DIGITAL LOGIC DESIGN LAB (EET1211)

LAB III: Design, Construct & examine the Combinational Circuit to Solve a Given Problem

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S. No.	Name Of The Experiment	Date of Submission	Page No.	Signature
01	Introduction to different ICs and examine the operation of Logic Gates	20/9/24	1-10	
02	Examine and Analyze the gate level minimization for Boolean function	4/9/24	11-21	
03	Design, construct and examine combinational circuit to solve a problem.	21/10/24	22-	

I. OBJECTIVE:

1. Design a combinational circuit with four inputs A, B, C and D and one output F. The output F value 1 when A=0 or (B=1 and C=1) or (B=1 and C=1 and D=1).

2. Design a combinational circuit with three inputs x, y and z and three outputs A, B and C. When binary input is 0, 1, 2 or 3 the binary output is two greater than the input. When the binary input 4, 5, 6 and 7, the binary output is two less than the input.

3. Design, construct, and test a circuit that generates an even parity bit from three message bits.

4. Minimize the Boolean function. Implement the Boolean function $F(A,B,C,D) = \Pi M(0,1,4,5,6,7,8,10,12,14)$ using Kmap and implement the function two-level NOR gate circuit.

II. PRE-LAB :

Objective 1.

a) obtain the truth table.

Ans. F = (A=0) or (B=1 and C=1) or (B=1 and C=1 and D=1)

$= \bar{A} + BC + BCD.$

$= \bar{A} + BC.$

A	B	C	D	$\bar{A}$	BC	$\bar{A}+BC$
0	0	0	0	1	0	1
0	0	0	1	1	0	1
0	0	1	0	1	0	1
0	0	1	1	1	0	1
0	1	0	0	1	0	1
0	1	0	1	1	0	1
0	1	1	0	1	1	1
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	0	0	0
1	0	1	1	0	0	0
1	1	0	0	0	0	0
1	1	0	1	0	0	0
1	1	1	0	0	1	1
1	1	1	1	0	1	1

b) Derive the boolean expression that uses the NAND gate to realize.

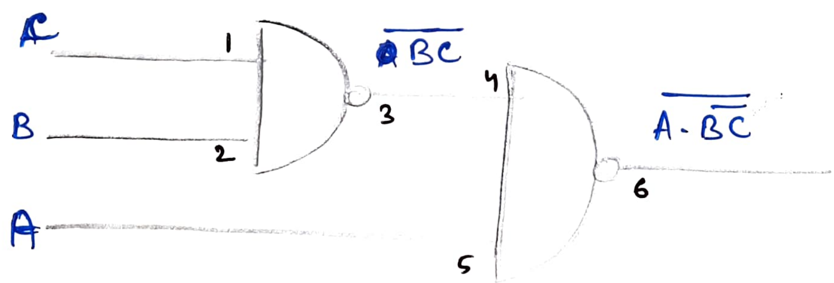
Ans. $\bar{A} + BC$

$= \overline{\overline{\bar{A}}} + \overline{BC}$

$= \overline{\overline{\bar{A}} \cdot \overline{BC}}$

$= \overline{A \cdot \overline{BC}}$

c) Draw the circuit using NAND gate only.



Objective 2:

a) Obtain the truth table.

Ans.

X	Y	Z	A	B	C
0	0	0	0	1	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	1	0	1
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

b) Obtain the boolean expression using minimization technique.

