United International University

Department of CSE

Course Code: CSE 1326

Course Name: Digital Logic Design Laboratory

Experiment no: 02

Experiment Name: Implementing Functions

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Objective:

The objective of this lab is to implement a simplified function using digital logic gates in both Logisim software and a physical trainer board. This exercise aims to enhance understanding of digital circuit design, function simplification, and practical implementation using integrated circuits (ICs). By creating a simple and minimized circuit design, this lab emphasizes the importance of circuit simplification in reducing hardware requirements and overall complexity in digital electronics applications. Through this process, we will also gain practical experience in circuit simulation, wiring, and troubleshooting using multimeter in both virtual and real environments.

Apparatus/Instruments used in the Lab:

1. ICs Used:

- 7404 (NOT Gate)
- 7408 (AND Gate)
- 7432 (OR Gate)

2. Logisim
3. Trainer board
4. Multimeter
5. Wires

Theory:

Simple logic gates:

i) AND Gate: Logic of this gate is- A.B

Which means if both input is 1 then the output will be 1. Else the output will be 0. Here's its truth table-

A	B	AB
0	0	0
0	1	0

1	0	0
1	1	1

ii) OR Gate: Logic of this gate is- A+B

Which means if any input is true then the output will be true. The output will be false only if all the input is false. Here's its truth table-

A	**B**	**AB**
0	0	0
0	1	1
1	0	1
1	1	1

iii) NOT Gate: Logic of this gate is- A=A'

Basically its changes the values of 0 to 1 and 1 to 0. If one wants to work with the opposite value of an input then this gate is used to do that. Here's the truth table of this gate-

A	**A'**
0	1
1	0

Truth Table: Truth table is a mathematical table used in logic, digital circuit design to represent the output values of a logical expression or function based on all possible combinations of its input values. The values of input must be in place serially from binary 0 .

Truth Table to Function: If the function is unknown then its not easy to implement the circuit. To make this easier we need to find out the function then simplify it to make it easier to implement in the trainer board. The truth table lists all possible input combinations and their corresponding outputs, providing a complete representation of the logic. Using this table, we can identify the conditions under which the output is true (1) or false (0) and express the function. There's 2 ways to do that.

1. Minterm (Sum of Products)-
   It is a specific type of product (AND) term that represents a single, unique combination of input variables that produces a true (1) output. We will SUM those minterms with the values of 1 to find the Logic function of that problem.

A	B	Minterm(SOP)
0	0	$A'.B'$
0	1	$A'.B$
1	0	$A.B'$
1	1	$A.B$

Suppose we have a function with minterms for outputs of 1 at indices 0, 2, and 3 for inputs A, B, and C. Logic Function will be $F(A,B)=A'\cdot B'+A\cdot B'+A\cdot B$

2. Maxterm (Product of Sums)-

It is a specific type of sum (OR) term that represents a single, unique combination of input variables that produces a false (0) output. We will Product those maxterms with the values of 0 to find the Logic function or expression of that problem.

A	B	Maxterm(POS)
0	0	$A+B$
0	1	$A+B'$
1	0	$A'+B$
1	1	$A'+B'$

Suppose we have a function with maxterms (output is 0) at indices 1, 2, and 3 for inputs A, B, and C. Logic Function will be $F(A,B)=(A+B')(A'+B)(A'+B')$

Function minimization: It is a process of simplifying a function or logical expression to its most efficient form. The goal is to reduce the number of logic gates, inputs, and connections required to implement the function.To implement a logic easily in the trainer board it must be minimized so that it can be done with ease. There are many laws and theorems to do that. Some important theorems are-

 Commutative Laws:

- $A + B = B + A$
- $A\cdot B = B\cdot A$

 Associative Laws:

- $(A+B)+C = A+(B+C)$
- $(A\cdot B)\cdot C = A\cdot(B\cdot C)$

 Distributive Laws:

- A(B+C) = AB + AC
- A + BC = (A+B)(A+C)

 Identity Laws:

- A + 0 = A
- A·1 = A

 Complement Laws:

- A + A' = 1
- A·A' = 0

 De Morgan's Laws:

- (A+B)' = A'B'
- (A·B)' = A' + B'

Solution of the mentioned problems:

(1)

F (A, B, C) = AC + B’C

Truth Table:

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

Diagram:

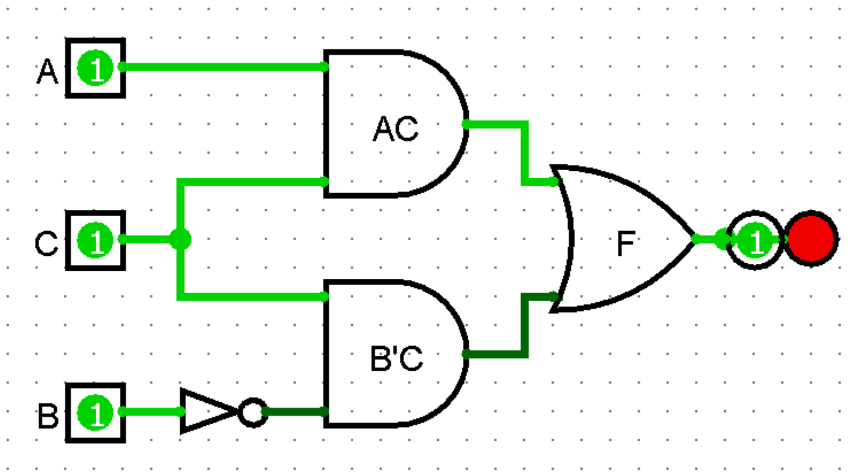

Figure 1: Logic gate diagram of F (A, B, C) = AC + B'C

(2)

F (A, B, C, D) = ABC′D + A′BCD′ + ABC + AB′C′D′ + ABD′ + AB′C

$= ABC'D+ABC+A'BCD'+AB'C'D'+ABD'+AB'C$
$=(ABC'D + ABC) + (A'BCD' + AB'C'D') + (ABD' + AB'C)$
$=AB(C'D + C) + A'D'(BC + B'C') + A(BD' + B'C)$
$=AB(C + C')(C + D) + A'D'(1) + ABD' + AB'C$
$=AB(C + D) + A'D' + ABD' + AB'C$
$=ABC + ABD + A'D' + ABD' + AB'C$
$=AC(B + B') + AB(D + D') + A'D'$
$=AC + AB + A'D'$

Truth Table:

A	B	C	D	AB	AC	A′D′	AB+AC+ A′D′
0	0	0	0	0	0	1	1
0	0	0	1	0	0	0	0
0	0	1	0	0	0	1	1
0	0	1	1	0	0	0	0
0	1	0	0	0	0	1	1
0	1	0	1	0	0	0	0
0	1	1	0	0	0	1	1

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

Number of literals:

In original:

A=5x A′=1x

B=4x B′=2x

C=3x C′=2x

D=1x D′=3x

Total = (5+1+4+2+3+2+1+3) = 21

In minimized function:

A=2x A′=1x

B=1x

C=1x

D=0x D′=1x

Total = (2+1+1+1+1) = 6

Diagram:

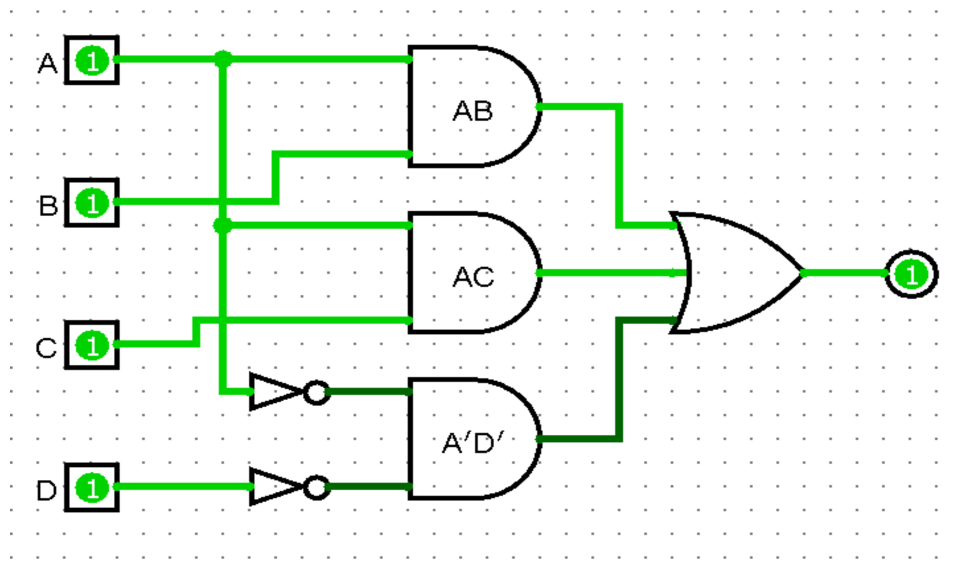

Figure 2:Logic Gate of Minimized function

Discussion:

This lab class was all about simplifying a complicated logic and then apply in the trainer board. This makes the process much easier to understand and apply. Getting expression from unknown problem using POS and SOP was also a very important topic. Learned to proceed step by step while implementing IC's in bread board/ trainer board with the help of a Multimeter. Else one simple pin's or a single wires failure will eat away one's mental peace.