Fault Tolerant Computing and VLSI Testing

Assignment 3

1.

2.

3. $FC = 80\% \implies DL = 1 - 0.9^{1-0.8} = 0.020852 = 20852PPM$

   $FC = 90\% \implies DL = 1 - 0.9^{1-0.9} = 0.010481 = 10481PPM$

   $FC = 99\% \implies DL = 1 - 0.9^{1-0.99} = 0.001053 = 1053PPM$

   $DL = 20PPM = 2 * 10^{-5} = 1 - 0.7^{1-FC}$

   $0.6^{1-FC} = 1 - 2 * 10^{-5} = 0.99998$

   $1 - FC = \log_{0.6} 0.99998 = 3.915 * 10^{-5}$

   $FC = 1 - 3.915 * 10^{-5} = 0.99996 = 99.996\%$

4.

AB	00	01	10	11
Z	1	1	1	0
P_0 stuck open	1	LastZ	1	0
P_0 stuck short	1	1	1	I_{DDQ}
P_1 stuck open	1	1	LastZ	0
P_1 stuck short	1	1	1	I_{DDQ}
N_0 stuck open	1	1	1	LastZ
N_0 stuck short	1	I_{DDQ}	1	0
N_1 stuck open	1	1	1	LastZ
N_1 stuck short	1	1	I_{DDQ}	0

5. TODO: Add tests here!

   $a \oplus (a + b) = a\overline{(a + b)} + \overline{a}(a + b) = a\overline{a}\overline{b} + \overline{a}a + \overline{a}b = \overline{a}b$

   $(a + b)\overline{b} = a\overline{b} + b\overline{b} = a\overline{b}$

   $(a \oplus (a + b)) + (a + b)\overline{b} = \overline{a}b + a\overline{b} = a \oplus b$

   Therefore, the boolean operation this circuit is equivalent to is exclusive-OR.

6. Test patterns are written as abc.

   Not that a * symbol is used where appropriate to represent the AND operation for clarity, in order to help distinguish between, for example, $\overline{a * c}$ and $\overline{a} * \overline{c}$

(i) $\overline{a}\frac{dz}{da} = \overline{a}(z(a=1) \oplus z(a=0)) = \overline{a}((\overline{c}+cb) \oplus cb)$
$= \overline{a}(\overline{\overline{c}+cb}cb + (\overline{c}+cb)\overline{cb}) = \overline{a}(\overline{c}\overline{cb}cb + \overline{c}\overline{c}b + cb\overline{cb})$
$= \overline{a} * \overline{c}\overline{c}b = \overline{a} * \overline{c}(\overline{c}+\overline{b}) = \overline{a} * \overline{c} + \overline{a} * \overline{c}b = \overline{a} * \overline{c}(1+\overline{b}) = \overline{a} * \overline{c} = 1$
The patterns $\{000, 010\}$ can detect the fault.

(ii) $h\frac{dz}{dh} = h(z(h=1) \oplus z(h=0)) = h(1 \oplus a\overline{c}) = h\overline{a\overline{c}} = h(\overline{a}+c)$
$= h\overline{a} + hc$
Note that $h = cb$.
$h\frac{dz}{dh} = \overline{a}bc + bc = bc(a+1) = bc = 1$
The patterns $\{011, 111\}$ can detect the fault.

(iii) $\overline{h}\frac{dz}{dh} = \overline{h}\overline{a} + \overline{h}c = \overline{cb}\overline{a} + \overline{cb}c = (\overline{c}+\overline{b})\overline{a} + (\overline{c}+\overline{b})c$
$= \overline{a}\overline{b} + \overline{a}\overline{c} + \overline{b}c + \overline{c}c = \overline{a}\overline{c} + \overline{a}\overline{c} + \overline{b}c = 1$
The patterns $\{000, 001, 010, 101\}$ can detect the fault.

(iv) $e\frac{dz}{de} = e(z(e=1) \oplus z(e=0)) = e((a\overline{c}+b) \oplus a\overline{c})$
$= e(\overline{a\overline{c}+b}a\overline{c} + (a\overline{c}+b)\overline{a\overline{c}}) = e(\overline{b} * \overline{a\overline{c}}a\overline{c} + a\overline{c}\overline{a\overline{c}} + b\overline{a\overline{c}}) = eb\overline{a\overline{c}}$
$= be(\overline{a}+c) = \overline{a}be + bec$
Note that $e = c$.
$e\frac{dz}{de} = \overline{a}bc + bc = bc(\overline{a}+1) = bc = 1$
The patterns $\{011, 111\}$ can detect the failure.

(v) $\overline{e}\frac{dz}{de} = \overline{a}b\overline{e} + b\overline{e}c = \overline{a}b\overline{c} + bc\overline{c} = \overline{a}b\overline{c}$
The pattern $\{010\}$ can detect the failure.

(vi) $c\frac{dz}{dc} = c(z(c=1) \oplus z(c=0)) = c(b \oplus a) = c(\overline{a}b + a\overline{b}) = \overline{a}bc + a\overline{b}c = 1$
The patterns $\{011, 101\}$ can detect the fault.

7. Test patterns are written as ab.

(a) $\overline{a}\frac{di}{da} = \overline{a}(i(a=1) \oplus i(a=0)) = \overline{a}(b \oplus 0) = \overline{a}b = 1$
The pattern $\{01\}$ can detect the fault.

(b) $\overline{d}\frac{di}{da} = \overline{d}(i(d=1) \oplus i(d=0)) = \overline{d}(ab \oplus 0) = \overline{d}ab$
Note that $d = a$.
$\overline{d}\frac{di}{da} = \overline{a}ab = 0 = 1$
We have reached a contradiction, therefore this fault cannot be detected.

(c) $\overline{g}\frac{di}{dg} = \overline{g}(i(g=1) \oplus i(g=0)) = \overline{g}(ab \oplus 0) = \overline{g}ab$
Note that $g = ab$.
$\overline{g}\frac{di}{dg} = \overline{ab}ab = 0 = 1$
We have reached a contradiction, therefore this fault cannot be detected.