MONASH University

FIT1047 Applied Session Week 3

BOOLEAN LAWS AND KARNAUGH MAPS

OBJECTIVES

- The purpose of this applied session is getting to know Boolean Expressions, and simplifications using Booleans Laws and K-maps.

INSTRUCTIONS

- Use Logisim to draw circuits. Apply Boolean laws and K-map to simplify equations.
- You may work in a small group.

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Activity 1: Boolean Equation Simplification (using Boolean Laws)

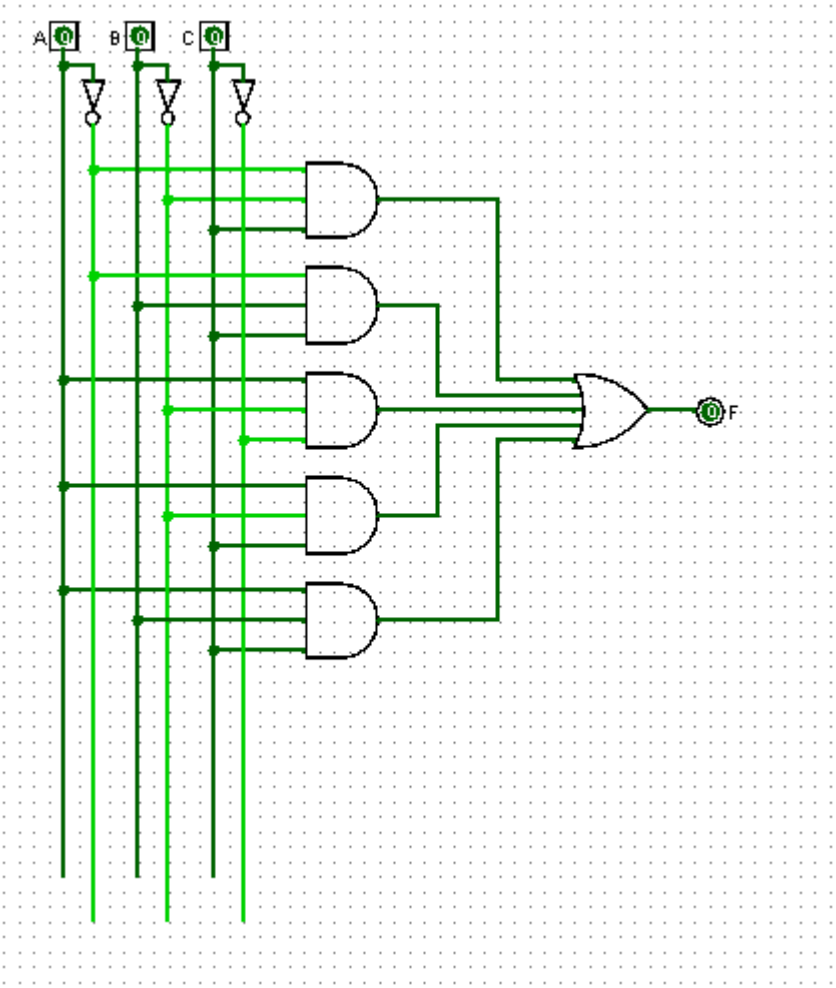
Given a Boolean expression:

$$F(A,B,C) = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + A\bar{B}C + ABC$$

- (i) Use Logisim to build a circuit for this function. Use only AND, OR and NOT gates. How many gates do you need?
- (ii) Write down the truth table for this function,
- (iii) Simplify the equation using Boolean Laws,
- (iv) Draw the logic diagram using the simplified Boolean expression.

Sample Solution:

(i) Use Logisim to build a circuit for this function. Use only AND, OR and NOT gates. How many gates do you need?



Number of gates used: Nine. To compare with different versions of logic circuits for the same logic equation, we may ignore the NOT gates used for negation of inputs.

