

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)

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

Question 2

1) 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).

		ab			
	cd	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).

		ab			
	cd	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

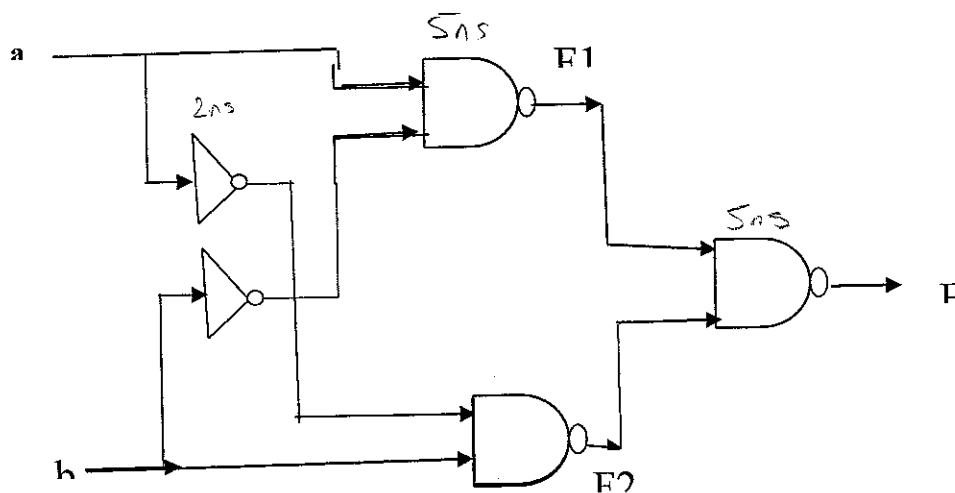
F1

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)



Q1

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

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

Q1.b

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

$$= \overline{A}\overline{B} + A\overline{C} + B\overline{C} + \underbrace{A\overline{B}C + ABC}_{AC}$$

$$= \overline{A}\overline{B} + A + B\overline{C} = \underbrace{\overline{A}\overline{B} + A}_{A + \overline{B}} + B\overline{C} = A + \overline{B} + \overline{B}B\overline{C} = A + \overline{B} + \overline{C}$$

Q1.c

$$F(A, B, C, D) = \overline{A}\overline{B}(\overline{0 + \overline{C}}) + A + \overbrace{(1 + \overline{D})}^{=1} + D$$

$$= 1$$

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

	ab	00	01	11	10
cd	00	X ₀	X ₄	X ₁₂	X ₈
	01	1 ₁	1 ₅	X ₉	0 ₂
	11	1 ₃	0 ₇	0 ₁₀	0 ₁₁
	10	X ₂	1 ₆	1 ₁₄	X ₁₃

F

$\bar{d} = \text{PI1} = \sum m(6, 14) + d(0, 2, 4, 8, 10, 12)$
 $\bar{a}\bar{b} = \text{PI2} = \sum m(1, 3) + d(0, 2)$
 $\bar{a}\bar{c} = \text{PI3} = \sum m(1, 5) + d(0, 4)$
 $b\bar{c} = \text{PI4} = \sum m(5) + d(4, 12, 13)$

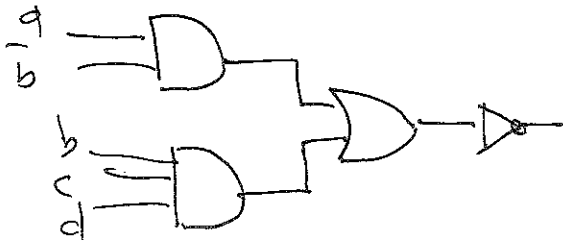
	ab	00	01	11	10
cd	00	X ₀	X ₄	X ₁₂	X ₈
	01	1 ₁	1 ₅	X ₉	
	11	1 ₃	0 ₇	0 ₁₀	
	10	X ₂	1 ₆	1 ₁₄	X ₁₃

F

EPI = PI1, PI2, PI3

Assume double rail

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



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

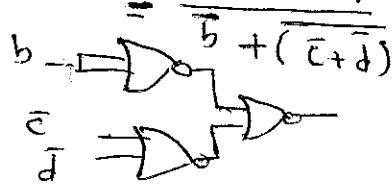
\bar{F}

Q3. a

assume double rail

	ab	00	01	11	10
cd	00	0	X	X	0
	01	0	1	X	0
	11	X	0	0	0
	10	X	1	1	X

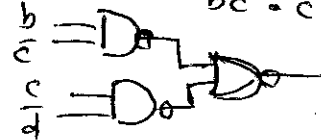
$$F = b \cdot (\bar{c} + \bar{d})$$



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

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

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



Q3 b

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

F1

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

F

$$F1 = F \cdot \left\{ \begin{matrix} (\bar{c} + c) \\ \downarrow F_2 \end{matrix} + \begin{matrix} \bar{a} \\ \downarrow F_3 \end{matrix} \right.$$

