Automatic Test Pattern Generation for stuck-at Faults.

Given: 1 A gate-level ckt model = golden model = fault-free circuit. = G

DO:- 2 Pick a net in G. Assume a net $x_i \in C$ is stuck-at-0. Derive a test for x_i stuck-at 0. Denoted $T\, x_i/0$.

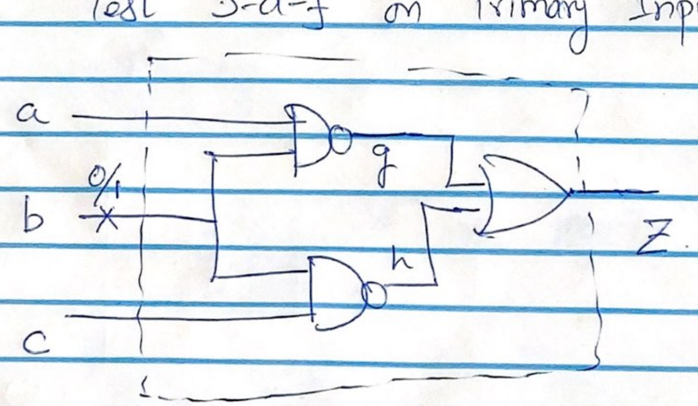
<u>Test</u>:- A set of vectors at Primary inputs that distinguishes the faulty and fault-free G under the presence of $x_i/0$.

3 Repeat 2 for $x_i/1$: Find $T x_i/1$

4 Repeat for all nets.

<u>Test set</u> = $\{ T x_i/0,\ T x_i/1 \ \ \forall x_i \in G \}$

Test s-a-f on Primary Inputs.



<u>Test b/1</u>

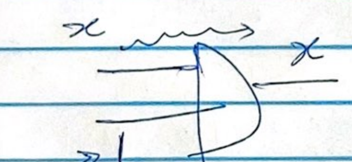
To test b/1

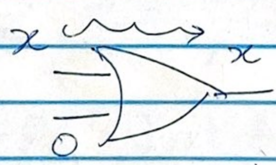
i) <u>Fault Activation</u> :- or excitation

Apply $\underline{\underline{b=0}}$, the value complement of stuck value

ii) <u>Fault propagation</u> : Apply values on the side-inputs (other inputs) such that the fault-effect propagates to P.O.

iii) For this, you need non-controlling values on the side-inputs. of the gates on the sensitized path.



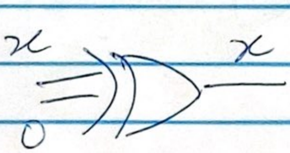


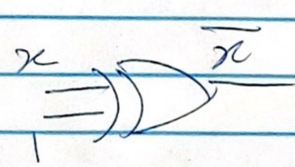
non-controlling value

0= controlling value

non controlling value.

<u>XORs</u> → no controlling values.

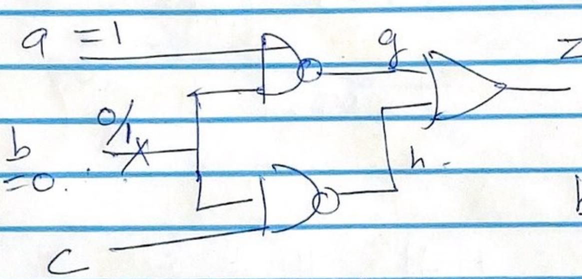




(3)

iv) Path sensitization.

- single path sensitization v/s.
- multi " ".



Single path sensitization.

$b \to g \to Z$.

① $b=0$: $0/_1$

fault-free (0), faulty value (1)

② $a=1$ = non-controlling value

$\Rightarrow g = 1/0$

$h = 0. \Rightarrow Z = 1/0 =$ fault-free = 1, faulty = 0

③ Can we get $h=0$? Justification needed.

with $b = 0/1$, $C = ?$ so that $h = 0$?

Not possible to get $h=0$.

④ Try a different single path.

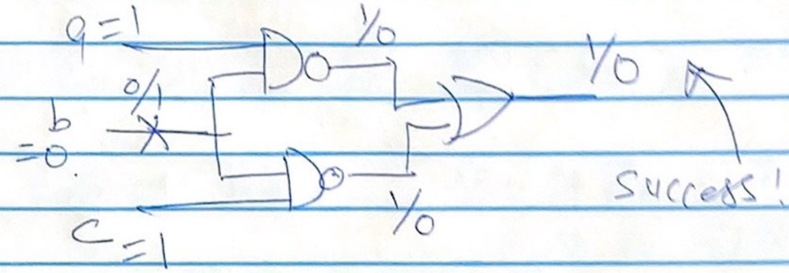
$b \to h \to z$.

$C=1 \quad h = 1/0, \quad g=0. \quad z = 1/0$.

