CSE206 (Digital Logic Design Sessional)

Experiment No. 02

Name of the Experiment

Truth tables and simplification using Boolean Algebra.

Group no.	**01**
Group Members	**1805061, 1805062, 1805063, 1805064, 1805065**
Section	**B1**
Department	**CSE**
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Problem No. 01

Problem specification:

We have to simplify the equation using Boolean algebra and implement it.

F (A, B, C, D) = A'B'C'D' + ABCD + ABC'D + A'B'CD' + A'BC'D + AB'C'D' + AB'CD' + A'BCD

Required instruments:

No.	Name of the Instrument	Quantity
1	IC - Hex 1-input Inverter gate (74x04)	1 piece
2	IC- Quad 2-input AND gate (74x08)	1 piece
3	IC- Quad 2-input OR gate (74x32)	1 piece
4	Input pin	2 pieces
5	Output pin	1 piece
6	Wires	A lot
7	Trainer Board	

Truth Table:

Here A, B, C, D are the input pins and F(A, B, C, D) is the output pin.

The truth table of the equation of F:

Inputs				Output
A	B	C	D	F (A, B, C, D)
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

Simplification of the Equation:

F (A, B, C, D) = A’B’C’D’ + ABCD + ABC’D + A’B’CD’ + A’BC’D + AB’C’D’ + AB’CD’ + A’BCD

= A’B’D’ (C+ C’) + ABD (C+ C’) + A’BD (C+ C’) + AB’D’ (C+ C’)

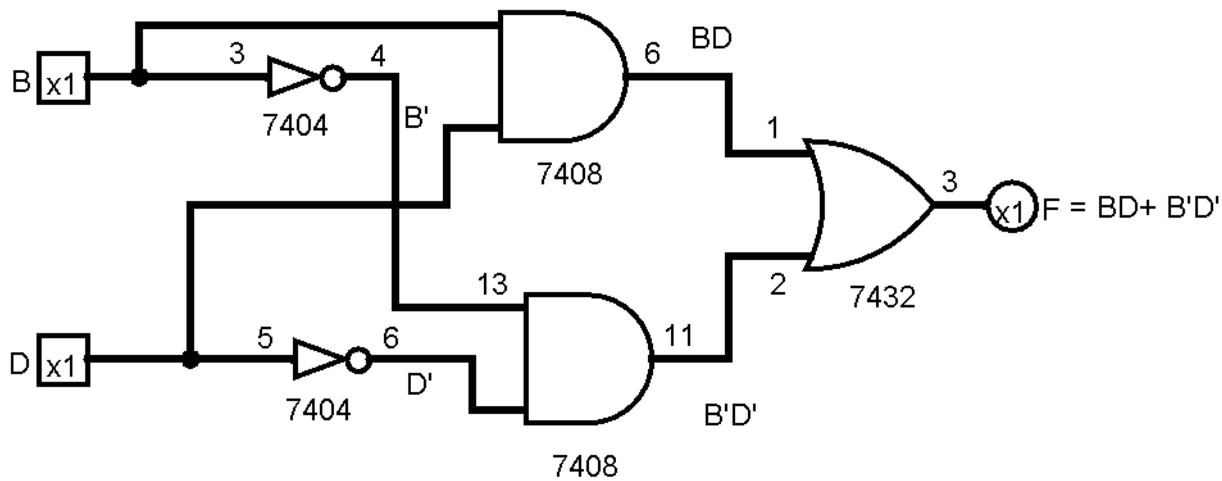
= A’B’D’ + ABD + A’BD + AB’D’ [A+A’ = 1 & A*1= A]

= BD (A+ A’) + B’D’ (A+ A’)

= BD + B’D’ [A+A’ = 1 & A*1= A]

So, the simplified equation is: BD + B’D’

Circuit Diagram:



Observation:

After simplifying the equation, we can see that the function represents x- nor gate. So, we can implement this equation with only one x- nor gate which can save our cost.

Problem no. 2

Problem Specification:

Derivation of the equations for a 3-bit gray to binary converter from Truth table and implementation of those with the required gates.

Required Instruments:

No.	Name of the Instrument	Quantity
1	IC - Hex 1-input Inverter gate (74x04)	1 piece
2	IC- Quad 2-input AND gate (74x08)	2 pieces
3	IC- Quad 2-input OR gate (74x32)	1 piece
4	Input pin	3 pieces
5	Output pin	3 pieces
6	Wires	A lot
7	Trainer Board	

Truth Table:

Let, A, B, C are three input pins and X, Y, Z are three output pins of a 3-bit gray to binary converter. In the input pins a 3-bit gray code will be put in and, in the output pins the corresponding binary code will be yielded.

The Truth table of a 3-bit gray to binary converter:

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

Required Equations:

From the Truth table, the equations of output pins X, Y, Z can be obtained.

Now,

$X = ABC' + ABC + AB'C + AB'C'$

$= A (BC' + BC + B'C + B'C')$

$= A (B (C' + C) + B' (C + C'))$

$= A (B . 1 + B' . 1)$ $\quad [P + P' = 1]$

$= A (B + B')$ $\quad [P . 1 = P]$

$= A . 1$

$= A$

$Y = A'BC + A'BC' + AB'C + AB'C'$

$= A'B (C + C') + AB' (C + C')$

$= A'B .1 + AB' .1$

$= A'B + AB'$

$Z = A'B'C + A'BC' + ABC + AB'C'$

$= A' (B'C + BC') + A (BC + B'C')$

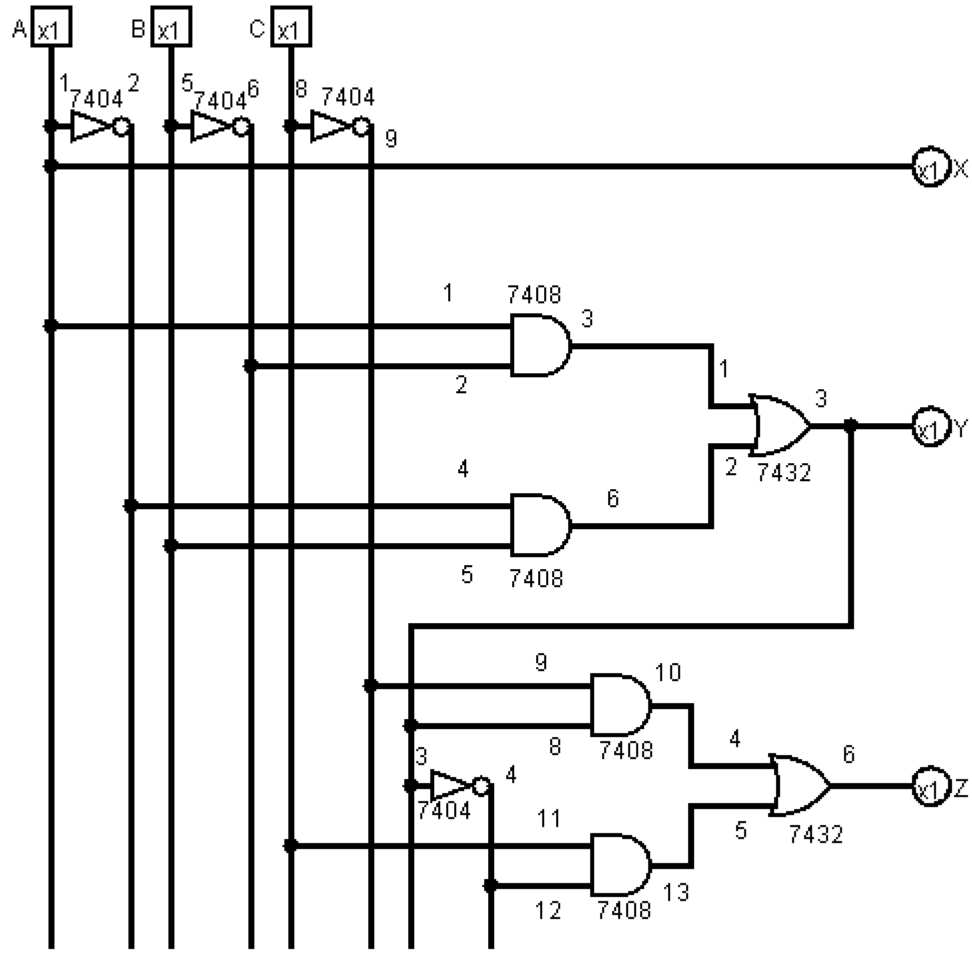
$= A' (B'C + BC') + A (B'C + BC')'$ $\quad [BC + B'C' = (B'C + BC')']$

