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Digital Logic Design, Spring 2008

Exam 1

March 4, 2008

Instructions:

- Make sure that your exam is not missing any sheets, then write your full name on the front.
- Write your answers in the space provided below the problem. If you make a mess, clearly indicate your final answer.
- The exam has a maximum score of 100 points.
- The problems are of varying difficulty. The point value of each problem is indicated. Pile up the easy points quickly and then come back to the harder problems.
- This exam is CLOSED BOOK. You are only allowed to use the single sheet of notes you made for this exam. Please hand in this sheet along with your test. Good luck!
- Each extra credit is only worth 1 point.

1 (10):
2 (10):
3 (20):
4 (20):
5 (40):
TOTAL (100):

Problem 1. (10 points):

Convert the decimal number -33_{10} into a 7-bit two's complement binary number. Suppose, I converted the 7-bit two's complement binary number into a 10-bit two's complement number. Show both the 7-bit and 10-bit two's complement binary numbers.

(64) (32) (16) (8) (4) (2) (1)

6 5 4 3 2 1 0

0 1 0 0 0 0 1 $= 33_{10}$

1 0 1 1 1 1 0

\+ 1

1 0 1 1 1 1 1 $= -33_{10}$

111 1 0 1 1 1 1 1 $= -33_{10}$

Problem 2. (10 points):

Convert the following decimal numbers to 4-bit two's complement binary numbers and add them -3_{10} and -5_{10}.

$0011 = 3_{10}$

1100

\+ 1

$1101 = -3_{10}$

$0101 = 5_{10}$

1010

\+ 1

$1011 = -5_{10}$

1 1 1

$1011 = -5_{10}$

$+ 1101 = -3_{10}$

$1000 = -8_{10}$ ✓

Remember two's complement numbers are asymmetrical

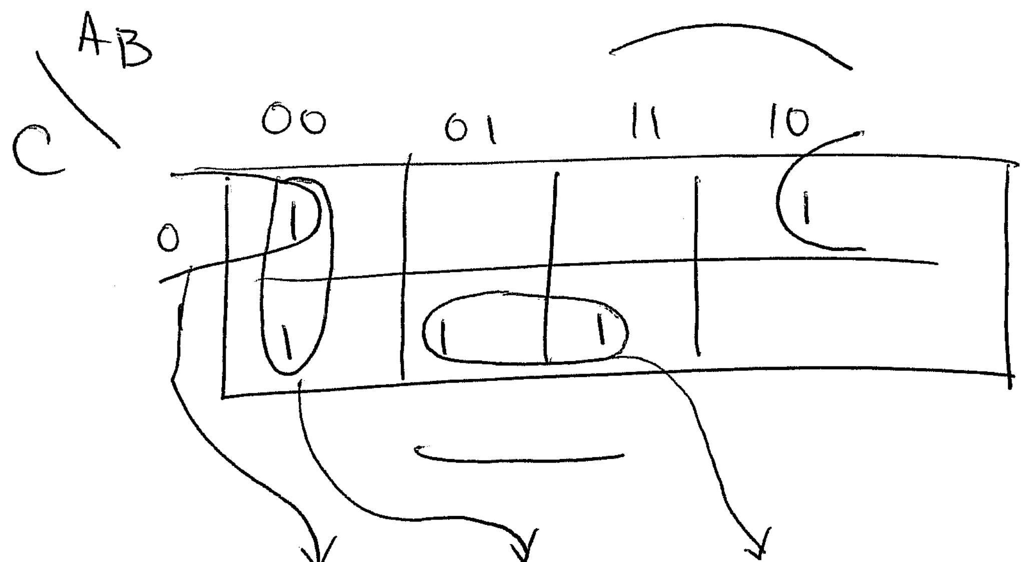
[-8, +7]

Problem 3. (20 points):

Find a minimal Boolean equation for the function below assuming three inputs A, B, and C, and one output Z.

A	B	C	Z
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Table 1: Problem 3.



$Z = \bar{B}\bar{C} + \bar{A}\bar{B} + BC$

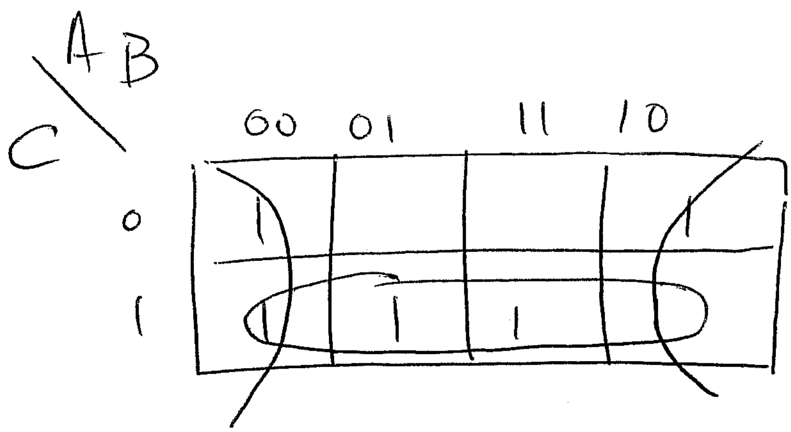
also

$Z = \bar{A}C + \bar{A}\bar{B} + BC$

Both are prime implicants

Problem 4. (20 points):

Suppose, in problem 3, the term for $A = 1$, $B = 0$, and $C = 1$ has a don't care output. Repeat problem 3 assuming this new minterm is now a don't care.