Ans. $A = \bar{x}y\bar{z} + \bar{x}yz + xy\bar{z} + xyz$

$= \bar{x}y(\bar{z}+z) + xy(\bar{z}+z)$

$= \bar{x}y + xy.$

$= y(\bar{x}+x)$

$= y.$

$B = \bar{x}\bar{y}\bar{z} + \bar{x}\bar{y}z + x\bar{y}\bar{z} + x\bar{y}z$

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

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

$= \bar{y}(\bar{x}+x)$

$= \bar{y}$

$C = \bar{x}\bar{y}z + \bar{x}yz + x\bar{y}z + xyz$

$= \bar{x}z(\bar{y}+y) + xz(\bar{y}+y)$

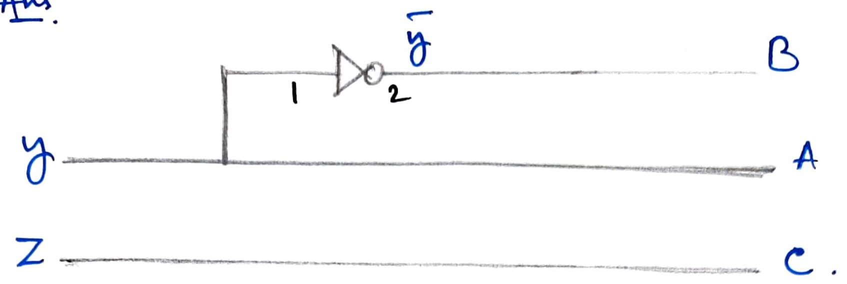
$= \bar{x}z + xz$

$= z(\bar{x}+x)$

$= z.$

c) Draw the circuit using minimum no. of gates.

Ans.



Objective 3:

a) obtain the truth table.

Ans.

x	y	z	F(x, y, z)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

b) Derive the boolean expression using minimization technique.

Ans. $F(x,y,z) = \bar{x}\bar{y}z + \bar{x}y\bar{z} + x\bar{y}\bar{z} + xyz$

$= \bar{x}\bar{y}z + xyz + \bar{x}y\bar{z} + x\bar{y}\bar{z}$

$= z(\bar{x}\bar{y} + xy) + \bar{z}(\bar{x}y + x\bar{y})$

$= z(x \odot y) + \bar{z}(x \oplus y)$

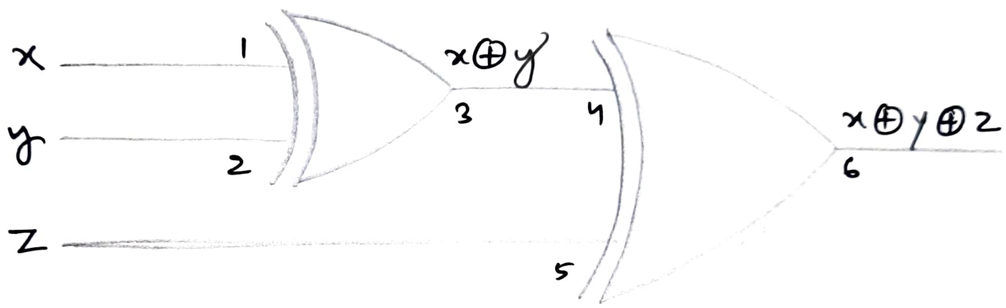
$= z(\overline{x \oplus y}) + \bar{z}(x \oplus y)$

$= (x \oplus y) \oplus z$

$= x \oplus y \oplus z.$

c) Draw the circuit using minimum no. of gates.

Ans.



Objective 4:

a) Solve the Boolean expression using K-map.

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0 (0)	0 (1)	(3)	(2)
$\bar{A}B$	0 (4)	0 (5)	0 (7)	0 (6)
AB	0 (12)	(13)	(15)	0 (14)
$A\bar{B}$	0 (8)	(9)	(11)	0 (10)

$\therefore \; \overline{F} = \bar{A}\bar{C} + \bar{A}B + A\bar{D}$

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

b) Obtain the truth table.

Ans.

A	B	C	D	$\bar{A}$	$\bar{B}$	$A+C$	$A+\bar{B}$	$\bar{A}+D$	F
0	0	0	0	1	1	0	1	1	0
0	0	0	1	1	1	0	1	1	0
0	0	1	0	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1
0	1	0	0	1	0	0	0	1	0
0	1	0	1	1	0	0	0	1	0
0	1	1	0	1	0	1	0	1	0
0	1	1	1	1	0	1	0	1	0
1	0	0	0	0	1	1	1	0	0
1	0	0	1	0	1	1	1	1	1
1	0	1	0	0	1	1	1	0	0
1	0	1	1	0	1	1	1	1	1
1	1	0	0	0	0	1	1	0	0
1	1	0	1	0	0	1	1	1	1
1	1	1	0	0	0	1	1	0	0
1	1	1	1	0	0	1	1	1	1

c) Derive the Boolean expression that uses only NOR gate to realize.

