EXPERIMENT #2: LOGIC GATES AND BOOLEAN ALGEBRA

OBJECTIVES:

- Study the operation of basic logic gates
- Obtain Boolean expressions from a logic circuit
- Build a logic circuit from Boolean expressions
- Simplify Boolean expressions using Boolean Algebra theorems and postulates
- Obtain truth tables and compute circuit cost for logic circuits

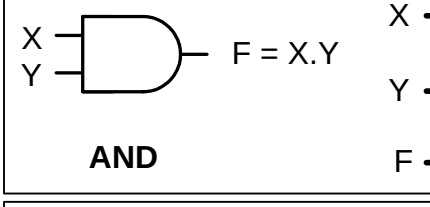
Equipment and ICs:

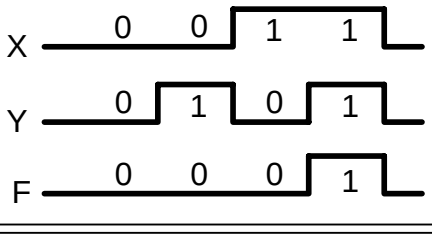
- Mini-Lab ML-2001 lab station
- 1 IC-7404 (Hex Inverters)
- 1 IC-7408 (Quadruple 2-input AND gates)
- 2 IC-7411 (Triple 3-input AND gates)
- 1 IC-7432 (Quadruple 2-input OR gates)
- 1 IC-7400 (Quadruple 2-input NAND gates)
- 1 IC-7402 (Quadruple 2-input NOR gates)
- 1 IC-7486 (Quadruple 2-input XOR gates)

Introduction:

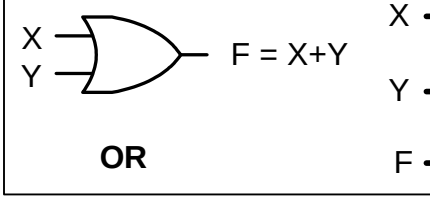
The three basic logic gates are AND, OR, and NOT. These logic gates are the building blocks of all digital circuits. Other logic gates such as NAND, NOR, XOR, XNOR are derived from the three basic logic gates. The graphic symbol, timing diagrams, and truth table for each logic gate is given below:

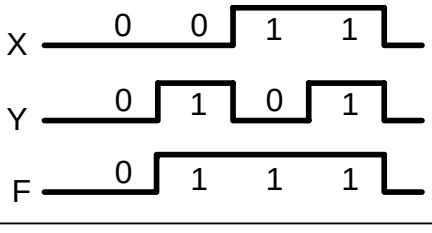
Graphic Symbol	Timing diagrams	Truth Table





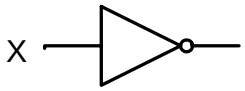
X	Y	F
0	0	0
0	1	0
1	0	0
1	1	1



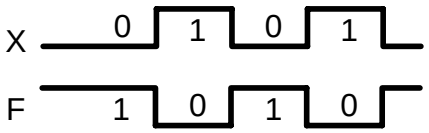


X	Y	F
0	0	0
0	1	1
1	0	1
1	1	1

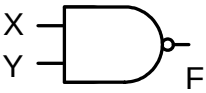
Graphic Symbol	Timing Diagrams	Truth Table



