Kyle Frudakis

Logic and Design

Lab 1

Quartus II

Lab1_PETRIE-frudakis.bdf　　　Lab1_PETRIE-frudakis.vwf　　　Simulator Tool

OUTPUT　X

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Lab 1
X = BCD/ + BCD + AB/D/ + ABC/D/

A
B
C
D
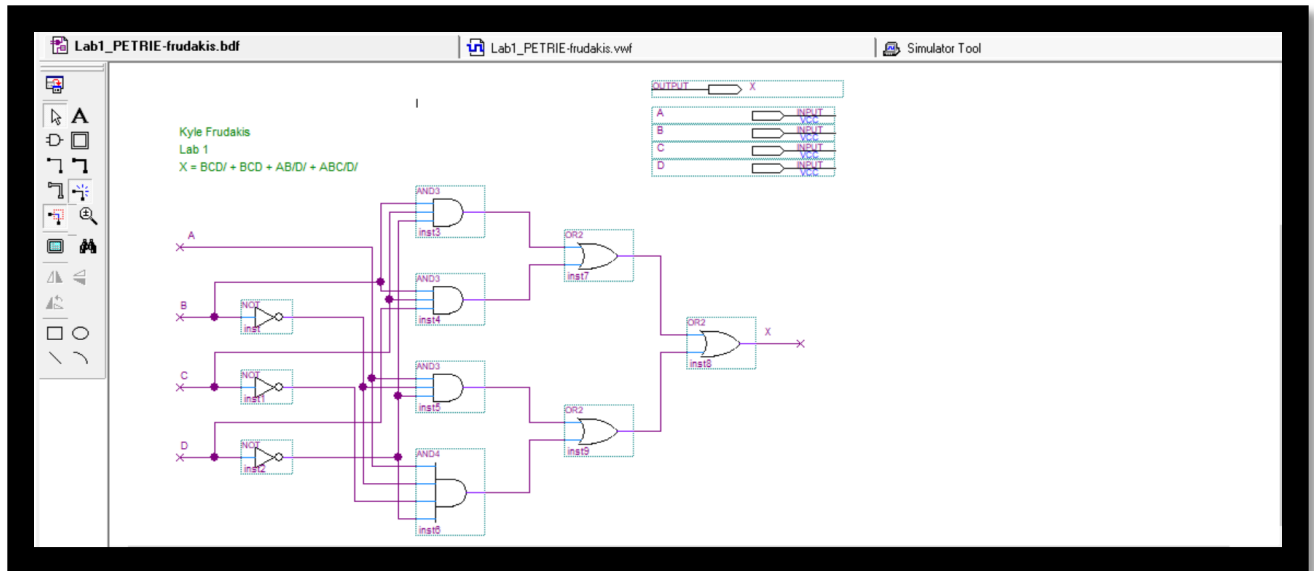
This circuit was the first attempt. There is a lot of cluttered wires at the beginning. I realized that the equation could be simplified.

Here is the Vector Wave form of the circuit above. It shows that the circuit gave the outputs that I wanted to get.

Lab1_PETRIE-frudakis.bdf　　　Lab1_PETRIE-frudakis.vwf　　　Simulator Tool

Master Time Bar: 0 ps　　Pointer: 33.34 ns　　Interval: 33.34 ns　　Start:　　End:

Name	Value at 0 ps	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111	0000	0001	0010
Inputs	B 000																			
X	B 0																			

