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Name Hanna Say

First Last

Student ID # [redacted]

University of California

Los Angeles

Computer Science Department

CSM51A/EEM16 Midterm Exam

Winter Quarter 2016

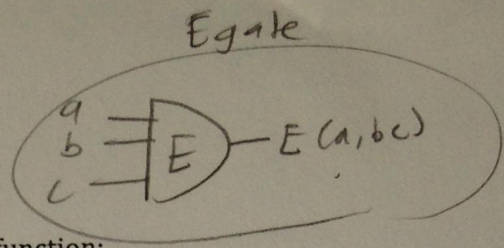
February 8th 2016

This is a closed book exam. Absolutely nothing is permitted except pen, pencil and eraser to write your solutions. Any academic dishonesty will be prosecuted to the full extent permissible by university regulations.

Time allowed 100 minutes.

Problem (possible points)	Points
1 (20)	20
2 (20)	20
3 (20)	20
4 (20)	16
5 (20)	20
Total (100)	96

20



Problem 1 (20 points)

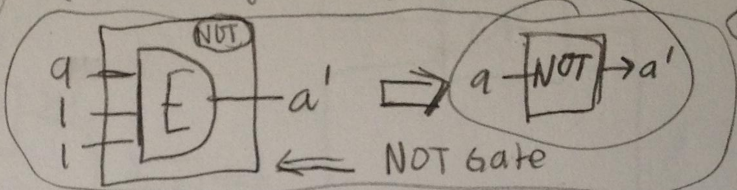
Use only the “E” gate defined below to implement Boolean function:
F=w’xy’+wxz+w’x’z+wx’y’z’
You may also use constants 0 and 1 as inputs.

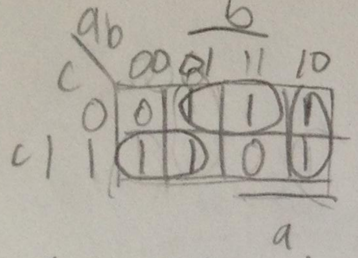
a	b	c	E(a,b,c)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

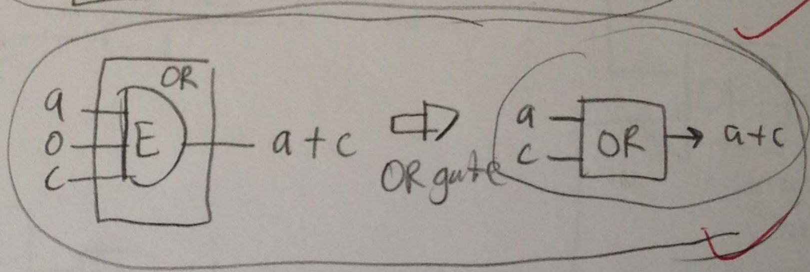
$E=(a+b+c)(a'+b'+c')=ab'+ac'+a'b+bc'+a'c+b'c$

