EEM16 Midterm

MELODY SZE WEI CHEN

TOTAL POINTS

64 / 80

QUESTION 1

Problem 1 20 pts

1.1 (a-c) 9 / 12

✓ **- 1 pts Question1 (a): 4 pts. Missing, or having 1 extra prime implicants**

✓ **- 2 pts Question1 (c): 4 pts. Missing or having extra terms**

① This "1X" is also a prime implicant, since it is also the largest circle can be drawn to cover this 1.

1.2 (d-f) 4 / 8

✓ **- 2 pts Question1 (e): 2 pts.**

✓ **- 1 pts Question1 (f): 3 pts. Incorrect hazard condition**

✓ **- 1 pts Question1 (f): 3 pts. Incorrect term to remove the risk.**

QUESTION 2

2 Problem 2 17 / 20

✓ **- 3 pts (c) not using the fewest NOR (7 gates)**

QUESTION 3

3 Problem 3 20 / 20

✓ **- 0 pts Correct**

QUESTION 4

Problem 4 20 pts

4.1 (a) 8 / 8

✓ **- 0 pts Correct**

4.2 (b) 3 / 5

✓ **- 5 pts incorrect**

+ 3 Point adjustment

💬 partial... shouldn't split into 2 groups of 8.

4.3 (c) 3 / 7

✓ **- 4 pts incorrect separation into 2 one-hot**

Midterm Exam

Name (Last, First): Melody Chen

Student Id #: 705120273

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		
Question 2		
Question 3		
Question 4		
TOTAL	**100**	

Question #1

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"	1	1	X	X
"11"	0	0	1	1
"10"	1	1	X	0

0X1X

01XX

X11X

100X

A	B	C	D	Y	
0	0	0	0	0	0
0	0	0	1		1
0	0	1	0		2
0	0	1	1	0	3
0	1	0	0	0	4
0	1	0	1		5
0	1	1	0		6
0	1	1	1	0	7
1	0	0	0		8
1	0	0	1		9
1	0	1	0	0	10
1	0	1	1		11
1	1	0	0		12
1	1	0	1		13
1	1	1	0		14
1	1	1	1		15

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

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

EssentialPrimeImplicants = $(C\wedge\bar{D}\wedge\bar{A})\vee(\bar{C}\wedge D)\vee(\bar{C}\wedge A)\vee(D\wedge A)$.

(c) Complete the following statement

$\neg Y = \prod M($ 1, 2, 5, 6, 8, 9, 11, 12, 13, 14, 15.

$Y = \prod M(0, 3, 4, 7, 10)$.

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

000X

110X.

101X.

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

$\neg Y =$
$(\bar{C}\wedge\bar{D}\wedge\bar{A})\vee(C\wedge D\wedge\bar{A})\vee(C\wedge\bar{D}\wedge A)$.

(e) Is the dual of this function itself? Circle one: Yes [✓ No]
Justify your answer: returns for function for y.

$y=((C\wedge\bar{D}\wedge\bar{A})\vee(\bar{C}\wedge D)\vee(\bar{C}\wedge A)\vee(D\wedge A))$

$D(y)=(C\vee\bar{D}\vee\bar{A})\wedge(\bar{C}\vee D)\wedge(\bar{C}\vee A)\wedge(D\vee A)$

Dual $\neq$ y

(f) If the logic is implemented using its minimal sum-of-product expression, is there a risk of a static hazard?
Circle one: [✓ Yes] No
Under what input conditions?

What product term(s) would you add to remove the risk? the one's with don't cares

Question #2

(a) Rewrite the following Boolean equation as a sum-of-products or product-of-sum. Hint: apply DeMorgan's theorem.

$$W = \neg\left(\neg(c \vee \neg(a \wedge \neg b)) \vee (d \wedge \neg e)\right)$$

Answer: $W = (c \vee \overline{(a \wedge \bar{b})}) \wedge \overline{(d \wedge \bar{e})} = (c \vee (\bar{a} \vee b)) \wedge (\bar{d} \vee e)$.