Circuit Diagram:

$X = A$

$Y = A'B+AB'$

$Z = A'(B'C+BC') +A(B'C+BC')'$



Observation:

From the equations of the output pins these observations can be made:

1. For output pin X, it just corresponds with the input pin A.

   So, $X = A = 0 \oplus A$

2. For output pin Y, $Y = A'B + AB'$.

   Now, we know that, $A'B+AB'$ is the equation for XOR Gate.

   $A'B+AB' = A \oplus B$

   So, $Y = A \oplus B = X \oplus B$

3. For output pin Z, $Z = A' (B'C + BC') + A (BC + B'C')$

   Let, $P = B'C + BC' = B \oplus C$

And, Q = BC + B’C’ = (B $\oplus$ C)’ = P’ [as BC + B’C’ is the equation for XNOR Gate]

So, Z = A’P + AP’

= A $\oplus$ P

= A $\oplus$ B $\oplus$ C

= Y $\oplus$ C

4. So, if we use XOR Gates to implement n-bit gray to binary converter, for i^{th} bit in the output, we can take the XOR of $(i-1)^{th}$ bit in the output for $i>1$ or 0 for $i=1$, and i^{th} bit in the input pattern.

Problem no. 3

Problem specification:

There are 3 inputs into a system. The system will glow LED 1 and LED 0 in such a way that the pattern represents the number of set bits in the input.

We have to derive truth table and corresponding equations for the condition and implement those with required gates.

Required instruments:

No.	Name of the Instrument	Quantity
1	IC - Hex 1-input Inverter gate (74x04)	1 piece
2	IC- Quad 2-input AND gate (74x08)	3 pieces
3	IC- Quad 2-input OR gate (74x32)	2 pieces
4	Input pin	3 pieces
5	Output pin	2 piece
6	Wires	A lot
7	LED	2 pieces
8	Trainer Board	

Truth Table:

A	B	C	L1	L0
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Deriving equations:

L0 = A’ B’ C + A’ C’ B + B’ C’ A + A B C

L1 = B C A’ + A C B’ + A B C’ + A B C

Simplification of the Equation:

L0 = A’ B’ C + A’ C’ B + B’ C’ A + A B C

Can’t be more simpler.

L1 = B C A’+ AC B’ + AB(C’+C) [C’+C=1,

L1=BCA’+ACB’+AB [A*1=A,

L1=BCA’+A(CB’+B)

L1= BCA’+A(B+C)(B+B’) [A+BC=(A+B)(A+C)