$E(a,a,a)=(a)(a')=0$

NOT gate $E(a,1,1)=(a+1+1)(a'+0+0)=(1)(a')=a'$



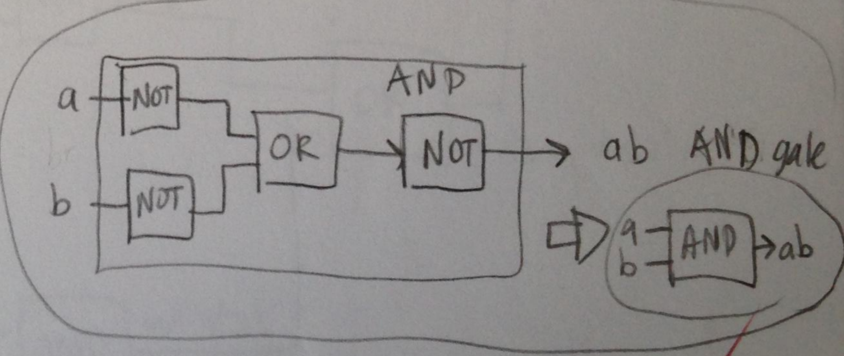




$E=bc'+ab'+a'c$

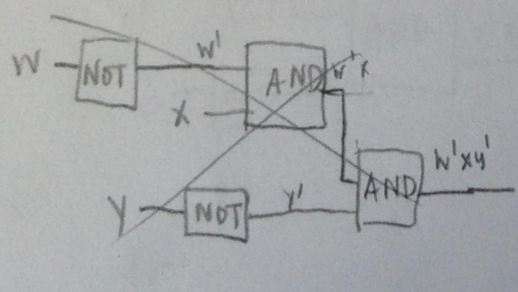
OR $E(a,0,c)=0+a+a'c=a+c$

AND $E(\quad)=$

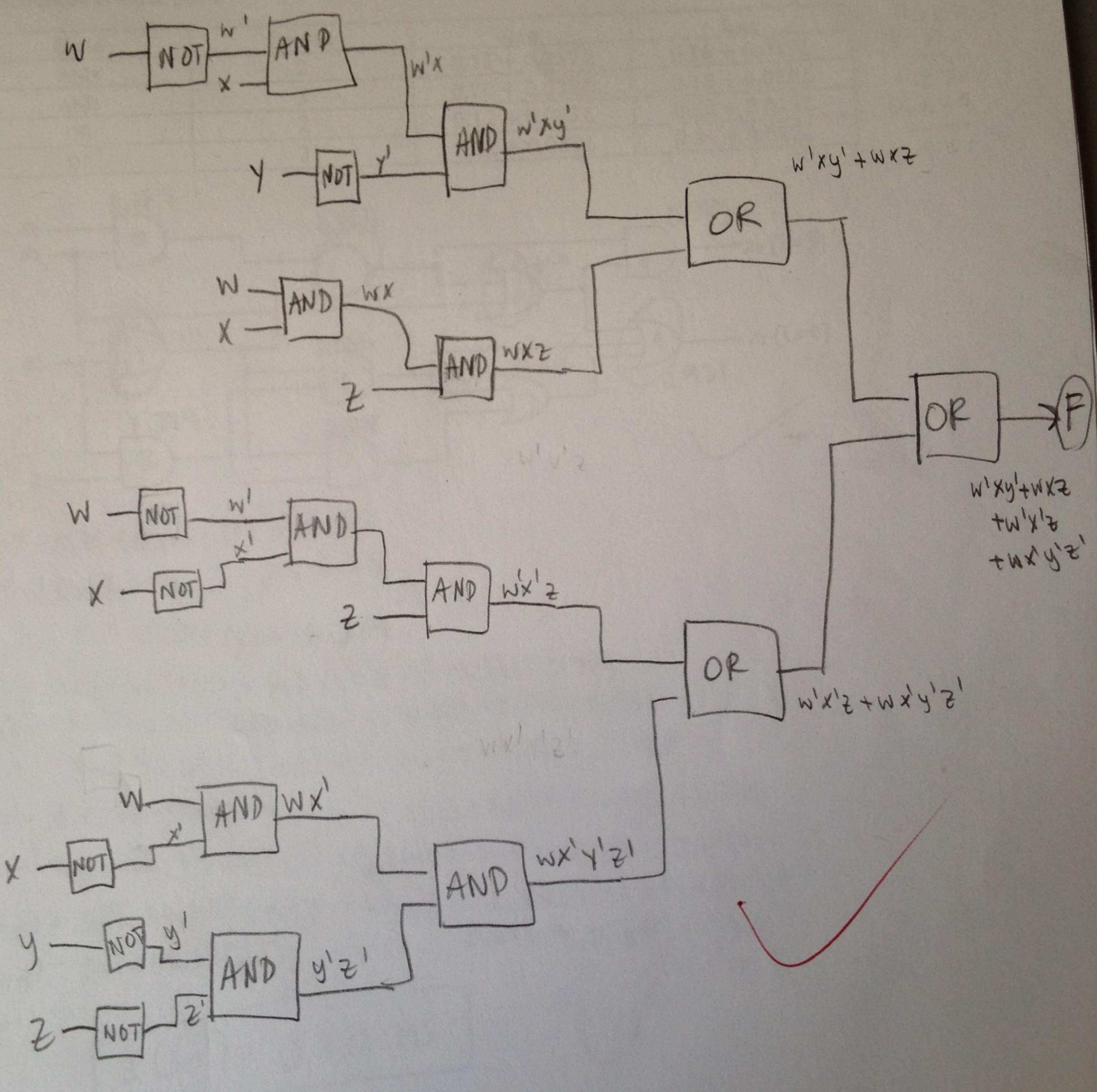


$(a'+b')'=ab$

NOT(OR (NOT(a), NOT(b))) ⇒ AND



Problem 1) Extra Page



0.074 + 0.150 = 0.224; 0.224 + 0.231 = 0.455
0.037 × 2 = 0.074
0.037 × 3 = 0.111
0.111 + 0.120 = 0.231
0.111 + 0.150 = 0.261
0.261 + 0.649 = 0.910
0.150 + 0.037 = 0.187
0.187 + 0.231 = 0.418
0.074 + 0.120 = 0.194; 0.194 + 0.455 = 0.649
0.120 + 0.037 = 0.157; 0.157 + 0.455 = 0.612
0.038 × 4 = 0.152; 0.152 + 0.120 = 0.272; 0.272 + 0.649 = 0.921

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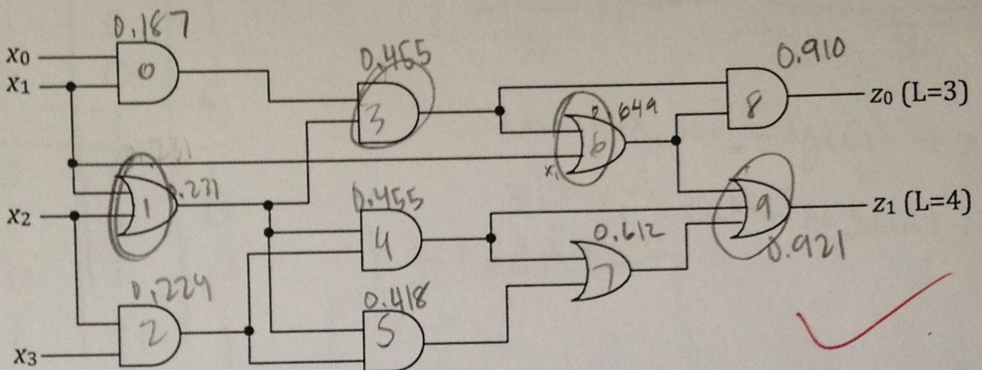
Problem 2 (20 points)

Given the network below, calculate the critical path delay. Consider L → H delay when calculating the critical path.

Gate	Fan-in	t_{pLH}	t_{pHL}
AND	2	$0.15 + 0.037L$	$0.16 + 0.017L$
AND	3	$0.20 + 0.038L$	$0.18 + 0.018L$
OR	2	$0.12 + 0.037L$	$0.20 + 0.019L$
OR	3	$0.12 + 0.038L$	$0.34 + 0.022L$



AND $d(G_0) = 0.15 + 0.037(1) = 0.187$
OR $d(G_1) = 0.12 + 0.037(3) = 0.231$
