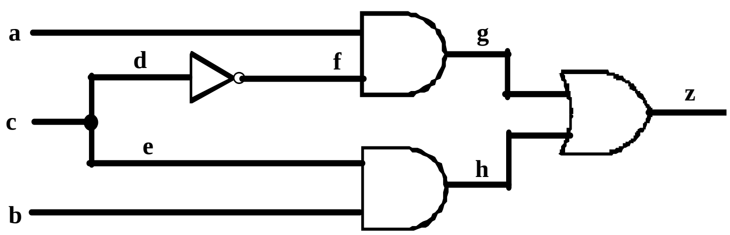
The University of Alabama in Huntsville
ECE Department
CPE 628 01
Fall 2008
Homework #3 Solution

4.2(15), 4.3(15), 4.4(15), 4.7(15), 4.8(20), 4.11(20)

4.2 Using the circuit shown, compute the detection probabilities for each of the following faults:



a. e/0
b. e/1
c. c/0

Recall that the detection probability is $d_f = T_f / 2^n$, where T_f is the set of vectors that can detect fault f, and n is the number of inputs in the circuit. In this circuit, we have 3 inputs, so there are a total of 8 possible vectors.

(a) For e/0, two vectors, abc = {011, 111} can detect it. Thus d_f = 0.25

(b) For e/1, one vector, abc = 010 can detect it. Thus d_f = 0.125

(c) For c/0, two vectors, abc = {011, 101} can detect it, Thus d_f = 0.25

4.3 Using the circuit shown, compute the set of all vectors that can detect each of the following faults using the Boolean difference.

a. e/0
b. e/1
c. c/0

(a) The set of vectors that can detect e/0 is

$$(e=1)\cdot\frac{d_z}{d_e} = e\cdot\left(z\cdot(e=0)\oplus z(e=1)\right)$$
$$= e\cdot\left(g\oplus(g+b)\right)$$
$$= e\cdot\left(g\cdot g \mp b+\overline{g}\cdot(g+b)\right)$$
$$= e\cdot\overline{g}\cdot b$$
$$= e\cdot\overline{a}\,\overline{c}\cdot b$$
$$= e\cdot\left(\overline{a}+c\right)\cdot b$$
$$= bc+\overline{a}bc$$
$$= bc$$

Thus, the set of vectors is {011, 111}.

(b) The set of vectors that can detect e/1 is

$$(e=0)\cdot\frac{d_z}{d_e}=e\cdot\left(z\cdot(e=0)\oplus z(e=1)\right)$$
$$=\bar{e}\cdot\left(g\oplus(g+b)\right)$$
$$=\bar{e}\cdot\left(g\cdot g\mp b+\bar{g}\cdot(g+b)\right)$$
$$=\bar{e}\cdot\bar{g}\cdot b$$
$$=\bar{e}\cdot\bar{a}\bar{c}\cdot b$$
$$=\bar{e}\cdot\left(\bar{a}+c\right)\cdot b$$
$$=bc\bar{e}+\bar{a}b\bar{e}$$
$$=\bar{a}b\bar{e}$$
$$=\bar{a}b\bar{c}$$

Thus, the set of vectors is {010}.

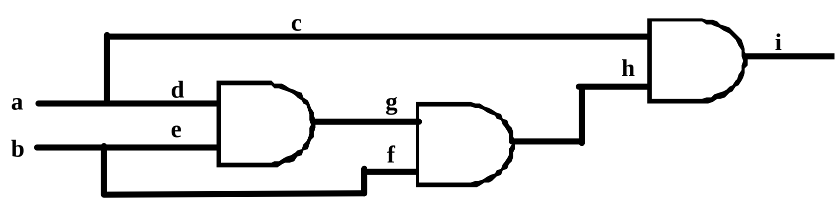
(c) The set of vectors that can detect c/0 is

$$(c=1)\cdot\frac{d_z}{dc}=e\cdot\left(z\cdot(c=0)\oplus z(c=1)\right)$$
$$=c\cdot(a\oplus b)$$
$$=c\cdot\left(a\cdot\bar{b}+\bar{a}\cdot b\right)$$
$$=a\bar{b}c+\bar{a}bc$$

Thus, the set of vectors is {011, 101}.

4.4 Using the circuit shown, compute the set of all vectors that can detect each of the following faults using the Boolean difference:

a. a/1
b. d/1
c. g/1



(a) The set of vectors that can detect a/1 is

$$(a=0)\cdot\frac{d_i}{da}=\bar{a}\cdot\left(i\cdot(a=0)\oplus i(a=1)\right)$$
$$=\bar{a}\cdot(0\oplus b)$$
$$=\bar{a}b$$

Thus, the set of vectors is {01}.

(b) The set of vectors that can detect d/1 is

$$(d=0)\cdot\frac{d_i}{dd}=\bar{d}\cdot\left(i\cdot(d=0)\oplus i(d=1)\right)$$
$$=\bar{d}\cdot(0\oplus ab)$$
$$=\bar{d}\cdot ab$$

But it is impossible to set a=1 and d=0 simultaneously. Thus, the set of vectors is $\varnothing$.

(c) The set of vectors that can detect g/1 is

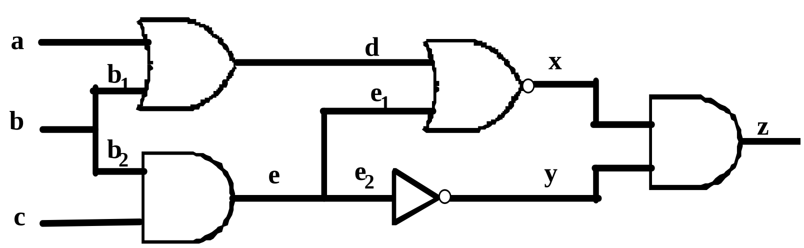
$$(g=0)\cdot\frac{d_i}{dg}=\bar{g}\cdot\left(i\cdot(g=0)\oplus i(g=1)\right)$$
$$=\bar{g}\cdot(0\oplus ab)$$
$$=\bar{g}\cdot ab$$
$$=\overline{ab}\cdot ab$$
$$=0$$

Thus, the set of vectors is $\varnothing$.