Ans: Given: $F = (A+C)(A+\bar{B})(\bar{A}+D)$.

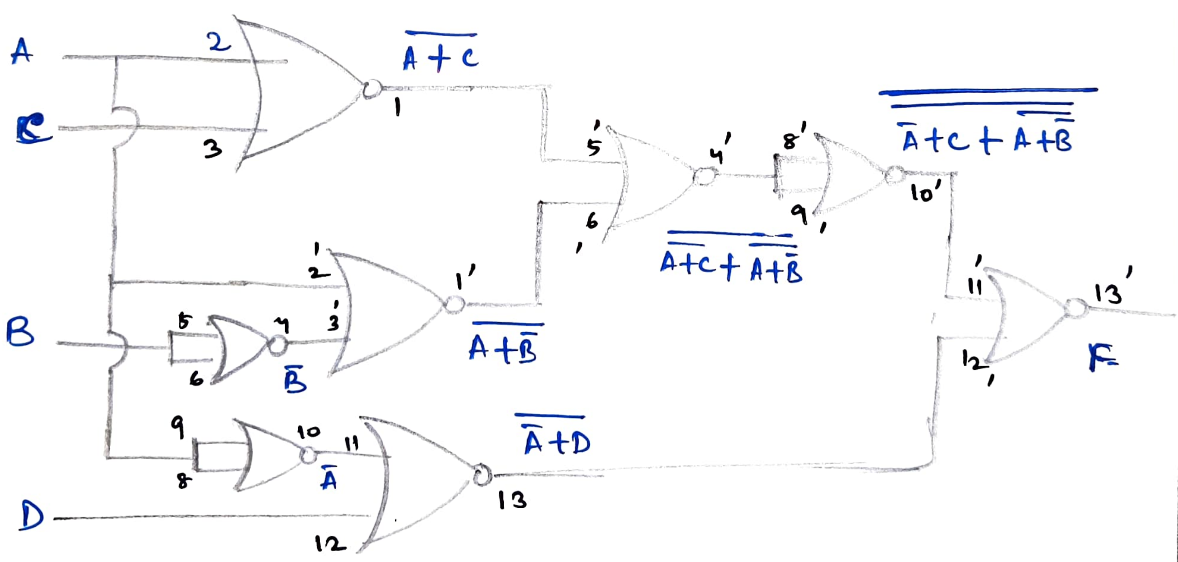
$A+C = \overline{\overline{A+C}}$

$\bar{B} = \overline{B+B}$; $A+\bar{B} = \overline{\overline{A+\bar{B}}}$

$\bar{A} = \overline{A+A}$; $\bar{A}+D = \overline{\overline{\bar{A}+D}}$

Then: $\overline{\overline{\overline{\overline{A+C}+\overline{A+\bar{B}}}}+\overline{\bar{A}+D}}$

d) Draw the logic gate using NOR gates only.



VII. LAB :

Components required :

Sl no.	Name of the Component	Specification	Quantity
1.	Universal Trainer Kit	Microlab	1
2	Connecting wires	23 SWG	As per required
3.	IC 7408	Quad 2-input AND gate	1
4.	IC 7432	Quad 2-input OR gate	1
5.	IC 7404	Hex inverter NOT gate	1
6.	IC 7400	Quad 2-input NAND gate	1
7	IC 7486	Quad 2-input XOR gate	1
8	IC 7402	Quad 2-input NOR gate	2

Observation :

7400 NAND gate :

I/P	O/P	Status
1, 2	3	Working
4, 5	6	
9, 10	8	
12, 13	11	

7486 IC (XOR gate)

I/P	O/P	status
1, 2	3	Working
4, 5	6	
10, 9	8	
13, 12	11	

7402 NOR gate

I/P	O/P	status
2, 3	1	Working
5, 6	4	
8, 9	10	
11, 12	13	

Objective 1 observation:

A	B	C	D	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1

0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	1

Objective 2:

X	Y	Z	A	B	C
0	0	0	0	1	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	1	0	1
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

Here;

$C = Z$

$B = \bar{y}$

$A = y$

Objective 3 :

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

Objective 4 :

A	B	C	D	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0

1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

CONCLUSION:

1) From objective 1, we conclude that for getting the output as per given instruction leads to the function:

$$\bar{A} + BC + BCD \text{ or } \bar{A} + BC.$$

which shows the required output. after converting into NAND gate expression.