AND $d(G_2) = 0.15 + 0.037(2) = 0.224$
AND $d(G_3) = 0.15 + 0.037(2) + d(G_1) = 0.224 + 0.231 = 0.455$
$d(G_4) = 0.15 + 0.037(2) + d(G_1) = 0.224 + 0.231 = 0.455$
$d(G_5) = 0.15 + 0.037(1) + d(G_1) = 0.187 + 0.231 = 0.418$
OR $d(G_6) = 0.12 + 0.037(2) + d(G_3) = 0.12 + 0.074 + 0.455 = 0.649$
$d(G_7) = 0.012 + 0.037(1) + d(G_4) = 0.157 + 0.455 = 0.612$
AND $d(G_8) = 0.15 + 0.037(3) + d(G_6) = 0.261 + 0.649 = 0.910$
OR $d(G_9) = 0.12 + 0.038(4) + d(G_6) = 0.272 + 0.649 = 0.921$

$d(CP) = 0.921$ ns

CP = G_1, G_3, G_6, G_9

$30_{10} = (11110)_2$

adding 4bit #

max $1111 = 15$

$8+4+2+1$

max $15+15 = 30$

max = $(11110)_2 \rightarrow$ 5bit

$\frac{30}{2} = 15$, $\frac{15}{2} = 7$ R1, $\frac{7}{2} = 3$ R1, $\frac{3}{2} = 1$ R1

1. 1bitadder
2. 4-bit adder
3. have 2 4-bit adders for E, F
4. 1 bit cmp → 5 bit cmp
5. 5 cmp for E & F → selector (mux)

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Problem 3 (20 points)

Four 4-bit numbers A,B,C, and D are given as inputs. E=A+B, F=C+D. Design a system that outputs the larger number between E and F. If E=F, output either E or F. You can use any type of gates to implement your design.

