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

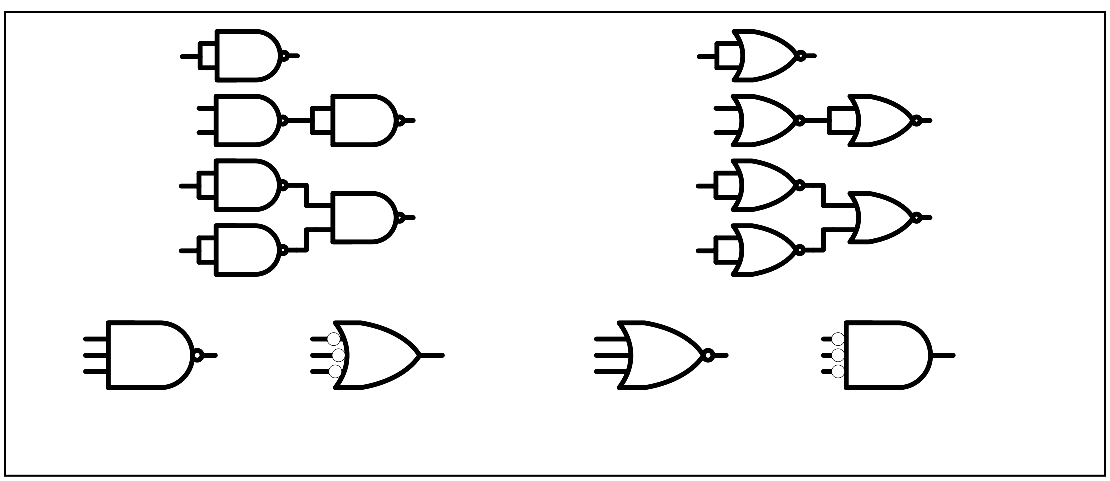
Equipment and ICs:

- 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

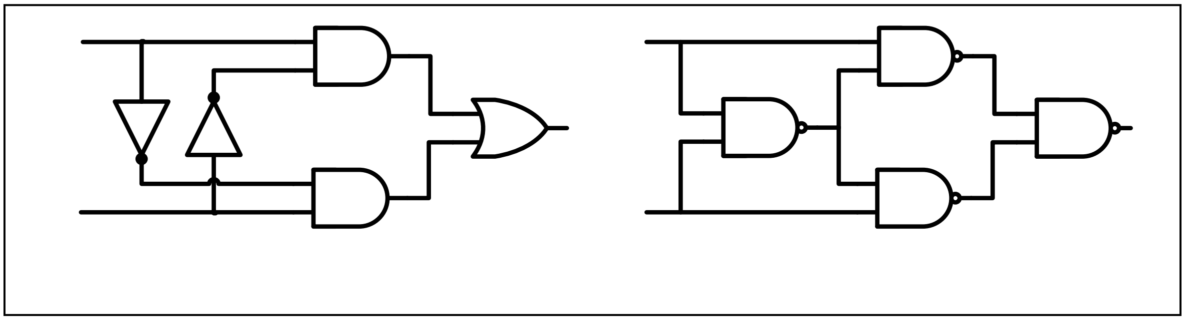
Introduction:

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)

