North South University

CSE231L

Experiment # 3

Name of Experiment: **Combinational Logic Design**

Date of Performance: 23 October, 2019

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Section: 13

Group: 3

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Objectives

- We have to become familiarized with the analysis of combinational logic networks.
- We have to learn the implementation of networks using the two canonical forms.

Equipments

- Trainer board.
- 1 × IC7411 Triple 3-input AND gates.
- 2 × IC 4075 Triple 3-input OR gates.
- 1 × IC7404 Hex Inverters (NOT gates)

Theory

Minterms and Maxterms: A binary variable may appear either in its normal form (x) or in its complement form (x'). Now consider two binary variables x and y combined with AND operation. Since each variable may appear in either form; there are four possible combinations: $x'y'$, $x'y$, xy', xy. Each of these four AND terms is called a minterm, or a standard product. If we have n variables, they can be combined to form 2^n minterms.

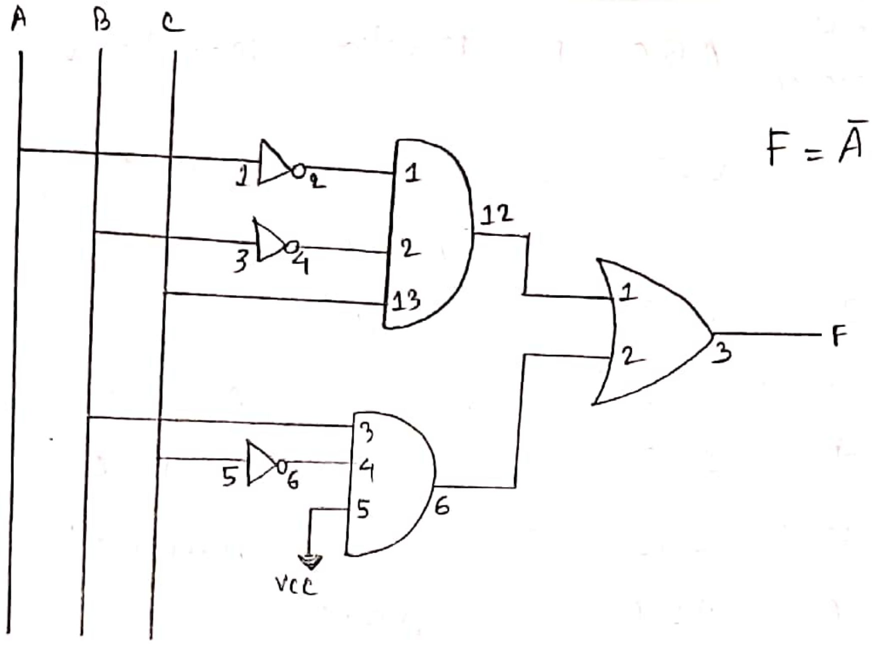
The four minterms and maxterms for 2 variables, together with symbolic ~~deg~~ designations, are listed in the table.

		Minterms		Maxterms	
x	y	Term	Designation	Term	Designation
0	0	$x'y'$	m_0	$x+y$	M_0
0	1	$x'y$	m_1	$x+y'$	M_1
1	0	xy'	m_2	$x'+y$	M_2
1	1	xy	m_3	$x'+y'$	M_3

Canonical Forms:

Boolean functions expressed as a sum of minterms of products of maxterms are said to be in 1st canonical From and 2nd canonical form respectively. Functions in their canonical form can also be expressed in a brief notation. For example, the function $F=x'y'+xy'$ (1st canonical form) can be expressed as $F(x,y)=\Sigma(0,2)$ and the function $X=(A+B)(A+B')$ can be expressed as $X(A,B)=\Pi(0,1)$. The numbers following the sum and product symbols are the indices of the minterms and maxterms of the respective functions.

Circuit Diagrams



$F = \bar{A}\bar{B}C + B\bar{C}$

Figure: 1st canonical form.

