EXPERIMENT #4: SIMPLIFICATION OF BOOLEAN FUNCTIONS

OBJECTIVES:

- Simplify Boolean functions using K-map method
- Obtain Boolean expressions from timing diagrams
- Design and implement logic circuits

Equipment and ICs:

- Mini-Lab ML-2001 lab station
- 1 - IC 7493 4-bit Ripple Counter
- 1 – IC 7408 Quadruple 2 input AND gates
- 1 – IC 7432 Quadruple 2 input OR gates
- 1 - IC 7404 Hex inverters
- 2 - IC 7411 Triple 3-input AND gate

Introduction:

The design of a circuit starts from a set of specifications which may be in the form of a problem statement, a truth table, or even a timing diagram. If the behavior of a circuit is specified in the form of timing diagrams, we proceed by first obtaining the truth table from the timing diagrams. The function can then be plotted on the K-map and simplified for implementation.

Simplification of Boolean expressions using algebraic manipulation is tedious and time consuming, and lacks specific rules to predict each succeeding step in the manipulative process. The map method is an efficient and straightforward procedure for minimizing Boolean functions of up to 4 variables. Maps for more than 4 variables are not easy to use. However, we will be working only with functions of up to 4 variables.

Example: Synthesizing a Circuit from a Timing Diagram:

In this experiment, we will design a circuit whose specification is given in the form of timing diagrams.

Figure 1 below shows timing diagrams for function F.

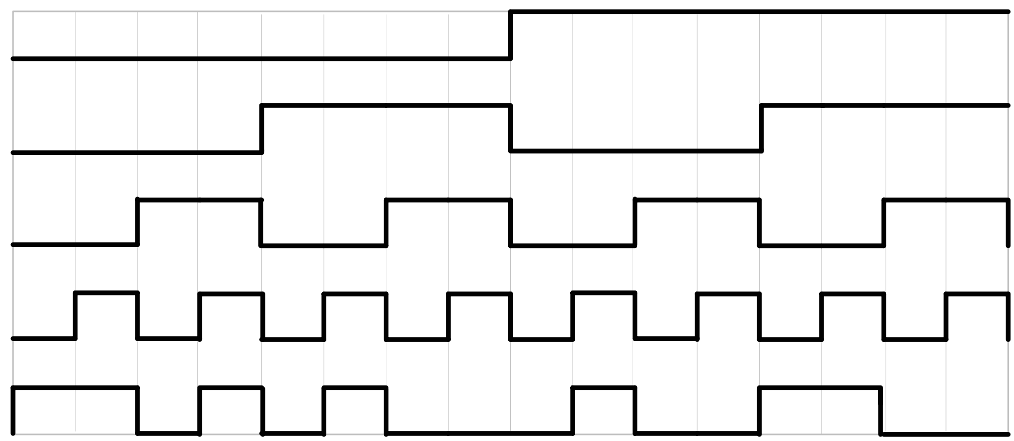
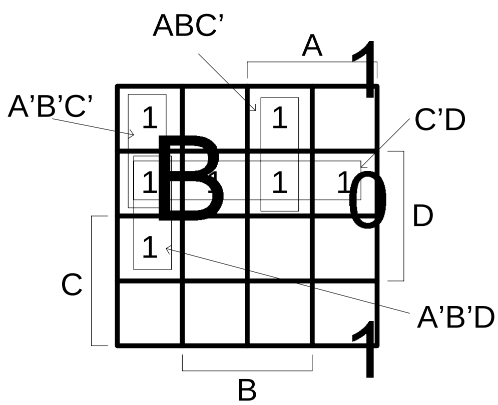


Figure 2 below shows the truth table obtained from the timing diagrams and the simplification of F using the map method.