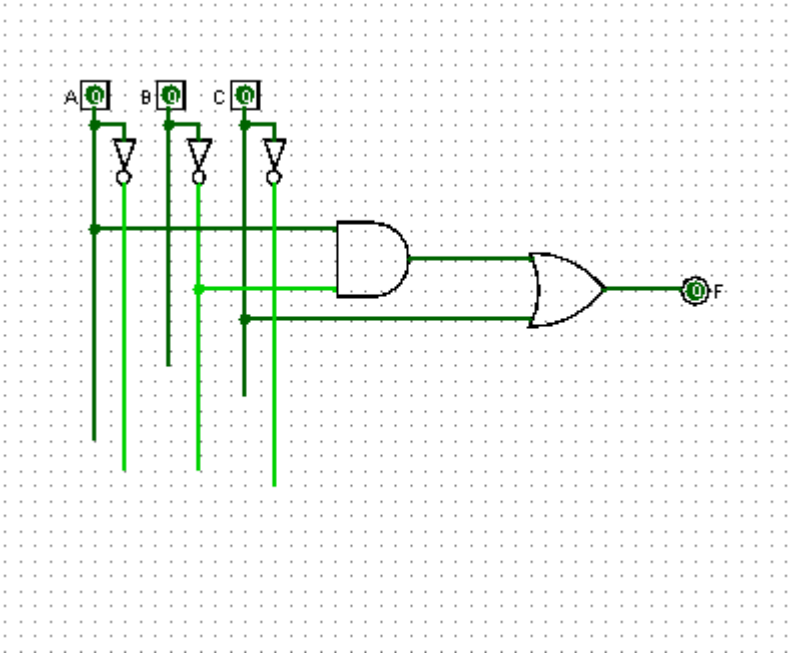
(ii) Write down the truth table for this function

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

(iii) Simplify the equation using Boolean Laws,

F = A'B'C + A'BC + AB'C' + AB'C + ABC
= A'B'C + A'BC + AB'C' + (AB'C + AB'C) + ABC [Rule: A + A = A]
= (A'B'C + A'BC) + (AB'C' + AB'C) + (AB'C + ABC)
= A'C(B' + B) + AB'(C' + C) + AC(B' + B) [Rule: AB+AC = A(B + C)]
= A'C . 1 + AB' . 1 + AC . 1 [Rule: A + A' = 1]
= A'C + AB' + AC
= C (A' + A) + AB'
= C . 1 + AB'
= C + AB'

(iv) Draw the logic diagram using the simplified Boolean expression.



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Activity 2: Boolean Equation Simplification (using K-map):

Given a Boolean Expression:

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

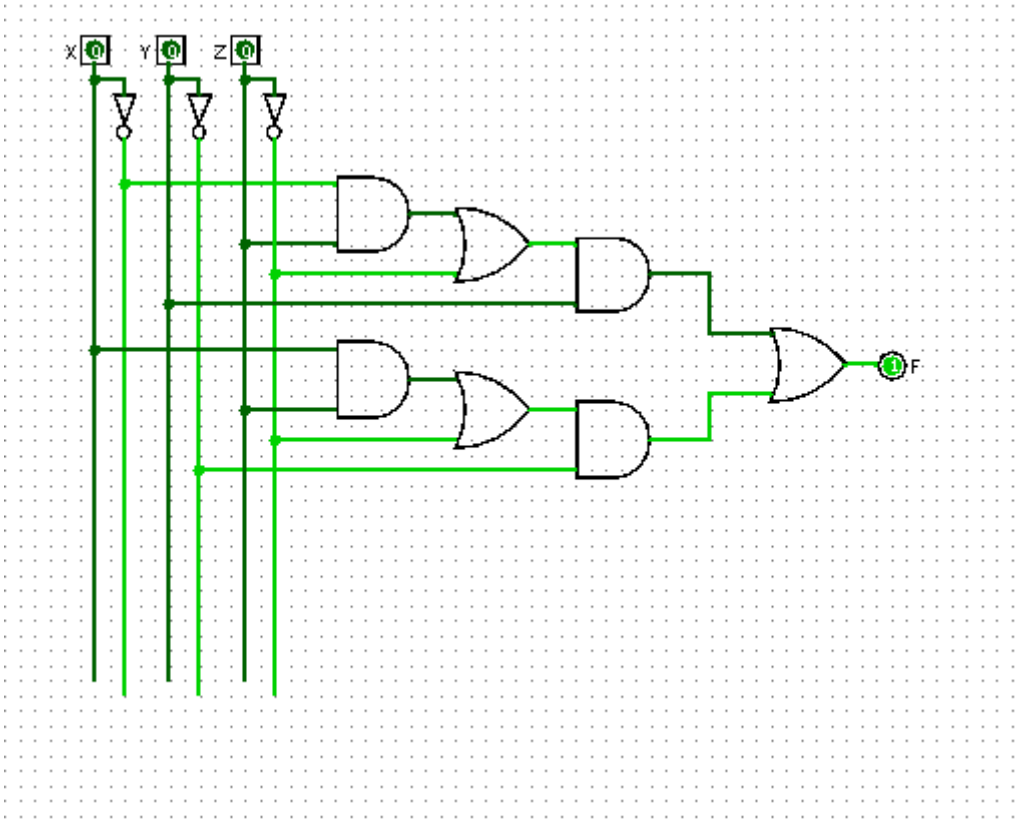
- (i) Write down the truth table,
- (ii) Draw a logic circuit using the original Boolean expression,
- (iii) Simplify the equation using K-map,
- (iv) Draw the logic circuit using the simplified Boolean expression.

