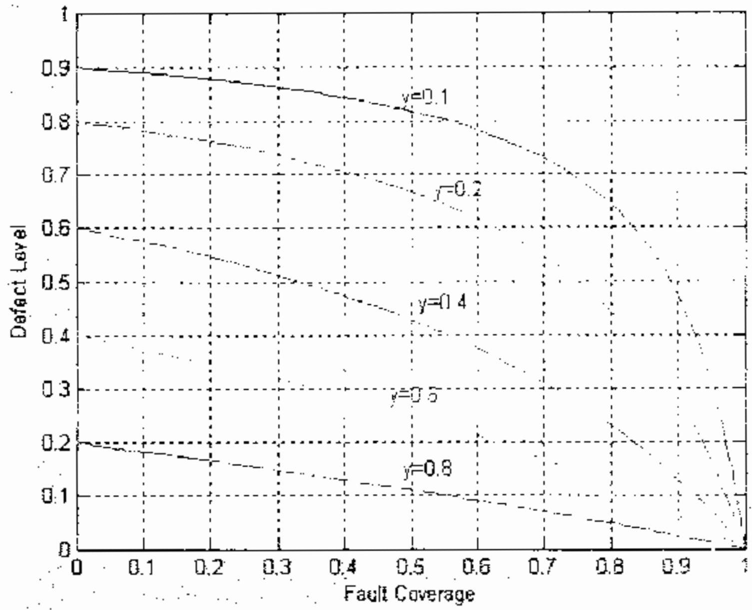
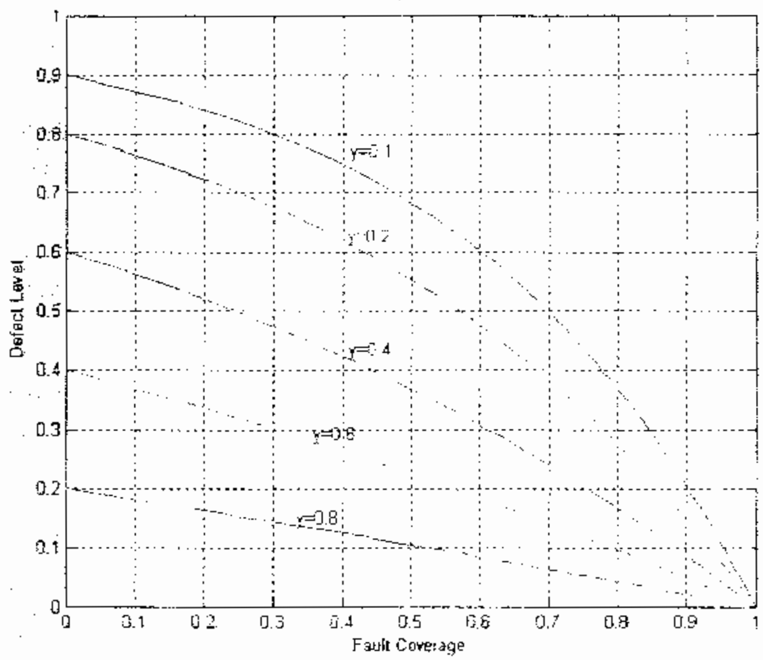
Q1. COE464 HW#2 042

i) By Formula Derived in class :



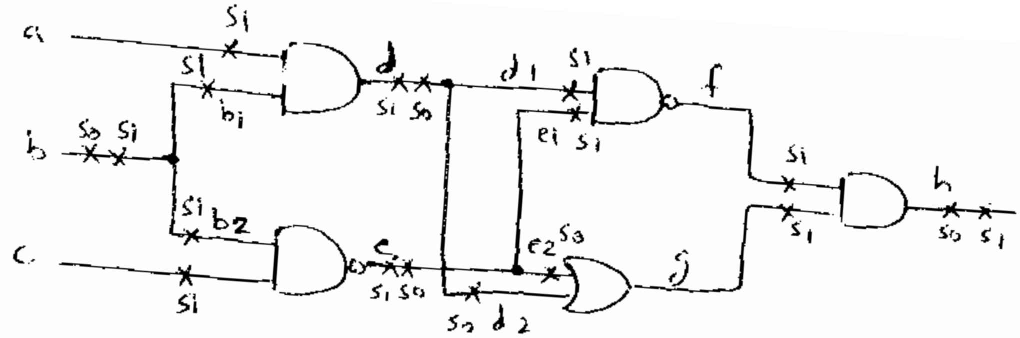
ii) By Williams and Brown model



Comparison

- For higher yield : The results are similar for the 2 models
- For lower yield : The defect level is lower in the Williams and Brown model especially for higher fault coverage

P2.



