Activity 4.2A – Logic Simplification

Purpose

1. To understand the laws and rules of Boolean Algebra
2. To simplify Boolean Expressions
3. To simulate simplified logic circuits and verify the truth tables

Equipment

Computer Simulation Software

Procedure

Boolean algebra is the most important mathematical tool of digital systems. In the same way that *normal* algebra has rules that allow you to simplify algebraic expressions, Boolean algebra has laws and rules that allow you to simplify expressions used to create logic circuits.

Laws of Boolean Algebra

LAW	Expression
Commutative	**Addition: A + B = B + A** **Multiplication: AB = BA**
Associative	**Addition: A + (B + C) = (A + B) + C** **Multiplication A (BC) = (AB) C**
Distributive	**A (B + C) = AB + AC**

Rules of Boolean Algebra

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

It is possible to simplify Boolean expressions by using the Laws and Rules listed above. As you know, a logic expression represents a logic circuit with a certain number of gates. By using reduction techniques we can convert a given circuit into a simpler one that performs the same function. This means that both the original circuit and the reduced circuit will have the same truth table. When two truth tables are identical, they are said to be *equivalent.* The advantage of using a simplified circuit is that it will contain fewer gates than the unsimplified original circuit. To reduce a circuit, you will continuously apply the laws and rules of Boolean Algebra until you get the smallest possible expression.

1. State the unsimplified Boolean expression for Figure 1, shown below, and place your answer in the space provided. Compete the truth table.

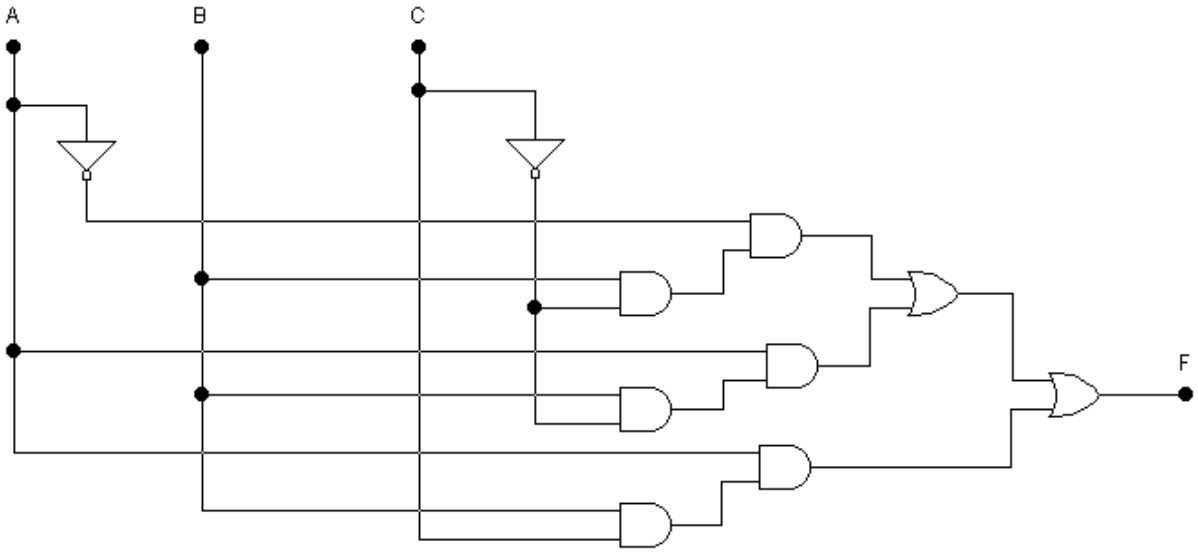

Fig. 1

Unsimplified Boolean Expression: _____

Truth Table for the unsimplified circuit

A	B	C	Z

2. Reduce the unsimplified expression to its simplest form using the Boolean Laws and Rules. Show all work below. List each Law or Rule you used next to the line where you applied it.

Simplified Expression: _____

Hand draw the simplified circuit below:

Recreate the Truth Table for the simplified circuit

A	B	C	Z

3. Draw the unsimplified circuit using the computer simulation software, and verify its truth table (step 1). Tape the circuit printout below.

4. Draw the simplified circuit using the computer simulation software, and verify that the truth table matches the unsimplified circuit's Truth Table. Tape the circuit printout below.

5. Simulate the following expression in its unsimplified form. Create its Truth Table.

$$Z = \overline{A}\,B\,C + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C} + A\,\overline{B}\,C + A\,B\,C$$

Unsimplified circuit Truth Table

A	B	C	Z

6. Use the Boolean Laws and Rules to reduce the circuit to its simplest form.

Simplified expression: _____

7. Simulate the simplified circuit, test its operation, and create its Truth Table.

Simplified circuit Truth Table

A	B	C	Z