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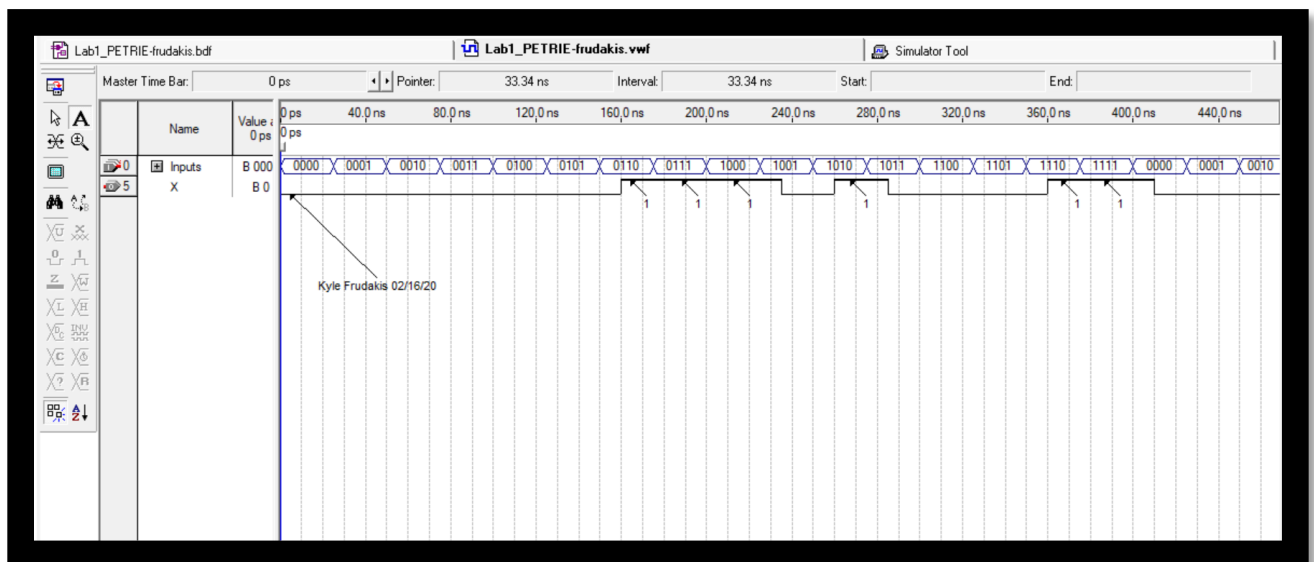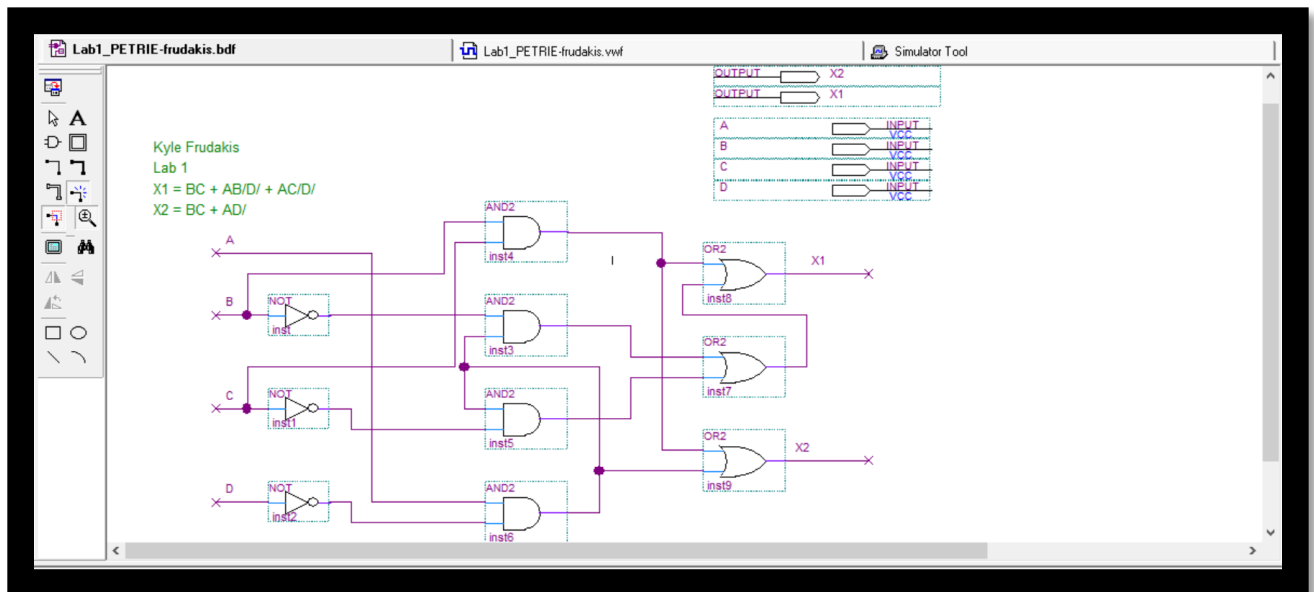
This is the simplified version of the circuit.
The wires are easier to follow.