4.7 Construct the table for the XNOR operation for the 5-valued logic similar to Tables 4.1, 4.2, and 4.3.

XNOR	**0**	**1**	**D**	$\bar{D}$	**X**
0	**1**	**0**	$\bar{D}$	**D**	**X**
1	**0**	**1**	**D**	$\bar{D}$	**X**
D	$\bar{D}$	**D**	**1**	**0**	**X**
$\bar{D}$	**D**	$\bar{D}$	**0**	**1**	**X**
x	**X**	**X**	**X**	**X**	**X**

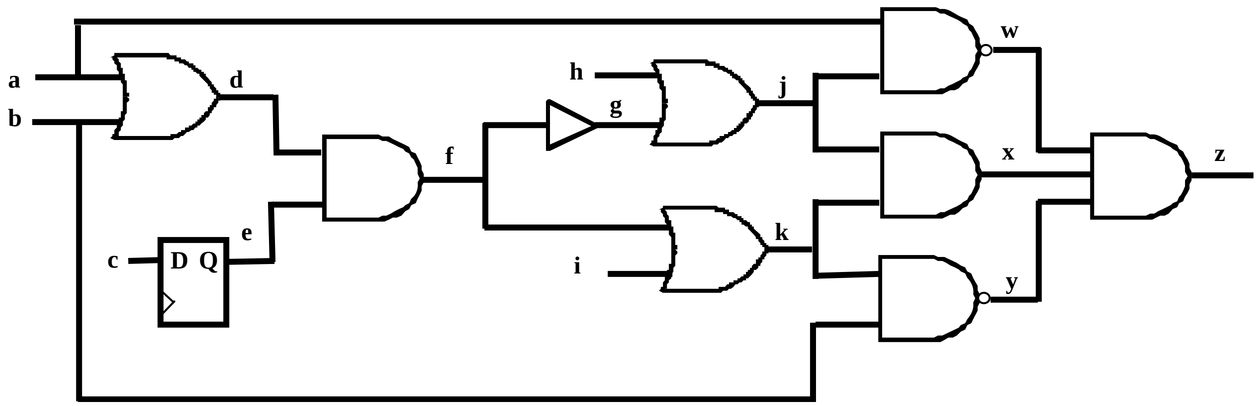
4.8 Using the circuit shown, use the D-algorithm to compute a vector for the fault b/1. Repeat for the fault e/0.



Initially, we place a $\bar{D}$ on b. The D-frontier at this time includes {d, e}. Next, we pick a D-frontier to propagate the fault effect across. Suppose we pick d. Then, the decision a=0 is made. At this time, the D-frontier becomes {x, e}. We pick the D-frontier that is closest to a PO. Thus, we pick x. The next decision is e1=0. This decision implies y=1 and z=D. In other words, the fault-effect has been propagated all the way to the PO. The J-frontier consists of {e1=0, b=$\bar{D}$}. To justify e1=0, c=0 is sufficient. Justifying b= $\overline{D}$ is likewise straightforward, simply by setting b=0. Thus the vector abc=000 detects the target fault b/1.

A similar decision process is made for the target fault e/0. However, in this case, one would conclude that the fault is untestable.

4.11 Using the circuit shown and PODEM, compute the vector that can detect the fault f/0. Note that even though the circuit is sequential, it can be viewed as a combinational circuit because the D flip-flop does not have an explicit feedback.



Objective	Backtrace	Assignment	Implications	Decision Tree
(f, 1)	(d, 1), (e, 1), (a, 1)	a = 1	d = 1	a = 1
(f, 1)	(e, 1), (c, 1)	c = 1	e = 1, f = D, g = D	a = 1, c = 1
(h, 0)	(h, 0)	h = 0	j = D, w = D’	a = 1, c = 1, h = 0
(x, 1)	(x, 1), (k, 1), (i, 1)	i = 1	k = 1, x = D, no path	a = 1, c = 1, h = 0, i = 1
		i = 0	k = D, x = D, no path	a = 1, c = 1, h = 0, i = 0
		h = 1	j = 1, w = 0, x = 0, no path	a = 1, c = 1, h = 1
		c = 0	f = 0, no excitation	a = 1, c = 0
		a = 0	w = 1	a = 0
(f, 1)	(d, 1), (b, 1)	b = 1	d =1	a = 0, b = 1
(f, 1)	(e, 1), (c, 1)	c = 1	f = D, g = D	a = 0, b = 1, c = 1
(h, 0)	(h, 0)	h = 0	j = D	a = 0, b = 1, c = 1, h = 0
(k, 1)	(i, 1)	i = 1	k = 1, y = 0, z = 0, no path	a = 0, b = 1, c = 1, h = 0, i = 1
		i = 0	k = D, x = D, y = D’, no path	a = 0, b = 1, c = 1, h = 0, i = 0
		h = 1	j = 1	a = 0, b = 1, c = 1, h = 1
(i, 0)	(i, 0)	i = 0	k = D, y = D’, x = D, no path	a = 0, b = 1, c = 1, h = 1, I = 0
		i = 1	k = 1, y = 0, z = 0, no path	a = 0, b = 1, c = 1, h = 1, i = 1
		c = 0	e = 0, f = 0, no excitation	a = 0, b = 1, c = 0
		b = 0	d = 0, f = 0, no excitation	a = 0, b = 0
No further options available, fault redundant				