$W =$ $(c \vee \bar{a} \vee b) \wedge (\bar{d} \vee e)$

(b) Rewrite the following Boolean equation as a sum-of-products or product-of-sum.

$$X = (c \vee (a \wedge b)) \vee (d \wedge e)$$

Answer: $X = ((c \vee a) \wedge (c \vee b)) \vee (d \wedge e)$

$= ((\vee a) \vee (d \wedge e)) \wedge ((c \vee b) \vee (d \wedge e))$

$= (c \vee a \vee d) \wedge (c \vee a \vee e) \wedge (c \vee b \vee d) \wedge (c \vee b \vee e)$

$X =$ $(c \vee a \vee d) \wedge (c \vee a \vee e) \wedge ((c \vee b \vee d) \wedge (c \vee b \vee e)$

$c \wedge d$

$\overline{(\bar{c} \vee \bar{d})}$

(c) Implement the following function using NOR gates only and the fewest NOR gates possible. You may use true and complemented versions of the *a*-*f* inputs,

$$Y = (a \wedge b \wedge c \wedge d \wedge e) \vee (c \wedge d \wedge f)$$

$\bar{Y} = \overline{((((a \wedge b) \wedge c) \wedge d) \wedge e) \vee ((c \wedge d) \wedge f)}$

$= (\overline{(((a \wedge b) \wedge c) \wedge d)} \vee \bar{e}) \wedge (\overline{(c \wedge d)} \vee \bar{f})$.

$= ((\overline{((a \wedge b) \wedge c)} \vee \bar{d}) \vee \bar{e}) \wedge ((\bar{c} \vee \bar{d}) \vee \bar{f})$.

$= (((\overline{(a \wedge b)} \vee \bar{c}) \vee \bar{d}) \vee \bar{e}) \wedge ((\bar{c} \vee \bar{d}) \vee \bar{f})$

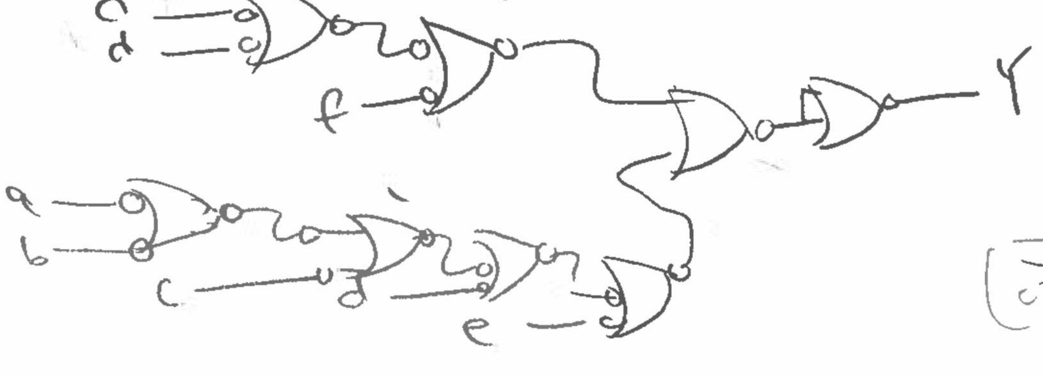
$= ((((\bar{a} \vee \bar{b}) \vee \bar{c}) \vee \bar{d}) \vee \bar{e}) \wedge ((\bar{c} \vee \bar{d}) \vee \bar{f})$

$\bar{\bar{y}} = \overline{((((\bar{a} \vee \bar{b}) \vee \bar{c}) \vee \bar{d}) \vee \bar{e})} \vee \overline{((\bar{c} \vee \bar{d}) \vee \bar{f})}$

$a \wedge b$

$\overline{(\bar{a} \vee \bar{b})}$

$a \wedge b$



$(\bar{c} + \vee \bar{d})$

Question #3

The following 12-bit word can be used to represent different numbers depending on the encoding

12b'1011_1101_0110 = 3030

11 10 9 8 7 6 5 4 3 2 1 0

(a) If the word is 2's complement, what is the corresponding integer? -1066.

0100_0010-1010

(b) If we convert the word into base-4, what is the represented number?

