FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

University of the Punjab

Sheet No.: 83
Invigilator Sign:
Date: 04-18-2024

Digital Logic Design
Mid- Term
BSDS & BSCS

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Session: F23	Student Signature: Zohaib

Instructor: Tariq Butt

Maximum Time: 90 Minutes

Maximum Marks: 50

47

Instructions:

- Read questions carefully before attempting
- Attempt all questions on the answer sheet
- Paper has 10 pages, including a cover sheet
- If there is any ambiguity in the paper, the benefit will be given to the students
- Understanding is part of the examination, therefore no query will be entertained during the exam

Examiner Signature:

DO NOT OPEN UNTIL YOU ARE TOLD TO DO SO

16

Question No.1: [9x2]

Give brief answers to all of the following parts.

1. Convert 240B.4 from hexadecimal to decimal number system.

$(240B.4)_{16} \rightarrow (\underline{A})_{10}$

$(240B.4)_{16} = (2\times16^3) + (4\times16^2) + (0\times16^1) + (11\times16^0) + (4\times16^{-1})$ $\because (B = 11)$

$= (2\times4096) + (4\times256) + (0) + (11) + \left(\frac{4}{16}\right)$

$= 8192 + 1024 + 11 + 0.25$

$= \boxed{(9227.25)_{10}}$

2. Convert 1024.25 from decimal to binary number system.

$(1024.25)_{10} \longrightarrow (A)_2$

2	1024	
2	512	0
2	256	0
2	128	0
2	64	0
2	32	0
2	16	0
2	8	0
2	4	0
2	2	0
	1	0

$0.25\times2 = 0.5$

$0.5\times2 = 1.0$

$0.0\times2 = 0.0$

$(1024.25)_{10}$

$= \boxed{(10000000000.01)_2}$

3. Perform M-N using r-1's complement where M=3250 and N=2740 are in decimal number system.

M = 3250

N = 2740

9's complement of N:

$$\begin{array}{r} 9999 \\ -2740 \\ \hline 7259 \\ +1 \end{array}$$

Now add M and 9's complement of N.

End carry (add it to answer)

$$\begin{array}{r} 3250 \\ +7259 \\ \hline 0509 \\ +1 \\ \hline 510 \end{array}$$

Thus

$\boxed{M-N = 510}$

4. Write down the function in Product of Maxterm form and express it in ∏ notation.
F(x,y,z)= x'y'z'+xyz+x'y'

x	y	z	F	$\bar{F}$
0	0	0	1	0
0	0	1	1	0
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	1	0

$\Rightarrow \bar{F} = \bar{x}y\bar{z} + \bar{x}yz + x\bar{y}\bar{z} + x\bar{y}z + xy\bar{z}$

$(\bar{F})' = F = (x+\bar{y}+z)\cdot(x+\bar{y}+\bar{z})\cdot(\bar{x}+y+z)\cdot(\bar{x}+y+\bar{z})\cdot(\bar{x}+\bar{y}+z)$

In POS Form.

$F = \pi(2,3,4,5,6)$

5. Prove that after minimizing the expression F=A'B'C'+AB'C'+AB'C using theorems of Boolean algebra, you get F=AB'+B'C'

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

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

$= \bar{A}\bar{B}\bar{C} + A\bar{B}$ $(\because C+\bar{C}=1)$

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

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

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

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

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

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

$\because (\bar{A}+A = 1)$

$\because (\bar{C}+C = 1)$

6. Find the complement of the function and then reduce it to minimum using Boolean Algebra.
F = (BC'+A'D)(AB'+CD')

$\bar{F} = \left[(B\bar{C} + \bar{A}D)(A\bar{B} + C\bar{D})\right]'$

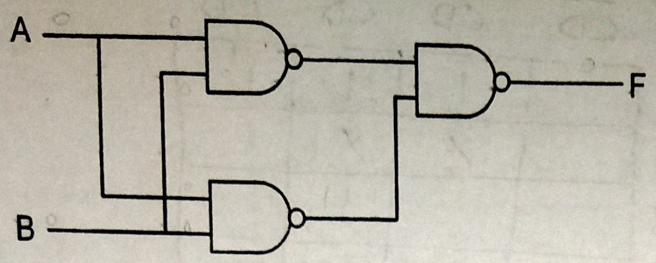
$= (B\bar{C} + \bar{A}D)' + (A\bar{B} + C\bar{D})'$

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

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

$= A\bar{B} + \bar{B}\bar{D} + AC + C\bar{D} + \bar{A}\bar{C} + \bar{A}D + B\bar{C} + BD$