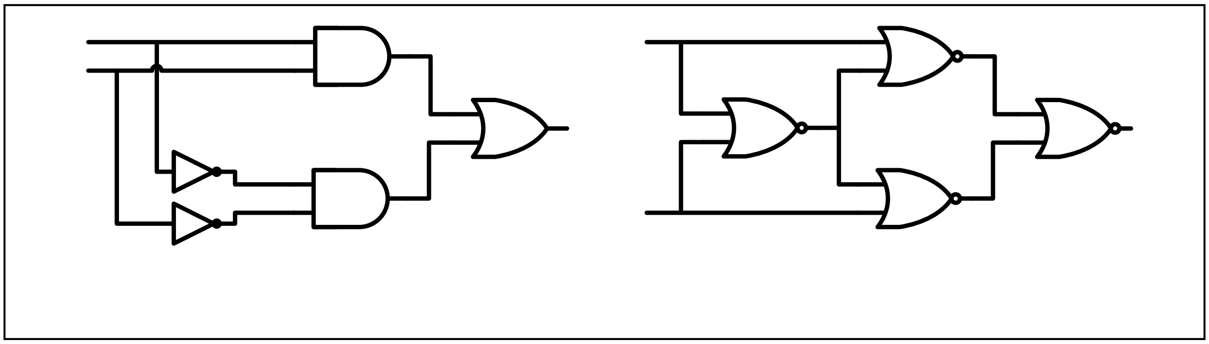
1. Obtain the Boolean expression for functions F_1 and F_2.
2. Obtain the truth table for functions F_1 and F_2.
3. What logic operation does each circuit perform?
4. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

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.

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:

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

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

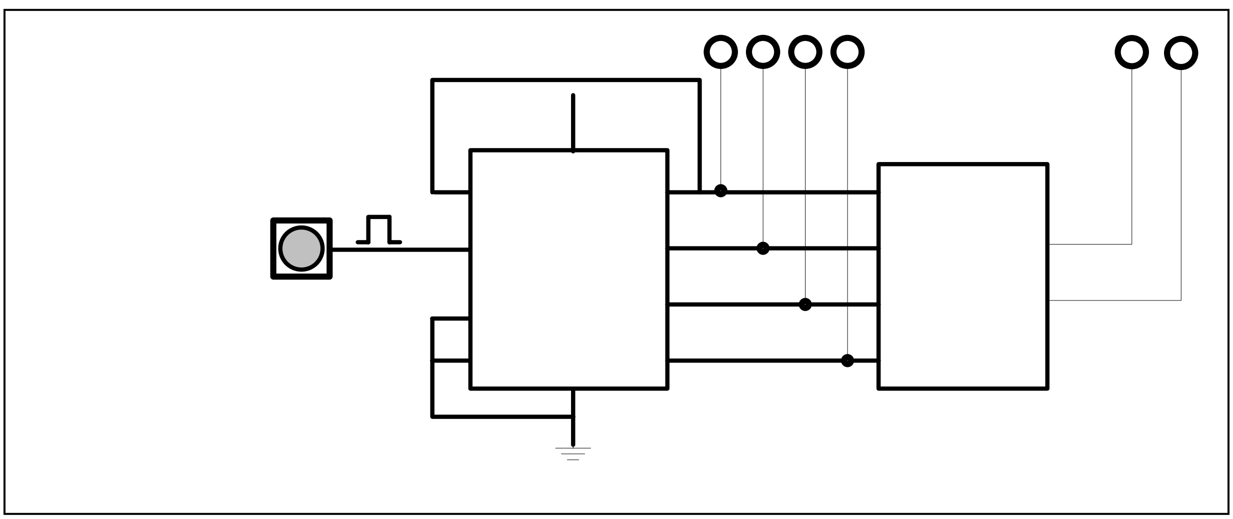
Pre-lab Work:

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.



2. Apply all 16 combinations (0000-1111) of 4 inputs to your circuit through IC 7493 by pushing the Pulser-button as many times. You can observe the input sequence on the 4 indicator lamps connected with the outputs of IC 7493.
3. Observe the outputs F and G for all combinations of inputs. Record your observations in a truth table.
4. Compare the truth table above with the truth table obtained in Step 1 of Pre-Lab work and verify the operation of the circuit.
5. Compute the cost of the circuit in terms of gates and ICs.

NOR Implementation:

6. Repeat all the above steps for functions F and G using minimum number of NOR ICs.
7. Compare the cost of building the circuit using NAND gates with that using NOR gates. Which one is more economical to build?

OBSERVATIONS:

