

**Laboratory 3****Gate Level Minimization using Karnaugh Maps****1. Introduction and Purpose of Experiment**

Students will learn to minimize Boolean Expressions using K-Maps and then simulate and implement them.

**2. Aim and Objectives**

**Aim:** To apply K-Maps to minimize Boolean expressions

**Objectives:** At the end of this lab, the student will be able to

- Apply K-Maps to simplify three- and four-variable Boolean Expressions
- Implement minimized expressions using basic and universal gates

**3. Experimental Procedure****a. Minimize the following expressions using K-Maps.**

1.  $F(A, B, C) = \sum(1, 3, 5, 7)$
2.  $F(A, B, C, D) = \sum(0, 2, 3, 7, 11, 13, 14, 15)$
3.  $F(A, B, C) = \sum(2, 3, 4, 5) + \phi(6, 7)$
4.  $F = \sim A \sim B \sim C \sim D + A \sim C \sim D + \sim B C \sim D + \sim A B C D + B \sim C D$
5.  $F(A, B, C, D) = \prod(1, 3, 5, 7, 13, 15)$
6.  $F(A, B, C, D) = \prod(1, 3, 6, 9, 11, 12, 14)$
7.  $F = (\sim A + B + \sim D) + (\sim A + \sim B + \sim C) + (\sim A + \sim B + C) + (\sim B + C + \sim D)$

**b. Draw truth tables and circuit diagrams for the minimized expressions in 3(a) considering:**

- 3(a) 1 and 3(a) 2: Use basic gates
- 3(a) 3 and 3(a) 4: Use NAND gates
- 3(a) 5: Use basic gates
- 3(a) 6 and 3(a) 7: Use NOR gates

**c. Use Logisim to generate truth tables and circuit diagrams for the expressions in 3(a).****d. Implement the minimized expressions of 3(a)3 to 3(a)6. Show the output to the course leader.****e. With an example, show why incorrect grouping in K-Maps may result in a non-minimized expression**

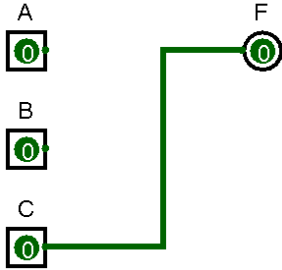
Your document should include:

- Handwritten truth tables and circuit diagrams for the expressions
- Logisim screenshots
- Answer to 3(e)

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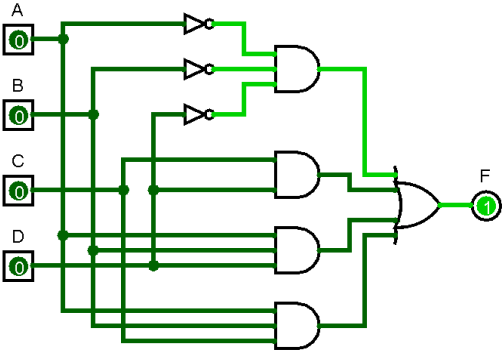
3.a.1.  $F(A, B, C) = \sum(1, 3, 5, 7)$



		B, C			
		00	01	11	10
A	0	0	1	1	0
	1	0	1	1	0
		C			

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

3.a.2.  $F(A, B, C, D) = \sum(0, 2, 3, 7, 11, 13, 14, 15)$

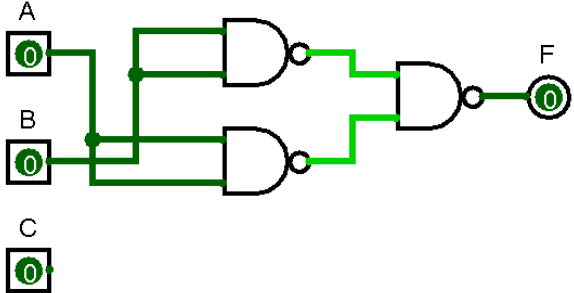


		C, D			
		00	01	11	10
A, B	00	1	0	1	1
	01	0	0	1	0
	11	0	1	1	1
	10	0	0	1	0

$\overline{A}\overline{B}\overline{D} + CD + ABD + ABC$

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

3.a.3.  $F(A, B, C) = \sum(2, 3, 4, 5) + \phi(6, 7)$

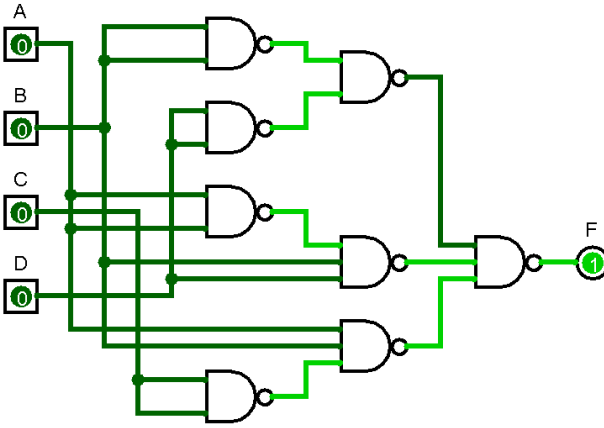


		B, C			
		00	01	11	10
A	0	0	0	1	1
	1	1	1	x	x

$B + A$

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

3.a.4.  $F = \sim A \sim B \sim C \sim D + A \sim C \sim D + \sim B C \sim D + \sim A B C D + B \sim C D$

