Topics for mid-term exam: Sample questions: closed book

Topic	Section	material
Number system	1.1-1.6, Hwk1	Radix conversion; 2's complement & signed arithmetic
Boolean algebra	2.4-2.8, Hwk2	Sum of products; Simplify the function to minimum number of literals
Complete problem statement to gate implementation	Hwk3	Implementation of logic expression using NAND gates
Karnaugh maps	3.2-3.6 Up to p.94; 103,104 Hwk3	3 and 4 variable maps, don't cares (x's); XOR
MSI: Decoder and Multiplexers	4.9, 4.11 up to p.162	

1. (4 X 5 = 20 points) Number system and Radix Conversion
For the numbers given below convert the radix as specified.

a. 1234 decimal to binary $(1234)_{10} \rightarrow (\ ?\ )_2$
b. 1011.11 to decimal $(1011.11)_2 \rightarrow (\ ?\ )_{10}$
c. 1011.11 to octal $(1011.11)_2 \rightarrow (\ ?\ )_8$
d. 1011.11 to hexadecimal $(1011.11)_2 \rightarrow (\ ?\ )_{16}$

2. (20 points) Boolean Algebraic Simplification
Simplify using only Boolean algebraic laws and theorems. Clearly show all the intermediate steps. Provide the result in sum of products form.
F(A, B, C) = A.B.C + A'.B.C + A'.B.C' + A.B'.C + A.C'

3. (4+ 2 + 9 + 5 = 20 points) Word Problem to Gate implementation
Consider a 4-input (**W, X, Y, Z**) and 1-output function that has logic-1 output whenever the majority of the inputs are logic-0.

a. Draw the truth table representing this function.
b. Express the function in sum of minterms format.
c. Simply the expression from above using algebraic simplification method.
d. Draw the combinational circuit for the simplified expression.

4. (10 points) NAND only implementations
Draw **the NAND only** implementations for the Boolean expression given below:
F (A,B, C, D) = A.B + B'.C'+ B.(C'+D)

5. (20 points) Signed Binary Arithmetic
Consider 8-bit binary containers with 1 bit for sign and 7 bits for magnitude. Consider numbers A = 65 and B= 72. Assume negative numbers are represented as 2's complement and the operations are in 2's complement. Perform the operations below in binary. **Specify if the result is positive, negative or overflow and explain your answer.**

a. X = A + B
b. Y = A – B
c. Z = –A –B
d. W = –A + B

6. (10 points) K-map with don't care conditions; simplify and implement using {and,or, not}
$F(w,x,yz) = \sum(0,2,4,6,10,14)$ $d(w,x,y,z) = \sum(3,8,9,11,12,13,15)$

7. a. Implement function in question 6 using 4X1 MUX. B. Implement F(a,b,c)= $\sum(0,2,4,6)$ using 3X8 decoder.

Midterm Review

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① a) $(1234)_{10} \rightarrow (?)_2$ radix 2

2 | 1234	
2 | 617	— 0
2 | 308	— 1
2 | 154	— 0
2 | 77	— 0
2 | 38	— 1
2 | 19	— 0
2 | 9	— 1
2 | 4	— 1
2 | 2	— 0
1	— 0
=	

$(10011010010)_2$

b) $(1011.11)_2 \rightarrow (\ )_{10}$ decimal

$1 \times 2^0 \rightarrow 1$

$1 \times 2^1 \rightarrow 2$

$0 \times 2^2 \rightarrow 0$

$1 \times 2^3 \rightarrow 8$

11 decimal

$\frac{1}{2^1} + \frac{1}{2^2}$

$= 0.5 + 0.25$

$= 0.75$ decimal

$(11.75)_{10}$

...	2^5	2^4	2^3	2^2	2^1	2^0	•	2^{-1}	2^{-2}	2^{-3}	2^{-4}	...

positional weights of location

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$(1101.11)_2$ to $(\quad)_8$?

$(\quad)_{10}$

Convert any radix to decimal then from decimal to Octal

$(11.75)_{10}$

base 10 → base 8

8 | 11

1 – 3 ↑ $(13)_8$

0.75×8

6 .00

$(13.6)_8$

d) Hexadecimal is mostly used for representation.

