King Mongkut's Institute of Technology Ladkrabang
Computer Engineering International Program
01276112 Digital System Fundamentals

Lab 3 - Boolean Simplification

Learning Outcomes

1. Simplify Boolean expression using Boolean algebra and K-Map
2. Debug digital circuit.

1. Boolean Algebra

These are laws, rules, and theorems of Boolean algebra:

Commutative law of addition

$$A + B = B + A$$

Commutative law of multiplication

$$AB = BA$$

Associative laws of addition

$$A + (B + C) = (A + B) + C$$

Associative laws of multiplication

$$A(BC) = (AB)C$$

Distributive Law

$$A(B + C) = AB + AC$$

Basic rules of Boolean algebra.

1. $A + 0 = A$	**7.** $A \cdot A = A$
2. $A + 1 = 1$	**8.** $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	**9.** $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	**10.** $A + AB = A$
5. $A + A = A$	**11.** $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	**12.** $(A + B)(A + C) = A + BC$

DeMorgan's First Theorem

$$\overline{XY} = \overline{X} + \overline{Y}$$

DeMorgan's Second Theorem

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

2. Experiment

1. Using the following Boolean expression for Experiment 1.1 – 1.4.

$$f_{(A,B,C,D)} = \sum m(1,3,5,6,7,9,12,13)$$

1.1. Construct the truth table for Boolean expression.

minterm	A	B	C	D	f(A,B,C,D)
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	0
9	1	0	0	1	1
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	0
15	1	1	1	1	0

1.2. Simplify Boolean expression using Boolean algebra. Specify laws, rules, and theorems that are used one-by-one.

$m(1) = A'B'C'D$

$m(3) = A'B'CD$

$m(5) = A'BC'D$

$m(6) = A'BCD'$

$m(7) = A'BCD$

$m(9) = AB'C'D$

$m(12) = ABC'D'$

$m(13) = ABC'D$

$A + A = A$

$A'BCD + A'BCD' = A'BC(D + D') = A'BC(1) = A'BC$

$f(A,B,C,D) = A'B'C'D + A'B'CD + A'BC'D + A'BCD' + A'BCD + AB'C'D + ABC'D' + ABC'D$

from $AB + AC = A(B + C)$: $A'B'D(C + C') + A'BD(C + C') + ABC'(D + D') + A'BC(D + D') + A'C'D(B + B') + AC'D(B + B')$

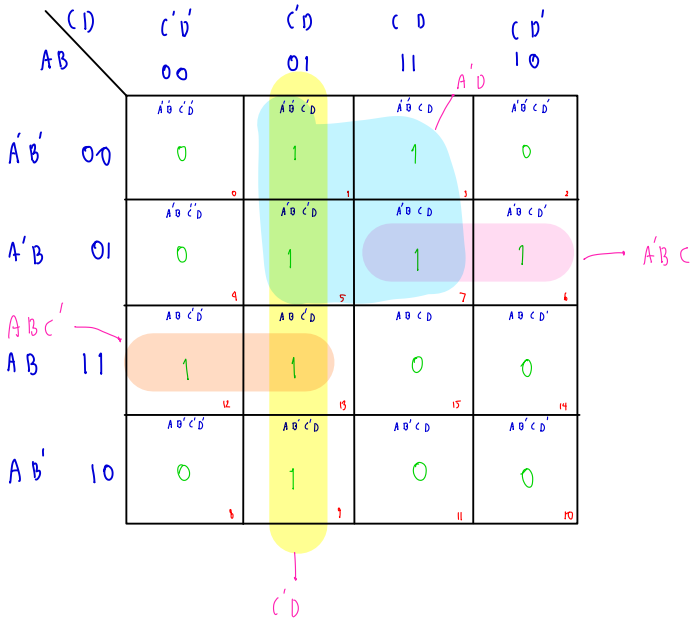
from $A + A' = 1$: $A'B'D + A'BD + ABC' + A'BC + A'C'D + AC'D$