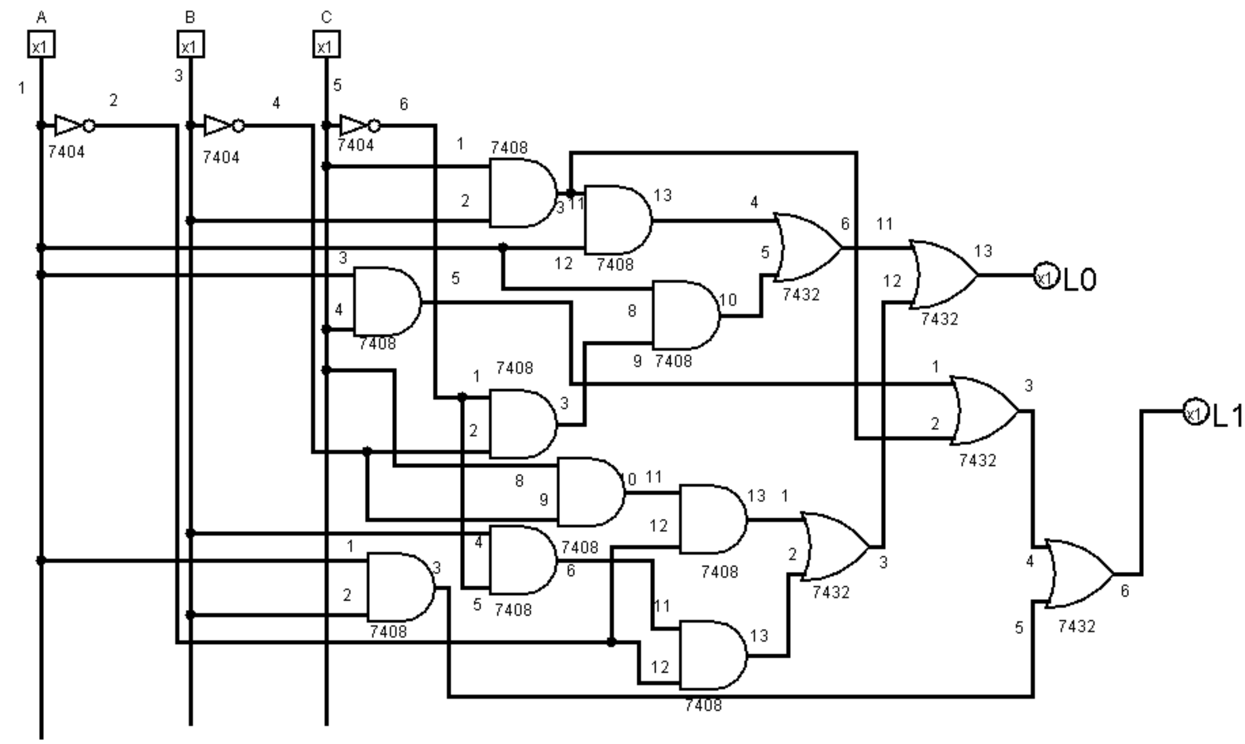
L1=BCA’+AB+AC

L1=B(CA’+A)+AC

L1=B(C+A)(A+A’)+AC

L1=BC+AB+AC

Circuit Diagram:



Observation:

It took 6 IC’s (one 7404, three 7408, two 7432) to implement the circuit. If we can use 744072(Dual 4-input) then it requires only 5 IC’s (one 7404, three 7408, one 744072)

Problem no. 4

Problem Specification:

For the following logic function, find out the truth table, write down the logic expression. Simplify the logic expression as far as possible using Boolean algebra and then implement it.

$$F(A, B, C, D) = \Sigma(6, 9, 12, 15)$$

Required Instruments:

No.	Name of the Instrument	Quantity
1	IC - Hex 1-input Inverter gate (74x04)	1 piece
2	IC- Quad 2-input AND gate (74x08)	3 pieces
3	IC- Quad 2-input OR gate (74x32)	1 piece
4	Input pin	4 pieces
5	Output pin	1 piece
6	Wires	A lot
7	Trainer Board	

Truth Table:

Let, A, B, C , D are four input pins and X is output pin of the given function,

F (A, B, C, D) =Σ (6, 9, 12, 15)

The Truth table of the given function:

A	B	C	D	X
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

Required Equations:

From the Truth table, the equations of output pins X, Y, Z can be obtained.

