

## EXPERIMENT #5: IMPLEMENTATION WITH ONLY NAND GATES/NOR GATES

### OBJECTIVES:

- Design and implement logic circuits using only NAND gates
- Design and implement logic circuits using only NOR gates

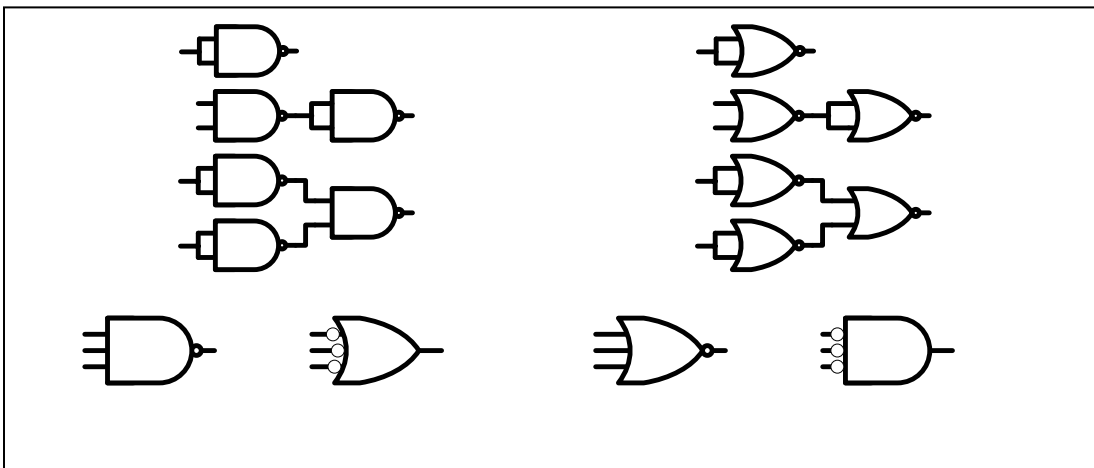
### Equipment and ICs:

- Mini-Lab ML-2001 lab station
- 1 - IC 7493 4-bit Ripple Counter
- 2 - IC 7400 Quadruple 2-input NAND gates
- 1 - IC 7410 Quadruple 3-input NAND gates
- 1 - IC 7420 Quadruple 4-input NAND gates
- 1 - IC 7402 Quadruple 2-input NOR gates
- 2 - IC 7427 Triple 3-input NOR gates

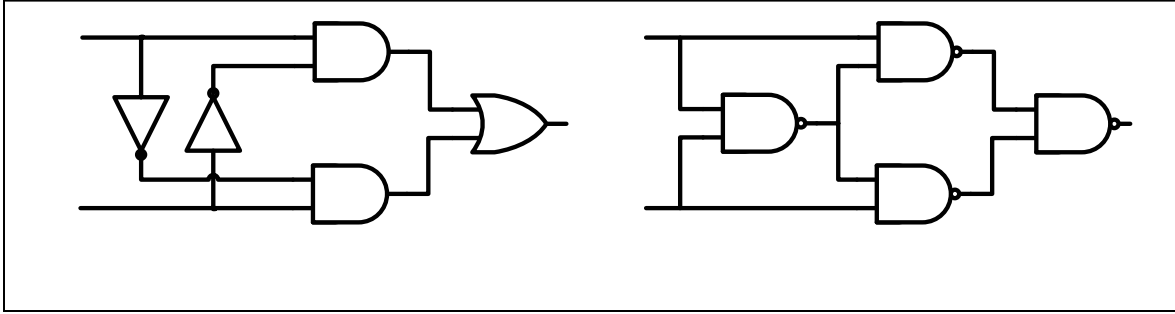
### Introduction:

#### **Implementation with only NAND gates or NOR gates**

Digital circuits are frequently constructed with NAND or NOR gates rather than with AND and OR gates. The logical operations of AND, OR, and NOT can be obtained with NAND or NOR gates only. Hence, NAND and NOR gates are called Universal gates because they can be used to implement any other type of gate.