from $AD + AC = A(B + C)$: $A'D(B + B') + C'D(A + A') + ABC' + A'BC$

from $A + A' = 1$: $A'D + C'D + ABC' + A'BC$

$f(A,B,C,D) = A'B + C'D + ABC' + A'BC$

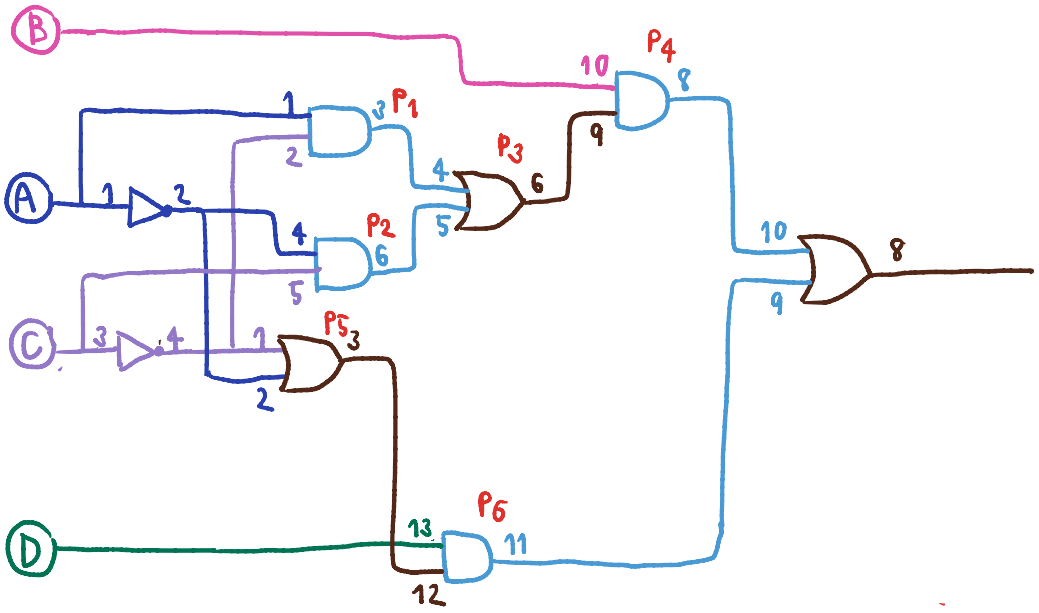
1.3. Simplify Boolean expression using K-Map.



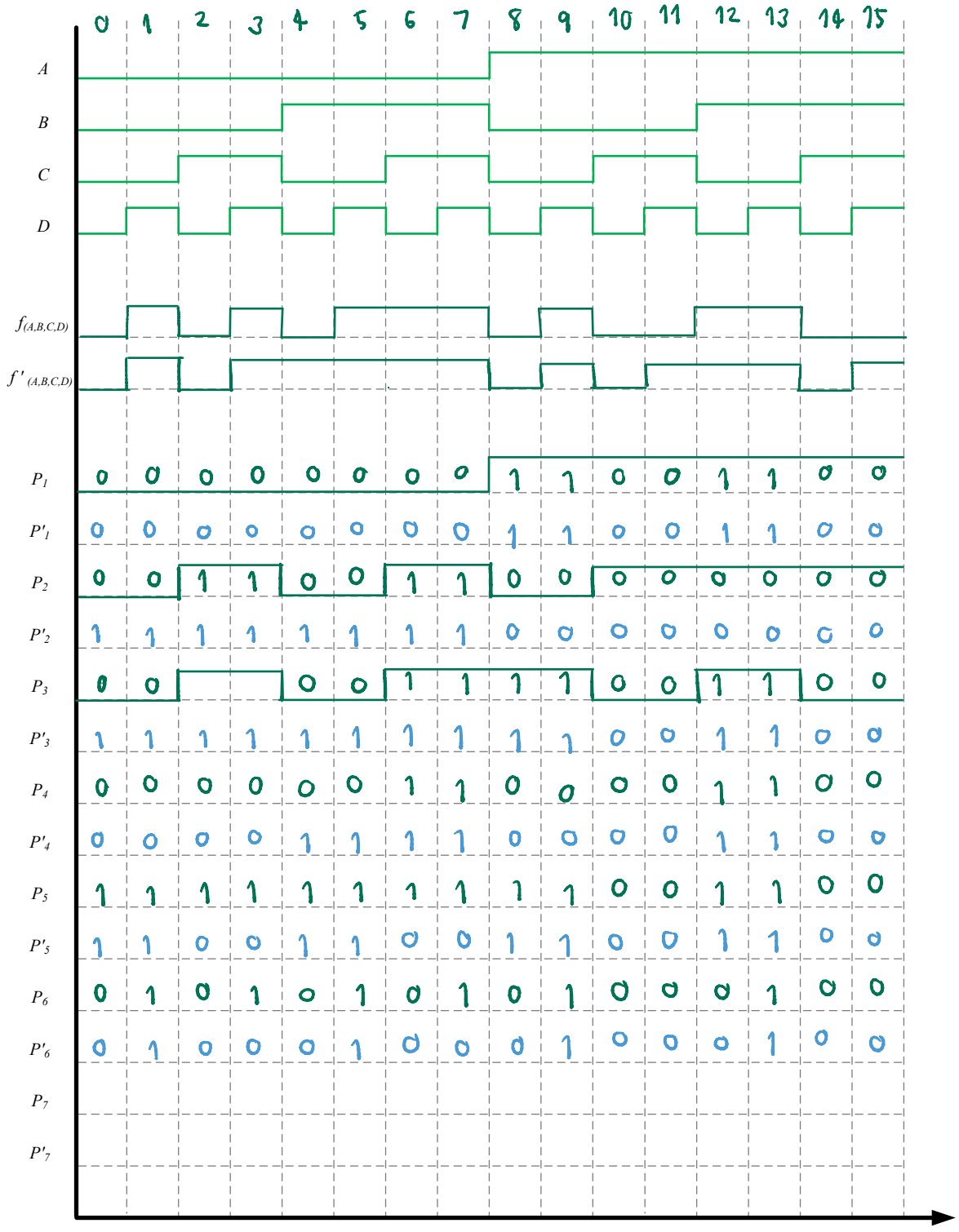
$\bar{C}D + \bar{A}D + AB\bar{C} + \bar{A}BC$

