DIGITAL DESIGN COEN 312 Lecturer: A. J. Al-Khalili,
Answer All Questions. Time Allowed 1 hr. Midterm exam. Oct. 13th, 2011

Question 1

(Use Boolean Algebra for Question 1)

1.a Prove De Morgan's Theorem (AB)' =A' + B' (4 marks)

1.b Simplify to obtain minimum SOP (2 marks)

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

1.c Simplify (2 marks)

F(A, B, C, D) = A'B'(0 +C')' + A + (1 + D')+D

Question2

I) Give **minimal POS** for F(a,b,c,d) given by the following K-map. (1 Mark)

a) Identify the **Prime Implicants clearly**. (1 mark)

b) Identify the **Essential Prime Implicants**. (1 mark)

c) Give the minimum **AND-OR-NOT** implementation. (2 marks).

cd \ ab	00	01	11	10
00	X	X	X	X
01	1	1	X	
11	1			
10	X	1	1	X

Question 3

3a) Give **minimal NOR-NOR** and **NAND NAND** implementation for F(a,b,c,d) given by the following K-map (2 marks).

cd \ ab	00	01	11	10
00		X	X	
01		1	X	
11	X			
10	X	1	1	X

3b) Using F given in K-map below determine minimum F1. (4 marks)

ab \ cd	00	01	11	10
00	X	X	X	X
01	1	1	X	
11	1	1	1	
10	X	1	1	X

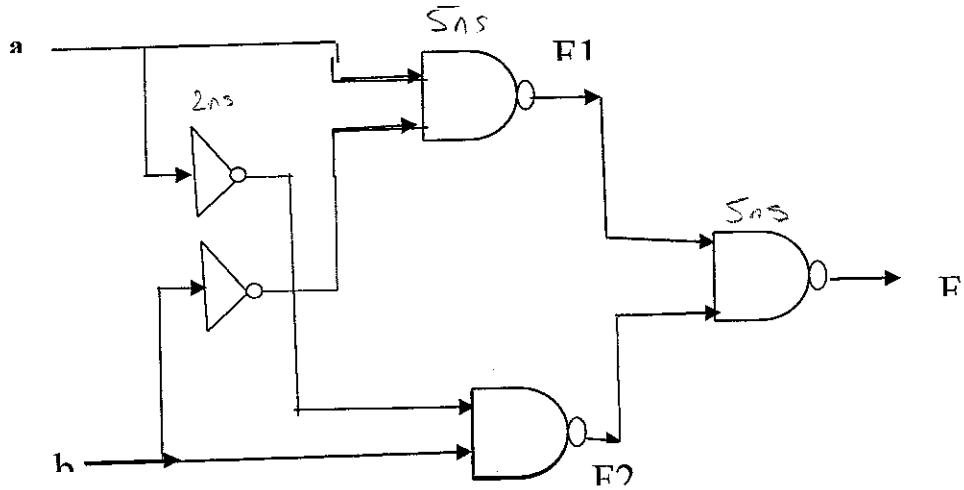
F1

ab \ cd	00	01	11	10
00		X	X	X
01	1	1	X	1
11		1	1	
10	X	1	1	X

F

Question 4

In the circuit below:
Delay of inverter =2ns
Delay of NAND =5ns
For change of input vector a b = 00 to 01 to 10,
draw timing diagram for the circuit. (6 marks)



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Q1

Q1.a Prove $\overline{AB} = \bar{A} + \bar{B}$

Since $X \cdot \bar{X} = 0$ then $(A \cdot B)(\bar{A} + \bar{B}) = A\bar{A}B + AB\bar{B}$

$= 0 \cdot B + A \cdot 0$

$= 0 + 0 = 0$

Q1.b

$F(A,B,C,D) = \bar{A}\bar{B} + A\bar{C}(\bar{C}+\bar{A}) + B\bar{C} + A\bar{B}C + ABC + B\bar{C}D$

$A\bar{C}$; $B\bar{C}$

$= \bar{A}\bar{B} + A\bar{C} + B\bar{C} + A\bar{B}C + ABC$

AC ; A

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

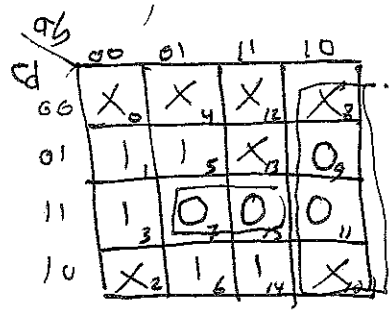
$A+\bar{B}$

Q1.c

$F(A,B,C,D) = \bar{A}\bar{B}\overline{(B+\bar{C})} + A + \underbrace{(1+\bar{D})}_{=1} + D$