It is clear to see that the same results appear even after some simplification.
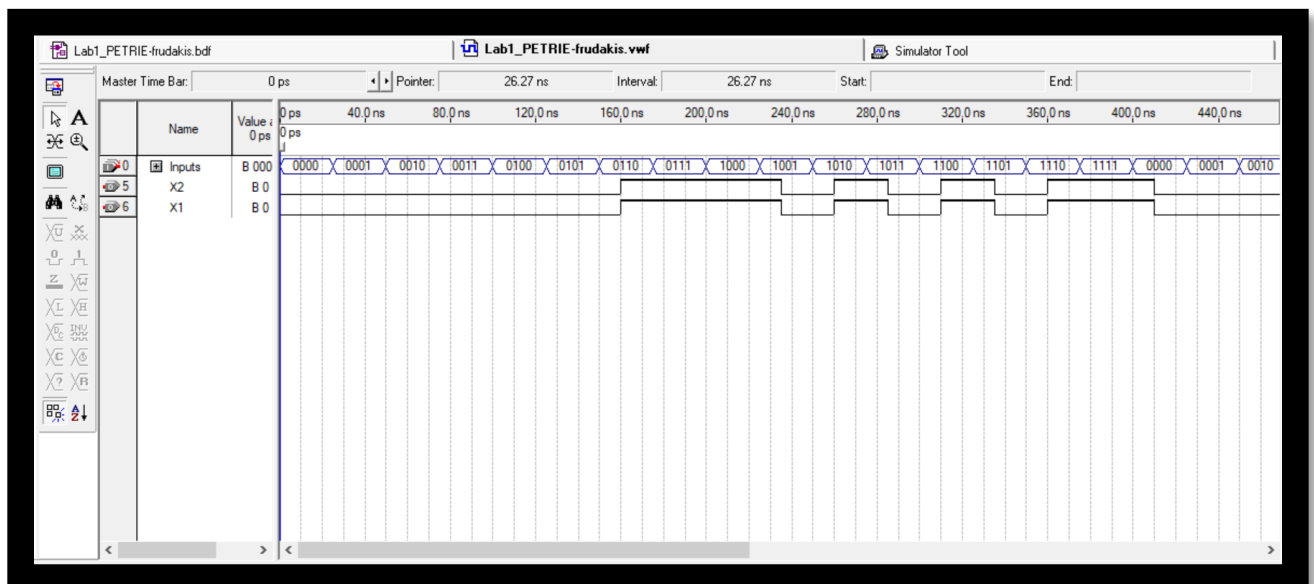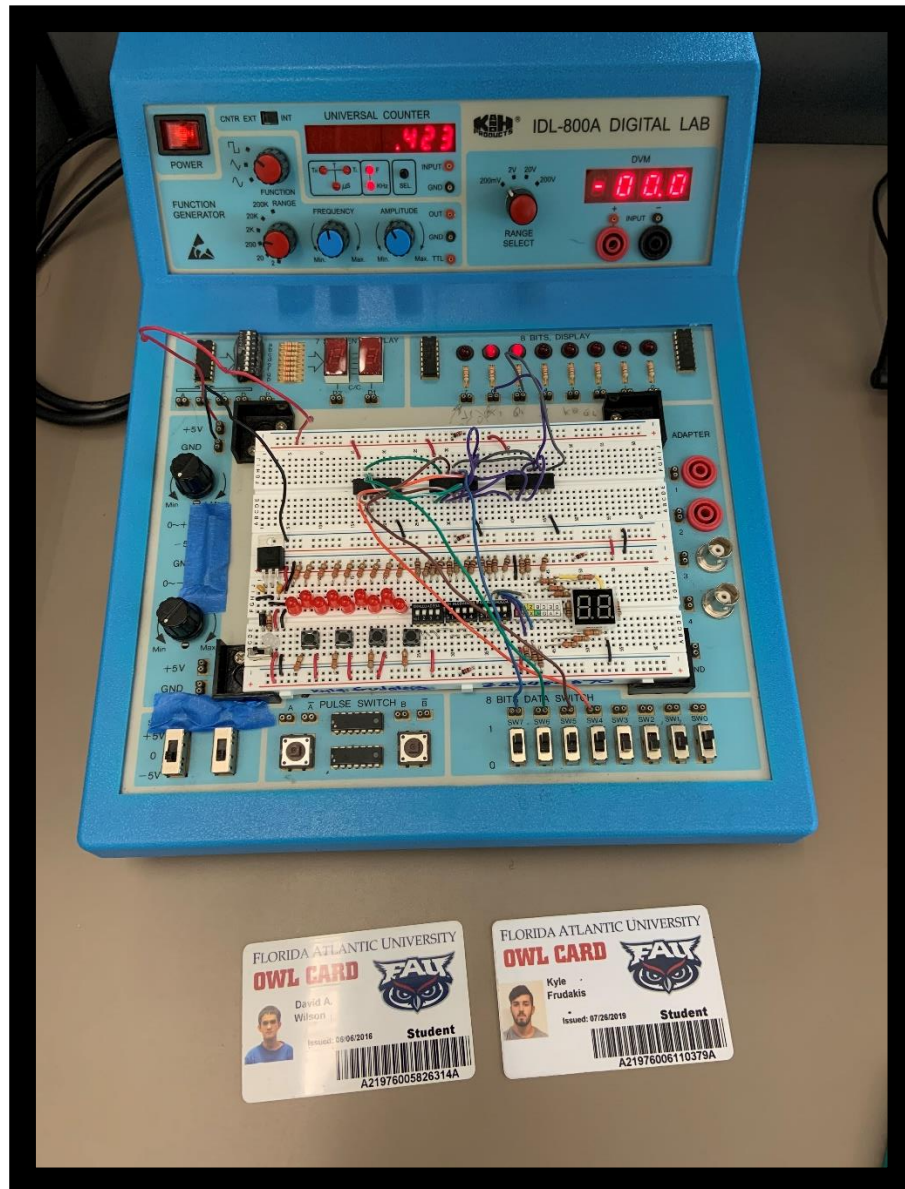
Here is a picture of the breadboard with the wires still in place. Note that this version is the simplified version in order to save wire and chips. The inputs are in the bottom right side of the board and the outputs are located at the