#75FFDE

Red green blue

I binary ⇒ Decimal (fraction: Yes)

II Decimal ⇄ any radix (fraction: NO)

2.

$$F(A,B,C) = ABC + A'BC + A'BC' + AB'C + AC'$$

$$= ABC + A'BC + A'BC' + AB'C + AC'(B+B')$$

$$= ABC + A'BC + A'BC' + AB'C + ABC' + AB'C'$$

$$= AB(C+C') + A'B(C+C') + AB'(C+C')$$

$$= AB + A'B + AB'$$

$$= (A+A')B + AB'$$

$$= B + A \cdot B'$$

$$= (B+A)\cdot(B+B') = B+A$$

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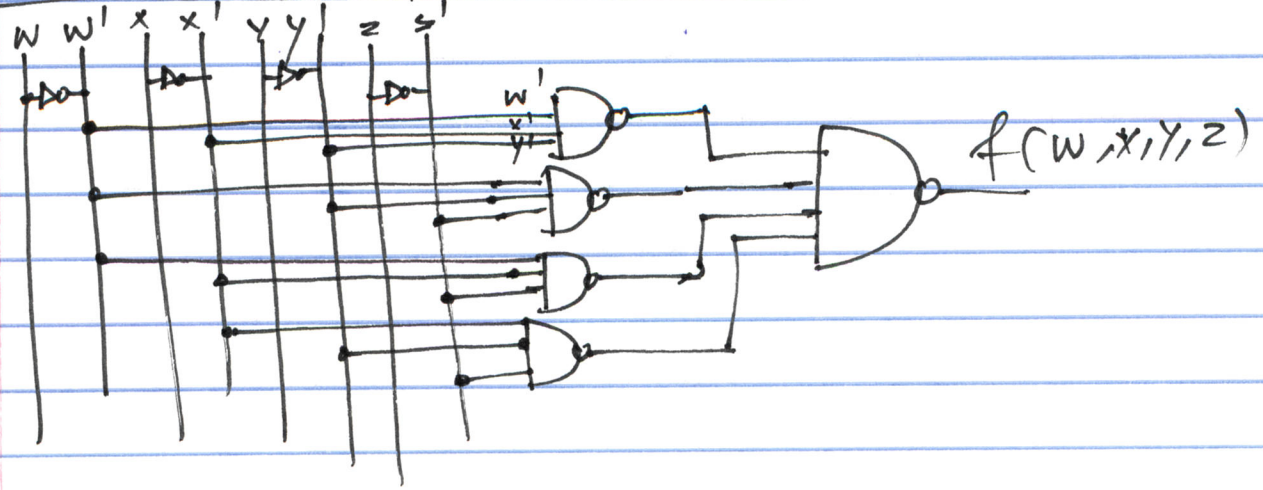
3. Truth Table

w	x	y	z	f(w,x,y,z)	
0	0	0	0	1	m_0
0	0	0	1	1	m_1
0	0	1	0	1	m_2
0	0	1	1	0	
0	1	0	0	1	m_4
0	1	0	1	0	
0	1	1	0	0	
0	1	1	1	0	
1	0	0	0	1	m_8
1	0	0	1	0	
1	0	1	0	0	
1	0	1	1	0	
1	1	0	0	0	
1	1	0	1	0	
1	1	1	0	0	
1	1	1	1	0	

$f(w,x,y,z) = \Sigma(m_0, m_1, m_2, m_4, m_8)$

wx \ yz	00	01	11	10
00	0 (1)	1 (1)	3	2 (1)
01	4 (1)	5	7	6
11	12	13	15	14
10	8 (1)	9	11	10

$= w'x'y' + w'y'z' + w'x'z' + x'y'z'$

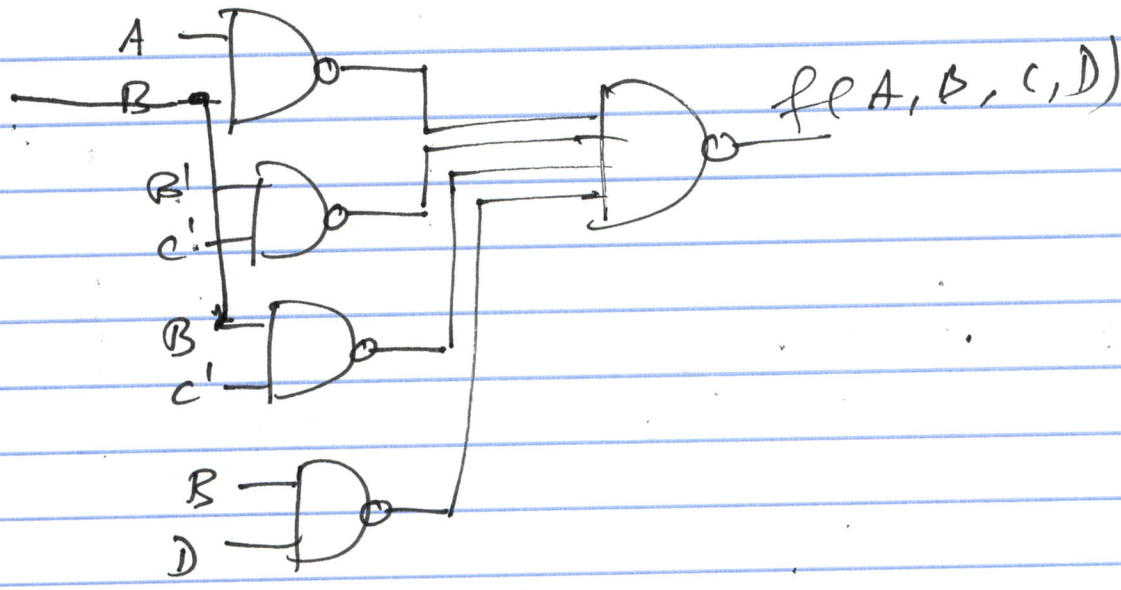


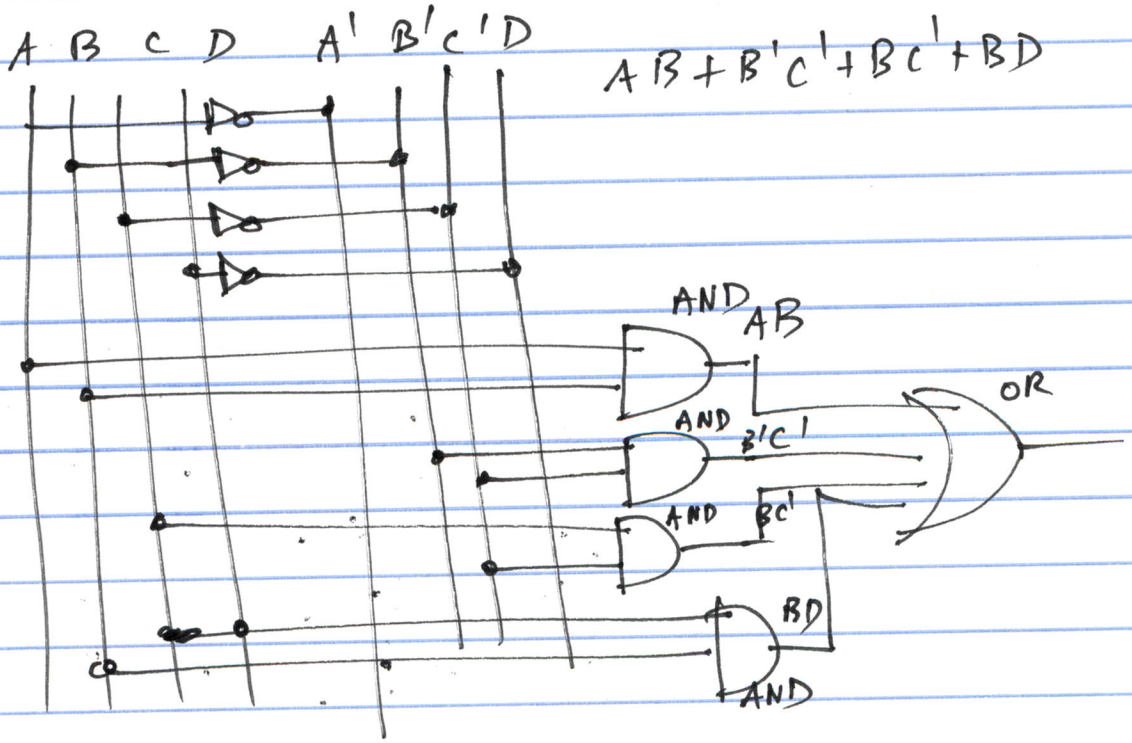
NAND only implementation March 8, 2017

(4) $F(A, B, C, D) = AB + B'C' + BC(C' + D)$

$= AB + B'C' + BC' + BD$

Convert to standard "sum of products form"