Justification not possible.

Single path sensitization Fails.

5 Try Multipath sensitization.



$T_{b/1} = \{a=1,\ b=0,\ c=1\}$.

IF no fault exists $Z=1$ } Detected.
If fault exists $Z=0$.

Sometimes: Single path sensitization works.
or
Sometimes multi path ✓
sometimes both may work
other times **None** may work → Untestable fault.

Test on PIs: $T_{x/1} = \bar{x} \cdot \frac{\partial Z}{\partial x}$

Activation   Propagation

Prove it   remember Boolean difference.

Fault free Z $T_{x/1}$

Faulty $Z_f = Z(x=1)$

Miter $Z \oplus Z_f(x=1) = T_{x/1}$

Shannon's Expansion $Z = x Z_x + \bar{x} Z_{\bar{x}}$

$= x Z_x \oplus \bar{x} Z_{\bar{x}}$

$T_{x/1} = x Z_x \oplus \bar{x} Z_{\bar{x}} \oplus Z(x=1)$

$= \underline{x Z_x} \oplus \bar{x} Z_{\bar{x}} \oplus \underline{Z_x}$

$= x Z_x \oplus Z_x \oplus \bar{x} Z_{\bar{x}}$

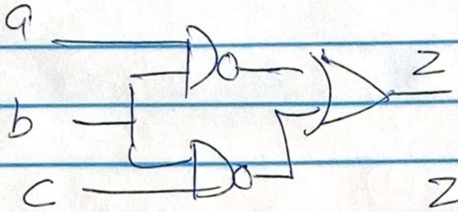
$= Z_x (x \oplus 1) \oplus \bar{x} Z_{\bar{x}}$

$= \bar{x} Z_x \oplus \bar{x} Z_{\bar{x}}$

$= \bar{x} \left[Z_x \oplus Z_{\bar{x}} \right] = \bar{x} \dfrac{\partial Z}{\partial x}$

$$\boxed{T_{x/0} = x \cdot \frac{\partial Z}{\partial x}}$$

Trick:- Shannon's OR = also XOR



$$Z = \overline{(ab)} + \overline{(bc)}$$

$$\frac{\partial Z}{\partial b} = Z_b \oplus Z_{\bar b}$$

$$= \left[\overline{a \cdot 1} + \overline{(1 \cdot c)}\right] \oplus \left[\bar 0 + \bar 0\right]$$

$$= \left[\bar a + \bar c\right] \oplus 1$$

$$= \overline{\left[\bar a + \bar c\right]} = a \cdot c.$$

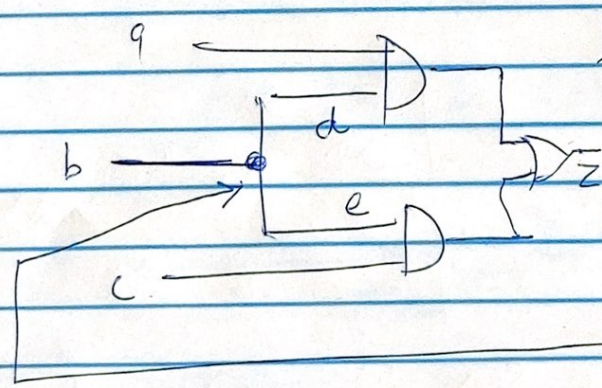
↑ Propagation condition.

$a = 1 \quad c = 1$

$T_{b/1} = b = 0, \; a = 1 \; c = 1$

$T_{b/0} : b = 1 \; a = 1, \; c = 1$

Fanout stems versus Fanout branches.



b = fanout stem

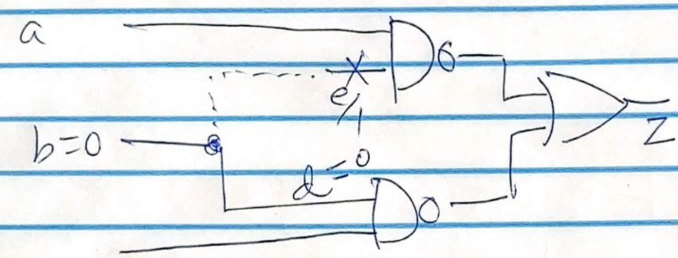
d, e = fanout branches.

fanout reconverges to Z = reconvergent fanouts.

Stem faults ≠ branch faults.

See slide # 19 $T\, e/1$

$T\, e/1$.



$b=0$, $\boxed{e=1}$ $Z=1$

$\Rightarrow d=0 \Rightarrow Z=1$ $Z_f=1$

<u>No Test</u> $\Leftrightarrow$ Redundancy.

Redundancy can be detected.

$e/1 \Rightarrow e=1$ has no effect on Z.

Put $e=1$ & simplify.