$= 1$

POS $F = (\bar{a} + b)(\bar{b} + \bar{c} + \bar{d})$



F

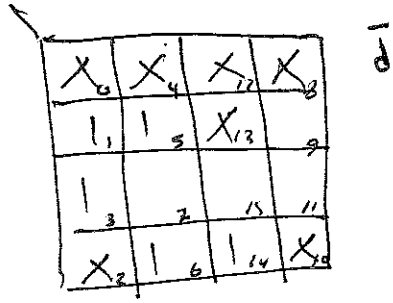
PI

$\bar{d}$ = $PI1 = \sum m(6,14) + d(0,2,4,8,10,12)$

$\bar{a}\bar{b}$ = $PI2 = \sum m(1,3) + d(0,2)$

$\bar{a}\bar{c}$ $PI3 = \sum m(1,5) + d(0,4)$

$b\bar{c}$ $PI4 = \sum m(5) + d(4,12,13)$



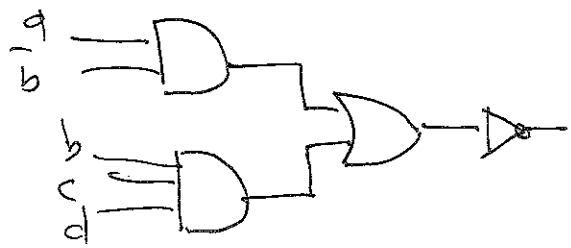
$\bar{d}$

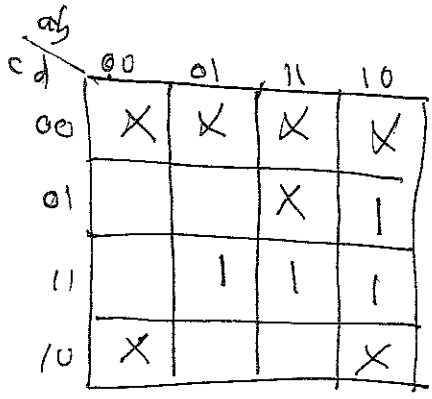
F

EPI = PI1, PI2, PI3 .

Assume double rail

$F = \overline{\bar{a}\bar{b}} + bcd$

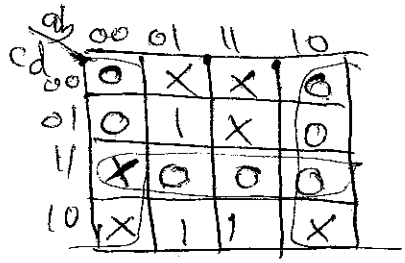




$\bar{F}$

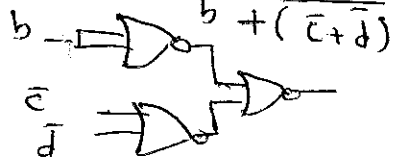
Q3 - a

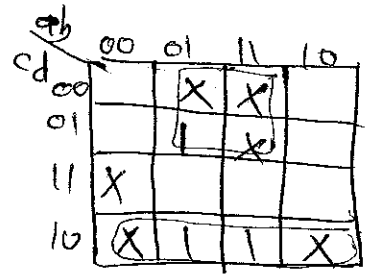
assume double rail



$F = b \cdot (\bar{c} + \bar{d})$

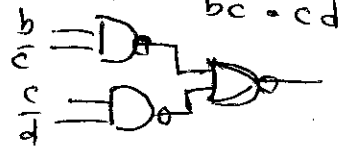
$= \overline{\bar{b} + (\bar{c} + \bar{d})}$



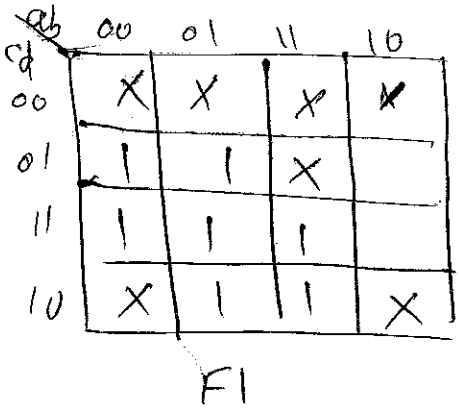


$F = b\bar{c} + c\bar{d}$

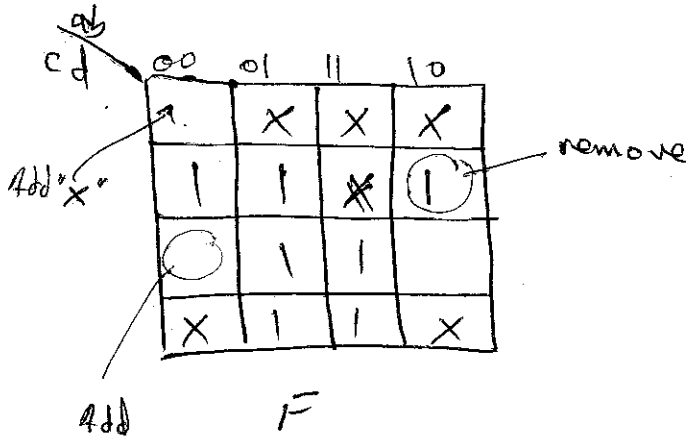
$F = \overline{\overline{b\bar{c}} \cdot \overline{c\bar{d}}}$