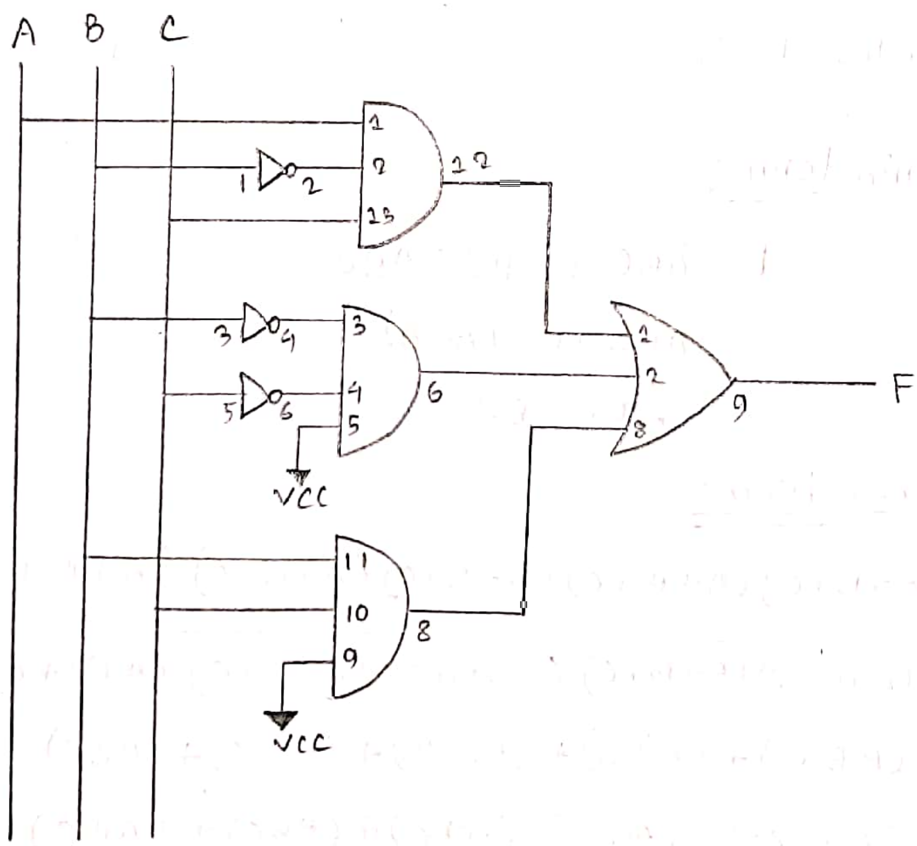


Figure: 2nd canonical form.

Results

Input Reference	ABC	F	Min term	Max term
0	000	0		A+B+C
1	001	1	A'B'C	
2	010	1	A'BC'	
3	011	0		A+B'+C'
4	100	0		A'+B+C
5	101	0		A'+B+C'
6	110	1	ABC'	
7	111	0		A'+B'+C'

Table : Truth-table to a combinational circuit.

For min term :

$$F = \bar{A}\bar{B}C + \bar{A}B\bar{C} + AB\bar{C}$$

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

$$= \bar{A}\bar{B}C + B\bar{C}$$

For max term :

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

$$\bar{F} = \overline{(A+B+C)(A+\bar{B}+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+\bar{C})}$$

$$= (A'B'C') + (A'BC) + (AB'C') + (AB'C) + (ABC)$$

$$= (A'B'C') + (AB'C') + (A'BC) + (ABC) + (AB'C)$$

$$= B'C'(A'+A) + BC(A+A') + AB'C$$

$$= AB'C + BC + B'C'$$

	Shorthand Notation	Function
1st Canonical Form	$F=\Sigma(1,2,6)$	$F=\bar{A}\bar{B}C+\bar{A}B\bar{C}+AB\bar{C}$
2nd Canonical Form	$F=\Pi(0,3,4,5,7)$.	$F=A\bar{B}C+BC+\bar{B}\bar{C}$

Questions

1| First canonical form: Boolean functions expressed as a sum of minterms are said to be in 1st Canonical Form. Example: $F=x'y'+xy'$.