top right. Two lights are on to give an example of a working situation.
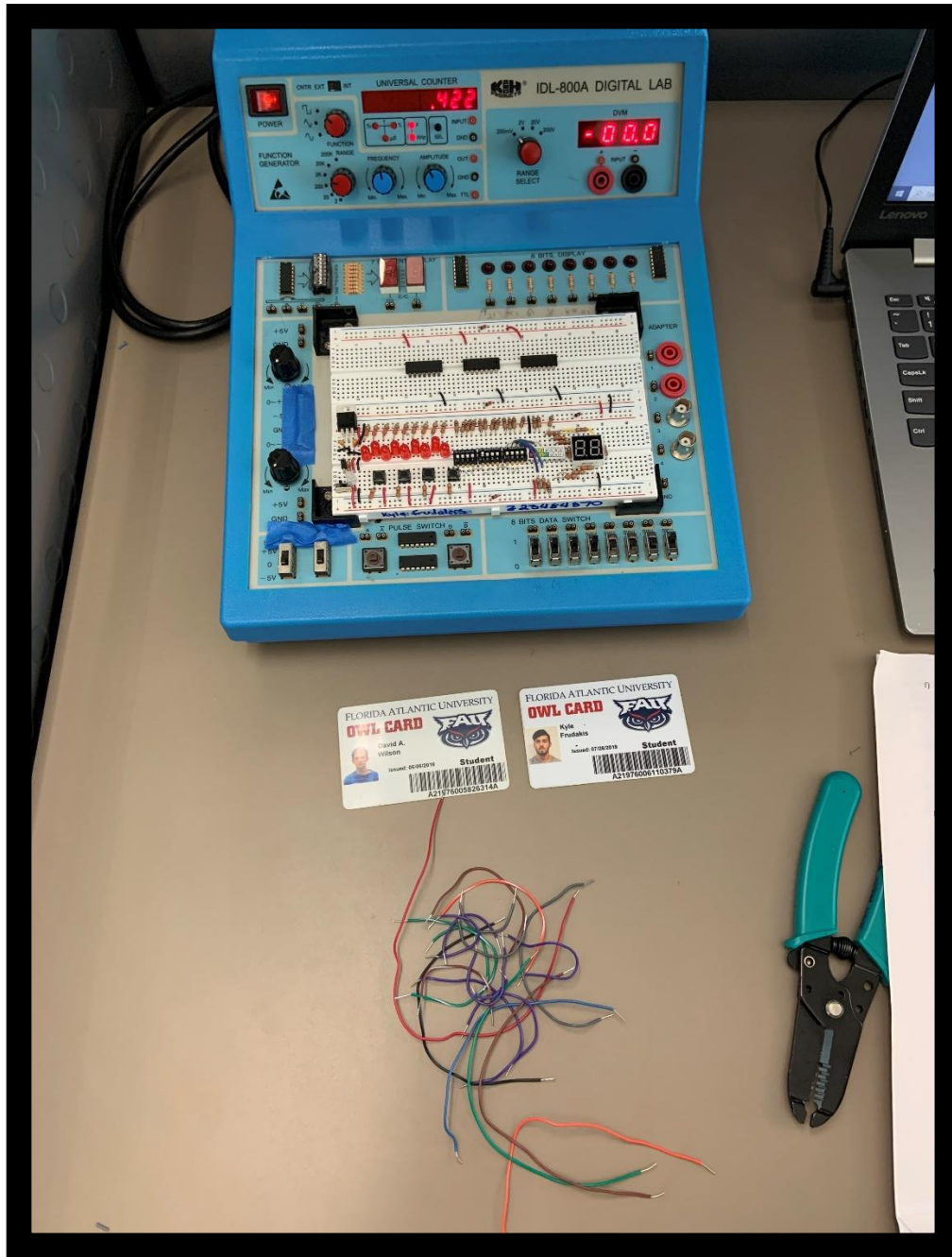
A picture of the breadboard is located above. I utilized only three chips as the bear minimum I needed. If I were to design the board with the original equation, I would need an "AND" chip with four inputs. Chips like that are more expensive and a waste of money for a project like this.