① 1-bit adder

x_i	y_i	Cin	Cout	Z_i
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Cout

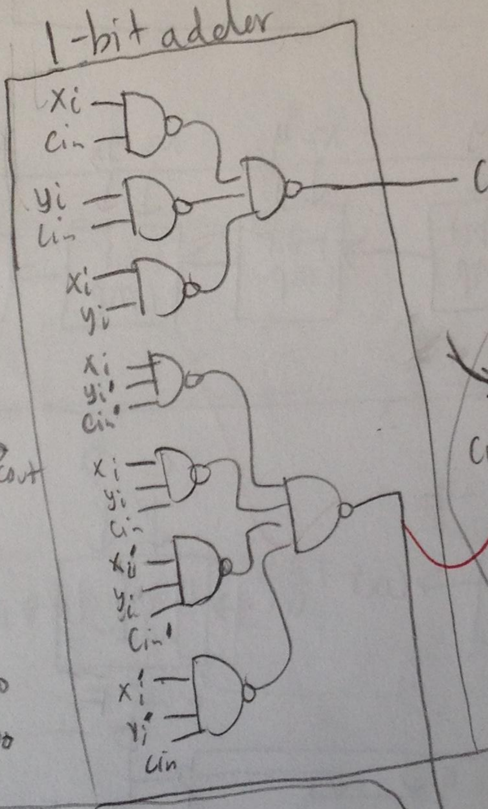
Cin \ x_iy_i	00	01	11	10
0	0	0	1	0
1	0	1	1	1

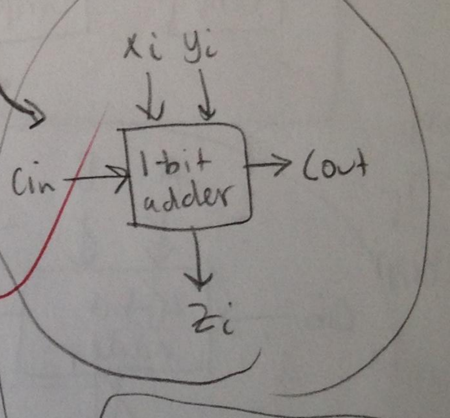
Z_i

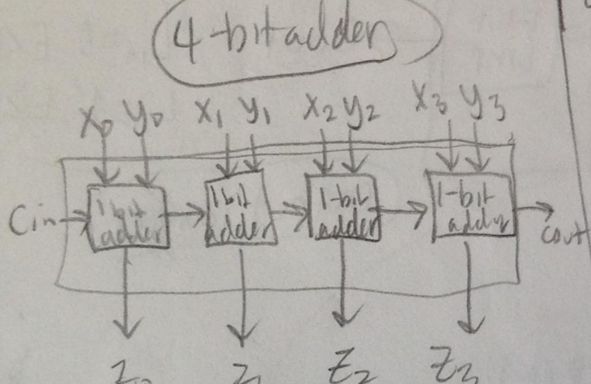
Cin \ x_iy_i	00	01	11	10
0	0	1	0	1
1	1	0	1	0

$C_{out} = x_iC_{in} + y_iC_{in} + x_iy_i$

$Z_i = x_iy_i'C_{in}' + x_iy_iC_{in} + x_i'y_iC_{in}' + x_i'y_i'C_{in}$

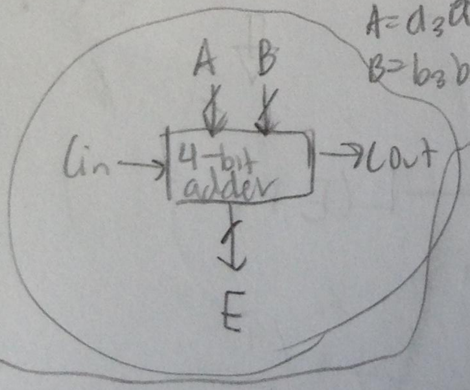






$A = a_3a_2a_1a_0$

$B = b_3b_2b_1b_0$



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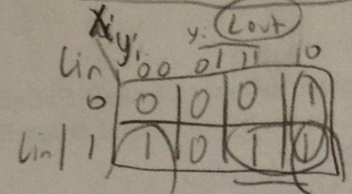
4. 1bit comparator X, Y = 4 bit numbers

