Stuck-at Fault Examples

Problem 1. The two level logic network of AND-OR gates shown below has inputs a, b, c, d, e, f, g, h, i, an output s, and three inaccessible internal signals p, q, and r. Find a minimum set of test vectors that will test all single stuck-at-0 and stuck-at-1 faults in the network. For each test, specify which faults are tested for s-a-0 and s-a-1.

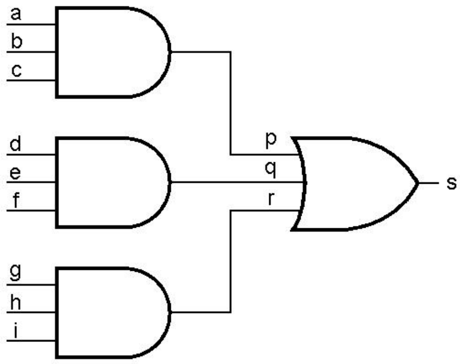

Figure 1. Combinatorial Network for Problem 1

Solution.

This problem was done in lecture. The minimum number of test vectors is 6. The test vectors, normal values of internal signals, and faults tested are detailed in the following table.

a	b	c	d	e	f	g	h	i	p	q	r	Faults tested
1	1	1	0	x	x	0	x	x	1	0	0	a0, b0, c0, p0, s0
0	x	x	1	1	1	0	x	x	0	1	0	d0, e0, f0, q0, s0
0	x	x	0	x	x	1	1	1	0	0	1	g0, h0, i0, r0, s0
0	1	1	0	1	1	0	1	1	0	0	0	a1, d1, g1, p1, q1, r1, s1
1	0	1	1	0	1	1	0	1	0	0	0	b1, e1, h1, p1, q1, r1, s1
1	1	0	1	1	0	1	1	0	0	0	0	c1, f1, i1, p1, q1, r1, s1

Problem 2. The logic network of NOR gates shown below has inputs a, b, c, d, e, f, and i, an output z, and two inaccessible internal signals g and h. Find a minimum set of test vectors that will test all single stuck-at-0 and stuck-at-1 faults in the network. For each test, specify which faults are tested for s-a-0 and s-a-1.

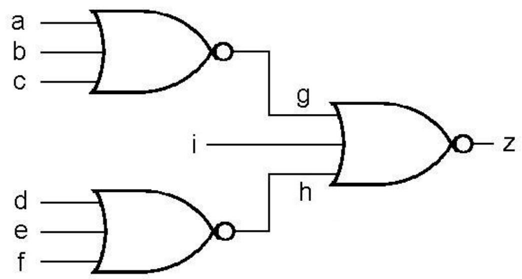

Figure 2. Combinatorial Network for Problem 2

Solution.

The tests for this problem are similar to the two-level logic network done in lecture. The minimum number of test vectors is 6. The test vectors, normal values of internal signals, and faults tested are detailed in the following table.

a	b	c	d	e	f	i	g	h	Faults tested
0	0	0	1	x	x	0	1	0	a1, b1, c1, g0, z1
1	x	x	0	0	0	0	0	1	d1, e1, f1, h0, z1
1	x	x	1	x	x	1	0	0	i0, z1
1	0	0	1	0	0	0	0	0	a0, d0, g1, h1, i1, z0
0	1	0	0	1	0	0	0	0	b0, e0, g1, h1, i1, z0
0	0	1	0	0	1	0	0	0	c0, f0, g1, h1, i1, z0

Problem 3. The logic network shown below has inputs a, b, c, d, and output f. Find all test vectors which can be used to find a stuck-at-1 fault for internal signal u.

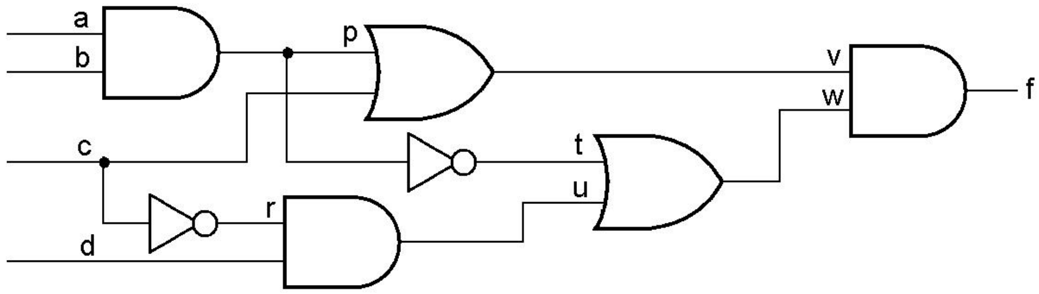

Figure 3. Combinatorial Network for Problem 3

Solution.

There are two parts to this solution. The first is to find all test vectors for which $u = 0$. For the second part find all test vectors which will propogate u to the output f. Test vectors common to both sets will be the solution.

To find test vectors which generate a 0 at u note that $u = \bar{c} \cdot d$. The (c, d) pairs $(0, 0)$, $(1, 0)$, and $(1, 1)$ will set $u = 0$. From this we have the set $\mathcal{G}$ of input vectors (a, b, c, d) for which $u = 0$,

$$\mathcal{G} = \{(x, x, 0, 0), (x, x, 1, x)\}.$$

where x denotes a don't care value.

To find the test vectors which sensitize a path to the output f use the boolean expression

$$f = v \cdot w = (a \cdot b + c) \cdot (\overline{a \cdot b} + u) = c \cdot \overline{a \cdot b} + a \cdot b \cdot u + c \cdot u.$$

From this expression $f = u$ only when $a \cdot b = 1$ and $c = x$. In other words we much have $a = 1$, $b = 1$, and c can be 0 or 1. Thus the set $\mathcal{P}$ of input test vectors (a, b, c, d) which sensitize the path is

$$\mathcal{P} = \{(1, 1, x, x)\}.$$

The test vectors (a, b, c, d) common to both sets are

$$\mathcal{G} \cap \mathcal{P} = \{(1, 1, 0, 0), (1, 1, 1, x)\}.$$

or $(1, 1, 0, 0)$, $(1, 1, 1, 0)$, and $(1, 1, 1, 1)$.