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

\bar{a}

	ab	00	01	11	10
cd	00	X	X	X	X
	01	1	1	X	0
	11	X	1	1	X
	10	X	1	1	X

\bar{F}_3

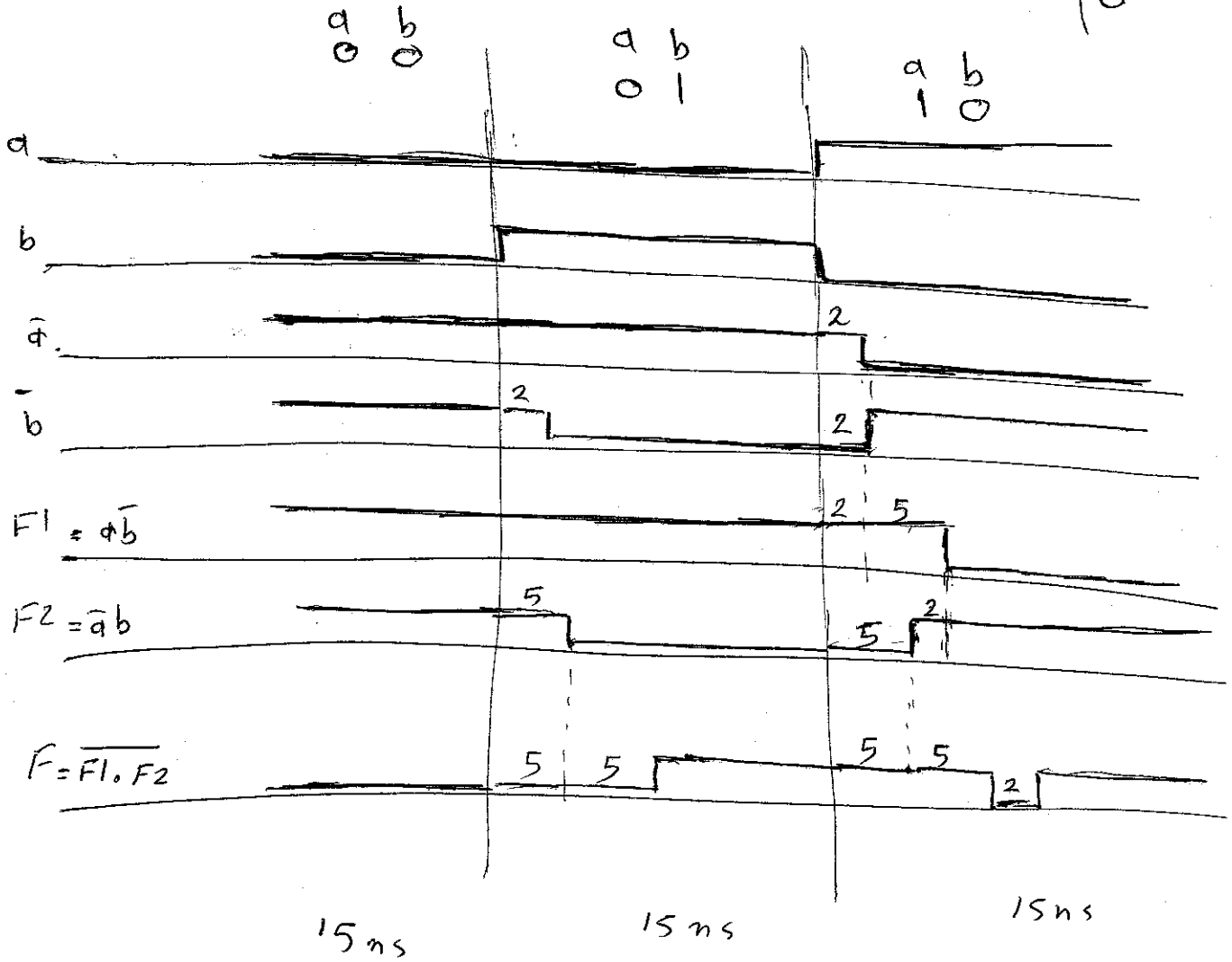
or $(\bar{a} + b)$

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MAJORITY

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

Q4



Critical Path = $2 + 5 + 5 = 12 \text{ ns}$

Period is taken to be 15 ns