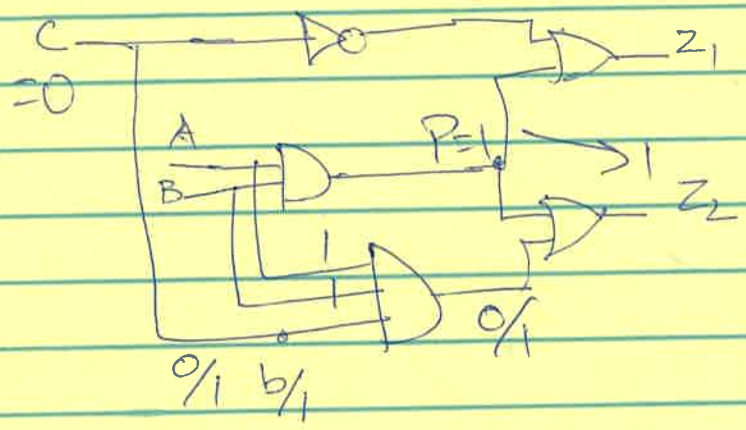
Q 1 (a) Test for $b/_1$



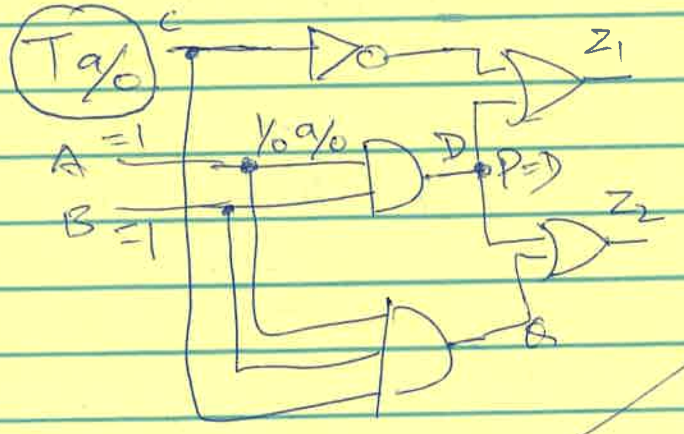
b/1 requires C=0. $b = 0/_1 = \bar{D}$

Side-inputs. A=B=1. But

P=1 ⇒ Z2=1

Fault propagation blocked at Z2. No Test $b/_1$.

ⓑ Distinguish between (fault effects) $a/_0$, $c/_0$.



A=1, B=1, a=D; P=D.

P → Z1 two outputs

P → Z2 to observe fault effect.

C=0 → Z1=1 blocks fault @ Z1

but C=0 ⇒ Q=0.

Q=0, P=D ⇒ Z2=D

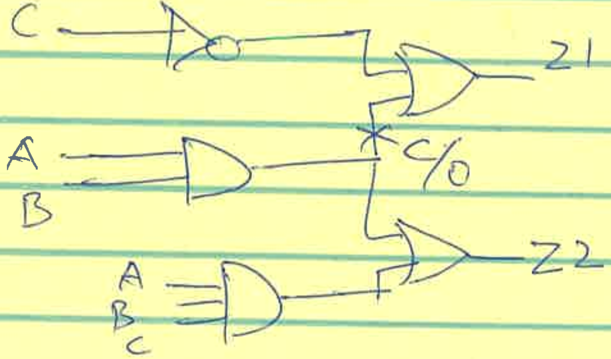
also C=1, A=1, B=1 ⇒ Q=1 ⇒ Z2 = 1 (blocked)

But C=1; P=D ⇒ Z1 = D (observed)

So $T_{a/0}$: { A=1 B=1 C=0 : fault observed @ Z2 = D.
A=1 B=1 C=1 : " " @ Z1 = D.

2 test vectors.

$T_{c/0}$:



c/0 can only be observed @ Z1

c/0 ⇒ c = 1/0 ⇒ A = B = 1

C = 1 , c = 1/0 ⇒ Z1 = 1/0 = D.

A=1 B=1 C=1 : fault effect observed @ Z1 = D.

A=1 B=1 C=1 = common test vector for a/0 , c/0.

w/ a/0. A=B=C=1
Z1=D, Z2=1

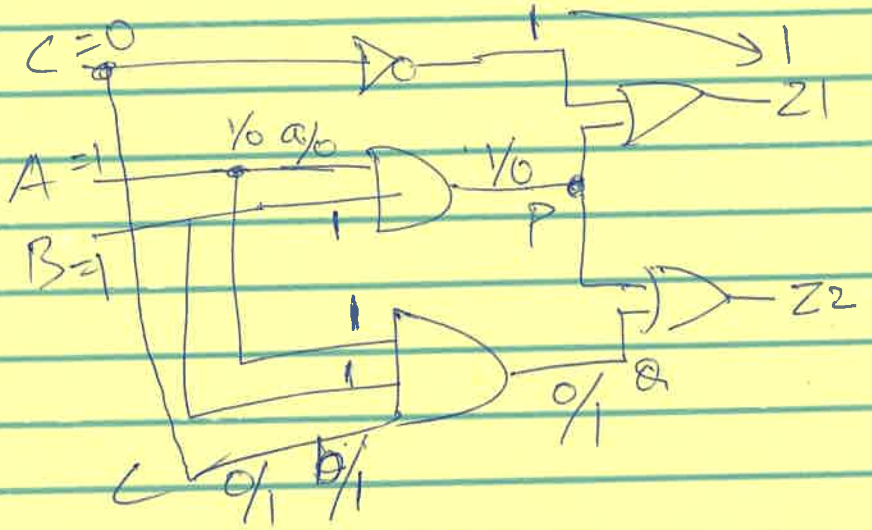
w/ c/0. A=B=C=1
Z1=D Z=1

Same outputs under the same & only common test vector.

Cannot distinguish their effects.

Q1 c

T{a/0, b/1}



a/0. Excitation A=1

b/1 Excitation C=0. → Z1=1

Focus fault observation only @ Z2

Fault propagation requires B=1

$$\Rightarrow \left.\begin{array}{l} P = 1/0 = D \\ Q = 0/1 = \overline{D} \end{array}\right\} \underline{Z2 = D + \overline{D} = 1}$$

No Test {a/0, b/1}

Q 2 (a) ⑥

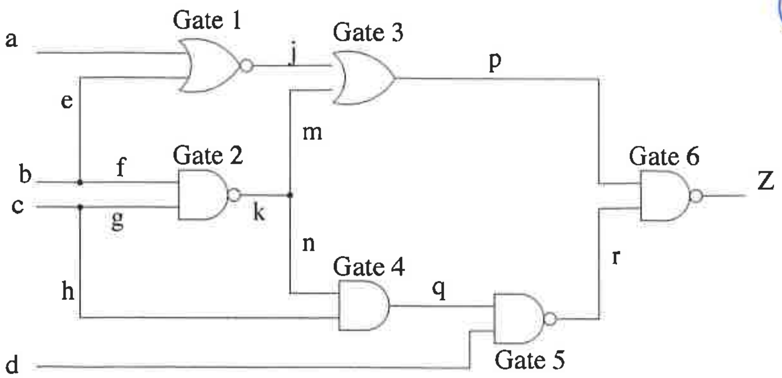


Fig. 3: The circuit diagram related to Checkpoint faults

No need to derive tests for indistinguishable faults.
// equivalent faults.

Find all equivalent faults, pick only one from each equivalence class.