Sample Solution:

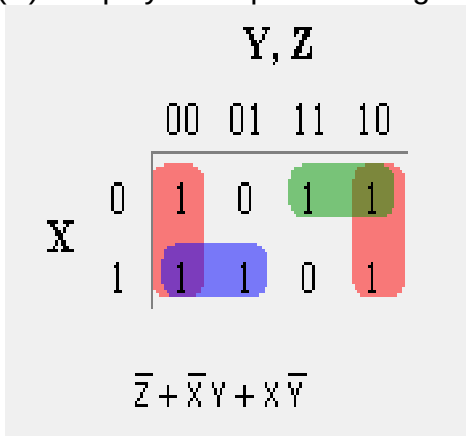
(i) Write down the truth table

X	Y	Z	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

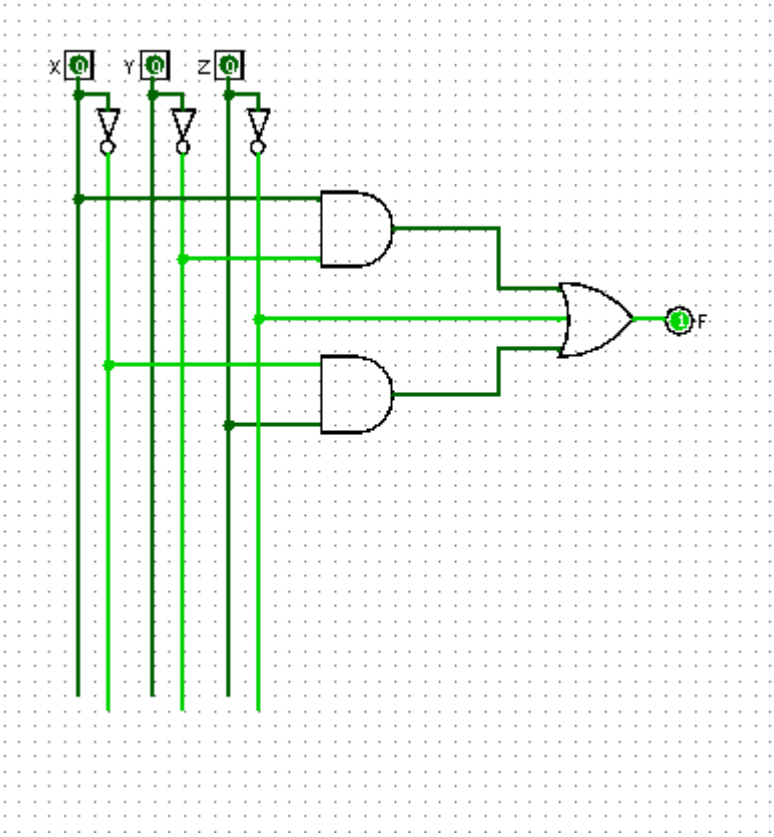
(ii) Draw a logic circuit using the original Boolean expression



(iii) Simplify the equation using K-map



(iv) Draw the logic circuit using the simplified Boolean expression



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Activity 3: Boolean Equations from Truth Tables

The truth table below describes a Boolean function with inputs A, B, C and D and output Z.

- (i) Create a Boolean equation using the SOP method
- (ii) Build a K-map and
- (iii) Derive a simplified equation from the K-map.

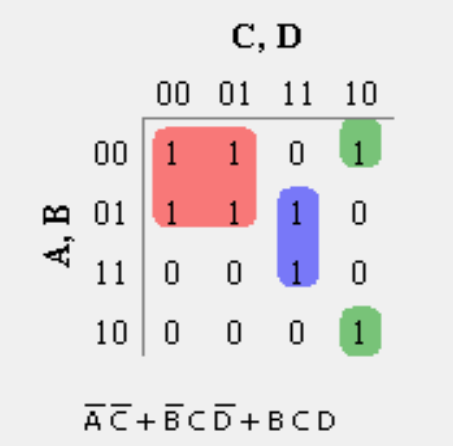
A	B	C	D	Z
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

Sample Solution:

(i) Create a Boolean equation using the SOP method.

$$Z = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BCD + A\bar{B}C\bar{D} + ABCD$$

(ii) Build a K-map and



(iii) Derive a simplified equation from the K-map.

$$Z = \bar{A}\bar{C} + \bar{B}C\bar{D} + BCD$$