ECE M16/CS M51A Midterm

Parth Deshpande

TOTAL POINTS

84.5 / 105

QUESTION 1

1 Question 1-a 4 / 5

- **- 0 pts** Correct
- **- 1 pts** Missing 2x2 PI top/bottom right corner
- **- 1 pts** Missing bottom row PI
- **- 1 pts** Missing Upper Center PI
- ✓ **- 1 pts Missing Lower Center PI**
- **- 1 pts** Missing Right Center PI
- **- 1 pts** Introducing additional wrong implicants (not PIs)
- **- 5 pts** Ambiguous circling.

QUESTION 2

2 Question 1-b 5 / 5

- ✓ **- 0 pts Correct**
- **- 1 pts** Missed center EPI
- **- 1 pts** Missed right center EPI
- **- 1 pts** Missed 2x2 top/bottom-right corner EPI
- **- 1 pts** Missed bottom row EPI
- **- 0.5 pts** Missed bottom row EPI but consistent with previous answer
- **- 1 pts** Mistake made with EPI expression (circle is translated wrong)
- **- 1 pts** Inconsistent with previous answer (given previous answer the answer given here is wrong)
- **- 0.5 pts** Missed 2x2 top/bottom right EPI but consistent with previous answer
- **- 0.5 pts** * + notation error
- **- 5 pts** No answer
- **- 2 pts** A should be B, C should be D

QUESTION 3

3 Question 1-c 5 / 5

- ✓ **- 0 pts Correct**
- **- 1 pts** Missed 2x2 bottom right corner
- **- 0.5 pts** Expression is wrong from the circle. (Wrong translation from circle).
- **- 1 pts** Expression inverses are wrong (dual form is given).
- **- 1 pts** Unnecessary PI included
- **- 2 pts** POS is given when SOP is asked.
- **- 1 pts** Top row PI is missed.
- **- 1 pts** Left center PI is missed
- **- 1 pts** Center PI is missed.
- **- 1 pts** Inverse at the beginning is wrong.
- **- 5 pts** Should have started with 0s.
- **- 2 pts** A should be B and C should be D
- **- 0.5 pts** Click here to replace this description.
- **- 1 pts** Simplifications are wrong.
- **- 4 pts** Formed correct POS but nothing else.

QUESTION 4

4 Question 2-a 5 / 5

- ✓ **+ 1 pts Answered yes.**
- ✓ **+ 1 pts Wrote the correct form**
- ✓ **+ 3 pts Provided proof**
- **- 1 pts** Proof incomplete
- **+ 5 pts** All correct

QUESTION 5

5 Question 2-b 5 / 6

- **+ 1 pts** Wrote XOR to Boolean
- **+ 2 pts** Expanded the Boolean expression
- **+ 1 pts** Simplified the expanded expression
- ✓ **+ 6 pts Got the final DNF**
- **+ 0 pts** Nothing
- ✓ **- 1 pts Did not simplify / not DNF / at least one term is wrong**

QUESTION 6

6 Question 2-c 2 / 6

- \+ **6 pts** Got the minimal terms
- ✓ + **2 pts** **Built on the previous answer**
- \+ **1 pts** Drew the k-map
- \+ **2 pts** Verified using k-map
- \+ **0 pts** Nothing
- \- **1 pts** minor mistake

QUESTION 7

7 Question 2-d 7 / 8

- \+ **2 pts** Used NOR for other logics
- \+ **2 pts** Gate diagram for previous logic
- ✓ + **8 pts** **All correct**
- \+ **0 pts** Nothing
- ✓ - **1 pts** **Not minimum / minor issue**

QUESTION 8

8 Question 3-a 4 / 4

- ✓ + **4 pts** **Correct**
- \+ **0 pts** Wrong

QUESTION 9

9 Question 3-b 3 / 3

- ✓ + **3 pts** **correct**
- \+ **0 pts** wrong

QUESTION 10

10 Question 3-c 0 / 4

- \+ **4 pts** correct
- ✓ + **0 pts** **wrong**
- \+ **2 pts** partially correct from previous wrong answer
- \+ **1 pts** taking 4's complement

QUESTION 11

11 Question 3-d 3 / 3

- ✓ + **3 pts** **Correct**
- \+ **0 pts** Wrong

QUESTION 12

Question 3-e 11 pts

12.1 3-e-1 4 / 4

- ✓ + **4 pts** **Correct**
- \+ **0 pts** Wrong

12.2 3-e-2 4 / 4

- ✓ + **4 pts** **Correct**
- \+ **0 pts** Wrong
- \+ **2 pts** partially correct from previously wrong answer
- \+ **1 pts** Taking 19's complement