**Part 1:**



**Pre-lab Work:** (All Pre-lab work must be shown in the Pre-lab report)

1. Obtain the Boolean expression for functions  $F_1$  and  $F_2$ .
2. Obtain the truth table for functions  $F_1$  and  $F_2$ .
3. What logic operation does each circuit perform?
4. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

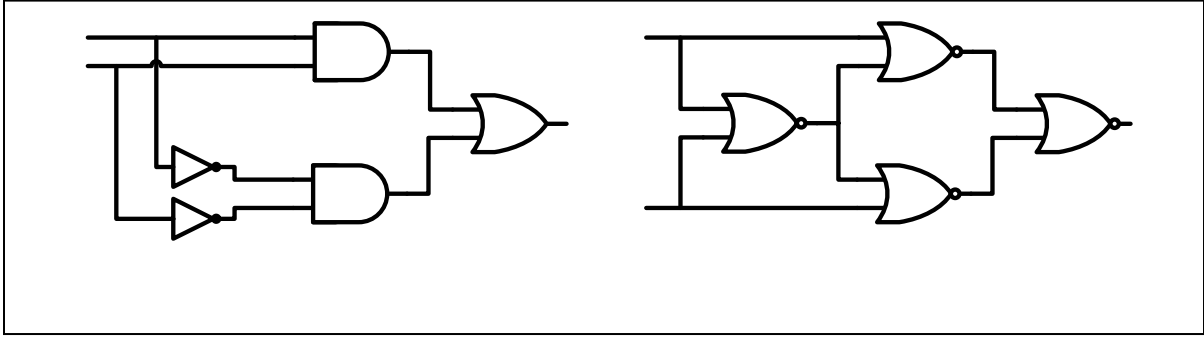
**Lab Work:** (All Lab work must be shown in the Lab report)

1. Implement the logic diagram of  $F_1$  on the proto-board.
  - a. Connect inputs X and Y to two switches.
  - b. Connect output F to one LED or indicator lamp.
2. Flip the switches On/Off, and verify the operation of the circuit for all 4 possible combinations of inputs X, and Y. Tabulate output values in a truth table.
3. Compare the truth table obtained above with the truth table obtained in Step 2 of Pre-lab Work.
4. Repeat Step 1, 2, and 3 above for function  $F_2$ .
5. Compare the cost of building the circuit for  $F_1$  with that of  $F_2$  in terms of the number of logic gates and ICs required to build each circuit.

**OBSERVATIONS:**



**Part 2:**



**Pre-lab Work:** (All Pre-lab work must be shown in the Pre-lab report)

1. Obtain the Boolean expression for functions  $G_1$  and  $G_2$ .
2. Obtain the truth table for functions  $G_1$  and  $G_2$ .
3. What logic operation does each circuit perform?
4. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

Y

**Lab Work:** (All Lab work must be shown in the Lab report)

1. Implement the logic diagram of  $G_1$  on the proto-board.
  - c. Connect inputs X and Y to two switches.
  - d. Connect output F to one LED or indicator lamp.
2. Flip the switches On/Off, and verify the operation of the circuit for all 4 possible combinations of inputs X, and Y. Tabulate output values in a truth table.
3. Compare the truth table obtained above with the truth table obtained in Step 2 of Pre-lab Work.
4. Repeat Step 1, 2, and 3 above for function  $G_2$ .
5. Compare the cost of building the circuit for  $G_1$  with that of  $G_2$  in terms of the number of logic gates and ICs required to build each circuit.

**OBSERVATIONS:**



**Part 3:**

A circuit has two outputs given by functions  $F$  and  $G$  as shown below:

$$F = wx + wxy + xyz' + wx'z + w'yz' + w'xyz$$

$$G = \Sigma (3, 6, 7, 10, 12, 13) + d (0, 8, 14, 15)$$

**Pre-lab Work:**

1. Obtain the truth table for functions  $F$  and  $G$ .
2. Obtain the most simplified SOP expression for the two functions.
3. Obtain the most simplified POS expression for the two functions.
4. Draw the logic diagram for each function **separately** using minimum number of NAND gates.
5. Draw the logic diagram for each function **separately** using minimum number of NOR gates.
6. Draw the logic diagram for the two functions **together** using minimum number of NAND gates.
7. Draw the logic diagram for the two functions **together** using minimum number of NOR gates.
8. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

**Lab Work:**

**NAND Implementation:**

1. Implement  $F$  and  $G$  together on the proto-board using minimum number of NAND ICs. Do not duplicate the same gate if the corresponding term is needed for both functions.
  - a. Connect the 4 outputs of IC 7493 to inputs  $w$ ,  $x$ ,  $y$ , and  $z$  and to four indicator lamps as shown in the figure below. (Remember that output  $Q_A$  is the least significant bit of the counter).
  - b. Connect outputs  $F$  and  $G$  to one LED each.