Number of collapsed faults based on fault equivalence is 18.

Fault list = { a/1, b/0, b/1, c/1, b1/1, b2/1, d/1, d/0, e/1, e/0, d1/1, d2/0, e1/1, e2/0, f/1, g/1, h/0, h/1 }

(i) <u>Deductive fault simulation</u>:

a. test vector = 101

$L_a = \phi$, $L_b = \{b/1\}$, $L_c = \phi$

$L_{b1} = L_b \cup \{b1/1\} = \{b/1, b1/1\}$

$L_{b2} = L_b \cup \{b2/1\} = \{b/1, b2/1\}$

$L_d = (L_{b1} - L_a) \cup \{d/1\} = \{b/1, b1/1, d/1\}$

$L_e = (L_{b2} - L_c) \cup \{e/0\} = \{b/1, b2/1, e/0\}$

$L_{d1} = L_d \cup \{d1/1\} = \{b/1, b1/1, d/1, d1/1\}$

$L_{d2} = L_d = \{b/1, b1/1, d/1\}$

$L_{e1} = L_e = \{b/1, b2/1, e/0\}$

$L_{e2} = L_e \cup \{e2/0\} = \{b/1, b2/1, e/0, e2/0\}$

$L_f = L_{d1} - L_{e1} = \{b1/1, d/1, d1/1\}$

$L_g = L_{e2} - L_{d2} = \{b2/1, e/0, e2/0\}$

$L_h = (L_f \cup L_g) \cup \{h/0\}$

$= \{b1/1, b2/1, d/1, d1/1, e/0, e2/0, h/0\}$

So, $\underline{7}$ faults are detected by the test vector 101

b. test vector = 010

$L_a = \{a/1\}$, $L_b = \{b/0\}$, $L_c = \{c/1\}$

$L_{b1} = L_b = \{b/0\}$

$L_{b2} = L_b = \{b/0\}$

$L_d = (L_a - L_{b1}) \cup \{d/1\} = \{a/1, d/1\}$

$L_e = (L_c - L_{b2}) \cup \{e/0\} = \{c/1, e/0\}$

$L_{d1} = L_d \cup \{d1/1\} = \{a/1, d/1, d1/1\}$

$L_{d2} = L_d = \{a/1, d/1\}$

$L_{e1} = L_e = \{c/1, e/0\}$

$L_{e2} = L_e \cup \{e2/0\} = \{c/1, e/0, e2/0\}$

$L_f = L_{d1} - L_{e1} = \{a/1, d/1, d1/1\}$

$L_g = L_{e2} - L_{d2} = \{c/1, e/0, e2/0\}$

$L_h = (L_f \cup L_g) \cup \{h/0\}$

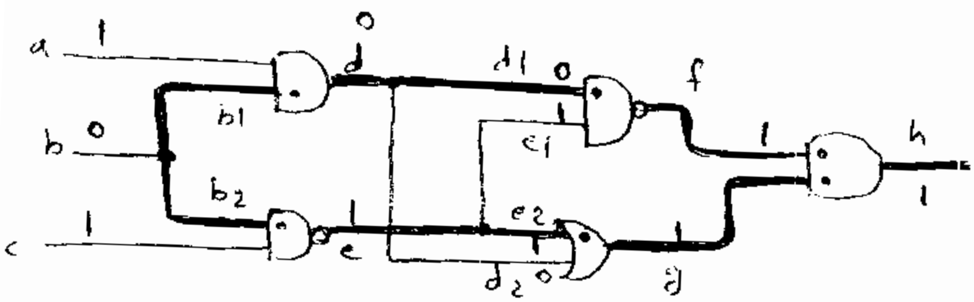
$= \{a/1, c/1, d/1, d1/1, e/0, e2/0, h/0\}$

So, $\underline{7}$ faults are detected by the test 010.

Note that if the test vector 010 is applied after the test 101, then only two faults are newly detected, namely $\{a/1, c/1\}$.

