Pre-Lab 4

Carefully read the entirety of Lab 4, then answer the following questions. Attach a separate sheet of paper, if necessary, to show all work and calculations.

1. Derive a minimum SOP or minimum POS expression for Circuit 5.

2. Derive a minimum SOP or minimum POS expression for Circuit 6.

3. Derive a minimum SOP or minimum POS expression for Circuit 7.

4. Derive a minimum SOP or minimum POS expression for Circuit 8.

5. Derive a minimum SOP or minimum POS expression for the red LED in Circuit 9.

6. Derive a minimum SOP or minimum POS expression for the yellow LED in Circuit 9.

7. Derive a minimum SOP or minimum POS expression for the green LED in Circuit 9.

Lab 4: Boolean Algebra

This lab will focus on minimizing circuits to make them as simple to build on a breadboard as possible.

For lab resources and information, go to the following URL or scan the QR code. doctor-pasquale.com/digital-systems-lab-4

4.1 Boolean Algebra

Boolean algebra refers to the type of mathematics that is used to express logical functions (using AND, OR, and NOT). It also contains many laws and theorems that can be used to minimize an expression. A minimum expression has the fewest terms and/or variables possible for any given logic function. The textbook outlines each of these laws and theorems, and explains how to find minimum expressions.

In lab, the goal is to make circuits as easy to wire as possible. This will make labs easier to wire. Because there are fewer parts, there will also be less to troubleshoot and debug.

Circuit 1: Fill out the following truth table for Mystery Box 1. When you have completed the truth table, show it to your instructor to receive a stamp. (You will derive a minimum expression, using Boolean algebra, in the lab homework.)

A	B	F
0	0	
0	1	
1	0	
1	1	

Instructor Stamp: _____

Circuit 2: Fill out the following truth table for Mystery Box 2. When you have completed the truth table, show it to your instructor to receive a stamp. (You will derive a minimum expression, using Boolean algebra, in the lab homework.)

A	B	F
0	0	
0	1	
1	0	
1	1	

Instructor Stamp: _____

Circuit 3: Fill out the following truth table for Mystery Box 3. When you have completed the truth table, show it to your instructor to receive a stamp. (You will derive a minimum expression, using Boolean algebra, in the lab homework.)

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

Instructor Stamp: _____

Circuit 4: Fill out the following truth table for Mystery Box 4. When you have completed the truth table, show it to your instructor to receive a stamp. (You will derive a minimum expression, using Boolean algebra, in the lab homework.)

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

Instructor Stamp: _____

Circuit 5: Build the circuit corresponding to the minterm expression given below. Draw your circuit diagram. Then, build the circuit and confirm that it operates as you expect it to. Demonstrate its functionality to your instructor to receive a stamp.

$$F(A, B, C) = \Sigma m(0, 1, 3, 6, 7)$$

Instructor Stamp: _____

Circuit 6: Build the circuit corresponding to the minterm expression given below. Draw your circuit diagram. Then, build the circuit and confirm that it operates as you expect it to. Demonstrate its functionality to your instructor to receive a stamp.

$$F(A, B, C, D) = \Sigma m(0, 1, 2, 6, 8, 9, 10, 13, 14)$$

Instructor Stamp: _____

Circuit 7: Build the circuit corresponding to the maxterm expression given below. Draw your circuit diagram. Then, build the circuit and confirm that it operates as you expect it to. Demonstrate its functionality to your instructor to receive a stamp.

$$F(A, B, C, D) = \Pi M(0, 3, 4, 6, 7, 11, 14, 15)$$

Instructor Stamp: _____

Circuit 8: Build the circuit corresponding to the maxterm expression given below. Draw your circuit diagram. Then, build the circuit and confirm that it operates as you expect it to. Demonstrate its functionality to your instructor to receive a stamp.

$$F(A, B, C, D) = \Pi M(0, 1, 2, 3, 4, 5)$$

Instructor Stamp: _____

Circuit 9: A row of parking spaces has 15 spots. If more than half are empty, a green LED (F_G) should light. If fewer than two spots are empty, a red LED (F_R) should light. Otherwise, a yellow LED (F_Y) should light. You receive a 4-bit binary number ($ABCD$) corresponding to the number of empty spaces. Design a circuit to fulfill this function. Draw your circuit diagrams. Then, wire the circuit on your breadboard and fill out the corresponding truth table. Demonstrate its functionality to your instructor to receive a stamp.

A	B	C	D	FR	FY	FG
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			

Instructor Stamp: _____

Lab 4 Homework

Carefully read each question before answering. Show all work or justify your answers to receive credit. Attach a separate sheet of paper, if necessary, to show all work and calculations.

1. Use Boolean algebra to find the minimum SOP or minimum POS expression for Mystery Box 1. Then, draw a circuit diagram of this simplified circuit.

2. Use Boolean algebra to find the minimum SOP or minimum POS expression for Mystery Box 2. Then, draw a circuit diagram of this simplified circuit.

3. Use Boolean algebra to find the minimum SOP or minimum POS expression for Mystery Box 3. Then, draw a circuit diagram of this simplified circuit.

4. Use Boolean algebra to find the minimum SOP or minimum POS expression for Mystery Box 4. Then, draw a circuit diagram of this simplified circuit.

5. Use Boolean algebra to convert $AB + CD + AC$ to a minimum POS expression. (Do a conversion; do not simply write up a truth table and derive the POS expression.)

6. Use Boolean algebra to convert $B'D + CD + BC'D'$ to a minimum POS expression. (Do a conversion; do not simply write up a truth table and derive the POS expression.)

7. There is an elevator in a two-story building. You know on which floor the elevator is at any time, and whether or not the buttons have been pressed on either the first or second floor. If a button has been pressed on the floor where the elevator already is, the door needs to open. If a button has been pressed on a floor where the elevator isn't, the elevator motor needs a signal to go either up or down. If both buttons have been pressed, the elevator doors must open before the motor moves in order to let people in on the current floor. Design three circuits (one to instruct the door to open, one to send the elevator up, one to send the elevator down). Clearly define each of the variables, including the significance of a 0 and 1 value. Show all work.