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# M.Tech. Degree Examination, June/July 2011

# Digital Circuit and Logic design

Time: 3 hrs. Max. Marks:100

**Note:** ***Answer any FIVE full questions.***



1 a. Find the function f ($x_1$, $x_2$, $x_3$, $x_4$) realized by the network shown in Fig. Q1 (a). Show the map of the function.

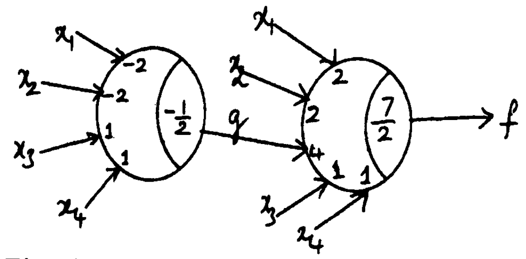



Fig. Q1 (a)

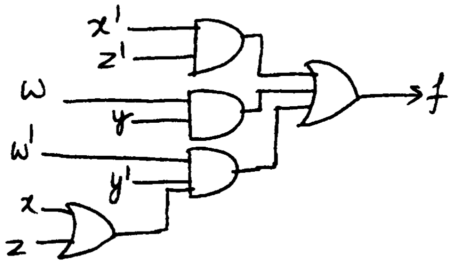
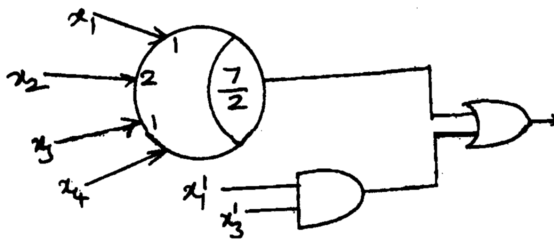



Fig. Q1(b) **(10 Marks)**

b. Analyze the circuit of Fig. Q1 (b), for state hazards. Redesign the circuit so that it becomes hazard free **(10 Marks)**

2 a. Assuming that the individual elements of the following circuit are hazard-free, find all the static hazards. Changing only the parameters of the threshold element, redesign the circuit so that all static hazards are eliminated. **(10 Marks)**



f ($x_1$, $x_2$, $x_3$, $x_4$)

Fig.Q2 (a)

b. Given the fault table shown below, where Z denotes the fault-free output for the corresponding test, find the minimal set of tests to detect all single faults. Find a preset set of tests to locate all single faults and show the corresponding fault dictionary. Find the minimal adaptive fault-location experiment. **(10 Marks)**

| Faults / Test | $f_1$ | $f_2$ | $f_3$ | $f_4$ | $f_5$ | Z |
|---|---|---|---|---|---|---|
| $T_1$ | | | 1 | 1 | 1 | 0 |
| $T_2$ | 1 | 1 | | | | 1 |
| $T_3$ | | | | 1 | 1 | 1 |
| $T_4$ | | 1 | | | | 0 |
| $T_5$ | | | | | 1 | 1 |

Table Q2 (b)

3 a. Find the equivalence partition for the machine shown in the table Q3 (a). Show a standard form of the corresponding reduced machine. Find a minimum-length sequence that distinguishes state A from state B. **(10 Marks)**

| PS | NS, Z | |
|---|---|---|
| | X=0 | X=1 |
| A | B, 1 | H, 1 |
| B | F, 1 | D, 1 |
| C | D, 0 | E, 1 |
| D | C, 0 | F, 1 |
| E | D, 1 | C, 1 |
| F | C, 1 | C, 1 |
| G | C, 1 | D, 1 |
| H | C, 0 | A, 1 |

Table Q3 (a)

b. Find all the state containments present in the machine shown in table Q3 (b). Find two minimum state machines that contain the given machine and prove that these machines are indeed minimal. **(10 Marks)**

| PS | NS, Z | |
|---|---|---|
| | X=0 | X=1 |
| A | B, 0 | C, 1 |
| B | D, 0 | C, 1 |
| C | A, 0 | E, 0 |
| D | - | F, 1 |
| E | G, 1 | F, 0 |
| F | B, 0 | - |
| G | D, 0 | E, 0 |