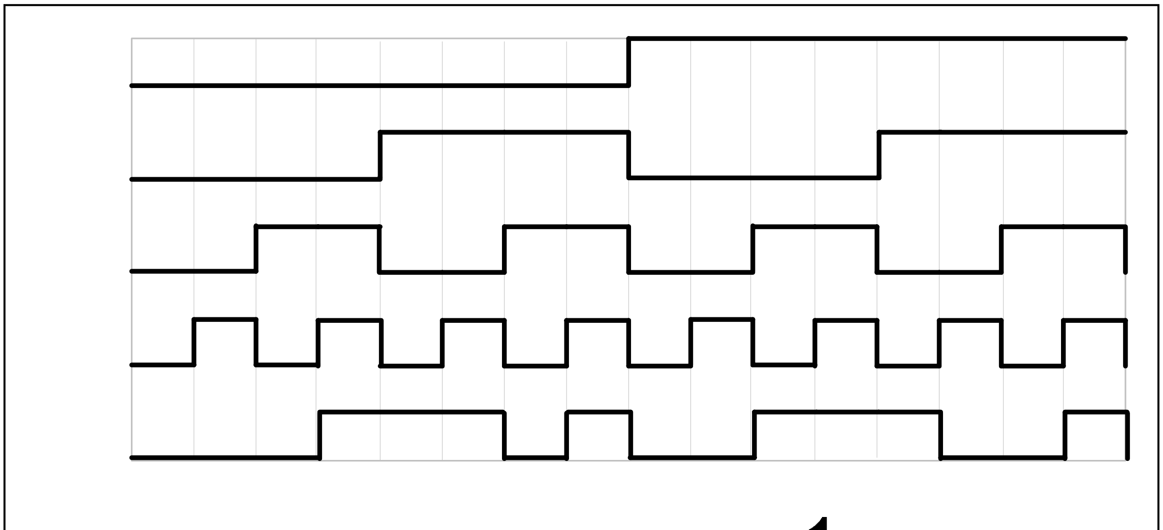
A	B	C	D	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0



F = A’B’C’ + A’B’D + C’D + ABC’

Figure 2

Part 1:



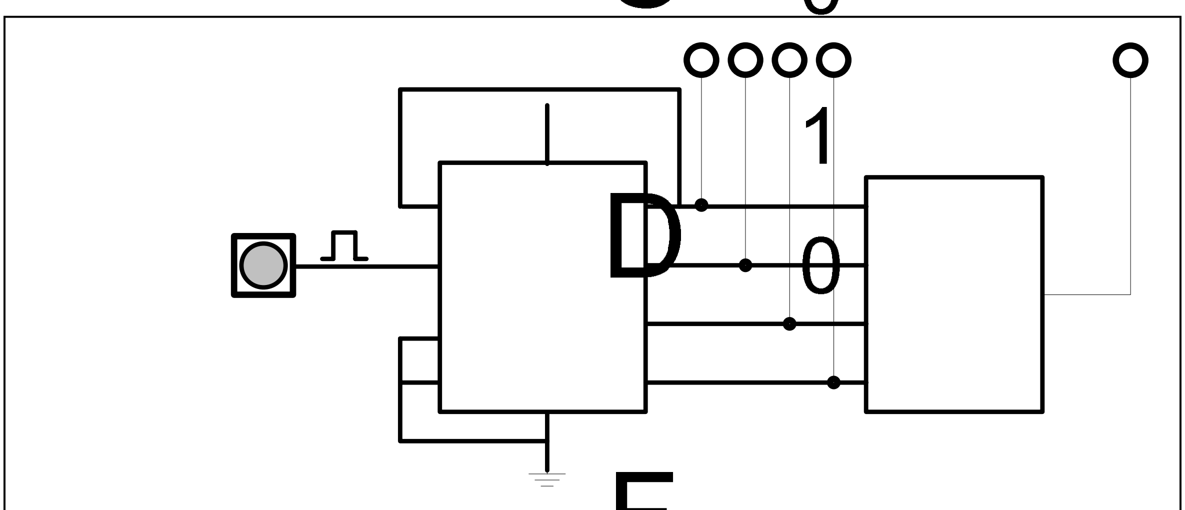
For the timing diagrams shown in Figure 3, perform the following tasks:

Pre-lab Work:

1. Obtain the truth table for F from the timing diagram.
2. Express function F as a Sum of Minterms expression.
3. Express function F as Product of Maxterms expression.
4. Find the minimum-cost SOP and POS forms for F using the map method.
5. Draw the logic diagram for F using the basic gates.
6. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

Lab Work:

1. Implement the logic diagram of F on the proto-board as shown below.
    a. Connect the 4 outputs of IC 7493 to inputs A, B, C, and D. (Remember that output Q_A is the least significant bit of the counter).
    b. Connect output F to one LED or indicator lamp.