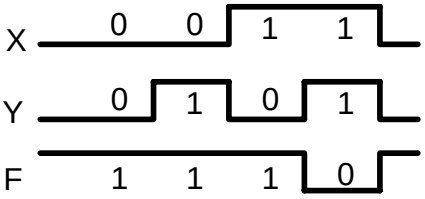
NOT



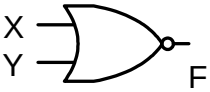
X	F
0	1
1	0



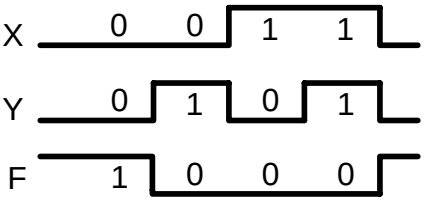
NAND



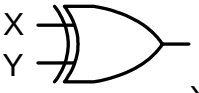
X	Y	F
0	0	1
0	1	1
1	0	1
1	1	0



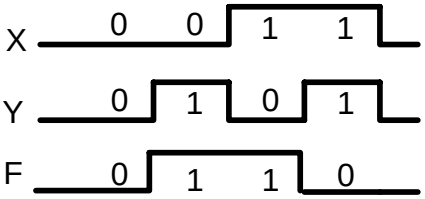
NOR



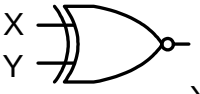
X	Y	F
0	0	1
0	1	0
1	0	0
1	1	0



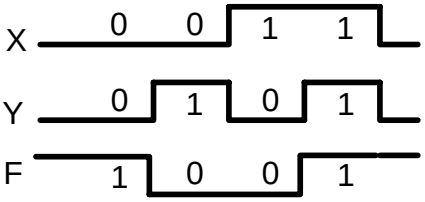
XOR



X	Y	F
0	0	0
0	1	1
1	0	1
1	1	0



XNOR



X	Y	F
0	0	1
0	1	0
1	0	0
1	1	1

Postulates and Theorems of Boolean Algebra

X + 0 = X	X.1 = X	
X + X' = 1	X.X' = 0	
X + X = X	X.X = X	
X + 1 = 1	X.0 = 0	
(X')' = X		Involution
X + Y = Y + X	XY = YX	Commutative
X + (Y + Z) = (X + Y) + Z	X(YZ) = (XY)Z	Associative
X(Y + Z) = XY + XZ	X + YZ = (X + Y)(X + Z)	Distributive
(X + Y)' = X'Y'	(XY)' = X' + Y'	DeMorgan
X + XY = X	X(X + Y) = X	Absorption

Part 1:

Pre-lab Work:

Review the logic operation, Boolean expression, and the timing diagrams of each of the logic gates: AND, OR, NOT, NAND, NOR, XOR, XNOR. See section **Introduction** above**.**

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

For the following logic gates, verify the logic operation each gate performs:

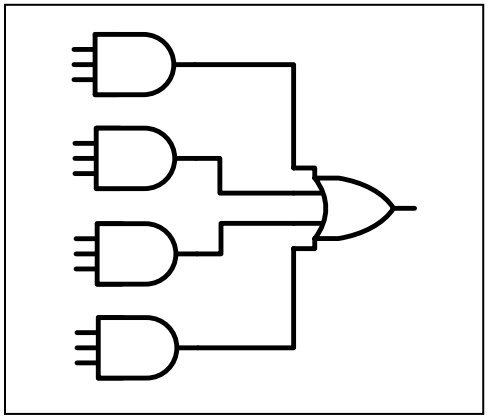
a. 2-input AND gate
b. 2-input OR gate
c. 2-input NAND gate
d. 2-input NOR gate
e. 2-input XOR gate
f. 2-input XNOR gate
g. Inverter gate

1. Connect logic gate on the proto-board.
    a. Connect the inputs to two switches (connect the NOT gate input to one switch)
    b. Connect the output to one LED or indicator lamp.

2. Flip the switches On/Off, and check the output LED. Verify the operation of the logic gate for all possible combinations of the inputs. Tabulate output values in a truth table. The output value is taken to be logic 1 if the output LED/Indicator Lamp is ON.

Part 2:

For the circuit shown in Figure 3, perform the following tasks:



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

1. Obtain the Boolean expression for F.
2. Obtain the truth table for F.
3. Simplify the function F to only four literals.
4. Draw the logic diagram of the simplified function, F_s
5. Obtain the truth table for F_s

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

1. Implement the logic diagram of F on the proto-board.
    a. Connect inputs A, B, and C to three switches.
    b. Connect output F to one LED or indicator lamp.
2. Flip the switches On/Off, and check the output for all 8 possible combinations of inputs A, B, and C. Tabulate output values for all inputs in a truth table.
3. Compare the truth table obtained in Step 2 above with the one obtained in Step 2 of Pre-lab Work.
4. Repeat Steps 1, and 2 for the simplified function F_s
5. Obtain the truth table for F_s and compare it with the truth table for F.
6. Compare the cost of building the circuit for F with that of F_s in terms of the number of logic gates and ICs required to build each circuit.

OBSERVATIONS:

