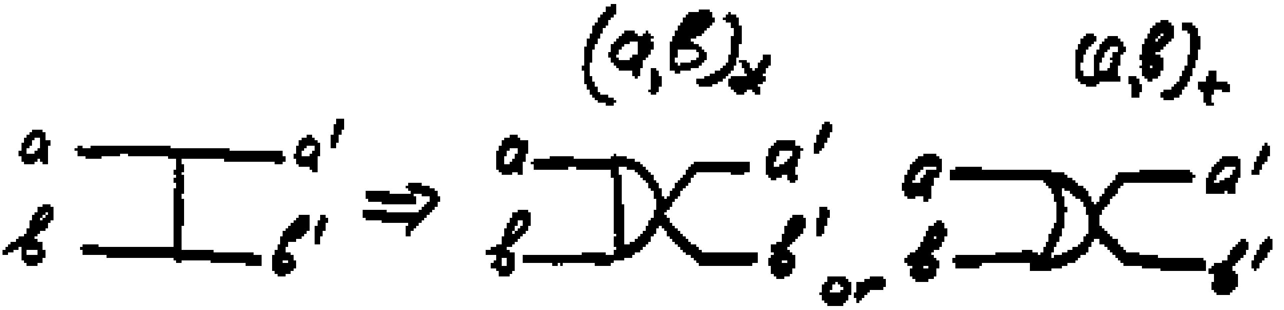
Detection of Bridging Faults

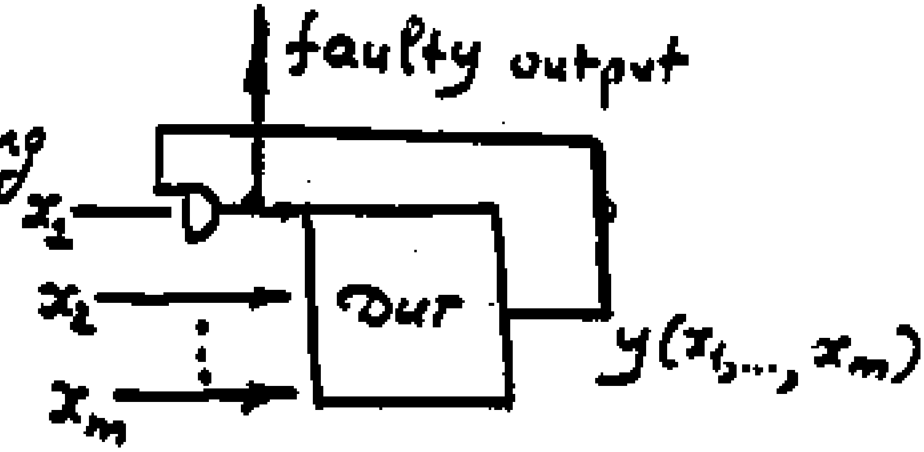
Fault Models



AND bridging OR bridging

Feedback bridging

$(y,x_1)_*$



Detection of Feedback Bridgings

If $f(0,\dots,0)=1$, then $(0,\dots,0)$ detects all $(y,x_i)_*$

If $f(1,\dots,1)=0$, then $(1,\dots,1)$ detects all $(y,x_i)_+$

To detect AND Feedback Bridgings:

1. Apply $a=(a_1,\dots,a_m)$: $f(a_1,\dots,a_m)=0$
2. Apply $b=(b_1,\dots,b_m)$: $f(b_1,\dots,b_m)=1$ and

   $\sum_i b_i \to \min$ $\quad ((b_1,\dots,b_m)\neq 0)$

To detect OR Feedback Bridgings

1. Apply $\tilde{a}=(\tilde{a}_1,\dots,\tilde{a}_m)$: $f(\tilde{a}_1,\dots,\tilde{a}_m)=1$
2. Apply $\tilde{b}=(\tilde{b}_1,\dots,\tilde{b}_m)$: $f(\tilde{b}_1,\dots,\tilde{b}_m)=0$

   and $\sum_i \tilde{b}_i \to \max$

"$\tilde{b}$" should be applied after "$\tilde{a}$"

