

## **BOOLEAN ALGEBRA**

### **OBJECTIVE:**

- To verify the rules and regulations of Boolean Algebra
- To simplify and modify Boolean logic functions by means of Demorgan's theorem.
- To design and implement a logic circuit.

### **APPARATUS:**

- PB-503
- 7400 Quadruple 2 input NAND gates.
- 7402 Quadruple 2 input NOR gates
- 7408 Quadruple 2 input AND gates
- 7432 Quadruple 2 input OR gates
- 7404 Hex inverters
- 7411 Triple 3-input AND gate

### **THEORY:** (See chapter 2 of the textbook)

1.  $A+0 = A$
2.  $A+1 = 1$
3.  $A \cdot 0 = 0$
4.  $A \cdot 1 = A$
5.  $A+A = A$
6.  $A+A' = 1$
7.  $A \cdot A = A$
8.  $A \cdot A' = 0$
9.  $(A')' = A$
10.  $A+AB = A$
11.  $A+A'B = A+B$
12.  $(A+B)(A+C) = A+BC$
13.  $A' \cdot B' = (A+B)'$
14.  $A'+B' = (A \cdot B)'$

### **Procedure 1:**

- a. Prove rule 1 using LogicWorks. The procedure is:
  - I. Open a new design window
  - II. Choose "ALL LIBRARY" in the Parts Palette
  - III. Put "OR" in the Filter window
  - IV. Select and double click on OR-2
  - V. Move to the cursor back into the circuit window. The cursor on the screen will now be replaced by a moving image of an OR gate.

- VI. Position the OR gate near the center of the circuit window and click the mouse button.
- VII. Press the spacebar to return to point mode.
- VIII. Move again to the Parts Palette and type on the Filter “switch” or part of the word switch e.g. “sw”.
- IX. Select Binary switch and connect it to an input of the OR gate in the design window. (If you want to move the binary switch around, press the shift key while moving it).
- X. Move again to the Parts Palette and select ground to be connected to the other input of the OR gate.
- XI. Using the same method get a Binary Probe and connect it to the output of the OR gate
- XII. Click on the binary switch to change it between 0 and 1 and notice how the rule  $A+0 = A$  is satisfied.

In the lab connect the circuit as shown in the figure using the switch S1-1 and LED-1 to verify the rule.

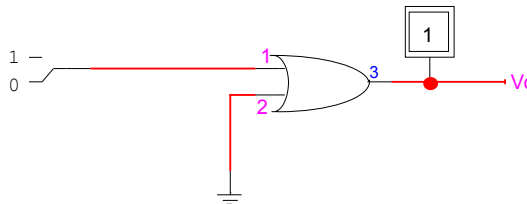


Fig.1 Verifying Rule 1

- b. Connect the circuit of Fig.2 Using LogicWorks. Which rule does this circuit illustrate?

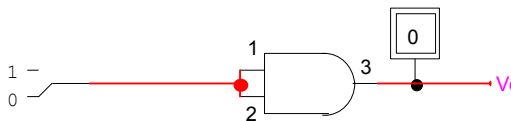


Fig.2

In the lab connect the circuit as shown in the figure using the switch S1-1 and LED-1 to verify the rule.

- c. Design a circuit that illustrates rule 10. Use clock generator of the PB-503 for A and one of the logic switches of S1 for B. Copy the circuit from LogicWorks and paste it in your lab report.
- d. Rule 6 illustrates that  $A+A'$  could be replaced with a wire to Vcc. What does rule 8 illustrate?
- e. Rule 11 states that  $A+A'B = A+B$ . Using LogicWorks design a circuit that illustrates each of these expressions.

$$A+A'B$$

$$A+B$$

Prove that these two circuits perform equivalent logic. (Connect two circuits and show that their outputs are the same).

## Procedure 2: Demorgan's Theorem

### Proof of equation (1)

Using LogicWorks construct the two circuits given in Figs.3 and 4 corresponding to the functions  $A' \cdot B'$  and  $(A+B)'$  respectively.

Show that for all combinations of A and B, the two circuits give identical results.

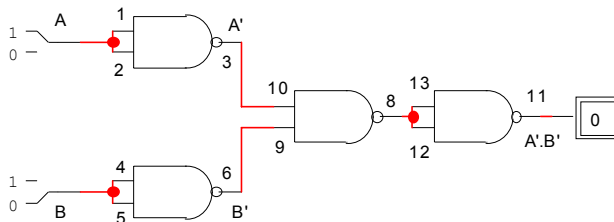


Fig.3

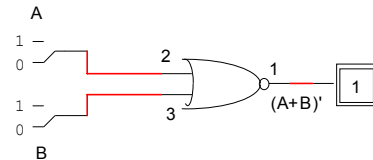


Fig.4

### Proof of equation (2)

Using LogicWorks construct two circuits given in Figs. 5 and 6, corresponding to the functions  $A'+B'$  and  $(A \cdot B)'$  respectively.

Show that, for all combinations of A and B, the two circuits give identical results.

In the lab connect these circuits and verify their operations.

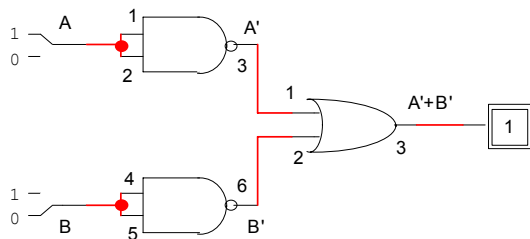


Fig. 5

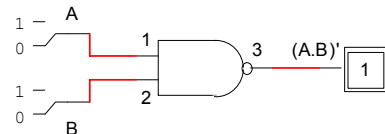


Fig. 6

## II. Design of a Digital Circuit

Consider the following problem:

Four chairs A, B, C, and D are placed in a row. Each chair may be occupied ("1") or empty ("0"). A Boolean function F is "1" if and only if there are two or more adjacent chairs that are empty.

1. Give the truth table defining the Boolean function F
2. Express F as a minterm expansion (standard sum of product)
3. Express F as a maxterm expansion (standard product of sum)

4. Using postulates and theorems of Boolean algebra, simplify the minterm expansion of  $F$  to a form with as few occurrences of each as possible.
5. Implement on LogicWorks for the pre-lab and then on PB-503, the simplified Boolean function with logic gates and check the operation of the circuit.

Notes:

- In LogicWorks use Binary Switches to represent the four chairs and connect the output of the circuit to a Binary Probe. Check that the Probe is “1” if and only if there are two or more adjacent chairs that are empty.
- For the hardware circuit in the lab, use logic switches S1-1, S1-2, S1-3, and S1-4 to represent the chairs and connect the output of the circuit to LED-1

**Result:**

Show all truth tables, circuits (using LogicWorks), etc. used in completing this experiment.