12.3 3-e-3 0 / 3

- \+ **3 pts** Correct
- ✓ + **0 pts** **Wrong**
- \+ **1 pts** partially correct

QUESTION 13

13 Question 4-a 8 / 8

- ✓ + **8 pts** **Correct**
- \+ **4 pts** Used blocks/non-gate components but correct output
- \+ **4 pts** Carry wrong
- \+ **4 pts** Difference output wrong
- \+ **0 pts** No design
- \+ **0 pts** Wrong output for carry and difference

QUESTION 14

14 Question 4-b 6 / 6

- ✓ + **6 pts** **Correct**
- \+ **3 pts** Didn't use half-subtractors but correct output
- \+ **3 pts** carry out wrong
- \+ **3 pts** difference wrong
- \+ **0 pts** Wrong/No design

QUESTION 15

15 Question 4-c 6.5 / 7

- ✓ + **7 pts** **Correct**
- \+ **6.5 pts** Missing first cin but otherwise correct
- ✓ - **0.5 pts** **Missing labels for the bit order (order does matter)**
- \+ **5 pts** Close design but not correct
- \+ **5 pts** Subtracted cin from all bits
- \+ **3 pts** Incomplete/Significant design issues but on right track
- \+ **2 pts** Implemented wrong device

- **0.5 pts** Implemented using half-sub instead of full-sub
+ **0 pts** Wrong/No design

QUESTION 16

16 Question 4-d 13 / 14

✓ + **2 pts** **Correct addition function**

✓ + **2 pts** **Correct subtraction function**

✓ + **3 pts** **Correct negation function**

✓ + **2 pts** **Correct multiplication function**

+ **3 pts** MUXs used properly for switching outputs

✓ + **2 pts** **Completed design/put together properly/correct outputs**

- **0.5 pts** Unclear which wires go where/splitting of wires

- **0.5 pts** Unclear which inputs are which for functions

- **0.5 pts** Wrong codes correspond to functions

- **0.5 pts** Wrong names for adder/subtractor

+ **0 pts** No Design

+ **2** **Point adjustment**

pc for mux +2

① need a mux here too

QUESTION 17

17 Question 5 0 / 5

+ **5 pts** Correct

+ **4.5 pts** Correct design idea; minor mistake

+ **4 pts** Correct design idea; wrong codes match

+ **3 pts** Correct design idea; not complete/significant mistake

+ **3 pts** Gray-Binary converters wrong

+ **2 pts** Did not handle Gray codes properly/Wrong idea for codes

+ **1 pts** Gray-binary converter only/Fundamentally wrong design

✓ + **0 pts** **No/Wrong design**

UCLA | ECEM16/CSM51A | Winter 2020 **Prof. Xiang 'Anthony' Chen**

Midterm Exam

Name (Last, First): Deshpande , Parth
Student Id #: 005129861
Student to Left: Robert
Student to Right: Daivik

Do not start working until instructed to do so.

1. *You must answer in the* ***space provided*** *for answers after every question. We will ignore answers written anywhere else in the booklet.* ***All pages in this booklet must be accounted*** *for otherwise it will not be graded.*
2. *You are permitted 1 page of notes 8.5x11 (front and back).*
3. *You may not use any electronic device.*

Following table to be filled by course staff only

	Maximum Score	Your Score
Question 1	15	
Question 2	25	
Question 3	25	
Question 4	35	
Question 5 (EC)	+5	
TOTAL	100	

Question #1 (15 pts)

Consider the following Karnaugh Map for the Boolean function, Y. A blank truth table is provided for your convenience.

AB

CD		"00"	"01"	"11"	"10"
	"00"	0	0	1	1
	"01"	0	1	0	1
	"11"	0	1	0	0
	"10"	1	1	X	X

100X

01X01

1XX0

XX10

A	**B**	**C**	**D**	**Y**
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

(a) Circle the prime implicants on the map. (5 pts)
How many prime implicants are there? 4

(b) Write the Boolean (sum-of-product) expression of the *essential* prime implicants of (b) (if any). (5 pts)

EssentialPrimeImplicants = $(A \wedge \neg B \wedge \neg C) \vee (\neg A \wedge B \wedge D) \vee (A \wedge \neg D) \vee (C \wedge \neg D)$

(c) Express as a minimal sum of product, $\neg Y$. (5 pts)
The K-map is provided for your convenience.