Q3 b

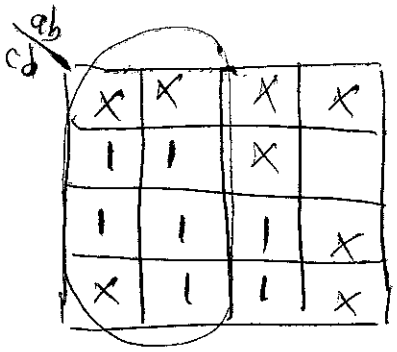


F1

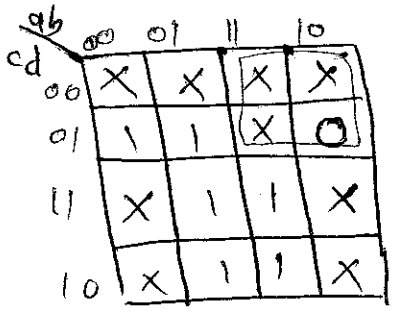


F

$$F1 = F \cdot \{(\underbrace{\bar{d} + c}_{F_2}) + \underbrace{\bar{a}}_{F_3}\}$$



$\bar{a}$



F_3

or $(\bar{a} + b)$

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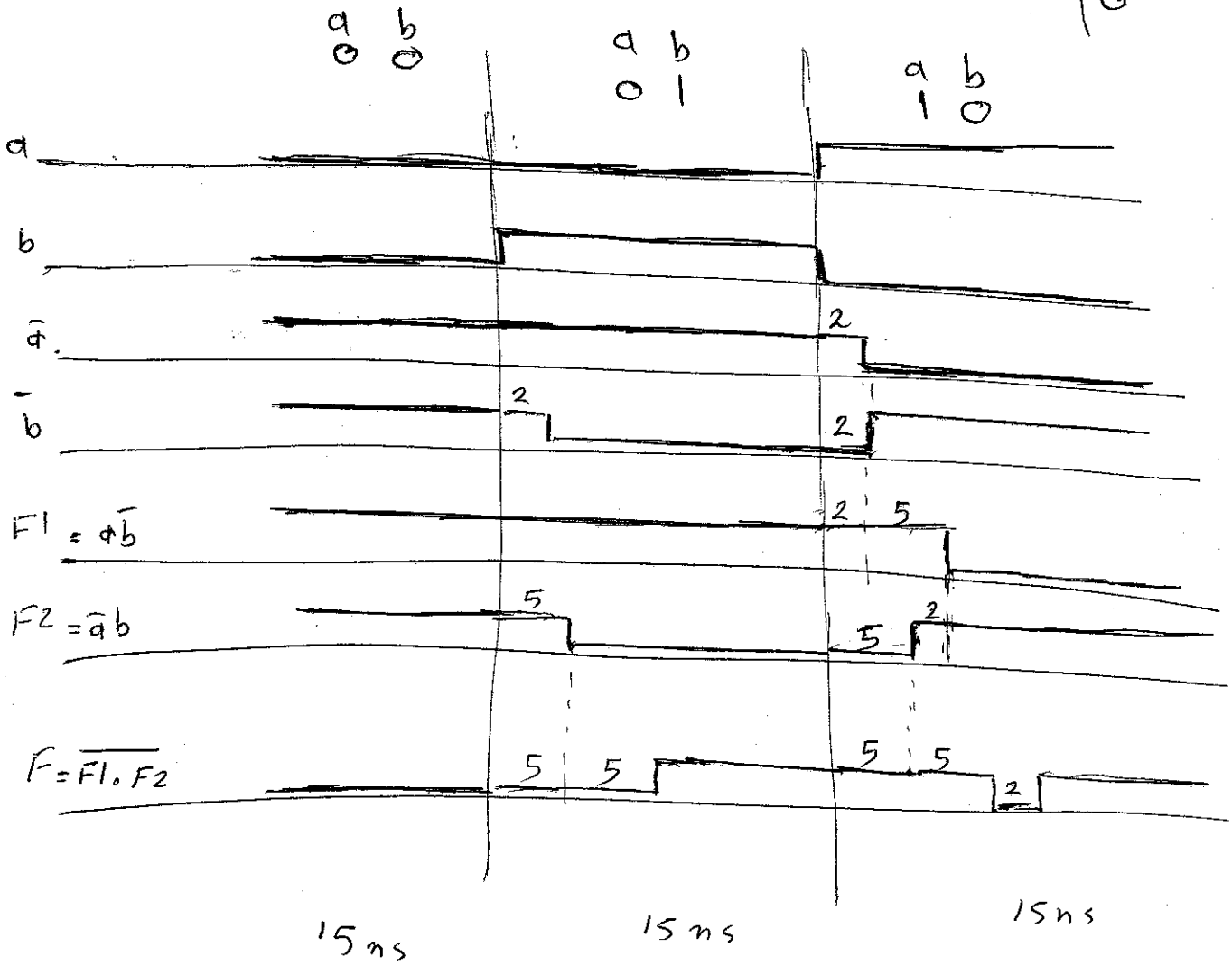
Q4

NAND

a	b	F
0	0	1
0	1	1
1	0	1
1	1	0



Critical Path = 2 + 5 + 5 = 12 ns

Period is taken to be 15 ns