$L_{in/out} = 0 : X < Y$

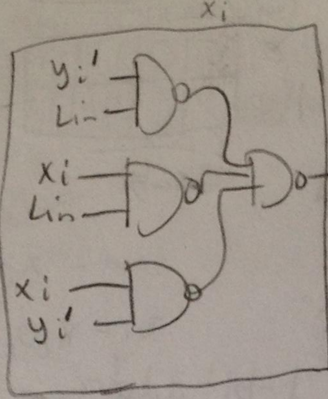
$L_{in/out} = 1 : X \geq Y$

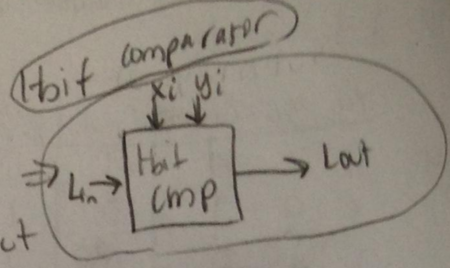
least sig to most sig bit

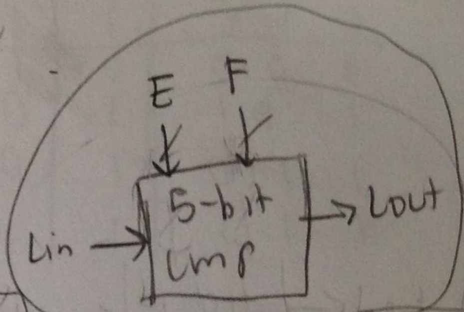
x_i	y_i	L_{in}	L_{out}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1