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*This lab assignment is based on, but greatly expands Lab 1 in the FAU Logic Design Lab Manual by Dr. Bassem Alhalabi.

The Problem: A security firm contracts you to build circuits that will let the guard know whether to open a door to a secure room. The engineer gives you the equation below, based on the value of 4 conditions: if it is a person (C=1), if it has badge (B=1), if it is a service animal or robot (A=1), if fingerprint is on file (D=1). The door will open (X=1), only if:

$$X = BC\bar{D} + BCD + A\bar{B}\bar{D} + AB\bar{C}\bar{D}$$

1.1 Construct the Truth Table (at right)

1.2 Plan the circuit: Plan the circuit in pencil using the template below. Outline and number only the gates needed, draw however many inputs are needed for each gate to implement X exactly as specified. Number each gate used 1, 2, 3 … How many gates do you need for this circuit?
NOT gates ____ AND gates ____ OR gates ____

ABCD	BCD'	BCD	AB'D'	ABC'D'	X
0000					
0001					
0010					
0011					
0100					1
0101					
0110					1
0111					1
1000					1
1001					
1010					
1011					
1100					1
1101					
1110					1
1111					

$$X = BC\bar{D} + BCD + A\bar{B}\bar{D} + AB\bar{C}\bar{D}$$

Look at the 7400 Series Family of Integrated Circuit in 1.4 on the next page. There are 2-input, 3-input and 4-input AND chips, but no 4-input ORs, so make the necessary changes to 1.2 in pencil to use only 2-input ORs.

1.3 Simulate the circuit: Create a project in Quartus called **lab1-PETRIE-yourlastname** following Dr. Petrie's step by step videos and guide. Create a new Block Diagram/Schematic (.bdf file) using the exact same name as the project. Construct the design you did in 1.2. Note there are no 4-input OR gate available. Save the schematic. Now follow the step by step to compile and correct any errors by correcting the .bdf file (don't worry about warnings). Save and compile again until no more errors. Generate a Timing Diagram (called Vector Waveform file, .vwf file), save with the exact same name as the project. Group the input variables and use the counter to set the values. Simulate. Make sure to save the project, the .bdf and .vwf files often. Check the .vwf to verify it produces same results as Truth Table 1.1. If it does not match the Truth Table, then determine if error is in the Truth Table or your design, or your Quartus Schematic. Save and keep the project and files to expand the Block Diagram with the rest of Lab 1. Take a picture or snip of the bdf and vwf windows including their file names for inclusion in the portfolio.

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The 7400 Series Family of Integrated Circuits (ICs)

1.4 Plan the wiring: Gates are packaged in ICs. Determine which and how many ICs from the 7400 Series family at right you will need to implement the circuit as you specified in 1.3 (Note there are no 4 input ORs in your kit so use 2-input OR ICs instead:

Quantity needed?	7400 Series IC #
1	7409
1	7411
1	7421
1	7432

Plan out the layout by numbering the gates used with the same number in your 1.2 plan. Labeling inputs and outputs of the gates or drawing the wiring use blue-A, Green-B, Brown-C, Orange-D, use the same color but dashed wire for NOT output. Note we don't have 4 input ORs in the kit, so we need to make due with using 2 input ORs. DO NOT WIRE X ON BREADBOARD.

1.6 Can circuit be simplified? Look at the handout on Boolean Algebra Postulates and Theorems. Identify by either writing the name or the equation of the postulate(s) or theorem(s) used to simplify.

$$X = BC\bar{D} + BCD + A\bar{B}\bar{D} + AB\bar{C}\bar{D}$$
$$= BC(\bar{D}+D) + (\bar{B}+B\bar{C})A\bar{D}$$
$$= BC\,(1) + (\bar{B}+\bar{C})A\bar{D} = BC + A\bar{B}\bar{D} + A\bar{C}\bar{D}$$
$$= BC + \overline{(BC)}A\bar{D} = BC + A\bar{D}$$

(handwritten notes: Factoring, Additive complement, multiplicative identity Or, distribution, DeMorgan's Law)

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As you verified in 1.a.6, the following Boolean function algebraically reduced to two different forms denoted below as X1 and X2 as follows.

$$X = BC\bar{D} + BCD + A\bar{B}\bar{D} + AB\bar{C}\bar{D}$$
$$= BC(\bar{D}+D) + (\bar{B}+B\bar{C})A\bar{D}$$
$$= BC + (\bar{B}+\bar{C})A\bar{D} = BC + A\bar{B}\bar{D} + A\bar{C}\bar{D} = X1$$
$$\text{or} = BC + \overline{(BC)}A\bar{D} = BC + A\bar{D} = X2$$

ABCD	BC	ABC	ACD	AD	X1	X2
0000						
0001						
0010						
0011						
0100					1	1
0101						
0110					1	1
0111					1	1
1000					1	1
1001						
1010					1	1
1011						
1100					1	1
1101						
1110					1	1
1111						

1.7 Construct the Truth Table: Verify the equivalence of X1 and X2 using the following truth table, note there are only 4 different subterms, 2 are the same, so list them only once in Truth Table. Compare it to the Truth Tale for X in 1.11 and verify they outputs are the same.

1.8 Plan the circuit with constraints: Design the circuit in pencil for the above two reduced functions, X1 and X2. However, there are constraints that you must abide by. Constraints: use exactly 3 NOT gates, 4 2-input AND gates, 3 2-input OR gates. Note: Look for things both equations have in common. After you are done, number the 10 gates used with 1, 2, 3, … 10, these numbers will be used in 1.10.

$$X1 = BC + A\bar{B}\bar{D} + A\bar{C}\bar{D}$$
$$X2 = BC + A\bar{D}$$

**1.9 Simulate:** Verify the circuit design/behavior by simulating the circuit using Quartus before you actually build the circuit on the breadboard. Open the Quartus project you build in 1.3 and add the X1 and X2 circuits to the X circuit Block Diagram / Schematic by drawing them below the circuit for X. Save. Compile. Debug if needed. Generate the Vector Waveform file adding the X1 and X2 outputs to it so it will display X, X1 and X2. Simulate. Check if all their waveforms are equivalent, X = X1 = X2. Save. Take a picture or snip of the new .bdf and .vwf files making sure to include the file name that is in the window in the picture or snip to include in the portfolio. The TA may ask you for these pictures at grading. If they do not, don't worry, I will add the Quartus points when I grade your portfolio.