AB

CD

	"00"	"01"	"11"	"10"
"00"	0	0	1	1
"01"	0	1	0	1
"11"	0	1	0	0
"10"	1	1	X	X

$\neg Y =$ $(A \land \neg C \land \neg D) \lor (\neg A \land \neg B \land D) \lor (A \land B \land D) \lor (A \land C)$.

Question #2 (25 pts)

(a) Is DeMorgan's theorem still true with more than two variables? If so, prove it in the case of three variables x, y and z. (5 pts)

$\neg(x \wedge y \wedge z) = \neg x \vee \neg y \vee \neg z \leftarrow$ Prove

$= \neg((x \wedge y) \wedge z)$

$= \neg(x \wedge y) \vee \neg z$

$(\neg x \vee \neg y) \vee \neg z = \neg x \vee \neg y \vee \neg z$ Hence proved $\neg(x \wedge y \wedge z) = \neg x \vee \neg y \vee \neg z$

(b) Rewrite the following Boolean equation in (Disjunctive) Normal form. (6 pts)

$$f = \overline{A \oplus B} + \overline{B \oplus C}$$

where $\oplus$ means XOR operation, i.e., $A \oplus B = A\bar{B} + \bar{A}B$

Answer:

$\neg((A \wedge \neg B) \vee (\neg A \wedge B)) \vee \neg((B \wedge \neg C) \vee (\neg B \wedge C))$

$\neg(A \wedge \neg B) \wedge \neg(\neg A \wedge B) \vee (\neg(B \wedge \neg C) \vee \neg(\neg B \wedge C))$

$((\neg A \vee B) \wedge (A \vee \neg B)) \vee ((\neg B \vee C) \wedge (B \vee \neg C))$

$((A \wedge \neg A) \vee (\neg A \wedge \neg B) \vee (B \wedge A) \vee (B \wedge \neg B)) \vee ((\neg B \wedge B) \vee (\neg B \wedge \neg C) \vee (C \wedge B) \vee (C \wedge \neg C))$

$f =$ $(\neg A \wedge \neg B) \vee (B \wedge A) \vee (\neg B \wedge \neg C) \vee (C \wedge B) \vee (A \wedge \neg A) \vee (B \wedge \neg B) \vee (C \wedge \neg C)$

(c) Simplify f from (b) to a minimum sum-of-products. List which Boolean properties you use at each step of the simplification. Hint: you may use K-map to ***verify*** your answer. (6 pts)

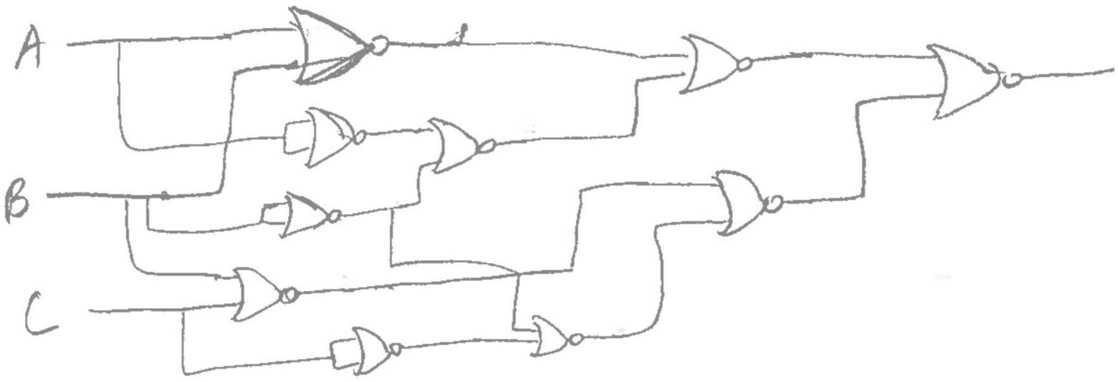
Answer:

$(\neg A \wedge \neg B) \vee (\neg B \wedge \neg C) \vee (B \wedge A) \vee (B \wedge C)$

$(\neg B \wedge (\neg A \vee \neg C)) \vee (B \wedge (A \vee C))$ Reverse Distributive

$f =$ $(\neg A \wedge \neg B) \vee (\neg B \wedge \neg C) \vee (B \wedge A) \vee (B \wedge C)$

(d) With only 2-input NOR gates, implement f with a minimal number of gates. Draw the gate diagram. (Note: no complemented inputs are given) (8 pts)



2048
\- 1645
-403

Question #3 (25 pts)

1024
512
64
32
8
4
1
1645

The following 12-bit word can be used to represent different numbers depending on the encoding 1 + 4 + 8 + 32 + 64 + 512 + 1024 + 2048

12b'1110_0110_1101

(a) If the word is 2's complement, what is the corresponding integer? (4 pts) -403.