$L_{out} = y_i' L_{in} + x_i L_{in} + x_i y_i'$

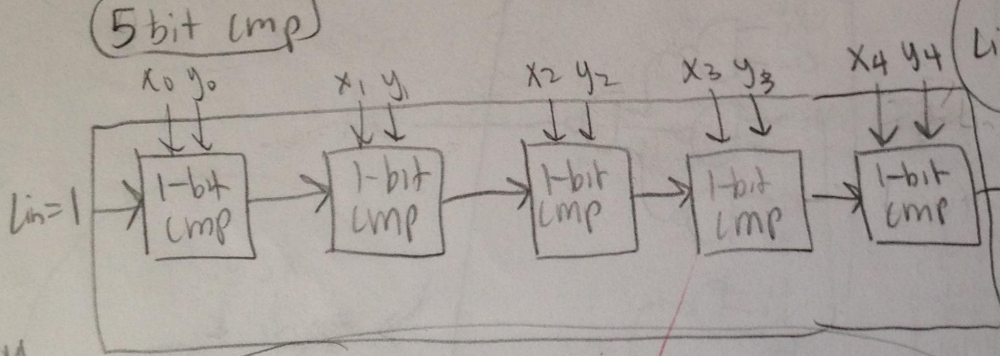


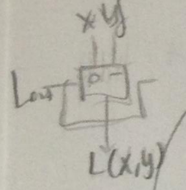




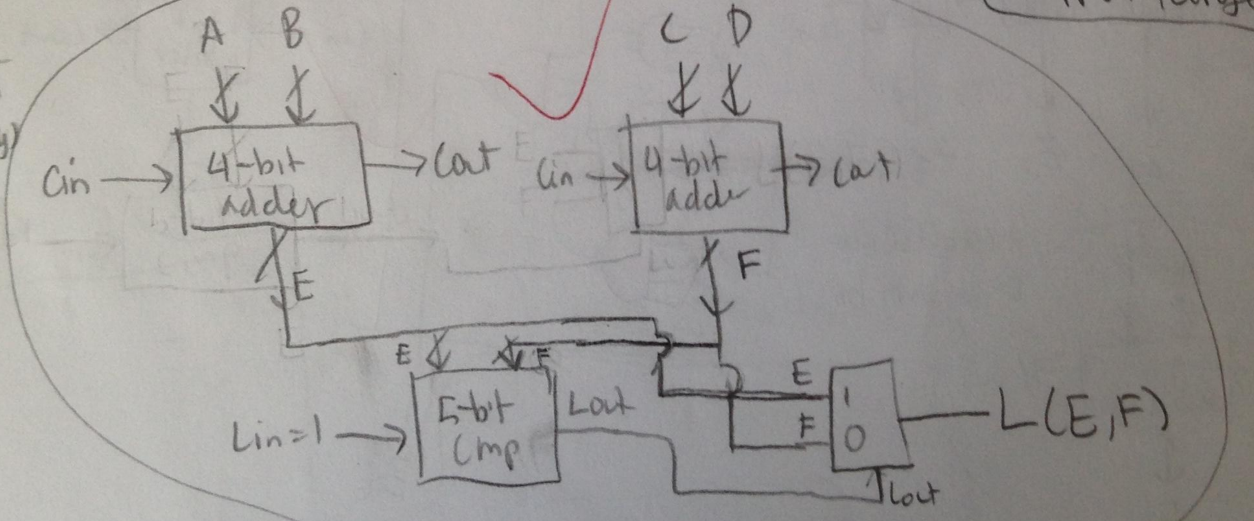
$L_{in} = 0 : E < F$

$L_{in} = 1 : E \geq F$





Output larger



easier to not don't care

16

M: PI

N: EPI

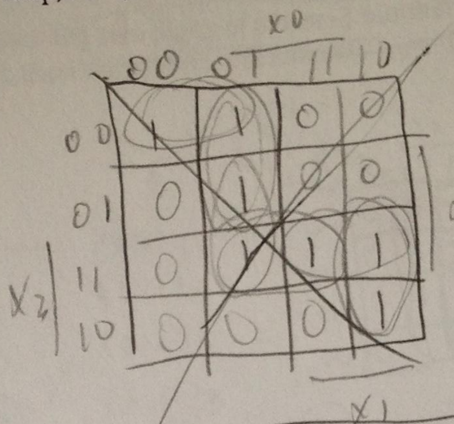
Problem 4 (20 points)

For a K-map, M denotes the number of prime implicants of the K-map, and N denotes the number of essential prime implicants of the K-map. Draw a 4×4 K-map that has the largest value of P=M-N among all the 4×4 K-maps.

= more most #PI > EPI

For example, in the following 4×4 K-map, M=3, N=2, P=M-N=1.

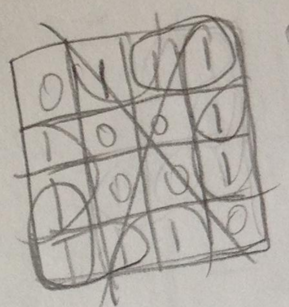
		X_0	X_0		
	0	0	0	0	
	1	1	0	0	X_2
X_3	1	1	1	0	X_2
X_3	0	0	1	0	
			X_1	X_1	