2) From objective 2; we conclude the output A matched with y; output B matched with $\bar{y}$ and output C matched with z and its verified from solving the expression.

3) From objective 3: we conclude, the even parity bit from three message bit leads to the function:

~~x ⊕ y ⊕ z~~

$x \oplus y \oplus z$.

4) From objective 4: we conclude NOR gate is the universal gate that can convert any Boolean expression using NOR gate.

IV POST LAB:

1. Design a combinational circuit with three inputs (x, y, z) and two outputs (F_1 and F_2). The output F_1 is 1 when binary value of the inputs is an even no. The output F_2 is 1 when binary value of input is an odd number.

Ans.

x	y	z	F1	f2
0	0	0	1	0
0	0	1	0	1
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	1	0
1	1	1	0	1

$\therefore F_1 = \sum m(0, 2, 4, 6)$

$= \bar{x}\bar{y}\bar{z} + \bar{x}y\bar{z} + x\bar{y}\bar{z} + xy\bar{z}$

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

$= \bar{x}\bar{z} + x\bar{z}$

$= \bar{z}(\bar{x}+x)$

$= \bar{z}$

$F_2 = \sum m(1, 3, 5, 7)$

$= \bar{x}\bar{y}z + \bar{x}yz + x\bar{y}z + xyz$

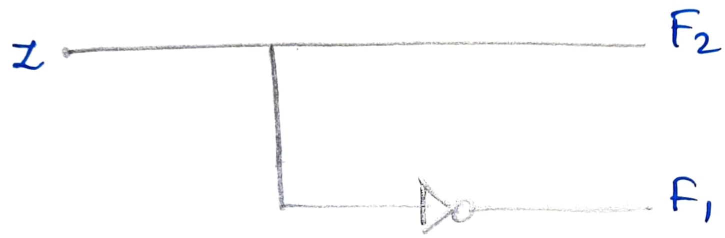
$= \bar{x}z(\bar{y}+y) + xz(\bar{y}+y)$

$= \bar{x}z + xz$

$= z(\bar{x} + x)$

$= z.$

Circuit Diagram:



Q2. Design a 2-bit comparator circuit with two inputs (A and B) and three outputs (A<B), (A=B) and (A>B)

Ans.

A_1	A_0	B_1	B_0	$A<B$	$A=B$	$A>B$
0	0	0	0	0	1	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	1	0	0
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0

0	1	1	1	1	0	0
1	0	0	0	0	0	1
1	0	0	1	1	0	1
1	0	1	0	0	1	0
1	0	1	1	1	0	0
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	0	0	1
1	1	1	1	0	1	0

$\therefore$ $\cancel{A>}$ $A<B : \sum m(1,2,3,6,7,9,11)$

$= \bar{A}_1 \bar{A}_0 \bar{B}_1 B_0 + \bar{A}_1 \bar{A}_0 B_1 \bar{B}_0 + \bar{A}_1 \bar{A}_0 B_1 B_0 +$
$\bar{A}_1 A_0 B_1 \bar{B}_0 + \bar{A}_1 A_0 B_1 B_0 + A_1 \bar{A}_0 \bar{B}_1 \bar{B}_0 +$
$A_1 A_0 \bar{B}_1 B_0.$

$A=B : \sum m(0,5,10,15)$
$= \bar{A}_1 \bar{A}_0 \bar{B}_1 \bar{B}_0 + \bar{A}_1 A_0 \bar{B}_1 B_0 + A_1 \bar{A}_0 B_1 \bar{B}_0 + A_1 A_0 B_1 B_0$

$A>B : \sum m(4,8,9,12,13,14)$
$= \bar{A}_1 A_0 \bar{B}_1 \bar{B}_0 + A_1 \bar{A}_0 \bar{B}_1 \bar{B}_0 + A_1 \bar{A}_0 \bar{B}_1 B_0 + A_1 A_0 \bar{B}_1 \bar{B}_0$
$+ A_1 A_0 \bar{B}_1 B_0 + A_1 A_0 B_1 \bar{B}_0$