

**SIMPLIFICATION OF BOOLEAN FUNCTIONS USING K-MAP
TECHNIQUES**

OBJECTIVE:

- **To develop the truth table for a combinational logic problem**
- To use Karnaugh map to simplify Boolean expressions.
- To draw and simplify sum of products expressions.
- To draw logic diagrams using NAND gates.

APPARATUS:

- PB-503
- 7400 Quadruple 2 input NAND gates.
- 7404 Hex inverters
- 7410 Triple 3-input NAND gates
- 7420 Dual 4-input NAND gates

THEORY:

See chapter 3 of the text, "simplification of Boolean functions"

Procedure:

Part 1: BCD invalid code detector

BCD is a 4-bit binary code representing the decimal numbers 0 through 9.

The binary numbers 1010 through 1111 are not used in BCD.

- a) Construct a truth table containing all possible inputs and desired output. Assume that the desired output for a valid code is a 1, and for an invalid code is 0. Complete the truth table as shown in Table 1. A is the most significant bit, and D is the least significant bit.
- b) Draw the Karnaugh map, and write the simplified Boolean expression for the valid codes as sum of products.

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

- c) Draw the circuit for the above simplified Boolean expression.
- d) Using the universal property of the NAND gate connect an equivalent circuit for these codes that uses only NAND gates.

Part 2: Boolean Functions (1)

1. Simplify the following two Boolean functions by means of Karnaugh maps.

$$F_1(A, B, C, D) = \sum m(0, 1, 4, 5, 8, 9, 10, 12, 13)$$

$$F_2(A, B, C, D) = \sum m(3, 5, 7, 8, 10, 11, 13, 15)$$

2. Draw the logic diagrams for outputs F_1 and F_2 in terms of the inputs A, B, C, and D.
3. Implement and draw the two functions F_1 and F_2 together by using minimum number of NAND gates.
4. Connect the circuit and verify its operation by preparing a truth table for F_1 and F_2 similar to Table 1.

Part 3: Boolean Functions (2)

1. Derive a truth table for the following Boolean Functions.

$$F=A'D+B'D+BC+AB'D$$

2. Draw a Karnaugh map.
3. Combine all the 1's to obtain the simplified function for F .
4. Combine all the 0's to obtain the simplified function for F' .
5. Using logicWorks, implement both F and F' using NAND gates and connect two circuits to the same input switches but to separate output LED's. Prove that both circuits are complement of each other. In the lab implement and verify the operations of the circuit.
6. Draw both circuits.

Part 4: A Majority

A nine member legislative committee requires a 2/3 vote to spend a billion dollars. The vote is tabulated and converted to BCD code. If 2/3 of the committee is in favor, the vote will be the BCD representation of 6, 7, 8, or 9.

1. Derive a truth table for the problem, Table 2.
2. Derive a minimum sum of products expression from the map. {Enter the invalid BCD codes on the map as don't cares (x)}.
3. Using LogicWorks, design a circuit that lights an LED if a majority has voted in favor of spending the billion dollars. Implement this circuit and verify its operation in the lab using hardware.