7. Write down the expression of F for the given circuit and give the simplified answer.



$$F = \overline{(\overline{AB}) \cdot (\overline{AB})}$$

$$F = [(\overline{A \cdot B}) \cdot (\overline{A \cdot B})]'$$

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

$$\boxed{F = A \cdot B}$$

8. Write down the function to meet the following requirement:
A battery-powered lamp in a room is to be operated from two switches, one at the back door and one at the front door. The lamp is to be on if the front switch is on and the back switch is off, or if the front switch is off and the back switch is on. The lamp is to be off if both switches are off or if both switches are on. Take x and y as two switches. Hint: You may draw truth table first to write down the function.

x	y	F
0	0	0
0	1	1
1	0	1
1	1	0

Front Switch Back Switch Lamp

$$\boxed{F = x\bar{y} + \bar{x}y}$$

$$\boxed{F = x \oplus y}$$

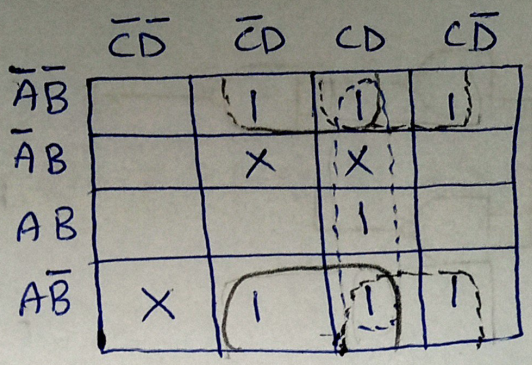
9. Draw the truth table for the following.
F (A, B, C) = (A'+B') (B'+C') (A +C)

$$\bar{F} = (AB) + (\cancel{B}C) + (\bar{A}\bar{C})$$

A	B	C	F
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	0

Question No.2: [5+5]

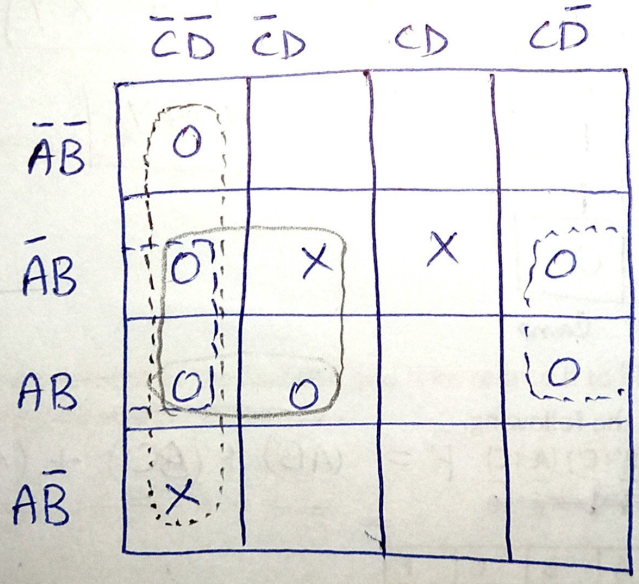
a. Simplify the following function using K-Map in SOP form.
F=B'D+B'C+ABCD
d=A'BD+AB'C'D'



$$F = C\bar{D} + \bar{B}D + \bar{B}C$$

5

b. Simplify the same function given in part (a) using K-Map in POS form.



$$\bar{F} = \bar{C}\bar{D} + B\bar{D} + B\bar{C}$$

$$(\bar{F})' = (\bar{C}\bar{D} + B\bar{D} + B\bar{C})'$$

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

5

Question No.3:

Design a circuit that accepts input in **Excess-3** code and generates output in **84-2-1** code. Assume inputs as A,B, C, and D and outputs as w,x,y, and z. [10]

Truth Table

Excess-3 | 8 4 -2 -1

term	decimal	A	B	C	D	W	X	Y	Z
m_3	0	0	0	1	1	0	0	0	0
m_4	1	0	1	0	0	0	1	1	1
m_5	2	0	1	0	1	0	1	1	0
m_6	3	0	1	1	0	0	1	0	1
m_7	4	0	1	1	1	0	1	0	0
m_8	5	1	0	0	0	1	0	1	1
m_9	6	1	0	0	1	1	0	1	0
m_{10}	7	1	0	1	0	1	0	0	1
m_{11}	8	1	0	1	1	1	0	0	0
m_{12}	9	1	1	0	0	1	1	1	1

Functions

$W = \Sigma(8, 9, 10, 11, 12)$

$X = \Sigma(4, 5, 6, 7, 12)$

$Y = \Sigma(4, 5, 8, 9, 12)$

$Z = \Sigma(4, 6, 8, 10, 12)$

$d = \Sigma(0, 1, 2, 13, 14, 15)$

Simplification using K-maps

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X		X
$\bar{A}B$				
AB	1	X	X	X
$A\bar{B}$	1	1	1	1