The given expression:

$$F=AB+ABC'$$

Yes, the given expression is in first canonical form. Because, it is expressed as a sum of minterms.

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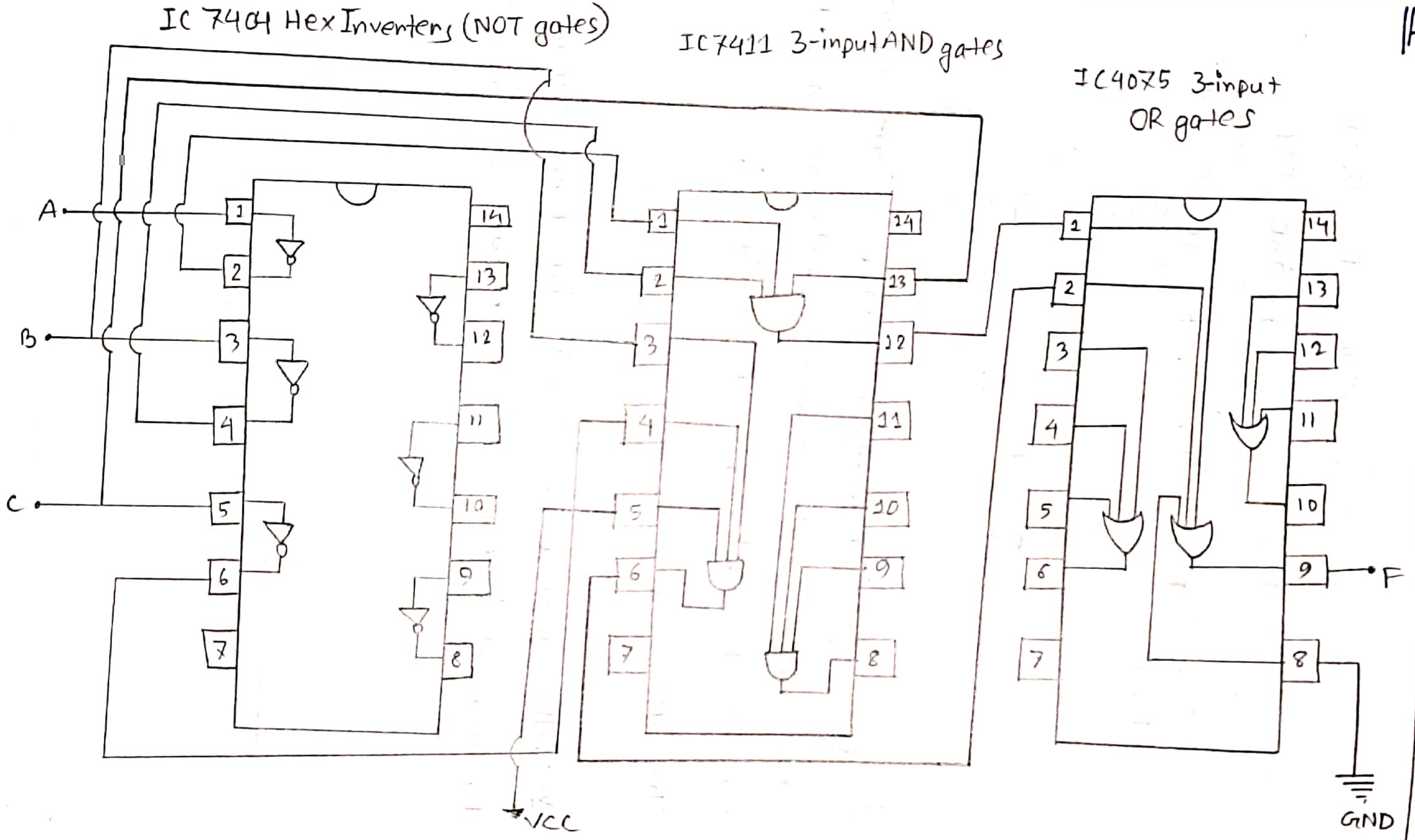