For gate G1: $a/_1 = e/_1 = j/_0$ —①

G2 $f/_0 = g/_0 = k/_1$ —②

G3 $j/_1 = m/_1 = p/_1$ —③

G4: $n/_0 = h/_0 = q/_0$ —④

G5: $q/_0 = d/_0 = r/_1$ —⑤

G6: $p/_0 = \underbrace{r/_0 = z/_1}$ —⑥

↳ ignore these. If I test for $p/_0$, I cannot distinguish it from $r/_0$ & $z/_1$, so drop. $r/_0$, $z/_1$ . . . . .

From ①-⑥ sets, Pick any one equivalent fault, disregard the rest.
I'll keep faults from the first column,
$\{a/_1, f/_0, j/_1, n/_0, q/_0, p/_0\}$ = 6 faults

(b). Checkpoints of the ckt = PIs + Fanout branches

PIs: $a/_0, a/_1, b/_0, b/_1, c/_0, c/_1, d/_0, d/_1$ = 8 faults.

FOB :— $e/_0, e/_1, f/_0, f/_1, g/_0, g/_1, h/_0, h/_1, m/_0, m/_1$
$n/_0, n/_1$ = 12 faults.

Total CKP~~ts~~ faults = 12 + 8 = 20

Checkpoint theorem states that it is sufficient to test for only the checkpoint faults.

No need to test for other faults.

All chkpts. tested ⟹ ~~al~~ the whole ckt is tested.

But it is not necessary to test all chkpoints. faults.

It might be possible to test for fewer than the Chkpt faults, in our case <20 tests needed, as shown in (c).

(c) In (a) we have already found all equivalence relations. Now we find dominance relations.

G1: $j/1 \supset a/0, e/0$ — ⑦

G2: $k/0 \supset f/1, g/1$ — ⑧

G3: $p/0 \supset j/0, m/0$ — ⑨

G4: $q/1 \supset n/1, h/1$ — ⑩

G5: $r/0 \supset q/1, d/1$ — ⑪

G6: $z/0 \supset p/1, r/1$ — ⑫

Note. $e/1$ is a Checkpoint fault.

But from ①. $e/1 = a/1$.
$a/1$ = PI. So if I test $a/1$, I also tested $e/1$. So remove $e/1$ from the test set.
= 19 faults

Also combine equiv + domin. relations.

From ③ $m/1 = j/1$
From ⑦ $j/1 \supset a/0$.
So if I test $a/0$, $j/1$ is tested (due to dominance)
and $m/1$ is also tested. (equiv. $= j/1$)
So, remove $m/1$ from the checkpoint fault list.
= 18 faults.

Also: from ⑤. $d/0 = g/0$. } d = PI. If I test
" ④ $g/0 = n/0$. } $d/0$, I also test $n/0$.
remove $n/0$ fanout branch fault from Test set.
= 17 faults.

But. $n/0 = h/0$. So, remove $h/0$ too. = 16 faults
$f/0 = g/0$. — ② So remove $g/0$. $\Longrightarrow$ 15 faults.

If these 15 faults are testable
the whole circuit is testable

Final list: $a/0, a/1, b/0, b/1, c/0, c/1, d/0, d/1$
$e/0, f/0, f/1, g/1, h/1, m/0, n/1$ } minimal set of 15 tests