(b) If we convert the word (treated as unsigned) into base-4, what is the represented number? (3 pts)

321321

16384
x 4
65536
x 4
262144
x 4
1048576

(c) If we take answer in (b), extending how we define 1's complement for base-2, write the 3's complement of the base-4 number. (4 pts)

012013

(d) What is this word in Hexadecimal? (3 pts) E6D

(e) In base-20 system, assume each digit is now 00, 01, 02, … 09, 10, 11, …19 (each called a "vigit"). For example, 01,19 is 39 in decimal. Using 3 "vigits":

1246
1240
380
6

How would one represent a base-10 integer 1246? (4 pts) 03 02 06

What's the 20's complement representation of -1246 (i.e. the 20's complement of the 1246)? (4 pts) 16 17 14

Using the first vigit as the sign vigit, what is the most positive value in base-10 integer that can be represented? (3 pts) 7999

19
x 4
7600
380
19

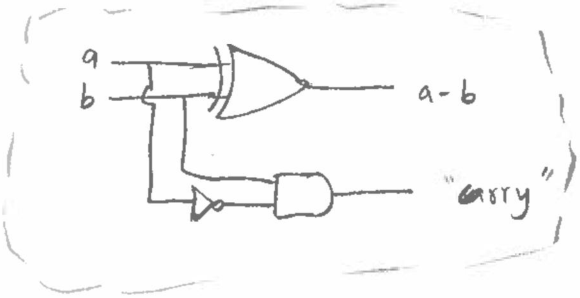
$+4^{11}+4^{10}+4^{9}+4^{6}+4^{5}+4^{3}+4^{2}+1$

Question #4 (35 pts)

(a) Implement a one-bit "half-subtractor" from gates. The carry-out of this subtractor is 1 when the result is -1. The truth table for this is shown below: (8 pts)

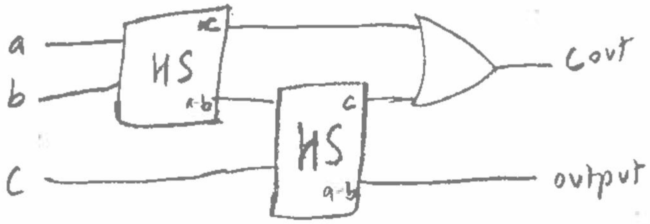
Cin

a	b	a - b	"carry"
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0



HS → Half subtractor.

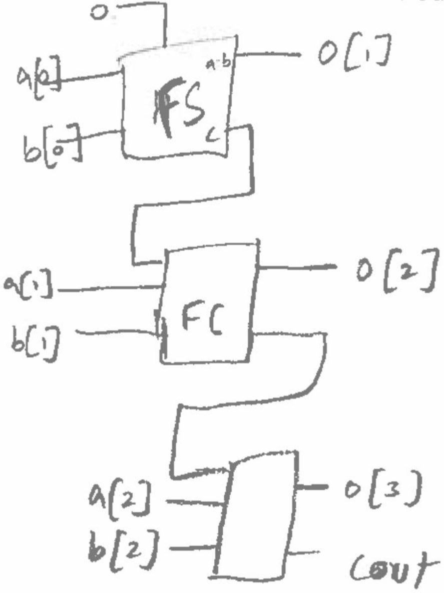
(b) Implement a "full-subtractor" from "half-subtractor" blocks. (6 pts)



a	b	c	O	Carry
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

a-b	c	s	c
0	0	0	0
1	1	1	1
0	1	1	1
1	0	0	

(c) Implement a 3-bit "subtractor" from 1-bit "full-subtractor" blocks. (7 pts)