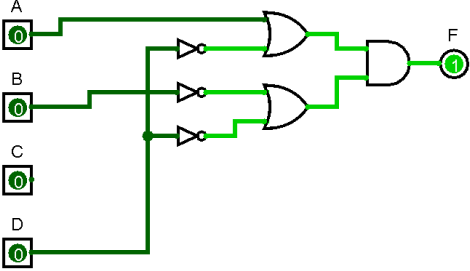


A	B	C	D	F
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

		C, D			
		00	01	11	10
A, B	00	1	0	0	1
	01	0	1	1	0
	11	1	1	0	0
	10	1	0	0	1

$\bar{B}\bar{D} + \bar{A}BD + AB\bar{C}$

3.a.5.  $F(A, B, C) = \prod(1, 3, 5, 7, 13, 15)$

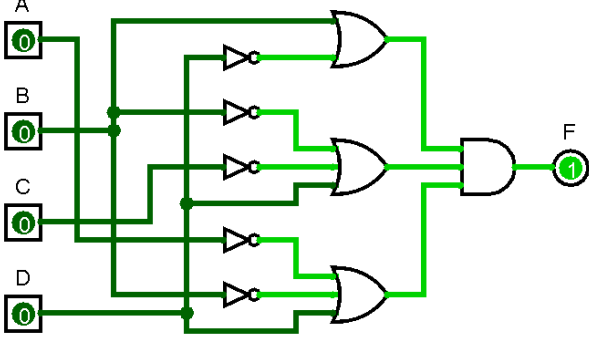


		C, D			
		00	01	11	10
A, B	00	1	0	0	1
	01	1	0	0	1
	11	1	0	0	1
	10	1	1	1	1

$(A + \bar{D})(\bar{B} + \bar{D})$

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

3.a.6.  $F(A, B, C, D) = \prod(1, 3, 6, 9, 11, 12, 14)$

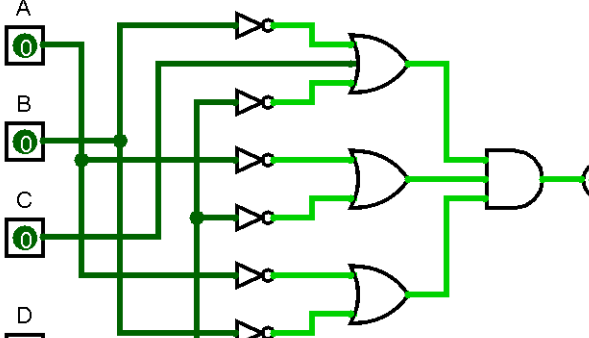


A	B	C	D	F
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

		00	01	11	10
A, B	00	1	0	0	1
	01	1	1	1	0
	11	0	1	1	0
	10	1	0	0	1

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

3.a.7.  $F = (\sim A + B + \sim D) + (\sim A + \sim B + \sim C) + (\sim A + \sim B + C) + (\sim B + C + \sim D)$



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

		00	01	11	10
A, B	00	1	1	1	1
	01	1	0	1	1
	11	0	0	0	0
	10	1	0	0	1

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

3.e Let's take the example of 3.a.4, where the K-Map is :

		C, D			
		00	01	11	10
A, B	00	1	0	0	1
	01	1	0	0	1
	11	1	0	0	1
	10	1	1	1	1

$(A + \bar{D})(\bar{B} + \bar{D})$

Since it is a POS form the 0's are grouped, forming two groups of 4 zeros, and the minimized expression is  $(A + \sim D)(\sim B + \sim D)$

If instead of that, the 6 zeros were grouped as 3 groups of 2 zeros each, we would have 3 terms in our expression, which would then be  $(A + B + \sim D)(A + \sim B + \sim D)(\sim A + \sim B + \sim D)$ , which is not minimized, doing further Boolean simplification the actual minimized expression is obtained and it reduces to  $(A + \sim D)(\sim B + \sim D)$ .

Hence it can be concluded that incorrect grouping in K-Map can lead to unnecessary terms in the expression, that have to be then further manually simplified.