6 PI

2 EPI

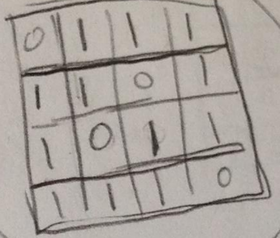
P=6-2=4



PI: ~~||||~~||

EPI: ||

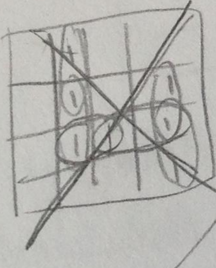
P=6-2=4

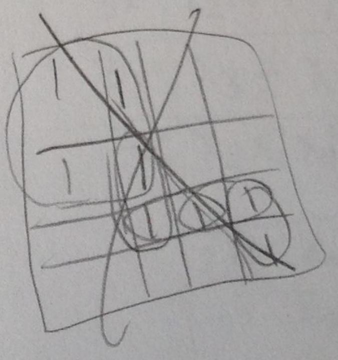


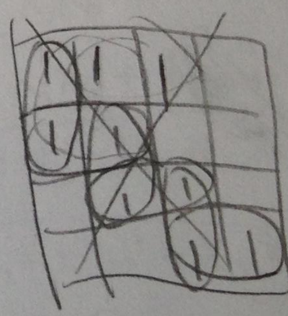
10 PI

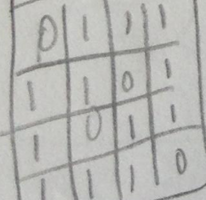
0 EPI

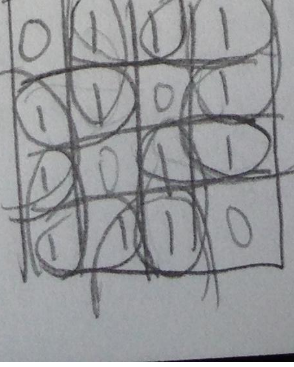
P=10-0=10







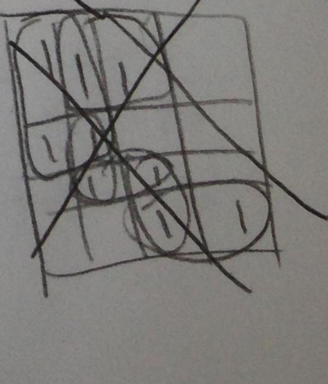




10 PI

0 EPI

P=10-0



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$0 \le x \le 8$ $y \le 2$ ±3 $z \le 2$ ±3

Problem 5 (20 points)

Use only multiplexers to design a system with input $x \in (0,1,2,\ldots 8)$, outputs y and z that implements the following equation

$$(x)_{10} = (yz)_3$$

In the system, x is encoded as $x_3x_2x_1x_0$ in binary. y is encoded as y_1y_0 in binary, and z is encoded as z_1z_0 in binary.
Note that the outputs y and z represent the two digits of a base-3 number.
For example, if x=7 ($x_3x_2x_1x_0$=0111), then the system will solve: $(7)_{10} = (21)_3$. Thus $y = 2$ (y_1y_0=10) and $z = 1$ (z_1z_0=01).

1. TT ✓
2. K-map ✓
3. expression ✓
4. decomp
5. MUX

	$x_3x_2x_1x_0$	y_1y_0	z_1z_0	
0	0 0 0 0	0 0	0 0	$(00)_3$
1	0 0 0 1	0 0	0 1	$(01)_3$
2	0 0 1 0	0 0	1 0	$(02)_3$
3	0 0 1 1	0 1	0 0	$(10)_3$
4	0 1 0 0	0 1	0 1	$(11)_3$
5	0 1 0 1	0 1	1 0	$(12)_3$
6	0 1 1 0	1 0	0 0	$(20)_3$
7	0 1 1 1	1 0	0 1	$(21)_3$
8	1 0 0 0	1 0	1 0	$(22)_3$
9	1 0 0 1	—	—	
10	1 0	—	—	
11	1 0	—	—	
12	1 1	—	—	
13	1 1	—	—	
14	1 1	—	—	
15	1 1	—	—	

DC (rows 9–15)

y_1 (columns x_3x_2, rows x_1x_0)

x_1x_0 \ x_3x_2	00	01	11	10
00	0	0	–	1
01	0	0	–	–
11	0	1	–	–
10	0	1	–	–

y_0

x_1x_0 \ x_3x_2	00	01	11	10
00	0	1	–	0
01	0	1	–	–
11	1	0	–	–
10	0	0	–	–

z_1

x_1x_0 \ x_3x_2	00	01	11	10
00	0	0	–	1
01	0	1	–	–
11	0	0	–	–
10	1	0	–	–

z_0

x_1x_0 \ x_3x_2	00	01	11	10
00	0	1	–	0
01	1	0	–	–
11	0	1	–	–
10	0	0	–	–

$y_1 = x_3 + x_2x_1$

$y_0 = x_2x_1' + x_2'x_1x_0$

$z_1 = x_3 + x_2'x_1x_0' + x_2x_1'x_0$

$z_0 = x_2x_1'x_0' + x_2'x_1'x_0 + x_2x_1x_0$

$y_1 \langle\; y_1x_3 = 1 + x_2x_1 = 1$; $y_1x_3' = x_2x_1$

$y_0 \langle\; y_0x_2 = x_1'$; $y_0x_2' = x_1x_0$

$z_1 \langle\; z_1x_1 = x_3 + x_2'x_0'$ [$z_1x_1x_3 = 1 + x_2'x_0' = 1$; $z_1x_1x_3' = x_2'x_0'$]

$z_1x_1' = x_3 + x_2x_0$ [$z_1x_1'x_3 = 1 + x_2x_0 = 1$; $z_1x_1'x_3' = x_2x_0$]

$z_0 \langle\; z_0x_2 = x_1'x_0' + x_1x_0$; $z_0x_2' = x_1'x_0$

$z_0x_2x_1 = x_0$

$z_0x_2x_1' = x_0'$

c' = as + bs'

as + 0 - AND

Problem 5) Extra Page

answer