233112

$4^5\ 4^4\ 4^3\ 4^2\ 4^1\ 4^0$

(c) If we take answer in (b), write the 3's complement of the base-4 number.

100 222

$2^{-6}/2$

(d) If the word is unsigned fixed point 6.6, what is the corresponding number?

47.34375

1011_11.01_0110

What is the absolute accuracy of this representation? 78 × 10^{-3}

(e) What is this word in Hexadecimal? BD6

$\frac{1011}{11}$ $\frac{1101}{13}$ $\frac{0110}{6}$

(f) If the word is 6E5 floating point number (IEEE format S+EEEEE+MMMMMM),

What is the bias? 15.

What is the corresponding real number? -1.3475.

$\underset{\text{Signbit}}{\downarrow 1}$ $\underbrace{01111}_{E}$ $\underbrace{010110}_{M}$

E = 15

(g) In base-20 system and using 3 "vigits" (base-20 digits) in 20's complement:

How would one represent a base-10 integer -1616? 15.19.4

What is the most positive value in base-10 integer that can be represented?

3999

4 | 3030 → 2
757 → 1
189 → 1
47 → 3
11 → 3
2

A B C D
10 11 12 13

$1.010110 \times 2^{E-\text{bias}}$

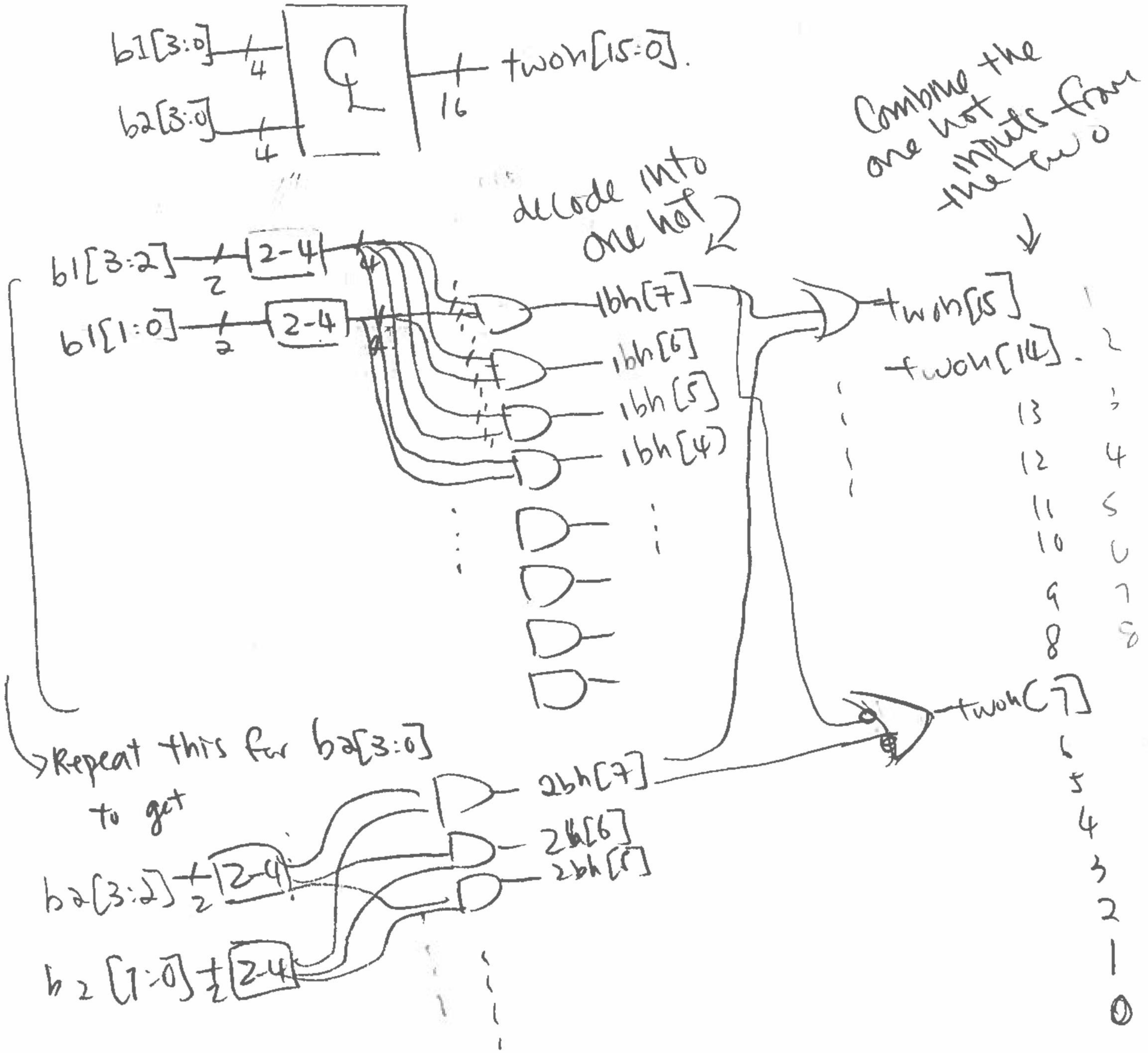
1.34375×2

20 | 1616 → 16
80 → 0
4 → 4

4.0.16 1616.

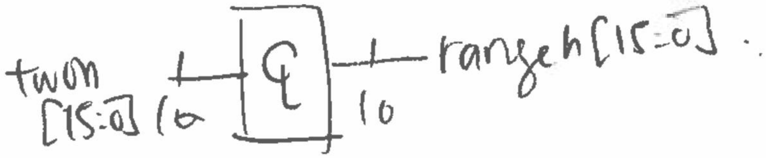
Question #4

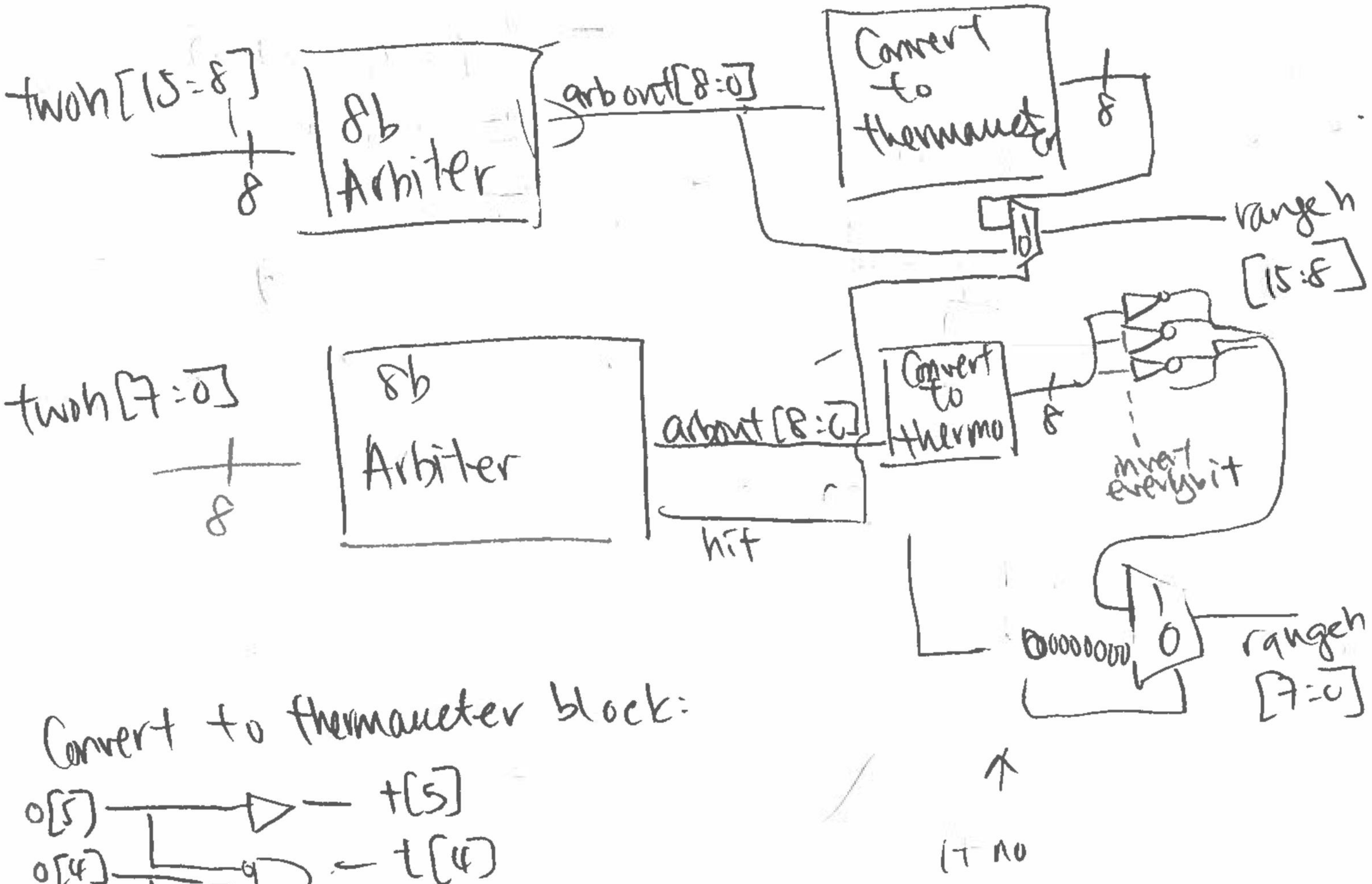
(a) Two 4-bit binary inputs, *b1[3:0]* and *b2[3:0]*, are needs to be decoded into a single 2-hot output vector, *twoh[15:0]*. This 2-hot vector has up to two positions of 1's and the remainder are 0's. If b1 is the same as b2, then only a single 1 is asserted. Design this logic. You may use 2:4 Decoders as building blocks and any number of AND, OR, or INV gates. Try to minimize the amount you use. You may describe connections to avoid an overly complex drawing of every signal and line.