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 to the outputs of IC 7493.
3. Observe the output F 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.

OBSERVATIONS:

A	B	C	D	F
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

Table: Circuit Cost

Function	Number of			
	Literals	Terms	Gates	ICs
F				

Part 2:

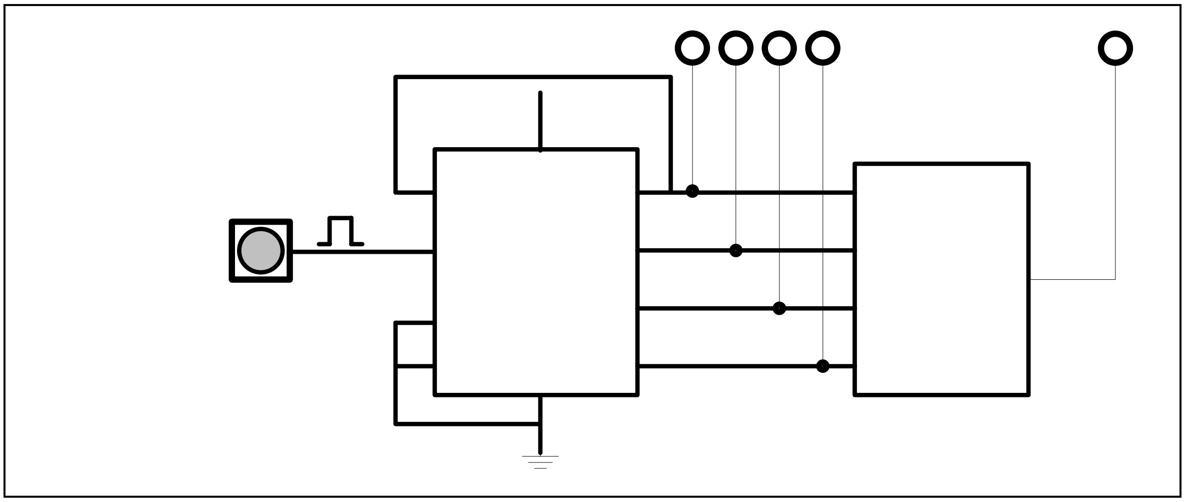
Design a circuit with output G and inputs x_1, x_0, y_1, and y_0. Let X = x_1x_0 be a number, where the four possible values of X, namely, 00, 01, 10, and 11, represent the four numbers 0, 1, 2, and 3, respectively. Similarly, let Y = y_1y_0 represent another number with the same four possible values. The output G should be 1 only if the number X is greater than or equal to the number Y.

Pre-lab Work:

1. Obtain the truth table for G.
2. Express function G as a Sum of Minterms expression.
3. Express function G as Product of Maxterms expression.
4. Find the minimum-cost SOP and POS forms for G using the map method.
5. Draw the logic diagram for G using the basic gates.
6. Draw and simulate your circuit in LogicWorks. Include your LogicWorks drawing in the pre-lab report.

Lab Work:

1. Implement the logic diagram of G on the proto-board as shown below.
   a. Connect the 4 outputs of IC 7493 to inputs x_1, x_0, y_1, and y_0. (Remember that output Q_A is the least significant bit of the counter).
   b. Connect output G to one LED or indicator lamp.



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 to the outputs of IC 7493.
3. Observe the output 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.

OBSERVATIONS:

x_1	x_0	y_1
0	0	0
0	0	0
0	0	1
0	0	1
0	1	0
0	1	0
0	1	1
0	1	1