Solutions for the End-of-the-Chapter Problems in Testing of Digital Systems

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(Chapters 1, 2, 5, 6, 7, 8, 9, 13, 14, 15, 16)

Chapter 1

Problem 1.1: (a) 16.34×10^{-3} years, (b) 7.53×10^{-3} years, (c) 1.12×10^{-7} years, and (d) 5.52×10^{-9} years.

Problem 1.2: $R(t) = \{1 - (1 - e^{-\lambda t})^3\}\{1 - (1 - e^{-\lambda t})^2\}$.

Problem 1.3: $FC = 1 - \frac{log(1-DL)}{logY}$.
(a) 0.9999608, (b) 0.9999102, (c) 0.9999923, (d) 0.9999825.

Problem 1.4:
(a) (i) $C_M = (1 - 0.7^{(1-0.95)}) \times \$500 \times 10 \times 3 = \$265.14$/system.
$ER = \$10,000 \times 5,000 = \$50$ million.
(ii) $C_M = (1 - 0.8^{(1-0.95)}) \times \$500 \times 10 \times 3 = \$166.43$/system.
(iii) $C_M = (1 - 0.8^{(1-0.99)}) \times \$500 \times 10 \times 3 = \$33.42$/system.
(b) (i) $C_E = 22 \times \$600/30 = \$440$/ASIC.
$C_A = \$30 \times \{1.1 \times 0.7^{(1-\sqrt{1.1})} - 1\} = \$3.58/die.$
$C_M = (1 - 0.7^{(1-0.99)}) \times \$500 \times 10 \times 3 = \$53.41$/system.
$C_S = \$10,000(1 - 0.95) = \$500$/system.
(ii) $D = 1$ mo., $W = 24$ mo., $ER = \$50M$.
$LR = 50M \times \frac{1(72-1)}{2\times24^2} = \$3,081,597$.
(iii) Since $LR = \$3,081,597$, total number of systems (units) sold in the new situation: $\frac{50,000,000-3,081,597}{50,000,000} \times 5,000 = 4,691$.
Lost revenue due to one-time engineering cost $= 30 \times \$440 = \$13,200$.
Increased die cost $= 4,691 \times 30 \times \$3.58 = \$503,813.40$.
Reduced manufacturing re-work $= 4,691 \times (\$53.41 - \$166.43) = -\$530,176.82$.
Lost revenue due to speed degradation $= 4,691 \times \$500 = \$2,345,500$.
$LR = \$3,081,597$.
Total cost on all system sales (sum of the above items) = \$5,413,933.58.
Original profit $= 5,000 \times 0.2 \times \$10,000 = \$10,000,000$.
Therefore, total difference in profit $= \$10,000,000 - \$5,413,933.58 = \$4,586,066.42$.

(c) Original life-cycle cost $= \frac{\$10{,}000}{0.4} = \$25,000.$
New life-cycle cost $= \$10,000 + \$15,000 \times 0.8 = \$22,000.$

Chapter 2

Problem 2.1: The advantages are: (i) a few behavioral faults can model a large number of lower-level faults, and (ii) the fault model is independent of circuit structure.
(a) An SAF at the output of the circuit that implements CC may result in B always or never executing.
(b) An SAF at the output of the circuit that implements switch(Id) may result in none of the specified cases being selected.
(c) If Y is SA1, then B_1 will always be selected.
(d) A unidirectional SA0 fault X would result in V_L being assigned to X.
(e) An SA0 fault on S will result in the "waitfor S" clause never being executed.

Problem 2.2: Let x_i and y_i be the two data inputs of the multiplexer and s be its select line. Then the functional test set and the SAFs it detects are as follows.

x_i	y_i	s	z_i	SAFs detected
0	1	0	1	$s/1,\ c_2/1,\ c_3/0,\ y_i/0,\ c_5/0,\ z_i/0$
1	0	0	0	$s/1,\ c_1/1,\ y_i/1,\ c_4/1,\ c_5/1,\ z_i/1$
1	0	1	1	$s/0,\ c_1/0,\ x_i/0,\ c_4/0,\ z_i/0$
0	1	1	0	$s/0,\ x_i/1,\ c_2/0,\ c_3/1,\ c_4/1,\ c_5/1,\ z_i/1$

Problem 2.3: Advantages: (i) easy to derive, (ii) implementation-independent as long as circuit restriction is met, and (iii) detects all detectable single SAFs and multiple SAFs.
Disadvantages: (i) possibly exhaustive, and (ii) applicable to restricted set of circuits only.

Problem 2.4: Yes. The single cell fault model allows faults inside a cell to change the truth tables of the functions implemented by the cell in an arbitrary manner. Thus, no matter how the single SAFs change the truth tables, they will be detected.

Problem 2.5: The test set is given below.

Test set for a ripple-carry adder

x_{41}	x_{42}	x_{31}	x_{32}	x_{21}	x_{22}	x_{11}	x_{12}	y_1
0	0	0	0	0	0	0	0	0
0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	0
0	0	1	1	0	0	1	1	0
1	1	0	0	1	1	0	0	1
0	1	0	1	0	1	0	1	1
1	0	1	0	1	0	1	0	1
1	1	1	1	1	1	1	1	1

The four rightmost x_{ij} bits in each row can be replicated to the left of the row as many times as