Lab Experiment 6

Simplification of Logic Circuit Using Boolean Algebra and DeMorgan's Theorem

COMPONENTS

- One NAND (74LS00), NOR (74LS02), NOT (74LS04), OR (74LS32), and AND (74LS08) gate
- Jumper Wires
- Protoboard
- Digital Board

INTRODUCTION

Many times in the design on logic circuits, the logic output in SOP expression might have to reduce to its simplest form or change its form to a more convenient one to implement the expression most efficiently.

Boolean algebra is used to describe how signals are combined to create a desired output. It is also a very important tool, along with the application of DeMorgan's theorem, uses to reduce expressions to minimal terms to minimize the hardware required in constructing a circuit.[1]

The Boolean rules are based on the expressions using inverters (NOT), AND, and OR gates, while DeMorgan's theorem are based on the equivalency of a NAND and NOR gates. The basic rules of Boolean algebra and DeMorgan's theorem are:

[1] Bignell and Donovan, *Lab Manual to Accomplany Digital Electronics:* Waveforms and Boolean algebra, page 33. Delmar Thomson Learning, Connecticut 2000.

AND operation (Logic Multiplication •)

Assuming X is a logic input

$$X \bullet 0 = 0$$

$$X \bullet 1 = X$$

$$X \bullet X = X$$

$$X \bullet \bar{X} = 0$$

OR operation (Logic Addition +)

Assuming X is a logic input

$$X + 0 = X$$

$$X + 1 = 1$$

$$X + X = X$$

$$X + \bar{X} = 1$$

Inverter (NOT) operation

Assuming X is a logic input

$$\bar{\bar{X}} = X$$

Distributive Theorem

Assuming $X, Y, and\ Z$ are logic inputs

$$X \bullet Y + X \bullet Z = X(Y + Z)$$

$$X + \bar{X} \bullet Y = (X + \bar{X}) \bullet (X + Y) = X + Y$$

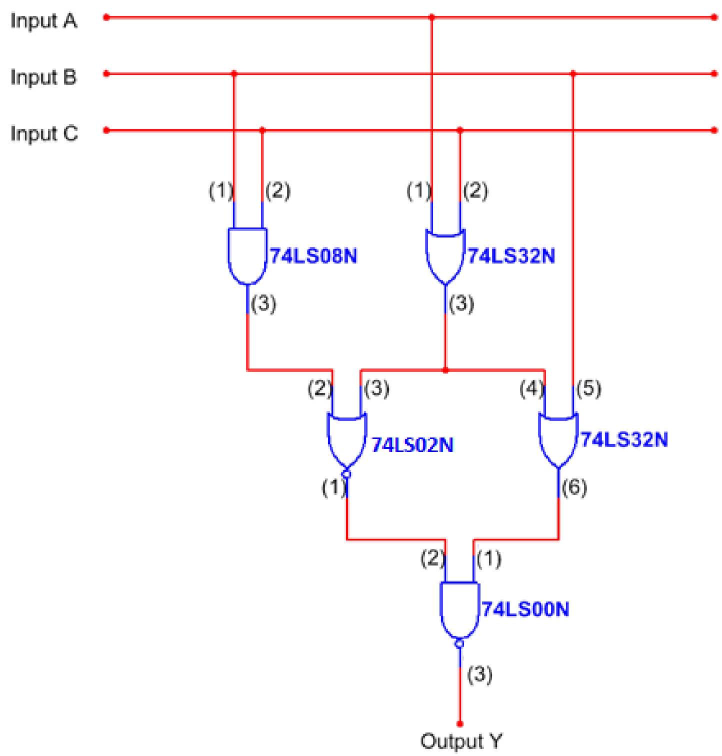
DeMorgan's Theorem

NAND operation ➔ $\overline{X \bullet Y} = \bar{X} + \bar{Y}$

NOR operation ➔ $\overline{X + Y} = \bar{X} \bullet \bar{Y}$

LABORATORY PROJECT

1. Predict the output Y for the following combination of logic circuit, Circuit 6.1.



Circuit 6.1 – 3-input Combination of Logic Circuit

2. Write the SOP of output **Y** for Circuit 6.1 ____
3. Use Boolean algebra and DeMorgan's theorem, if it is necessary, and simplify the SOP equation from step 2.
   Show work below:

4. Obtain a NAND (74LS00), NOR (74LS02), OR (74LS32), and AND (74LS08) gate from your IC's chips.
5. Build Circuit 6.1 in a protoboard. Remember that the numbers in parenthesis are the pin number of the respective gates. Also, use switch 8 and LED 1 as input A, switch 7 and LED 2 as input B, switch 6 and LED 3 as input C, and LED 8 as output Y
6. With the circuit built, manage the inputs according to Table 6.1, and observe and record the output Y (LED 8). Use "1" when the LED is ON and "0" when the LED is OFF.

Inputs			**Outputs**
C	**B**	**A**	**Y**

Table 6.1 - Truth Table Circuit 6.1

7. Using the output from Table 6.1, write the SOP equation for all output that are "1"

   The SOP equation from Table 6.1 is: ____

8. Simplify the SOP equation from the previous step, step 7, using Boolean algebra and DeMorgan's theorem.

   Show work below:

   The simplified/equivalent SOP equation is ______________________________________

9. Draw the simplified logic circuit below including the IC chip pin numbers. Also indicate the switch and LED that is connected to each input.

   Simplified SOP logic circuit

10. Build the simplified logic circuit, which is the sketch circuit from step 9, in a protoboard.
11. Construct a truth table according to your simplified logic circuit in step 9. Name the truth table as Table 6.2 – Simplified/equivalent circuit

   Construct Truth Table 6.2 below:

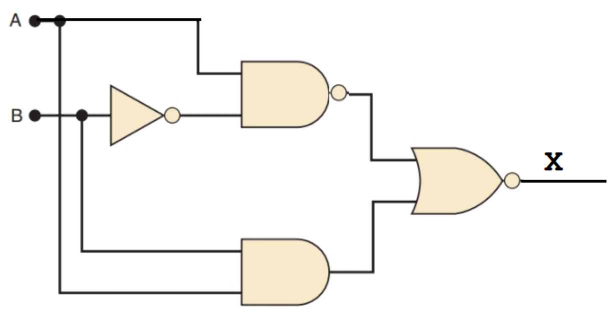
Inputs			**Outputs**
C	**B**	**A**	**Y**

Table 6.2 -Truth Table Circuit 6.2 (Step 9)

12. With the circuit in step 10 built, manage the inputs according to Table 6.2, and observe and record the output Y. Use “1” when the LED is ON and “0” when the LED is OFF.

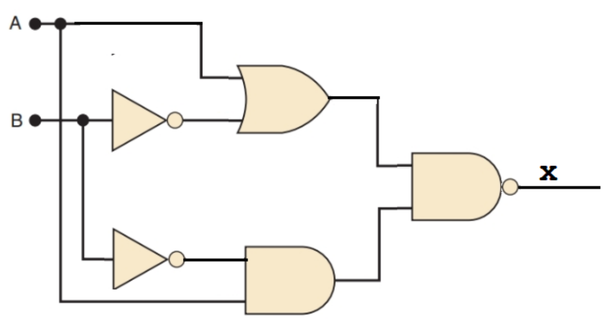
QUESTIONS

1. Does Table 6.1 and Table 6.2 match? Justify your answer
2. Find the SOP equation of the following logic circuits and use Boolean algebra and DeMorgan's theorem to find their equivalent simplified logic circuit:
   a)



- SOP equation of output X = ______________________________
- Simplified SOP equation of X using Boolean algebra and DeMorgan's theorem
  ____
- Draw the simplified SOP circuit

b)



- SOP equation of output X = ______________________________
- Simplified SOP equation of X using Boolean algebra and DeMorgan's theorem
  ____
- Draw the simplified SOP circuit

Student's name: __________________________ Lab instructor's signature_________________________

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