(ii) <u>Critical path tracing</u> :

∴ test vector = (101)



FFR	Critical lines	Stems to check	Checked stems	Capture line
h	h, f, g, d1, e2	d, e		
		e	d	f or h
d	d, b1	b, e		
		b	e	g or h
e	e, b2	b		
		∅	b	–

Thus, the detected faults are :

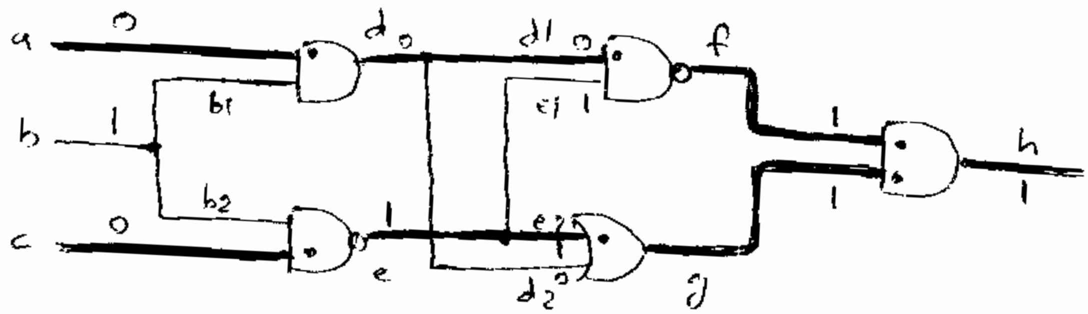
{h/0, f/0, g/0, d1/1, e2/0, d/1, e/0, b1/1, b2/1}

The detected faults from the collapsed set are :

{h/0, d1/1, e2/0, d/1, e/0, b1/1, b2/1}

⇒ 7 faults are detected.

b. test vector = 010



FFR	Critical lines	Stems to check	Checked stems	Capture line
h	h, f, g, d1, e2	d, e		
		e	d	f or h
d	d, a	e		
		∅	e	g or h
e	e, c	∅		

Thus, the detected faults are:

{h/0, f/0, g/0, d1/1, e2/0, d/1, e/0, a/1, c/1}

The detected faults from the collapsed set are:

{h/0, d1/1, e2/0, d/1, e/0, a/1, c/1}

So, 7 faults are detected by the test 010.

Q3. Exact fault coverage $= \dfrac{4563}{4603} = 99.13\%$

(i)

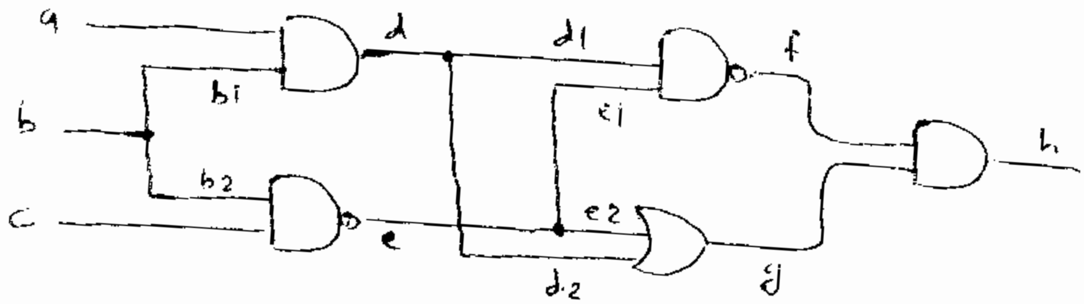
Sample m	fault Coverage	Error
50	100 %	+ 0.88 %
100	99 %	− 0.13 %
500	99 %	− 0.13 %
1000	99.3 %	+ 0.17 %

As can be seen, a sample of 100 faults gives a good estimate of the fault coverage

(ii) No. of test vectors after reversing the test set and reducing it is 273 vectors.

The reduction happens as a vector at the end of the test may detect all the faults detected by a test vector at the beginning of the test set. When we reverse the order of the vectors, the vector that was in the beginning of the test will be removed as it will no longer detect any additional faults.