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

1.4. Draw logic diagram and ***specify IC pin No.*** for all input and output pins from each gate. In addition, label P_1 to P_7 for all gate output except the last gate that give circuit output.



2. Build digital circuit according to logic diagram in Experiment 1.4 and verify the circuit by construct timing diagram below. Use $f_{(A,B,C,D)}$ for circuit output signal and use P_1 to P_7 for all gate output signal labelled in Experiment 1.4.



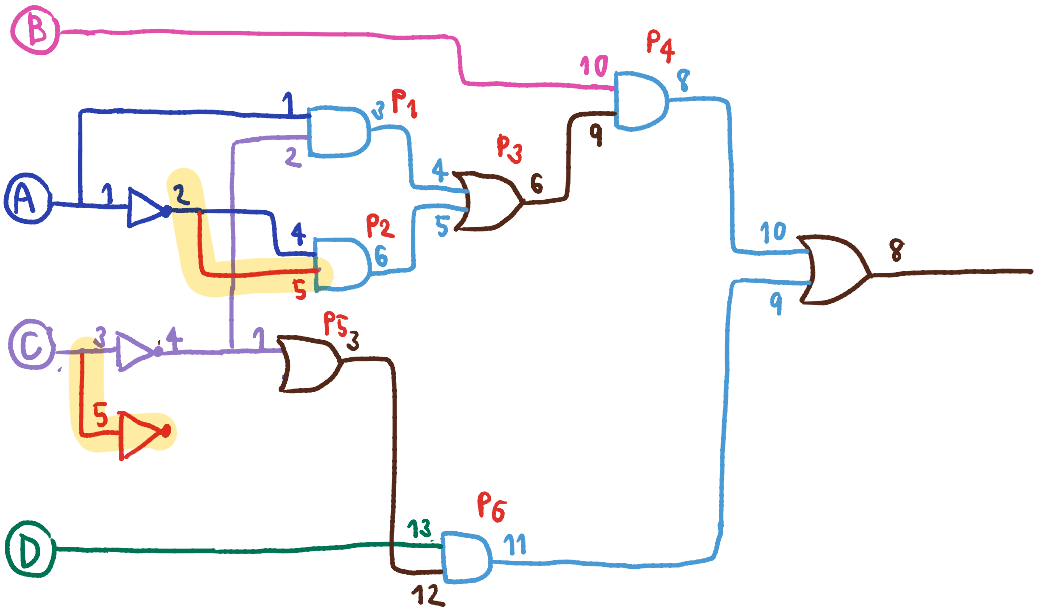
3. Ask TA to rewire and/or remove a few wires from the circuit without you knowing. Then verify the circuit by constructing timing diagram from Experiment 2 use labels $f'_{(A,B,C,D)}$ and P'_1 to P'_7. Compare to the original result.

3.1. Specify minterms that give incorrect output.

4, 11, 15

3.2. Copy circuit diagram from Experiment 1.4 and specify the incorrect wiring and correct the circuit.

Incorrect Circuit



Lab 3 Submission

Date 29/12/2024 Group No. 13

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Checkpoints

Experiment 1 (10 pts)

Experiment 2 (10 pts)

Experiment 3 (10 pts)

Questions

1. Describe the benefit of Boolean simplification.

1) Reduce number of logic gate, less hardware cost

2) Reduce complexity, more easy to understand, analyze and optimize

2. Compare two methods of Boolean simplification between Boolean algebra and K-Map.

Boolean algebra use rules and theory to simplify step-by-step. While K-Map is a grid or map use to visually simplify Boolean expressions by finding patterns

Boolean algebra is more suitable for larger expressions (any number of variables)

K-Map is easier for small expressions (2-4 variables)