$Z = C + \overline{B}$

Problem 5. (40 points):

Assume, Sally Expert is a recent OSU graduate and wants to design a finite state macine. You can assume there are no resets for this problem. Assuming one input, X, and one output, Z, design the implementation for the state diagram in Figure 1 using:

1. Using binary encoding
2. Using one-hot encoding

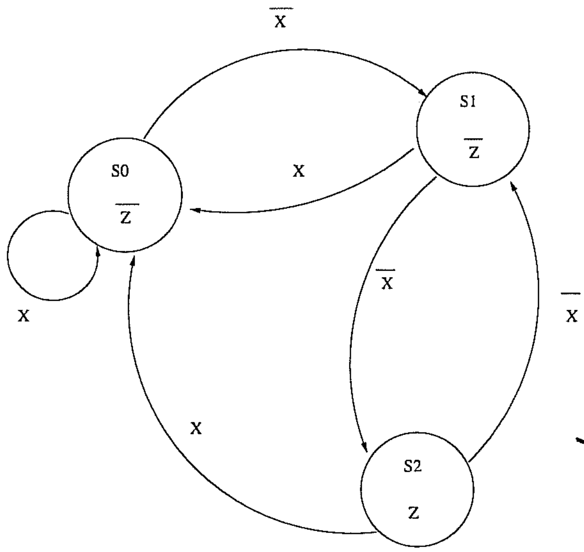


Figure 1: Problem 5.

→ Moore Machine

Output only depends on present state

Current State	Input	Next State	Output
S0	ϕ	S1	$\overline{Z}$
Sϕ	1	Sϕ	$\overline{Z}$
S1	ϕ	S2	$\overline{Z}$
S1	1	Sϕ	$\overline{Z}$
S2	ϕ	S1	Z
S2	1	Sϕ	Z

Encodings

State	Binary Encoding
S0	00
S1	01
S2	10

State	One-Hot Encoding
S0	001
S1	010

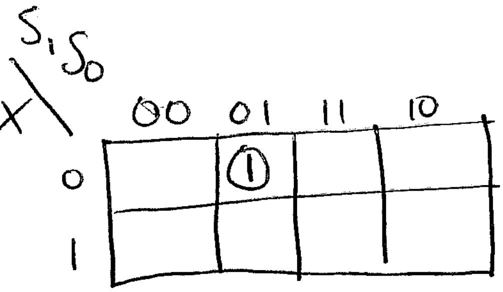
5. (continued)

Current State S_1	Current State S_0	Input X	Next State S_1^*	Next State S_0^*	Output Z
ϕ	ϕ	ϕ	ϕ	1	ϕ
ϕ	ϕ	1	ϕ	ϕ	ϕ
ϕ	1	ϕ	1	ϕ	ϕ
ϕ	1	1	ϕ	ϕ	ϕ
1	ϕ	ϕ	ϕ	1	1
1	ϕ	1	ϕ	ϕ	1
1	1	X	ϕ	ϕ	ϕ

← assume some value and explain why.

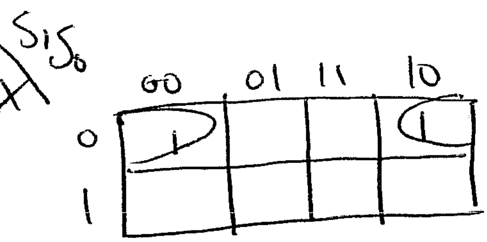
I chose ϕϕ for $S_1^* S_0^*$ so my FSM would go back to Sϕ

I would accept most items as long as its explained.

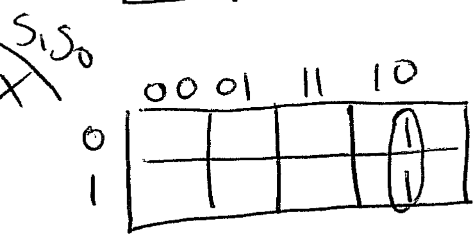


$S_1^* = \overline{S_1} S_0 \overline{X}$

→ only 1 minterm



$S_0^* = \overline{S_0}\ \overline{X}$



$Z = S_1 \overline{S_0}$

5. (continued)

Current State S_2	S_1	S_0	Input X	Next State S_2^*	S_1^*	S_0^+	Output Z
0	0	1	0	0	1	0	0
0	0	1	1	0	0	1	0
0	1	0	0	1	0	0	0
0	1	0	1	0	0	1	0
1	0	0	0	0	1	0	1
1	0	0	1	0	0	1	1
0	0	0	X	X	X	X	X
0	1	1	X	X	X	X	X
1	0	1	X	X	X	X	X
1	1	0	X	X	X	X	X
1	1	1	X	X	X	X	X

Chosen for bad states

$S_0 X$ \ $S_2 S_1$	00	01	11	10
00	X	1	X	
01	X		X	
11		X	X	X
10		X	X	X

$$S_2^* = S_1 \cdot \overline{X}$$

Problem 6. (+1 points):
Can you tell me a good but short joke (a funny nice one, please).

Prob 5 (cont)

S_0X \ S_2S_1	ϕϕ	ϕ1	11	1ϕ
ϕϕ	X		X	1
ϕ1	X		X	
11		X	X	X
1ϕ	1	X	X	X

$S_1^* = \overline{S_1} \cdot \overline{X}$

or

$= S_0 \overline{X}$

S_0X \ S_2S_1	ϕϕ	ϕ1	11	1ϕ
ϕϕ	X		X	
ϕ1	X	1	X	1
11	1	X	X	X
1ϕ		X	X	X

$S_0^* = X$

S_0X \ S_2S_1	ϕϕ	ϕ1	11	1ϕ
ϕϕ	X		X	1
ϕ1	X		X	1
11		X	X	X
1ϕ		X	X	X

$Z = S_2$

Problem 7. (+1 points):
How many bytes are in a 128-bit word?

$$128 \text{ bits} \cdot \left(\frac{1 \text{ byte}}{8 \text{ bits}}\right) = 16 \text{ bytes}$$