Table Q3 (b)

4 a. The direct sum $M_1 + M_2$ of two machines $M_1$ and $M_2$ is obtained by combining the tables of the individual machines as shown in table Q4 (a), so that each state of the direct sum is denoted by a distinct symbol. i) Use the direct sum to find whether state A of machine $M_1$ is equivalent to state H of machine $M_2$. ii) Prove that machine $M_1$ is contained in machine $M_2$. iii) Under what starting conditions are machines $M_1$ and $M_2$ equivalent? **(10 Marks)**

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| A | B, 0 | C, 1 |
| B | D, 1 | C, 0 |
| C | A, 1 | C, 0 |
| D | B, 1 | C, 0 |

Machine $M_1$
Table:Q4(a)(i)

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| E | H, 1 | E, 0 |
| F | F, 1 | E, 0 |
| G | E, 0 | G, 1 |
| H | F, 0 | E, 1 |

Machine $M_2$
Table Q4 (a) (ii)

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| A | B, 0 | C, 1 |
| B | D, 1 | C, 0 |
| C | A, 1 | C, 0 |
| D | B, 1 | C, 0 |
| E | H, 1 | E, 0 |
| F | F, 1 | E, 0 |
| G | E, 0 | G, 1 |
| H | F, 0 | E, 1 |

Direct sum of machines $M_1$ and $M_2$
Machine $M_1 + M_2$
Table Q4 (a) (iii)

b. Find the reduced state table for the machine of Table Q4 (b). Design the circuit using a single S-R flip-flop.

| | NS, $Z_1 Z_2$ | | | |
|---|---|---|---|---|
| | 00 | 01 | 11 | 10 |
| A | A, 00 | E, 01 | - | A, 01 |
| B | - | C, 10 | B, 00 | D, 11 |
| C | A, 00 | C, 10 | - | - |
| D | A, 00 | - | - | D, 11 |
| E | - | E, 01 | F, 00 | - |
| F | - | G, 10 | F, 00 | G, 11 |
| G | A, 00 | - | - | G, 11 |

Table Q4 (b)

**(10 Marks)**

5 a. Given the machine shown in table Q5 (a) and the two assignments α and β, derive in each case the logical equations for the state variables and the output and compare the results. Express explicitly in each case the dependency of the output and the state variables.

| PS | NS | | Z | |
|---|---|---|---|---|
| | x=0 | x=1 | x=0 | x=1 |
| A | D | C | 0 | 0 |
| B | F | C | 0 | 1 |
| C | E | B | 0 | 0 |
| D | B | E | 1 | 0 |
| E | A | D | 1 | 1 |
| F | C | D | 1 | 0 |

Table Q5 (a)

| | $y_1$ | $y_2$ | $y_3$ |
|---|---|---|---|
| A | 0 | 0 | 0 |
| B | 0 | 0 | 1 |
| C | 0 | 1 | 0 |
| D | 0 | 1 | 1 |
| E | 1 | 0 | 0 |
| F | 1 | 0 | 1 |

Assignment α

| | $y_1$ | $y_2$ | $y_3$ |
|---|---|---|---|
| A | 1 | 1 | 0 |
| B | 1 | 0 | 1 |
| C | 1 | 0 | 0 |
| D | 0 | 0 | 0 |
| E | 0 | 0 | 1 |
| F | 0 | 1 | 0 |

Assignment β

**(10 Marks)**

b. In the following set of partitions, $\Pi_1$ and $\Pi_2$ designate closed partitions, while $\lambda_0$ and $\lambda_i$ designate output-consistent and input-consistent partitions respectively. Construct the corresponding Π-lattice by obtaining all the necessary sums and products. Show schematic diagram demonstrating the possible machine decompositions that yield minimal interdependencies of the state variables, as well as the outputs.