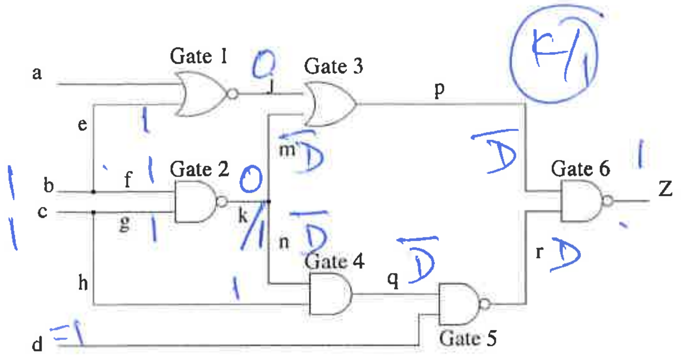


Fig. 3: The circuit diagram related to Checkpoint faults

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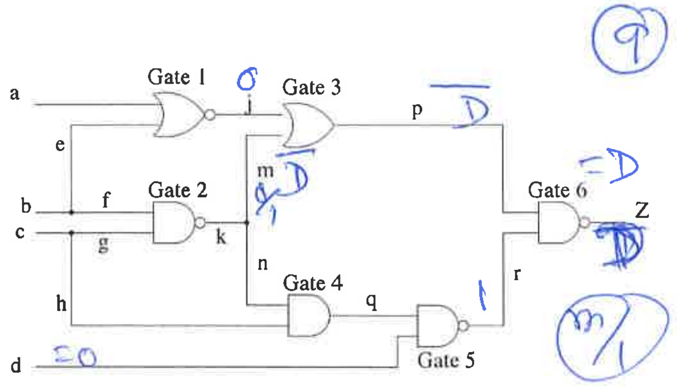


Fig. 3: The circuit diagram related to Checkpoint faults

Q 3

K/1 $K=0 \Rightarrow K=\bar{D}$ 0/1

multipath. $K \to m \to p \to Z$

$k \to n \to q \to r \to Z$

$p=\bar{D}$, $q=\bar{D}$, $d=1$

$\Rightarrow r=D$

$Z=1$ ×

try single path $K \to m \to p \to Z$

put $d=0$. $r=1$ @ Gate5

$K=\bar{D}$, $b=e=1$, $j=0$.

$m=\bar{D}$ $p=\bar{D}$ // $Z=D$

$r=1$

$a=0$ or 1

$b=1$

$c=1$

$d=0$.

} $Z=D$.

m/1 : $m=0$. $\Rightarrow m=0/1=\bar{D}$

$k=0$.

$f=1$, $g=1 \Rightarrow b=1, c=1$

$d=0$.

$a=0, b=1, c=1, d=0$.

$Z=D$

Same as K/1.

Q4 ⓑ

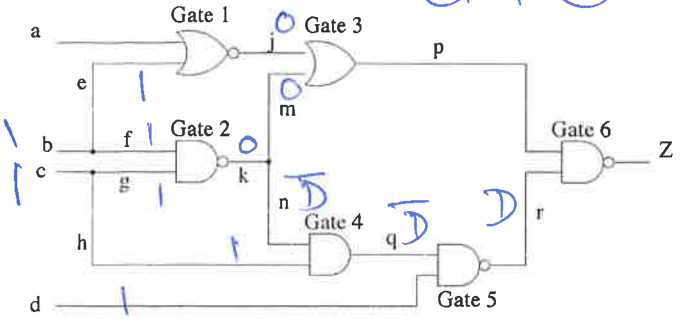


Fig. 3: The circuit diagram related to Checkpoint faults

$n/1$. $n=0$. ~~n~~$= 0/1 = \overline{D}$

only single path possible.

$n \to q \to r \to Z$.

$\left.\begin{matrix} h=1 = c=1 \\ b=1 \end{matrix}\right\} \to k=0$. $n=\overline{D}$

$\Downarrow$

$m=0$.

$d=1$

$b=1 \Rightarrow e=1 \Rightarrow \left.\begin{matrix} j=0 \\ + \\ m=0. \end{matrix}\right\}$

$\Rightarrow p=0 \to Z=1$

No test.

$n/1$ = redundancy.

Put $n=1$ & simplify

⑩.