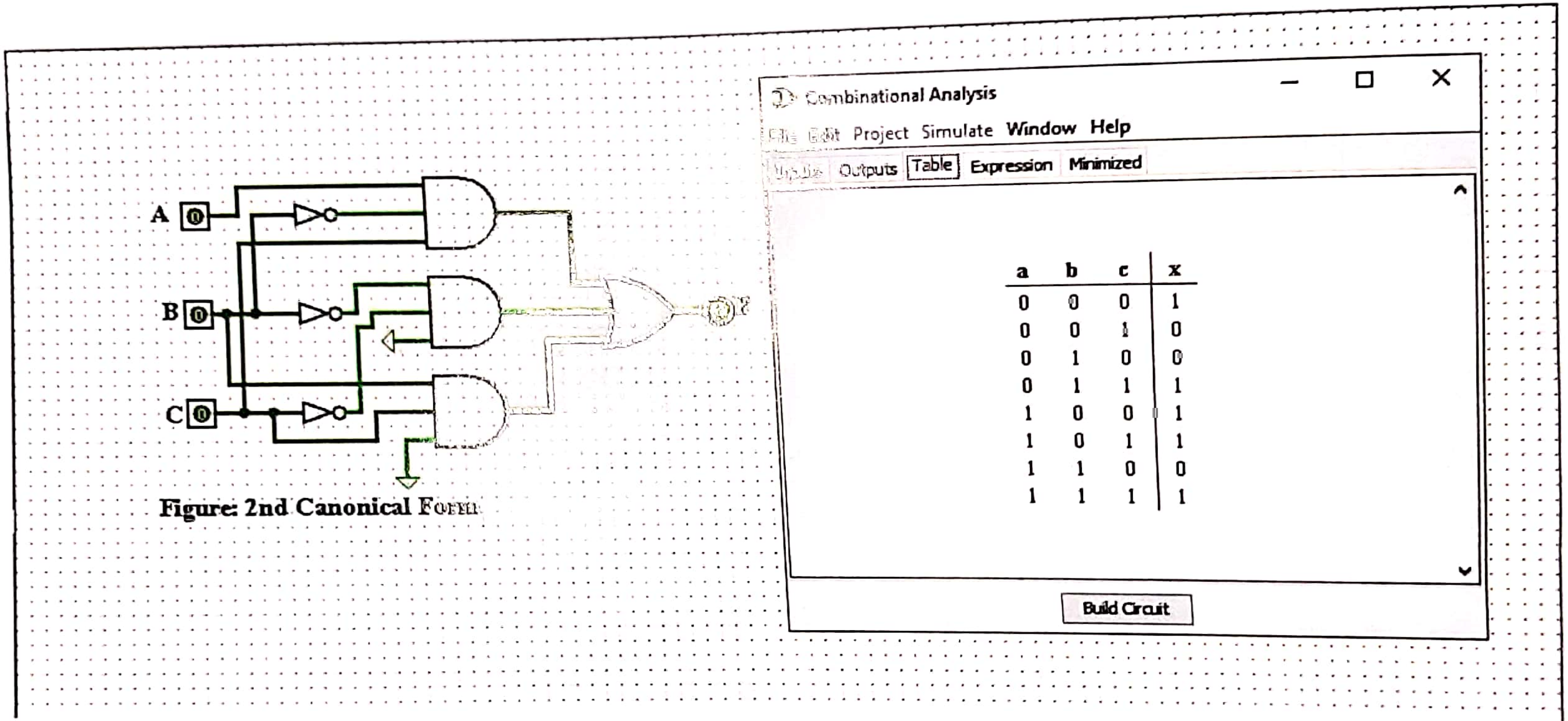


1st Canonical Form



a	b	c	x
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

Figure: 2nd Canonical Form

2| Printout of the logisim circuit screenshot and truth-table screenshot of the 2nd canonical form.

Discussion

Because of human error and equipment error, we didn't get our expected results. In the lab, we observed that completing the truth table from the given inputs we made circuit of it. In this experiment, we first found out the minterms and the maxterms of the given function. Before writing the 1st canonical form, we first simplified the equation so that our circuit gets simplier. We did the same for the 2nd canonical form. That's how we got much simplier forms of circuits. In this experiment, we used IC 7411 Triple 3-input AND gates, IC 4075 Triple 3-input OR gates, IC 7404 Hex inverters (NOT gates). We connected one min term at a time and checked the output. Once all min terms had been connected and verified, we got our results. Similarly, we did for the max terms.

CSE231L/EEE211L
Lab 3 - Combinational Logic Design (Canonical Forms)

Data Sheet: Instructor's Signature: ....

Section: 13	Group No.: 3	Date: 23 October, 2019

Input Reference	*A B C*	*F*	Min term	Max term
0	0 0 0	0		$A+B+C$
1	0 0 1	1	$A'B'C$	
2	0 1 0	1	$A'BC'$	
3	0 1 1	0		$A+B'+C$
4	1 0 0	0		$A'+B+C$
5	1 0 1	0		$A'+B+C'$
6	1 1 0	1	ABC'	
7	1 1 1	0		$A'+B'+C'$

Table F.1 - Truth table to a combinational circuit

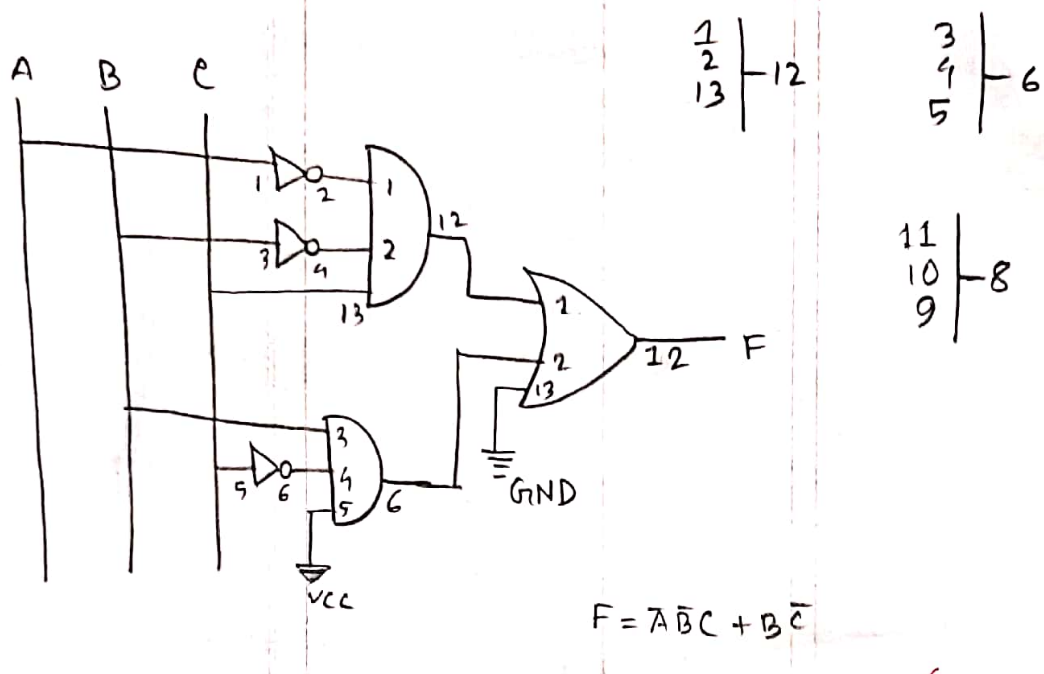
	Shorthand Notation	Function
1st Canonical Form	$F=\Sigma(1,2,6)$	$F=\bar{A}\bar{B}C+\bar{A}B\bar{C}+AB\bar{C}$
mid ← 2nd Canonical Form	$F=\Pi(0,3,4,5,7)$	$F=A\bar{B}C+BC+\bar{B}\bar{C}$