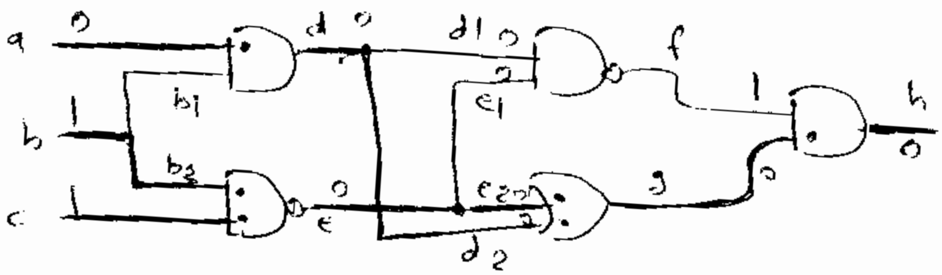
Q4.



Fault list = { d/1, e/0, b/1 }.

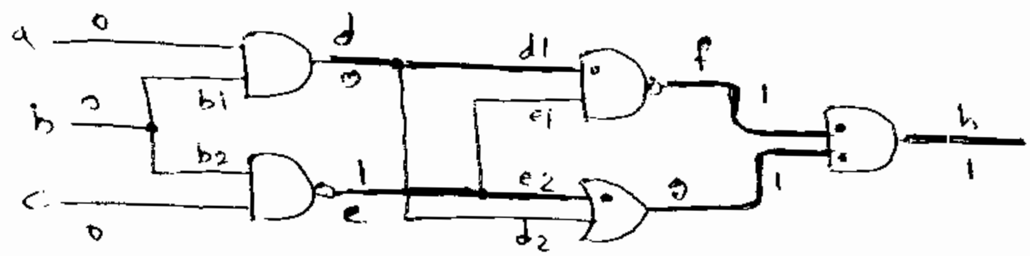
Test set T = { 011, 000, 111, 101 }

1. test vector 011



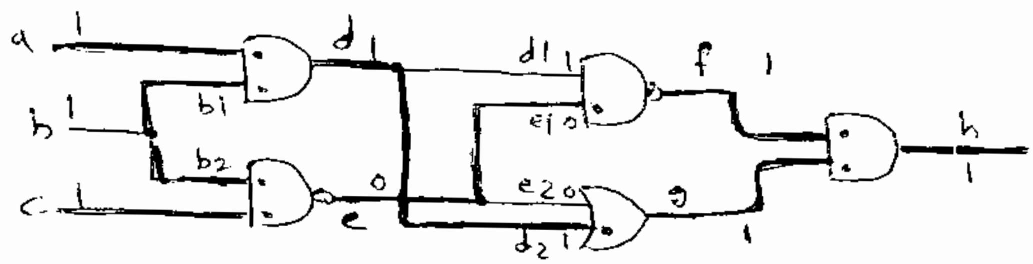
line	0-count	1-count	Sensitization-Count
a	1	0	1
b	0	1	–
c	0	1	1
b1	0	1	0
b2	0	1	1
d	1	0	–
e	1	0	–
d1	1	0	0
d2	1	0	1
e1	1	0	0
e2	1	0	1
	0	1	0

2. test vector 000



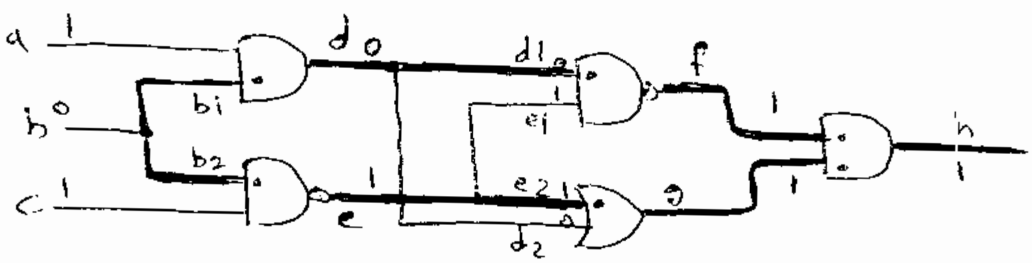
line	0-count	1-count	sensitization-count
a	2	0	1
b	1	1	–
c	1	1	1
b1	1	1	0
b2	1	1	1
d	2	0	–
e	1	1	–
d1	2	0	1
d2	2	0	1
e1	1	1	0
e2	1	1	2
f	0	2	1
g	1	1	2
h	1	1	–

