{4good} \oplus Op_{4bad}$

$Op_{5good} \oplus Op_{5bad}$.

Q.3

→ 4-bit address ⇒ 8-bit data.

$2^4 = 16$ Rows.

Consider 2 Rows

Aim = To show this 2 Rows are fault free.

1: 10 10 10 10 = d

2: 01 01 01 01 = m

Q_n = Read address n

→ decoder-error :- If there is a decoder error the Read output is zero or $R_1 \neq d$

$R_2 \neq m$

for example :-

if address 1 and 2 are coupled.

(i.e.) address 1 is coupled to address 2

the output of R1 = zero

Write address ① ⇒ 10101010

~~10 10 10 10~~

10101010

~~01/01~~.

Write address ② ⇒ 01010101

10 10 10 10 R1 = zero

01 01 01 01 R2 = 01010101.

→ We will do the above process. for 2 times.

case ①

1: 10101010 d

2: 01 01 01 01 m

case ②

1: 01 01 01 01 m

2: 10 10 1010 d

from this all stuck-at 0 and all stuck-at-1 can be tested in this 2 Rows.

as we have only stored d or m in the memory any other output from the memory Read results in fault.

→ No-Read :- Read output is "1111111"

→ if the word "1010 1010" "01010101"

Read output $R_1 \neq d$ or $R_2 \neq m$

← fliped bit

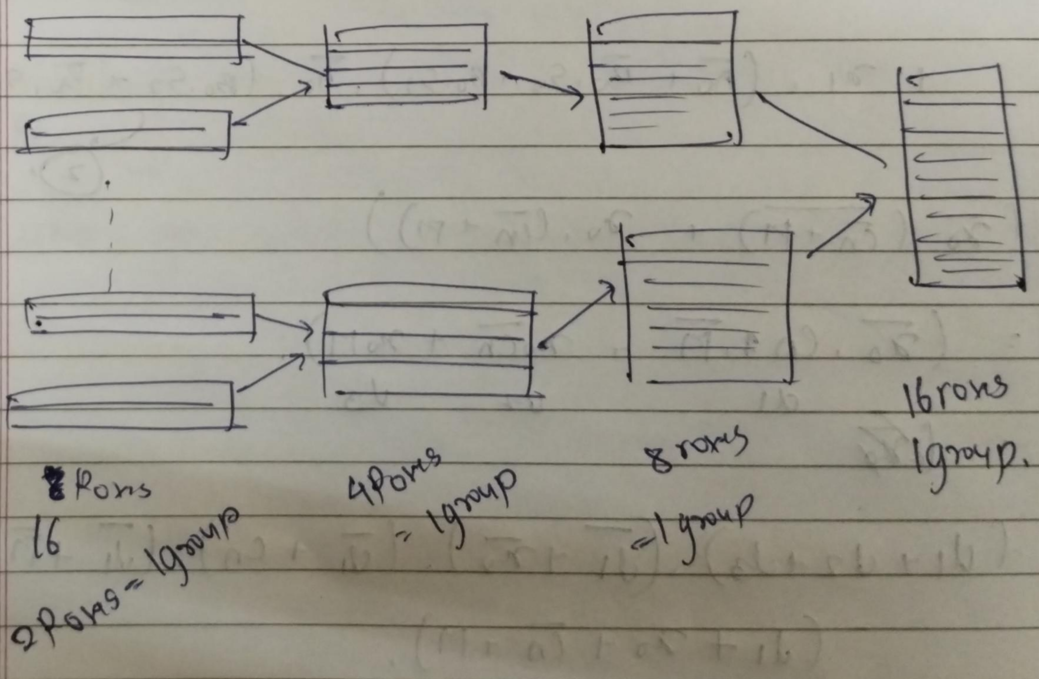
eg 1: 11 10 10 10 $R_1 \neq d$

2: 0 1 0 1 0 1 0 1

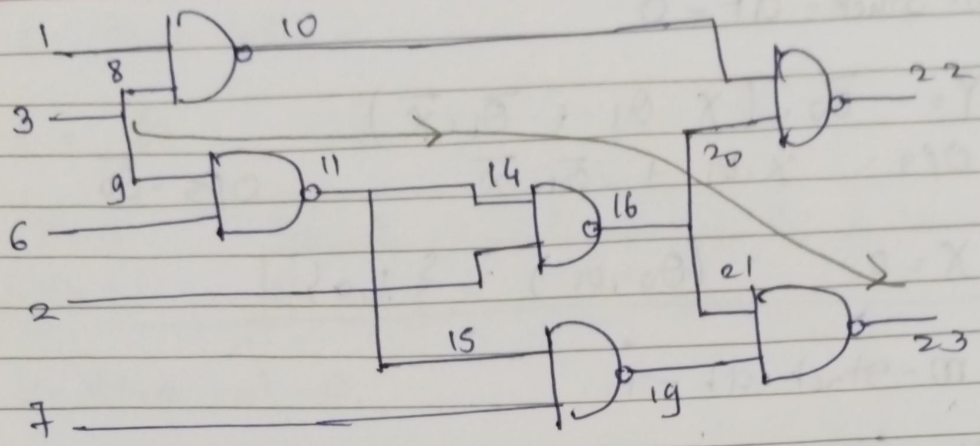
So from above process we can check the fault in 2 consetive Rows.

~~Divide the memory ins~~

⇒ group the memory in 2 Rows and check for fault if no fault detected then further make group of 4 Rows and this goes until we have just a single group.



Q.4



In order to find the maximum delay along the provided path we need to find 2 input vectors which will togel the output of every NAND gate.

$\Rightarrow$ test vector