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(5) Signed Binary Arithmetic, A=66, B=72

Step 1 convert A, B to binary; obtain -A, -B

2's complement

Hint

7

10001

00010001

2 | 66
2 | 33 - 0
2 | 16 - 1
2 | 8 - 0
2 | 4 - 0
2 | 2 - 0
1 - 0

A: 0 1 0 0 0 0 1 0

2 | 72
2 | 36 - 0
2 | 18 - 0
2 | 9 - 0
2 | 4 - 1
2 | 2 - 0
1 - 0

B: 0 1 0 0 1 0 0 0

-A 2's Complement of +A

0 1 0 0 0 0 1 0 | A
1 0 1 1 1 1 0 1 | 1's comp.
+ 1
1 0 1 1 1 1 1 0 | 2's comp

-A: 1 0 1 1 1 1 1 0

2's complement of B

1 0 1 1 0 1 1 1
+ 1

-B: 1 0 1 1 1 0 0 0

a. X = A + B

0 1 0 0 0 0 1 0
+ 0 1 0 0 1 0 0 0
1 0 0 0 1 0 1 0

0 since carry into the MSB ≠ Carry out of the MSB

it is a overflow

b. Y = A - B

= A + (-B)

= A + 2's complement of B

0 1 0 0 0 0 1 0
1 0 1 1 1 0 0 0
1 1 1 1 0 1 0

0

no overflow

result is negative

automatically it is in 2's complement form

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c. $Z = -A - B = (-A) + (-B)$

= 2 complement of A + 2's complement of B

```
  0 1 1 1
  1 0 1 1 1 1 1 0
+ 1 0 1 1 1 0 0 0
  ---------------
1 0 1 1 1 0 1 1 0
```

Carry into the MSB = 0
Carry out of the MSB = 1
overflow has occurred.

d. $N = -A + B = (-A) + B$

2's complement of A + B

```
  1 1 1 1
  1 0 1 1 1 1 1 0
  0 1 0 0 1 0 0 0
  ---------------
1 0 0 0 0 0 1 1 0
```

+72 −66

+6

no overflow ⇒ answer is positive.

16 [00000110] 8 bits

8 bit container

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(6) $f(w,x,y,z) = \Sigma(0, 2, 4, 6, 10, 14)$

$d(w,x,y,z) = \Sigma(3, 8, 9, 11, 12, 13, 15)$

wx \ yz	00	01	11	10
00	0: 1	1:	3: d	2: 1
01	4: 1	5:	7:	6: 1
11	12: d	13: d	15: d	14: 1
10	8: d	9: d	11: d	10: 1

1 group of 8's:

$f(w,x,y,z) = z'$

z' ———————— $f(w,x,y,z)$

(7) ~~z = f(~~

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(7)

$F(w,x,y,z) = \sum(0,2,4,6,10,14)$

Implement using a 4×1 Mux.

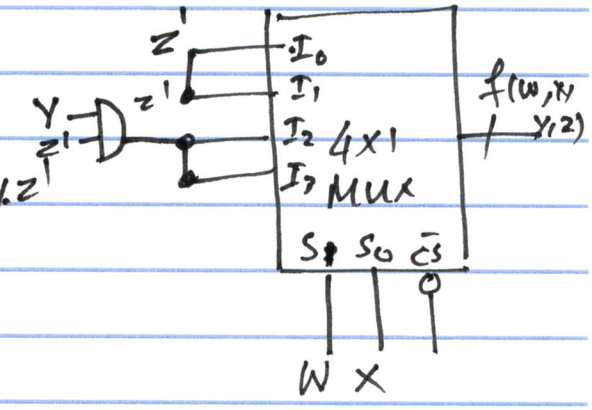
w	x	y	z	f(w,x,y,z)
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

$I_0 = ?$ $\quad y'z' + yz' = z'(y'+y) = z'$

I_1 $\quad y'z' + yz' = z'(y'+y) = z'$

$I_2 = yz'$

$I_3 =$



(7)

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$F(a,b,c) = \Sigma\ 0, 2, 4, 6)$