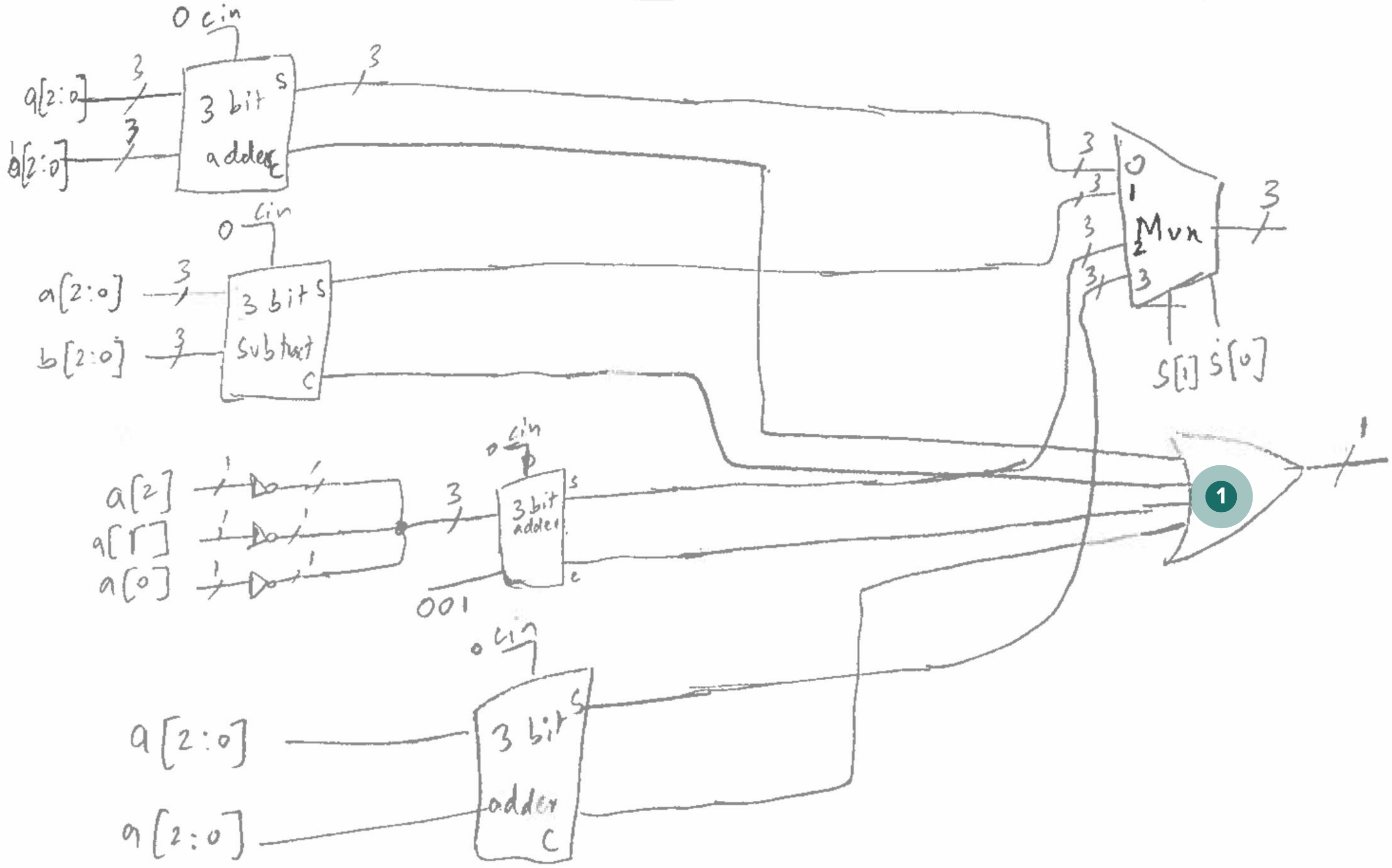
(d) Processors use a block called an ALU (Arithmetic Logic Unit) as part of their processing capability. Here we will implement a very basic ALU with a total of 4 functions, selected by a 2-bit code. Using the building blocks discussed in lecture and the 3-bit subtractor block, implement a 3-bit ALU that can add, subtract, negate one argument, and multiply by 2. The select codes are listed in the table below. Note that there are 3 inputs (3-bit a, 3-bit b, and the 2-bit select code) and 2 outputs (3-bit result and a 1-bit carry). (14 pts)

Hint: Multiplying a number is like shifting the bits to the left and using 0 as the lowest bit. An example: a = 1 = 3'b001 -> 2a = 2 = 4'b0010

Select Code	Result (3-bits)	Carry bit
00	a + b	carry out
01	a - b	carry out
10	-a	0
11	2*a	Product MSB

Select = S
a
b

000
001
010
011
100



Question #5 (Extra Credit - 5 pts)

Implement a 4-bit Gray code +1 incrementor using building blocks (no gates). The 4-bit Gray codes are shown below.

Decimal Number	Gray Code
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000