Name: DEEPAK R Reg. No: 18ETCS002041

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. $F = {\sim}A{\sim}B{\sim}C{\sim}D + A{\sim}C{\sim}D + {\sim}BC{\sim}D + {\sim}ABCD + B{\sim}CD$
      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

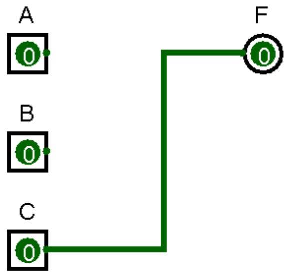
Your document should include:

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

Name: DEEPAK R

Reg. No: 18ETCS002041

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

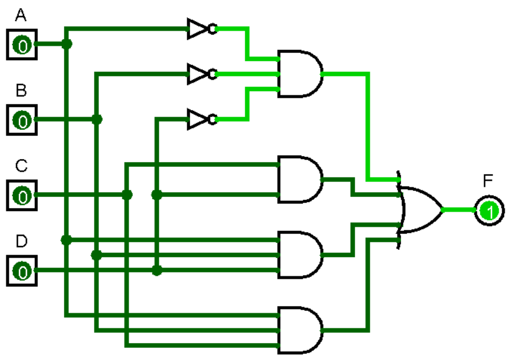


A \ B, C	00	01	11	10
0	0	1	1	0
1	0	1	1	0

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

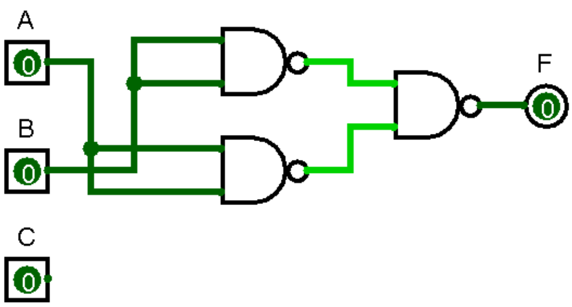


A, B \ C, D	00	01	11	10
00	1	0	1	1
01	0	0	1	0
11	0	1	1	1
10	0	0	1	0

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

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

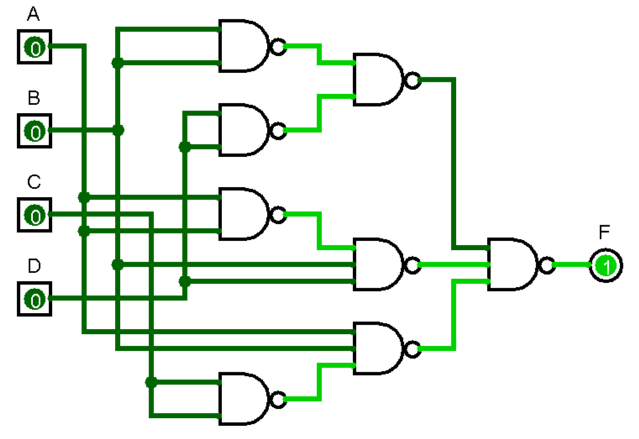


A \ B, C	00	01	11	10
0	0	0	1	1
1	1	1	x	x

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. $F = \sim A \sim B \sim C \sim D + A \sim C \sim D + \sim BC \sim D + \sim ABCD + B \sim CD$...

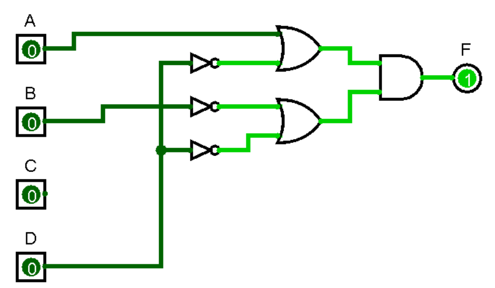


A	B	C	D	F
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

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

$\overline{B}\,\overline{D} + \overline{A}BD + AB\overline{C}$

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

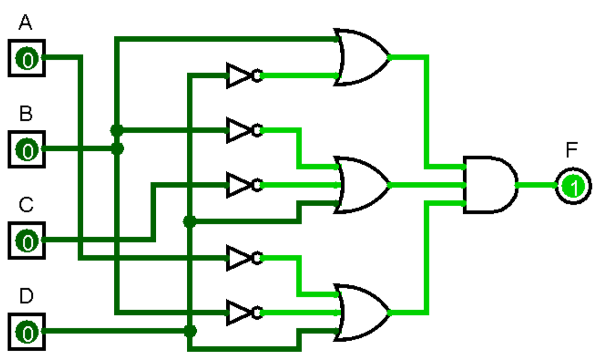


A, B \ C, D	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	1	0	0	1
10	1	1	1	1

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

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

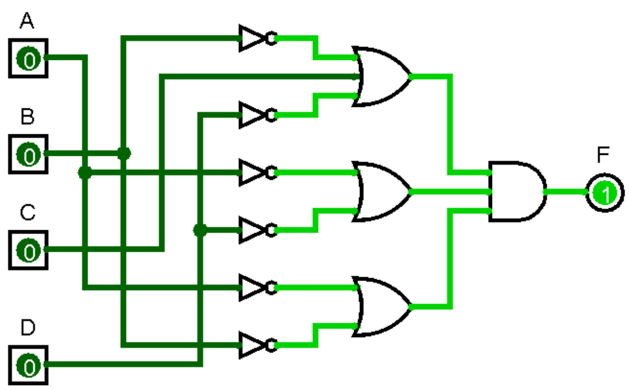


		C, D			
		00	01	11	10
A, B	00	1	0	0	1
	01	1	1	1	0
	11	0	1	1	0
	10	1	0	0	1

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

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

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

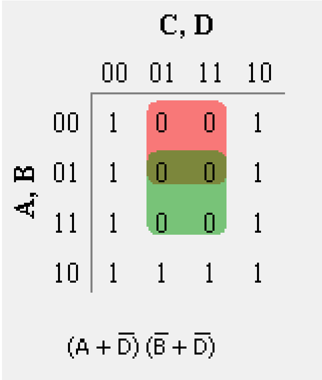


		C, D			
		00	01	11	10
A, B	00	1	1	1	1
	01	1	0	1	1
	11	0	0	0	0
	10	1	0	0	1

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

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

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



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.