$W = A$

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X		X
$\bar{A}B$	1	1	1	1
AB	1	X	X	X
$A\bar{B}$				

$X = B$

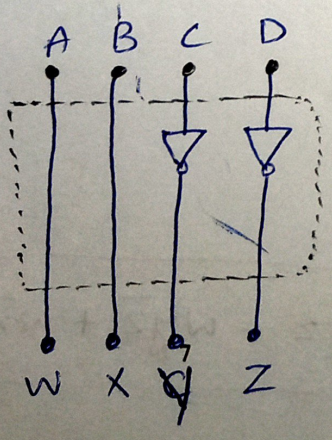
	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X		X
$\bar{A}B$	1	1		
AB	1	X	X	X
$A\bar{B}$	1	1		

$Y = \bar{C}$

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X		X
$\bar{A}B$	1			1
AB	1	X	X	X
$A\bar{B}$	1			1

$Z = \bar{D}$

Circuit



(Excess-3) Inputs

(84-2-1) outputs

10

Question No.4:

We want to design a circuit that takes 4bit number as input and generates output "0" if the input number is a multiple of 3 and "1" otherwise. Assume inputs are represented by w,x,y and z. Perform the following:

i. Draw the truth table [3]

ii. Write down the function in Σ() notation and simplify it. [3]

3, 6, 9, 12, 15

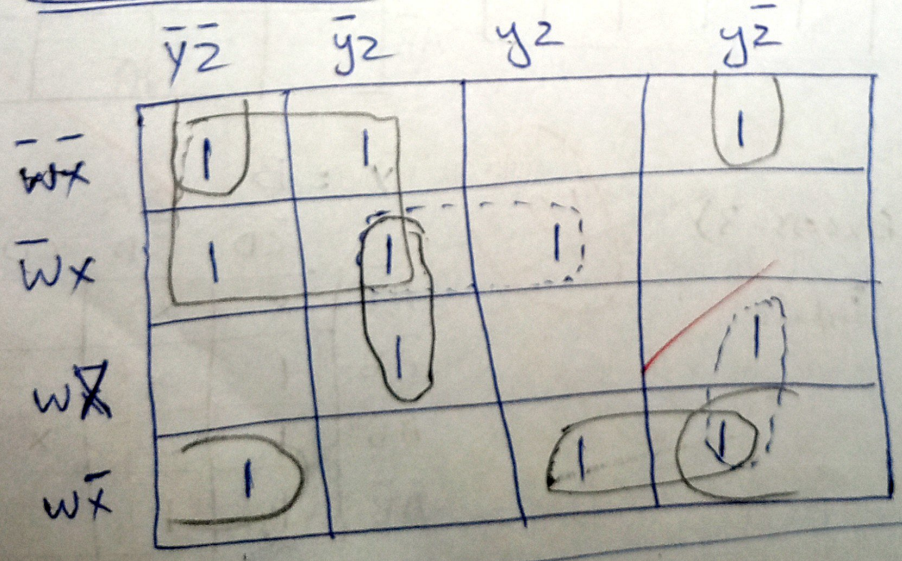
Multibles of 3

	W	x	y	z	F
0	0	0	0	0	1
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	0
4	0	1	0	0	1
5	0	1	0	1	1
6	0	1	1	0	0
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	1
12	1	1	0	0	0
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	0

6

$F = \Sigma(0, 1, 2, 4, 5, 7, 8, 10, 11, 13, 14)$

Simplification



$F = \bar{w}\bar{y} + \bar{x}\bar{z} + x\bar{y}z + \bar{w}xz + wy\bar{z} + w\bar{x}y$

Question No.5: **[4+2]**

An alarm sounds when certain conditions occur in a nuclear reactor. The output F of a logic circuit that drives the alarm must have a value of 1 if:

Either carbon dioxide pressure too low and temperature <=300° C (P-0 & T-1)

or water pressure > 10 bar and temperature > 300° c (W-0 & T-0)

The inputs to the system are:

Input	Binary	Condition
P	0	carbon dioxide pressure too low
	1	carbon dioxide pressure acceptable
T	0	temperature > 300°C
	1	temperature < = 300°C
W	0	water pressure > 10 bar
	1	water pressure < = 10 bar

Draw the truth table for the above system and write down logic expression for the function:

P	T	W	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

$F = \Sigma(0, 2, 3, 4)$

$F = \bar{P}\bar{T}\bar{W} + \bar{P}T\bar{W} + \bar{P}TW + P\bar{T}\bar{W}$