Table F.2 - 1st and 2nd canonical forms of the combinational circuit of Table F.1

$$F=A\bar{B}C+\bar{A}B\bar{C}+AB\bar{C}$$
$$=\bar{A}\bar{B}C+B\bar{C}(A+\bar{A})$$
$$=\bar{A}\bar{B}C+B\bar{C}$$

$$F=(A+B+C)(A+\bar{B}+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+\bar{C})$$
$$\bar{F}=\overline{(A+B+C)(A+\bar{B}+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+\bar{C})}$$
$$=(\bar{A}\bar{B}\bar{C})+(A'BC)+(AB'C')+(AB'C)+(ABC)$$
$$=(A'B'C')+(AB'C')+(A'BC)+(ABC)+(AB'C)$$
$$=B'C'(A'+A)+BC(A+A')+AB'C$$
$$=AB'C+BC+B'C'$$

1st Canonical Form



2nd Canonical Form

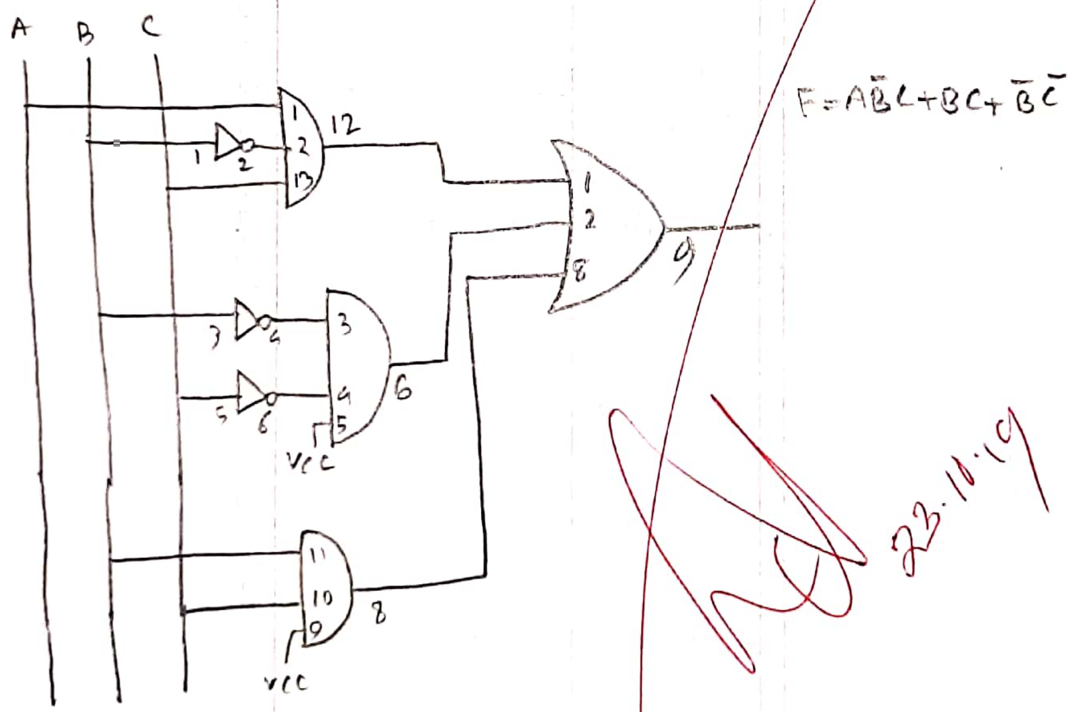


Figure F.1 - 1st and 2nd canonical circuit diagrams of the combinational circuit of Table F.1