Now,

X = AB’C’D + ABCD + ABC’D’ + A’BCD’

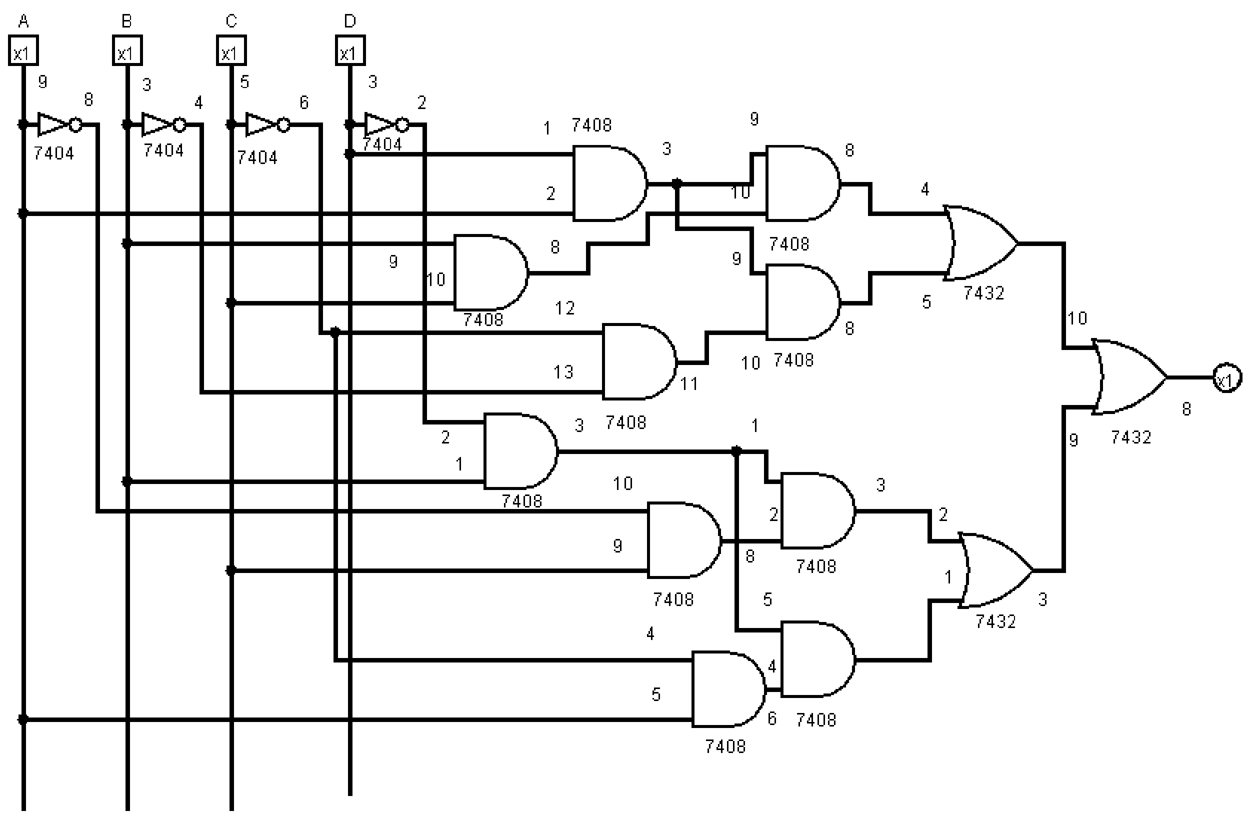
= ABCD + AB’C’D + A’BCD’ + ABC’D’

= AD (BC + B’C’) + BD’(A’C + AC’))

=AD(B X-NOR C) + BD’(A X-OR C)   [P’Q’+PQ = P X-NOR Q

& PQ’+P’Q=P X-OR Q]

Circuit Diagram:



Observation:

From the equations of the output pins these observations can be made:

1. For output pin,

$$X = AD(BC + B'C') + BD'(A'C + AC')$$

$$= AD(B \oplus C)' + BD'(A \oplus C)$$

Now, we know that, A'B+AB' is the equation for XOR Gate. And AB + A'B' is the equation of XNOR Gate.

Therefore, $BC + B'C' = (B \oplus C)'$

And $A'C+AC' = A \oplus C$