To detect all AND and OR bridgings $(x_i,y)_+$ and $(x_i,y)_*$ apply 4 patterns:
$(a, b, \tilde{a}, \tilde{b})$

10.3

Example $f(x_1,\dots,x_{12})=1$ iff there are at least 9 ones in an input vector $(x_1,\dots,x_{12})$

Take $a=(a_1,\dots,a_{12})=(0,\dots,0)$

$$b=\tilde{a}=(\underbrace{1,\dots,1}_{9},0,0,0)$$

$$\tilde{b}=(\underbrace{1,\dots,1}_{8},0,0,0,0)$$

Test sequence

$(a=(0,\dots,0)$, $b=\tilde{a}=(\overbrace{1,\dots,1}^{9},0,0,0)$, $\tilde{b}=(\underbrace{1,\dots,1}_{8},0,0,0,0))$ detects all feedback bridgings $(y,x_i)_*$ and $(y,x_i)_+$ $(i=1,\dots,12)$

Detection of Nonfeedback Bridgings[10.4]

(T_{ij}) - input test matrix $\Rightarrow$

rows of (T_{ij}) are test patterns

Test T detect all bridgings $(x_i, x_j)_*$ and $(x_i, x_j)_+$ only if columns of (T_{ij}) are different $\Rightarrow$ $T(m) \geq \lceil \log_2(m+2) \rceil$

Example 8-bit adder

$$(T_{ij}) = \begin{pmatrix} \underbrace{\begin{matrix} 0&0&0&0&0&0&0&0&1&1&1&1&1&1&1&1 \\ 0&0&0&0&1&1&1&1&0&0&0&0&1&1&1&1 \\ 0&0&1&1&0&0&1&1&0&0&1&1&0&0&1&1 \\ 0&1&0&1&0&1&0&1&0&1&0&1&0&1&0&1 \end{matrix}}_{16} \end{pmatrix} \begin{matrix} t1 \\ t2 \\ t3 \\ t4 \end{matrix}$$

This is the controllability condition

in addition to this we need observability

OUTPUT TEST MATRIX FOR an 8-bit ADDER

OBSERVABILITY CONDITION

$$\begin{array}{c}\left(\begin{array}{ccccccccc} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \end{array}\right) \end{array} \begin{array}{l} t_1 \\ t_2 \\ t_3 \\ t_4 \end{array}$$

s/1 not detected

s/0 not detected

All columns are different $\Rightarrow$ all output bridgings are detected by (t_1, t_2, t_3, t_4)

this test is optimal since $m = 16$, $\lceil \log_2 m \rceil = 4$

FOR DETECTION OF INPUT (OUTPUT) STUCK-AT and BRIDGING FAULTS

NECESSARY CONDITIONS:

1) All columns in input (output) test matrices are different (to detect bridgings)

2) Every column contains at least one 1 and at least one 0 (to detect stuck-at faults)

For input faults

$$T(m) \geq \lceil \log_2 (m+2) \rceil$$

Minimal Numbers of Test Patterns for Detection of SSFs and bridgings at I/O of Standard components

device	Number of test patterns
1 m-bit shift register with parallel load	$\lceil \log_2(m+2) \rceil + 1$
m-bit counter with parallel load	$\lceil \log_2(m+2) \rceil + 1$
3 $m \times 2^m$ decoder/demultiplexer	$2^m + 1$
4. $m \times 1$ multiplexer	$2m$
5. m-bit adder/subtractor	$\lceil \log_2 m \rceil + 3$
6 m-bit multiplier	$2\lceil \log_2 m \rceil + 2$

(M.G. Karpovsky, S. Su, Proc. 17th Design Automation Conference, pp 494-506, 1980)