$\Pi_1 = \{\overline{A,B,E,F}; \overline{C,D,G,H}\}$ ; $\Pi_2 = \{\overline{A,F,C,H}; \overline{B,D,E,G}\}$

$\lambda_0 = \{\overline{A,B,G,H}; \overline{C,D,E,F}\}$ ; $\lambda_i = \{\overline{A,C}; \overline{B,D}; \overline{E,G}; \overline{F,H}\}$ **(10 Marks)**

6 For the machine shown in Table Q6 (a). find $\lambda_i$ and $\lambda_0$ and construct the Π- lattice. Choose as a basis for your state assignment three partitions, $T_1$, $T_2$ and $T_3$ (which may or may not be closed), such that the following functional dependencies will result.

$$\left.\begin{aligned} Y_1 &= f_1(y_1) \\ Y_2 &= f_2(x, y_2, y_3) \\ Y_3 &= f_3(x, y_2, y_3) \\ z &= f_0(y_1, y_2) \end{aligned}\right\}$$

| PS | NS | | Z |
|---|---|---|---|
| | x=0 | x=1 | |
| A | F | D | 0 |
| B | D | E | 0 |
| C | E | F | 0 |
| D | A | B | 0 |
| E | B | C | 0 |
| F | C | A | 1 |

Table Q6

**(07 Marks)**

Specify the desired relationship between the chosen T's and $\lambda_i$ and $\lambda_0$. Based on the chosen T's, make a state assignment and derive the corresponding logical equations. **(20 Marks)**

7 a. For the machine shown in Table Q7 (a), find the shortest homing sequence. Determine whether or not synchronizing sequence exists and if it does exist, find the shortest one.

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| A | A, 1 | E, 0 |
| B | A, 0 | C, 0 |
| C | B, 0 | D, 1 |
| D | C, 1 | C, 0 |
| E | C, 0 | D, 0 |

Table Q7 (a)

**(10 Marks)**

b. You are presented with a machine that is known to be described by one of the two state tables shown in Table Q7 (b). No information is available regarding the initial state of the machine. Device a procedure for identifying the machine, and find all minimal preset experiments which can perform this task.

[Hint: Construct a machine which is the direct sum of the two machines]

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| A | A, 0 | B, 0 |
| B | C, 0 | A, 0 |
| C | A, 1 | B, 0 |

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| D | E, 0 | F, 1 |
| E | F, 0 | D, 0 |
| F | E, 0 | F, 0 |

Table Q7 (b)

**(10 Marks)**

8 a. Find the preset distinguishing experiment that determines the initial state of the machine shown in Table Q8 (a). Given that it cannot be initially in state E, can you identify the initial state when the initial uncertainty is (ABCDE)?

| PS | NS, Z | |
|---|---|---|
| | x=0 | x=1 |
| A | B, 1 | A, 1 |
| B | E, 0 | A, 1 |
| C | A, 0 | E, 1 |
| D | C, 1 | D, 1 |
| E | E, 0 | D, 1 |

Table Q8 (a)

**(10 Marks)**

b. Show that every machine of the form shown in Fig. Q8 (b) has synchronizing sequence. Find such a sequence and specify its length.

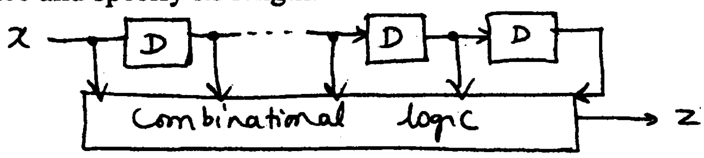



Fig. Q8 (b)

Does every machine of this form have also a distinguishing sequence? Prove that it does or show a counter example. Can every finite-state machine be realized in this form? **(10 Marks)**

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