1	3	6	2	7
X	0	1	1	X
X	1	1	1	X

X = don't care.

$$\frac{\partial f}{\partial x} = 1 = f_x \oplus f_{\bar{x}} = \text{if change in } x \text{ togels } f.$$

$x_{11} = \overline{x_3 . x_6}$ we are changing x_3.

$$\frac{\partial x_{11}}{\partial x_3} = \overline{x_6} \oplus 0 = x_6 = 1$$

similarly $x_{16} = \overline{x_{11} . x_2} = x_3 . x_6 + \overline{x_2}$

$$\frac{\partial x_{16}}{\partial x_3} = (x_6 + \overline{x_2}) \oplus (\overline{x_2}) = 1 \oplus \overline{x_2} = 1$$

$\Downarrow$

$x_6 . x_2$

$\overline{x_2} = 0$

$\underline{x_2 = 1}$

for $x_6 = 1$ $\quad x_2 = 1$ $\quad x_{11} = \overline{x_3}$ $\quad x_{16} = x_3$

$x_{19} = x_3 + \overline{x_7}$

so $x_{23} = \overline{x_{21} \cdot x_{19}}$

$x_{23} = \overline{x_3} + \overline{x_3} \cdot x_7 = \overline{x_3} = 1$

$x_3 = 0$

~~x_3~~ X_7 = don't care.

Solution $(1, 6, 2, 7) = (X, 1, 1, X)$.

To find using SAT solver.

find solution for.

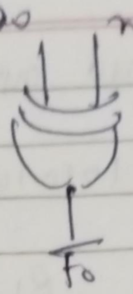
$$\boxed{\frac{\partial x_{11}}{\partial x_3} \cdot \frac{\partial x_{16}}{\partial x_3} \cdot \frac{\partial x_{23}}{\partial x_3} = 1}$$

x_6 $\quad x_6 \cdot x_2$ $\quad 1$

$$\boxed{x_6 \cdot x_2 = 1}$$

Optimal

Q. 1



$F_0 = \cancel{\oplus M}\ x_0 \oplus x_1$

$x_0 = \overline{C_n . \overline{M}} = \overline{C_n} + M$.

$x_1 = \left(\overline{A_0} + \overline{B_0}.S_0 + B_0.S_1\right).\left(B_0.\overline{A_0}.S_2 + \overline{B_0}.\overline{A_0}\,S_3\right)$

$x_1 = B_0\overline{A_0}.S_2 + \overline{B_0}.\overline{A_0}.S_3 + \overline{B_0}.\overline{A_0}.S_3.S_0$
$+ B_0.S_1.\cancel{B_0}\overline{A_0}.S_2$.