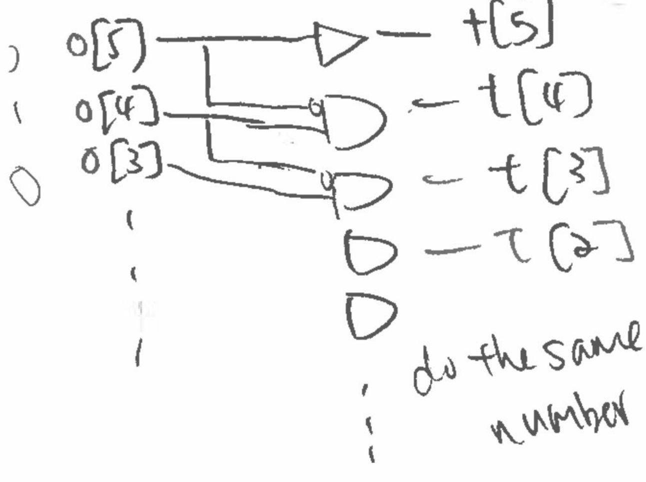
want to output one if only one is one

(b) Next, you are tasked to code the *twoh[15:0]* signals into a vector that indicates a range, similar to a thermometer code. The 16-bit input, *twoh[15:0]*, produces 16-bit outputs, *rangeh[15:0]*, whereby the positions in between the 2 asserted signals of the *twoh[15:0]* are all 1's. For instance, with b1[3:0]=4'b0110 and b2[3:0]=4'b0010, rangeh[15:0]=16b'0000_0000_0011_1110. You may use any building block we have covered in lecture as well as any number of AND, OR, or INV gates. Again you can describe connections to avoid drawing every signal and line.





Convert to thermometer block:



do the same for n
number of inputs

(c) Finally, encode inverse the function of (a) by accepting the *twoh[15:0]* signal as input and output 2 binary values *bo1[3:0]* and *bo2[3:0]* to indicate the binary position of the two hot bits. You may use any building block we have covered in lecture as well as any number of AND, OR, or INV gates. Again you can describe connections to avoid drawing every signal and line.