# Experiment No. (2)

# DESIGN AND IMPLEMENTATION OF COMBINATIONAL LOGIC CIRCUIT

**Object:** To study how to design the logic circuit by representing the Boolean expression in POS-form and SOP-form and how to implement the Boolean expression by using the logic gates.

**Theory:** In combinational logic circuit, the output of the circuit depends only on the inputs to the circuit. Combinational logic problems are normally given in the form of logical statements or a truth-table. To design and implement the problem, Boolean logical expression (equations) are derived for the output logic function in terms of the binary variables representing the inputs. The logic expressions are given either in the forms of a sum of products (SOP) or in the form product of sums (pos). For table (2.1) shown below:

**Table (2.1)**

| Seq. | Inputs | | | Output |
|---|---|---|---|---|
| | *X* | *Y* | *Z* | *F* |
| 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 |
| 2 | 0 | 1 | 0 | 1 |
| 3 | 0 | 1 | 1 | 1 |
| 4 | 1 | 0 | 0 | 0 |
| 5 | 1 | 0 | 1 | 0 |
| 6 | 1 | 1 | 0 | 1 |
| 7 | 1 | 1 | 1 | 1 |

We can derive the logical expression for the function (*F*) as:

$$F = \overline{X}\,\overline{Y}\,\overline{Z} + \overline{X}Y\overline{Z} + \overline{X}YZ + XY\overline{Z} + XYZ$$

This expression is called the canonical sum of products. A product term which contains each of the n-variables as factors in either complemented or not complemented forms is called a minterm. So (*F*) can be written in another form such as:

$$F(X,Y,Z) = \sum(0,2,3,6,7)$$

Because *F*=1 in sequences 0, 2, 3, 6, and 7.

A logical equation can also be expressed as a product of sums. This is done by considering the combinations for which *F*=0. According to the truth-table, *F*=0 in sequences 1, 4, and 5 hence:

$$\overline{F} = \overline{X}\,\overline{Y}Z + X\overline{Y}\,\overline{Z} + X\overline{Y}Z$$

$$F = \overline{\overline{F}} = \overline{\overline{X}\,\overline{Y}Z + X\overline{Y}\,\overline{Z} + X\overline{Y}Z}$$

$$F = (X + Y + \overline{Z})(\overline{X} + Y + Z)(\overline{X} + Y + \overline{Z})$$

The product of sums can be expressed as:

$$F(X,Y,Z) = \Pi(1,4,5)$$

A sum which contains each of n-variables complemented or not is called a maxterm.

## Procedure:

*A chemical process is activated only if at least two out of three keys are inserted. Assuming that an inserted key produces logic (1), design a minimal logic circuit to activate the chemical process.*

1. **From above statements, the number of inputs are three (*A*, *B*, and *C*) and the number output is one (*F*). From the problem description we can build the following truth-table (Table (2.2)). Obtain (*F*) shown in table (2.2) in the form:**

a. SOP.

b. POS.

**Table (2.2)**

| Seq. | Inputs | | | Output |
|---|---|---|---|---|
| | *A* | *B* | *C* | *F* |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 2 | 0 | 1 | 0 | 0 |
| 3 | 0 | 1 | 1 | 1 |
| 4 | 1 | 0 | 0 | 0 |
| 5 | 1 | 0 | 1 | 1 |
| 6 | 1 | 1 | 0 | 1 |
| 7 | 1 | 1 | 1 | 1 |

**2. Simplify (*F*) by using:**

a. Boolean algebra.

b. Karnuagh map.

**3. Implement the (*F*) Boolean expression by using logic gates.**

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**Part :** ....................................................... **Group:** .......................................................

# Discussion:

**1. If** $AB = AC$**, then it is necessarily true that** $B = C$**? Show by a truth-table?**

**2. Determine whether or not the following equations are correct?**

**a.** $ABC + \overline{A}BC = A$

**b.** $A\overline{B}C + AB\overline{C} = A(B \oplus C)$

**Name: ........................................................** **Stage : ........................................................**

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**3. Write a Boolean expression for the following conditions: (*F*) is a (0) if any two of the three variables A, B, and C are 1's, (*F*) is a (1) for all other conditions, then simplify the expression using Karnaugh map?**

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# Discussion:

**1. Write a Boolean expression for the following statement: (*F*) is a (1) if A, B, and C are all 1's or if only one of the variables is a (0), then simplify the expression using Karnaugh map?**

**2. Find the Karnaugh map of the following functions, then simplify them?**

**a.** $F = A(\overline{B} + C) + \overline{A}C$

**b.** $Z = AB + C + \overline{A}(B + \overline{C}) + \overline{A}B\overline{C}$

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## 3. Find (*F*) for the circuit below?