$\overline{F_0}$ - stuck-at-one.

so $(x_0, x_1) = (0,0)$ or $(1,1)$. to detect the fault.

sat solver for $(x_0 = x_1)$. → x_0 XNOR x_1

$(x_0 + \overline{x_1}).(x_1 + \overline{x_0}).(\cancel{x_0 A_0}\ \overline{x_0}.(\overline{\overline{C_n} + M}) +$
$x_0.(\overline{C_n} + M))$ — ①

$(\overline{x_1}.(\overline{(\overline{A_0} + \overline{B_0}.S_0 + B_0.S_1).(B_0.\overline{A_0}.S_2 + \overline{B_0}.\overline{A_0}.S_3)}$
$+ x_1.(\overline{A_0} + \overline{B_0}.S_0 + B_0.S_1).\overline{A_0}.(B_0.S_2 + \overline{B_0}.S_3)).$ ②

for ① ⇒ $(\overline{x_0}.(\overline{\overline{C_n} + M}) + x_0.(\overline{C_n} + M))$

$= (\underbrace{\overline{x_0}.C_n.\overline{M}}_{d_1} + \underbrace{x_0\overline{C_n}}_{d_2} + \underbrace{x_0 M}_{d_3})$.

: $\cancel{(d_1)}$

$(d_1 + d_2 + d_3).(\overline{d_1} + \overline{x_0}).(\overline{d_1} + C_n).(\overline{d_1} + \overline{M})$.
$(d_1 + x_0 + \overline{C_n} + M)$.

For (1) $\overline{x_1}.\overline{(B_0.s_1 + \overline{B_0}.s_3 + \overline{B_0}.s_3.s_0 + B_0.s_1.\overline{B_0}.s_2).\overline{A_0}}$

$+ x_1.(\overline{A_0}.(B_0 s_2(1+s_1) + \overline{B_0}.s_3(1+s_0)))$

$= \overline{x_1}.\overline{\overline{A_0}.(B_0.s_2 + \overline{B_0}.s_3)} + x_1.\overline{A_0}.(B_0.s_2 + \overline{B_0}.s_3)$

$= \overline{x_1}.(A_0 + (\overline{B_0}+\overline{s_2}).(B_0+\overline{s_3}))$

$+ x_1.\overline{A_0}.B_0.s_2 + \overline{B_0}.s_3.x_1.\overline{A_0}$

$= \overline{x_1}.(A_0 + \overline{B_0}.\overline{s_3} + \overline{s_2}.B_0 + \overline{s_2}.\overline{s_3})$

$+ x_1.\overline{A_0}.B_0.s_2 + \overline{B_0}.s_3.x_1.\overline{A_0}$

$\Rightarrow \underbrace{\overline{x_1}.A_0}_{u_4} + \underbrace{\overline{x_1}.\overline{B_0}.\overline{s_3}}_{u_5} + \underbrace{\overline{x_1}.\overline{s_2}.B_0}_{u_6} + \underbrace{\overline{x_1}.\overline{s_2}.\overline{s_3}}_{u_7}$

$+ \underbrace{x_1.\overline{A_0}.B_0.s_2}_{u_8} + \underbrace{x_1.\overline{B_0}.s_3.\overline{A_0}}_{u_9}$

similary make CNF for the above express using ~~for~~ Renaming method.

and get solution using CNF / SAT solver.

optional

Q. 2

⇒ to get $\overline{G}$-stuck at-0 and $\overline{P}$ stuck at-0.

for good limit $\overline{P} = 1$ and $\overline{G} = 1$ simultaneously.

So $\overline{P} = 1$ and $\overline{G} = 1$ for.

$S_0 = 1$ $S_1 = 1$ $S_2 = 1$ $S_3 = 1$
$\overline{A_3} = 1$ $\overline{A_2} = 1$ $\overline{A_1} = 1$ $\overline{A_0} = 1$
$\overline{B_3} = 1$ $\overline{B_2} = 1$ $\overline{B_1} = 1$, $\overline{B_0} = 1$

With the help of this test vector we can detect $\overline{P}$-stuck-at-0 and $\overline{G}$-stuck-at-0 simultaneously.