

**Question 1.**

1.a Convert  $57_{10}$  to binary (1 Mark)

1. b Perform the following operation in binary A-B  
 A= 011001 B= 010111 (3 Marks)

**Show your steps clearly including the Carries/Borrows**

**Question 2**

(Use Boolean Algebra for Question 2)

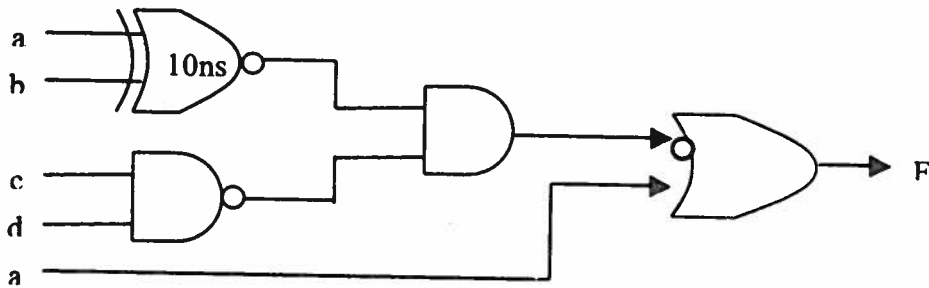
2.a Simplify to obtain minimum SOP (3 Marks)

$$F(W,X,Y,Z) = [Y \oplus (X + Y')] [( W \odot ( W + Y)]$$

2.b Simplify to obtain minimum SOP (2 Marks)

$$F(a,b,c,d) = a'b'(c + d')(1 + 0) + ab(c'd + cd') + (a'b + 0)cd$$

2.c Minimize the following circuit, draw final minimized circuit. Determine speed of operation before and after minimization. All gates have equal delay of 10ns. (4 Marks)



**Question 3**

3.a Give minimal SOP for F(a,b,c,d) given by the following K-map (3 Marks)  
 Identify the Prime Implicants and the Essential Prime Implicant clearly.

$F(a,b,c,d) =$

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

3.b Give the minimal POS of  $F(A,B,C) = (A + C)(B + C)$  (1 Mark)

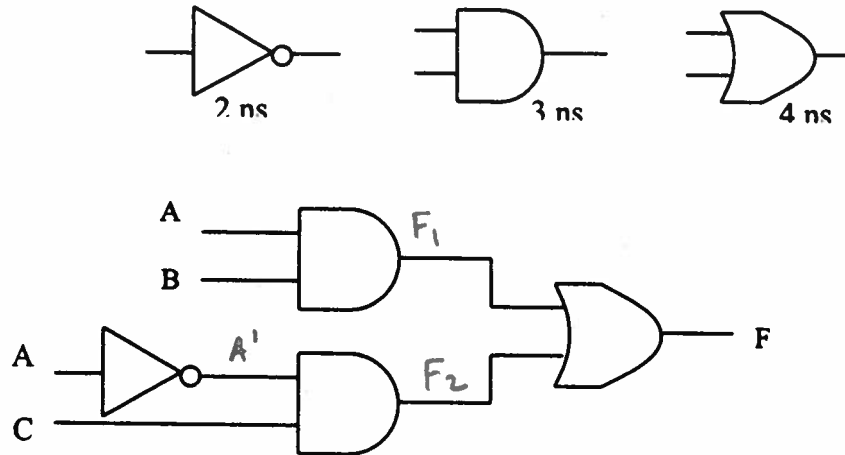
3.c Give the minterm list of  $F(A,B,C,D) = A.B$  (1 Mark)

3.d Give the minimal NOR-NOR implementation of  
 $F(A,B,C,D) = ABC + A(D + CB)$  (2 Marks)

### Question 3

3.1 Draw the timing diagram for  $F(A,B,C) = A B + (A' C)$  for the following consecutive inputs.  $ABC = 000, 010, 101, 010, 111, 000$  (\*\*follow these vectors in order given. Start from  $ABC = 000$ \*\*). Assume the following gate delays, AND = 3ns, OR gate = 4ns, and inverter = 2ns. (5 Marks)

$$F = AB + A' C$$



### Question 4.

1.a Convert  $57_{10}$  to binary

(1 Mark)

1. b Perform the following operation in binary A-B

$$A = 011001 \quad B = 010111$$

(3 Marks)

Show your steps clearly including the Carries/Borrows

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Q1

57 <sub>10</sub>	28	1
28	14	0
14	7	0
7	3	1
3	1	1
1	0	1

$$57_{10} = 111001_2$$

A - B

A	0	1	1	0	0	1	
B	0	1	0	1	1	1	
<hr/>							
	0	0	0	0	1	0	

Borrow ←  
 Borrow ←

---	25 <sub>10</sub>
---	23 <sub>10</sub>
---	2 <sub>10</sub>

OR Using 2's Complement

$$B = 010111$$

$$101000 \text{ is Complement of } B$$

$$101001 \text{ is } 2's \text{ complement}$$

A	0	1	1	0	0	1
	1	0	1	0	0	1
<hr/>						
	0	0	0	0	1	0

← A - B a positive number

~~1101001~~  
~~1101001~~ 1101001  
~~1101001~~ 1101001

Q2

a)  $A \oplus B = \bar{A}B + A\bar{B}$   
 3 marks  $A \odot B = AB + \bar{A}\bar{B}$

,  $\overline{A+B} = \bar{A}\bar{B}$   
 ,  $\overline{AB} = \bar{A} + \bar{B}$

$[Y \oplus (X + \bar{Y})]$

$Y(\overline{X + \bar{Y}}) + \bar{Y}(X + \bar{Y})$

$Y(\bar{X} \cdot Y) + \bar{Y}X + \bar{Y}$

$Y\bar{X} + \bar{Y}$

$(\bar{Y} + \bar{X})$

$[W \odot (W + Y)]$

$W(W + Y) + \bar{W}(\overline{W + Y})$

$W + \bar{W}\bar{Y}$

$(W + \bar{Y})$

$(\bar{Y} + \bar{X}) \cdot (W + \bar{Y}) = W\bar{Y} + \bar{Y} + W\bar{X} + \bar{X}\bar{Y}$   
 $= \bar{Y} + W\bar{X}$

b)  $F = \bar{a}b(c + \bar{d})(1 + 0) + ab(\bar{c}d + c\bar{d}) + (\bar{a}b + 0)cd$   
 2 marks  $= \bar{a}\bar{b}c + \bar{a}\bar{b}\bar{d} + ab\bar{c}d + abc\bar{d} + \bar{a}bcd$  remove b  
 $= \bar{a}\bar{b}c + \bar{a}\bar{b}\bar{d} + ab\bar{c}d + abc\bar{d} + \bar{a}cd$   
 $= \bar{d}(\bar{b}c + \bar{b}\bar{d} + cd) + ab\bar{c}d + abc\bar{d}$   
 remove by consensus theorem  
 $= \bar{a}\bar{b}\bar{d} + \bar{a}cd + ab\bar{c}d + abc\bar{d}$

c) from diagram directly  
 4-Marks

$F = \overline{(a \oplus b) \cdot cd} + a$   
 $= (a \oplus b) + cd + a$   
 $= a\bar{b} + \bar{a}b + a + cd = a + b + cd$



speed before minimization  
 " after "

$3 * 10 \text{ ns} = 30 \text{ ns}$  or  $33.3 \text{ MHz}$   
 $2 * 10 \text{ ns} = 20 \text{ ns}$  or  $50 \text{ MHz}$

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Q3

a)

		ab			
		00	01	11	10
cd	00	1 <sup>0</sup>	X <sup>4</sup>	X <sup>12</sup>	X <sup>8</sup>
	01	1	1 <sup>5</sup>	1 <sup>13</sup>	1 <sup>9</sup>
	11	1 <sup>3</sup>	7	1 <sup>15</sup>	1 <sup>11</sup>
	10	X <sup>2</sup>	X <sup>6</sup>	X <sup>14</sup>	X <sup>10</sup>

$E - PI 1 = \sum m(0, 2, 4, 6, 8, 10, 12, 14) = \bar{D}$   
~~PI 2~~  $PI 2 = \sum m(8, 9, 10, 11) = A\bar{B}$   
 either  $PI 3 = \sum m(8, 9, 12, 13) = A\bar{C}$   
 $E - PI 4 = \sum m(4, 5, 12, 13) = B\bar{C}$   
 $E - PI 5 = \sum m(2, 3, 10, 11) = c\bar{B}$

$F(A, B, C, D) = \bar{D} + \left( \begin{matrix} A\bar{B} \\ A\bar{C} \end{matrix} + B\bar{C} + c\bar{B} \right)$

3 Marks

b)  $F(A, B, C) = (A+C)(B+C) = (A+B)(B+C)$  1 Mark

No minimization

c)  $F(A, B, C, D) = AB$

		ab			
		00	01	11	10
cd	00	0	4	12	8
	01	1	5	13	9
	11	3	7	15	11
	10	2	6	14	10

$F(A, B, C, D) = \sum m(12, 13, 14, 15)$

1 Mark

d)  $F(A, B, C, D) = ABC + A(D + CB) = ABC + AD + ABC$

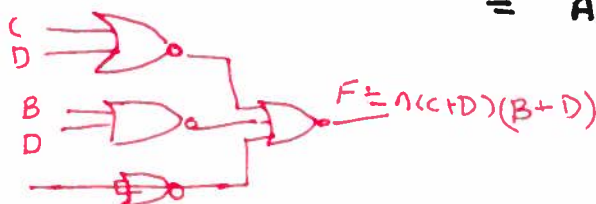
$= ABC + AD$

From Kmap

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

$F(A, B, C, D) = A \cdot (C+D) \cdot (B+D)$

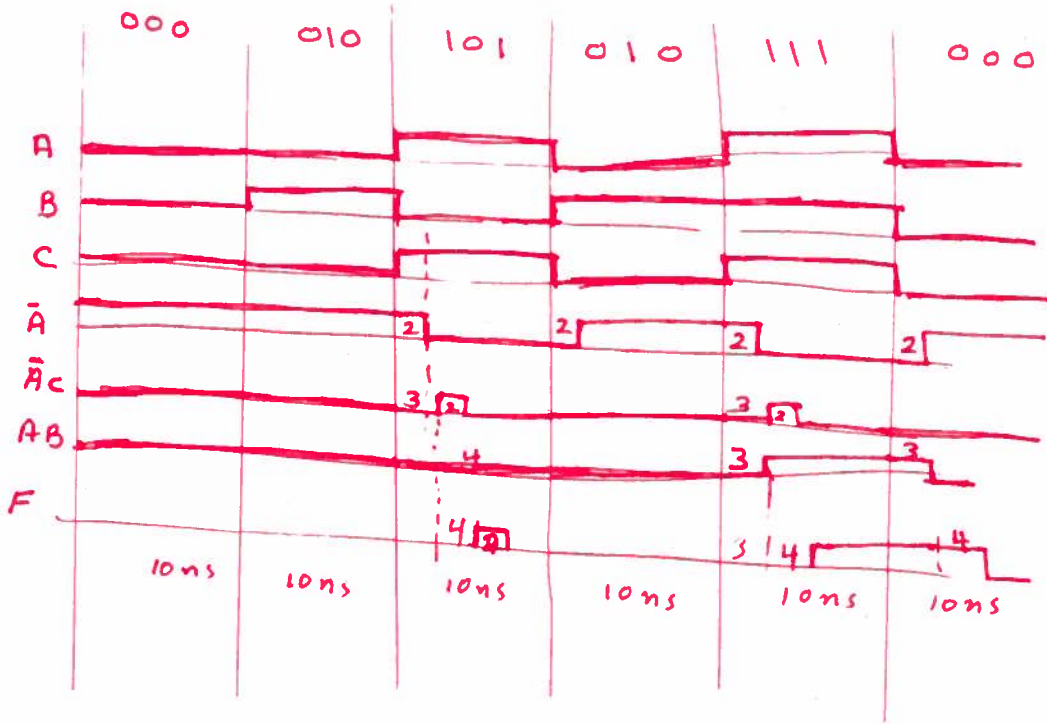
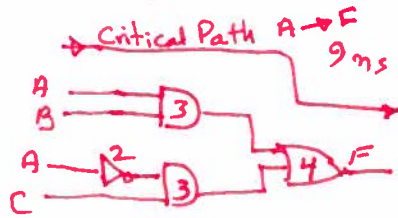
$= \overline{\overline{A(C+D)(B+D)}}$   
 $= \overline{\bar{A} + \overline{(C+D)} + \overline{(B+D)}}$



2 Marks

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Q4.



5 Marks