Computer Aided Design

Instructor: Dr.Beitollahi

Solutions: Homework 4

Topic: Advanced VHDL & FPGA

Lectures: 7-8-9-10-11

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Theory:

Q4) Design a Finite State Machine (FSM) for a smart home lighting system that can turn the lights on/off, dim, and brighten. (10 points)

- Variable Answers …

Q5) Implement these two functions on a single PAL with minimum number of resources. (10 points)
(*hint:* You can use S_0 to construct S_1)

$$S_0 = \overline{A_1}\,\overline{A_0}\,B_0 B_1 + \overline{A_1}\,\overline{A_0}\,B_0 \overline{B_1} + \overline{A_1}\,A_0\,\overline{B_0}B_1 + \overline{A_1}\,A_0\,\overline{B_0}\,\overline{B_1} + A_1\overline{A_0}\,B_0 B_1 + A_1\overline{A_0}\,B_0\overline{B_1} + A_1 A_0\,\overline{B_0}\,B_1 + A_1 A_0\,\overline{B_0}\,\overline{B_1}$$

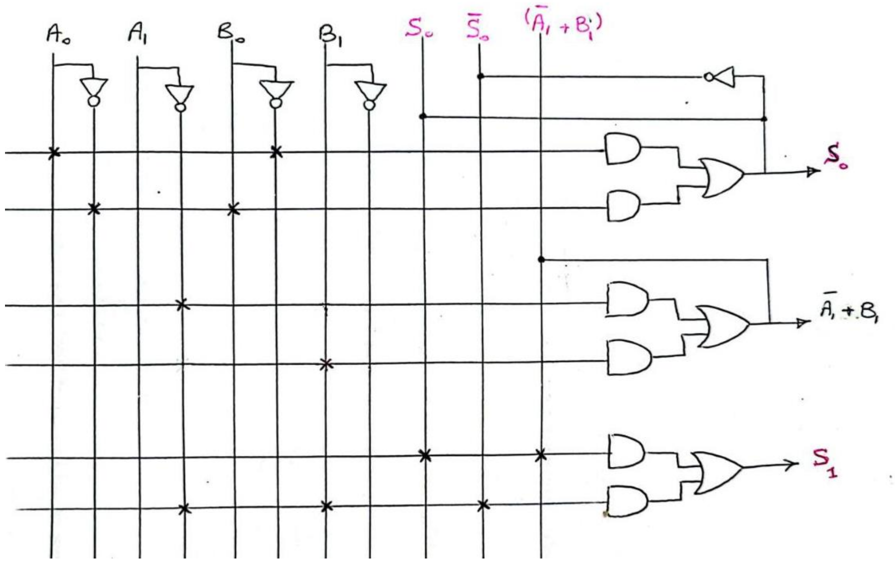
$$= \overline{A_1 A_0}B_0 + \overline{A_1}A_0\overline{B_0} + A_1\overline{A_0}B_0 + A_1 A_0\overline{B_0}$$

$$= \overline{A_0}B_0 + A_0\overline{B_0}$$

$$S_1 = A_0\,\overline{B_0}\,(A_1 + \overline{B_1}) + \overline{A_0}\,B_0\,(\overline{B_1} + A_1) + \overline{A_1}\,B_1\,(\overline{A_0}\,\overline{B_0} + A_0 B_0)$$

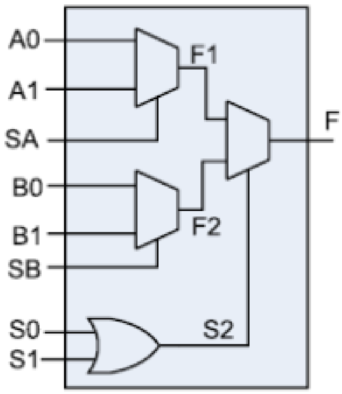
$$= (A_1 + \overline{B_1})(\overline{A_0}B_0 + A_0\overline{B_0}) + (\overline{A_1}B_1)(\overline{A_0 B_0} + A_0 B_0)$$

$$= (A_1 + \overline{B_1})\,S_0 + (\overline{A_1}B_1)\,\overline{S_0}$$



Q6) Implement the following function on the given logic module. (15 points)

$$F = (A.B) + (B'.C) + D$$



Logic Module

- Expand F based on B (using Shannon's expansion theorem):
  - $F = B \cdot (A + D) + B' \cdot (C + D) = B \cdot F2 + B' \cdot F1$
  - $F2 = A + D = A + (A'.\ D) = (A \cdot 1) + (A' \cdot D)$
  - $F1 = C + D = C + (C'.D) = (C \cdot 1) + (C' \cdot D)$
- Connect A, B, C to the select lines:
  - $S2 = B$
  - $SA = C$
  - $SB = A$
- '1' and D are the inputs of the MUXes:
  - $S0 = \text{'0'},\ S1 = B$
  - $A0 = D,\ A1 = \text{'1'}$
  - $B0 = D,\ B1 = \text{'1'}$

Q7) Using the programmable logic device shown below, implement a circuit in which input is a 3-bit number *x* and its output is *x* + 3. (15 points)
Put a cross in the circles or fill up the circles where the connection should be made.

d_2	d_1	d_0	d_2'	d_1'	d_0'	carry
0	0	0	0	1	1	0
0	0	1	1	0	0	0
0	1	0	1	0	1	0
0	1	1	1	1	0	0
1	0	0	1	1	1	0
1	0	1	0	0	0	1
1	1	0	0	0	1	1
1	1	1	0	1	0	1

$$\rightarrow d_2' = \bar{d}_2 \bar{d}_1 d_0 + \bar{d}_2 d_1 \bar{d}_0 + \bar{d}_2 d_1 d_0 + d_2 \bar{d}_1 \bar{d}_0 = m(1, 2, 3, 4)$$

$$\rightarrow d_1' = \bar{d}_2 \bar{d}_1 \bar{d}_0 + \bar{d}_2 d_1 d_0 + d_2 \bar{d}_1 \bar{d}_0 + d_2 d_1 d_0 = m(0, 3, 4, 7)$$

$$\rightarrow d_0' = \bar{d}_2 \bar{d}_1 \bar{d}_0 + \bar{d}_2 d_1 \bar{d}_0 + d_2 \bar{d}_1 \bar{d}_0 + d_2 d_1 \bar{d}_0 = m(0, 2, 4, 6)$$

$$\rightarrow \text{carry} = d_2 \bar{d}_1 d_0 + d_2 d_1 \bar{d}_0 + d_2 d_1 d_0 = m(5, 6, 7)$$