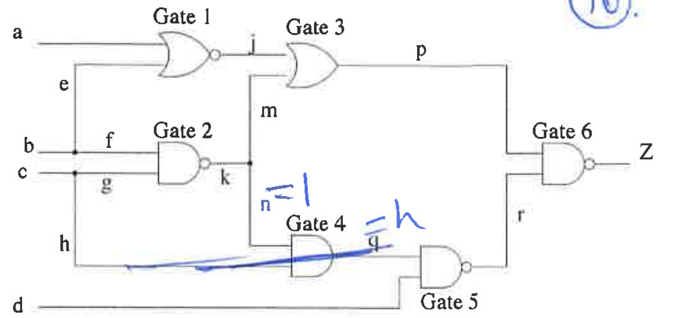


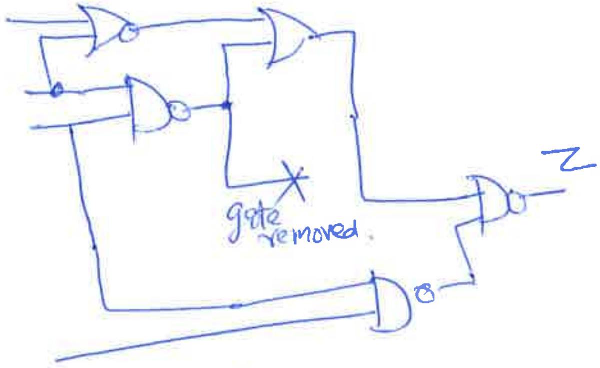
Fig. 3: The circuit diagram related to Checkpoint faults

$n=1$

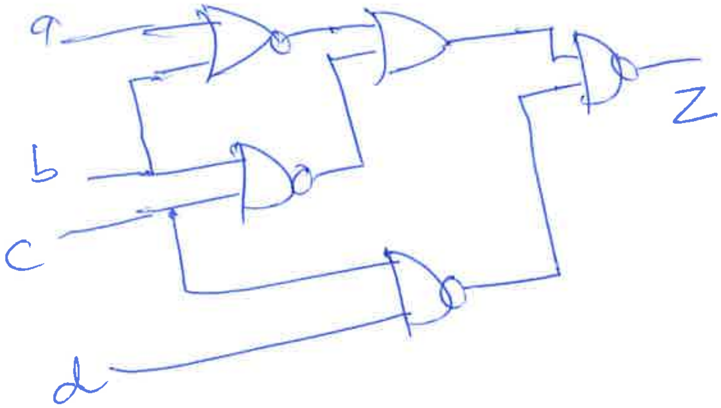
$q=h$.

gate 4 = redundant

remove G4.



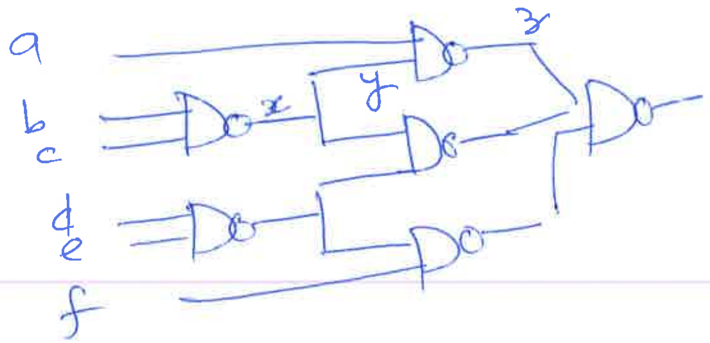
$\Downarrow$



Q 4 PI = fanout free, but internal fanouts may exist.

Given test set T that detects all s/1 faults.

Does it detect all s/0 faults too? Yes, Proof —



Any net is either:

① Primary input = gate input; eg. 'a'.

② Fanout stem = gate output eg. net x

③ Fanout branch = gate input, eg. net y

④ non-fanout gate output., e.g. z.

Nand input s/0 = output s/1

If output s/1 tested, gate input s/0 tested.

⇒ all PI s/0 tested., e.g. a/0 = z/1
and all fanout branches tested. y/0 = z/1
takes care of ① and ③.

Nand Gate { output s/0 dominates gate input s/1
eg. x/0 ⊃ b/1 T detects b/1 (given)
So T " x/0 (given)

this takes care of ② & ④.

All s/0 also tested.

⑬

Q 5

was a free gift experiment.