3. Test vector 111



line	0-count	1-count	Sensitization-count
a	2	1	2
b	1	2	-
c	1	2	2
b1	1	2	1
b2	1	2	2
d	2	1	-
e	2	1	-
d1	2	1	1
d2	2	1	2
e1	2	1	1
e2	2	1	2
f	0	3	2
g	1	2	3
h	1	2	-

4. test vector 101



line	0 - count	1 - count	Sensitization - count
a	2	2	2
b	2	2	-
c	1	3	2
b1	2	2	2
b2	2	2	3
d	3	1	-
e	2	2	-
d1	3	1	2
d2	3	1	2
e1	2	2	1
e2	2	2	3
f	0	4	3
g	1	3	4
h	1	3	-

line l	$C_0(l)$	$C_1(l)$	$S(l)$
a	0.5	0.5	0.5
b	0.5	0.5	–
c	0.25	0.75	0.5
b1	0.5	0.5	0.5
b2	0.5	0.5	0.75
d	0.75	0.25	–
e	0.5	0.5	–
d1	0.75	0.25	0.5
d2	0.75	0.25	0.5
e1	0.5	0.5	0.25
e2	0.5	0.5	0.75
f	0	1	0.75
g	0.25	0.75	1
h	0.25	0.75	–

Next, we compute line observability.

$O(h) = 1$

$O(f) = S(f)\, O(h) = 0.75$

$O(g) = S(g)\, O(h) = 1$

$O(d_1) = S(d_1)\, O(f) = 0.5 \times 0.75 = 0.375$

$O(d_2) = S(d_2)\, O(g) = 0.5 \times 1 = 0.5$

$O(e_1) = S(e_1)\, O(f) = 0.25 \times 0.75 = 0.1875$

$O(e_2) = S(e_2)\, O(g) = 0.75 \times 1 = 0.75$

$O_u(d) = O(d_1) + O(d_2) - O(d_1)\, O(d_2)$

$= 0.375 + 0.5 - (0.375 \times 0.5) = 0.6875$

$O_L(d) = \max\{o(d_1), o(d_2)\} = 0.5$

Let us compute $O(d) = 0.5\ O_L(d) + 0.5\ O_u(d)$

$\Rightarrow O(d) = 0.5 \times 0.5 + 0.5 \times 0.6875 = 0.594$

$O_u(e) = o(e_1) + o(e_2) - o(e_1)\ o(e_2)$
$= 0.1875 + 0.75 - (0.1875 \times 0.75) = 0.797$

$O_L(e) = \max\{o(e_1), o(e_2)\} = 0.75$

$O(e) = 0.5 \times 0.75 + 0.5 \times 0.797 = 0.7735$

$o(b_1) = S(b_1)\ o(d) = 0.5 \times 0.594 = 0.297$

$o(b_2) = S(b_2)\ o(e) = 0.75 \times 0.7735 = 0.580$

$O_u(b) = o(b_1) + o(b_2) - o(b_1)\ o(b_2)$
$= 0.297 + 0.58 - (0.297 \times 0.58) = 0.705$

$O_L(b) = \max\{o(b_1), o(b_2)\} = 0.58$

$O(b) = 0.5 \times 0.58 + 0.5 \times 0.705 = 0.6425$

Next, we compute the detection probabilities.

$d_{b/1} = Co(b)\ O(b) = 0.5 \times 0.6425 = 0.32$

$d_{d/1} = Co(d)\ o(d) = 0.75 \times 0.594 = 0.446$

$d_{e/0} = Ci(e)\ O(e) = 0.5 \times 0.7735 = 0.387$

Thus, detection probability with the four test vectors is computed as follows.

$$d^4_{b/1} = 1 - (1 - 0.32)^4 = 0.786$$

$$d^4_{d/1} = 1 - (1 - 0.446)^4 = 0.906$$

$$d^4_{e/0} = 1 - (1 - 0.337)^4 = 0.859$$

Next, let us determine the faults detected by each of the test vectors.

vector	detected faults
011	d/1
000	d/1, e/0
111	ϕ
101	d/1, e/0

Thus, as we can see both the faults d/1 and e/0 have high detection probability and they are detected. However, fault b/1 has a high detection probability while it is not detected by the test set T.