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1.10 Plan your wiring of just X1 and X2: Use the following chip pin-out to conveniently plan your wiring X1 and X2 (not X, you do not wire X) on your breadboard with **constraint**: using exactly 1/2 7404 (3 NOT gates in the 74LS04), 1 7408 (4 AND gates in the 74LS08), and 3/4 7432 (3 OR gates in the 74LS32) chips on your breadboard. Number the gates used with the corresponding number of the gates in 1.8. Connect inputs ABCD to 4 DIP switches using the colors designated. Use white wire to connect the ANDs and ORs to output X1. Use yellow to connect the ANDs and ORs to output X2. This is done to make tracing and debugging easier. Test all the 16 different input combinations and observe the two outputs to be equivalent and matching the 1.1 and 1.7 Truth Tables.

Suggested color code
Inputs:
BLUE
GREEN
BROWN
ORANGE
In Between:
WHITE
YELLOW
Outputs:
GREY
PURPLE
Vcc and GND
RED
BLACK

$$X1 = BC + A\bar{B}\bar{D} + A\bar{C}\bar{D}$$
$$X2 = BC + A\bar{D}$$

(handwritten: A-blue, B-green, C-brown, D-orange, and so combo - white, output - yellow)

1.11 Implement: Use your wiring plan to wire the circuit on the breadboard, and check the output for all combinations of inputs in Table 1.1

1.12 Deploy: If you received extra parts in your kit to connect your circuit to your computer via USB. Follow the directions provided in the extra kit, go to the link provided, and create an account with your fau.edu email, select LACCEI Gallery, select FAU, select Logic Design, select Lab 0. It will guide you through a series of steps to test the circuit for each input, if you succeed, then you will see on your computer a guard and someone or something asking entrance to the security door, you will control with your circuit if the guard lets them in or not. You will now remove the wires to your input switches and press Submit on the screen. You will see if your circuit functions in the real world

1.13 Get it graded: Take a picture of the breadboard with your name showing, together with your ID and the ID of the TA grades it to submit as part of Lab 1 portfolio. After it is graded, you will be asked to pull the wires from your lab circuit. Do NOT pull the test platform wires just the ones in the upper breadboard. Leave the three ICs plugged into your board with power and ground connected. KEEP THE WIRES TO REUSE FOR NEXT LAB.

- CDA3201 • Introduction to Logic Design • Dr. Maria Larrondo Petrie Lab Assignment 1*

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1.14 Reflect on Impact: Examine the equations the engineer gave you for programming the lock mechanism, is it correct or can you think of a better equation? Why go through the trouble of simplifying a switching function? Engineering design projects can have very serious impacts. Consider the following areas, circle the ones your circuit could potentially impact. For the ones you circled, briefly discuss the impact you considered:

- **Public Health:**

- **Safety:** The circuit is all about safety. If it's too complicated, the designer could mess up & let people in who aren't suppose to get in

- **Global:**

- **Cultural:**

- **Social:**

- **Environmental:** The circuit lets the security guard know when the door is open so it creates a safe environment in the building

- **Economic:**

1.15 Submit your portfolio to Canvas: To get all your lab points, you need to get your lab graded by the Teaching Assistant (TA), and submit under Canvas > Assignment > Lab 1 a **portfolio** (report) consisting of one pdf file that includes:
- Header: Cover page or header with your name, my name, number, Logic Design class and class section
- Handwork: copy of planning work you did by hand (take picture of this worksheet or annotate this pdf electronically)
- Simulation: a copy of the work you did in Altera Quartus
  - Schematic do all 3 circuits in one schematic window, must include comment with your name and Z#, the file name must include your name as part of the file name so it appears on the schematic screen window. You can take a picture of the screen or use Snipping Tool under Start menu to capture the pertinent part of the screen containing the Block Diagram window with the file name containing your name.
  - Vector Waveform simulation (simulated timing diagram) a picture or screen shot that include output for all 3 circuits in the Vector Waveform window with the file name containing your name.
- Wiring: a picture of your breadboard with the wired circuit and your FAU OWL card (if you got it graded in the lab also include with TA OWL card and make sure the name and Z# written on your board are showing).
- Link to Video demo required only for online students who cannot come to campus to get labs graded by TA in EE-203. Enter this video link also under Lab 1 Online Grading assignment.

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These last five pictures are of my handwritten work. They provide the circuit designing of both version of my circuit as well as their truth tables. A layout of how the wires are to be put around the chips for both examples are within my handwritten work.