Jeide, Matthew Date 11/5/2024 Period 2

W12 DE 2.1.1 Part B AOI Design: Truth Tables to Logic Expressions

Read the introduction in each section carefully.

INTRODUCTION

The first step in designing a new product is clearly defining the design requirements or design specifications. These design specifications detail all of the features and limitations of the new product.

In digital electronics, the process of translating these design specifications into a functioning circuit starts with the creation of a **truth table**. A truth table is simply a list of all possible binary input combinations that could be applied to a circuit and the corresponding binary outputs that the circuit produces. Once the truth table is complete, a Boolean expression can easily be written directly from the truth table.

In this activity you will learn how to translate design specifications into truth tables, and in turn, write unsimplified logic expressions from these truth tables.

In future activities we will learn how to use Boolean algebra, as well as a graphical technique called Karnaugh mapping, to simplify these logic expressions.

Procedure

Truth Tables to Logic Expressions

Observe the truth table and its unsimplified logic expression.

A	B	Z	Minterms
0	0	0	
0	1	1	$\overline{A}B$
1	0	1	$A\overline{B}$
1	1	0	

$$Z = \overline{A}B + A\overline{B}$$

Figure 1. Truth Table and Minterm

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Seat Belt Alarm Circuit

Now that you understand the mechanics of converting from a truth table to a logic expression (and vice-versa), let's revisit a circuit design we were introduced to in Unit 1. Your new car has an audio alarm that buzzes whenever the *door is open* and the *key is in the ignition* or *when the key is in the ignition* and *the seat belt is not buckled*.

3. Using the following variable names and assignment condition complete the truth table that captures the functionality of this audio alarm.

- D: Door → 0 = Door Open / 1 = Door Close
- K: Key → 0 = Key Not in Ignition / 1 = Key in Ignition
- S: Seat Belt → 0 = Not Buckled / 1 = Buckled
- B: Buzzer → 0 = Buzzer Off / 1 = Buzzer On

Double click image below to enter the values.

D (Door)	K (Key)	S (Seat Belt)	B (Buzzer)
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Figure 2. Truth Table

Multisim Design
Functions with Minterms: F_1=

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4. Using the truth table you created in the prior step, write the un-simplified logic expression for the buzzer (i.e., variable B). Be sure that your answer is in the **Sum-of-Products** form.

Note: Subsequent activities, you will see that this logic expression can be simplified to:

$$B = \overline{D}\,K + K\,\overline{S}$$

Some of you may have been able to extract this simplified logic expression directly from the specifications. If so, you may be asking yourself, "Why did I have to go through the process of creating the truth table and writing the unsimplified logic expression first? This was a simple problem." As you progress through this class, the design problems will become more difficult. The process that you are learning now will become invaluable in solving more challenging problems.

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Humidity Sensor Circuit

A person with a green house would like you to design a digital **logic circuit** that monitors the conditions in the green house. The room temperature is monitored by a temperature sensor and the humidity is monitored by a humidity sensor. The air quality of the room is monitored by a special sensor that measures air particle density. The three sensors output a one (1) to indicate an out-of-range condition. Located outside of the room is an ALERT light that is on (1) whenever two or more sensors are out of range.

5. Create a truth table that captures the functionality of this room monitoring system.

T	**H**	**Q**	**F_1**
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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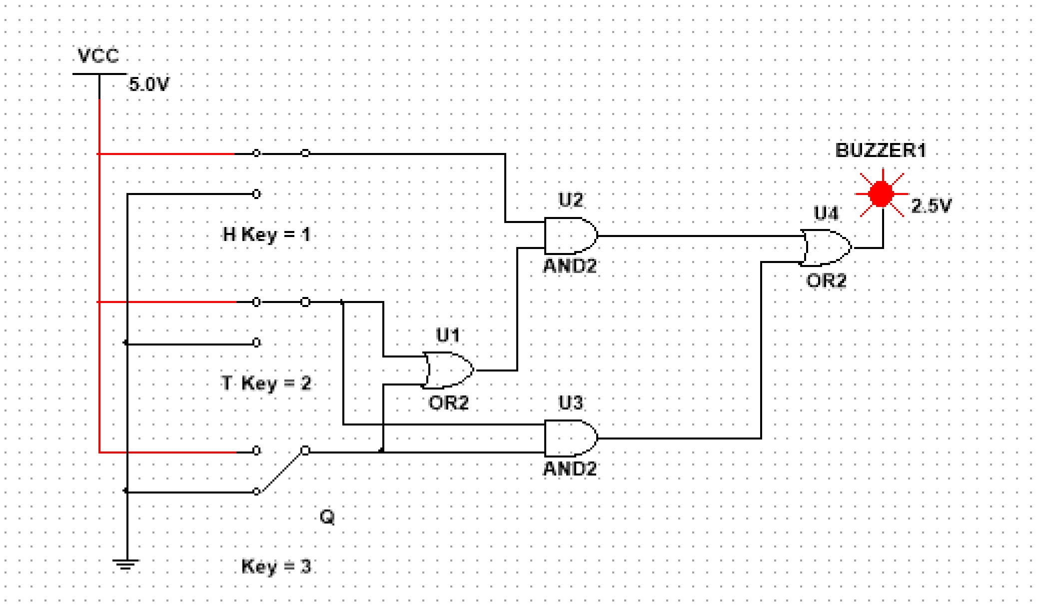
6. Using the truth table that you just created, write the unsimplified logic expression for the ALERT light so that your answer is in the Sum-of-Products form.

$F_1 = H(T + Q) + TQ$



CONCLUSION

A digital logic circuit with two inputs has four input combinations. One with three inputs has eight combinations. One with four inputs has 16 combinations.

1. How many input combinations would a digital logic circuit have if it has five inputs? How about six inputs?

2 ** 5 = 32
2 ** 6 = 64

2. Mathematically express the relationship between the number of input (N) and the number of input combinations (C).

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$C = 2^N$

3. Write the unsimplified logic expression for the truth table below.

$$Z = \overline{XY} + \overline{X}Y + X\overline{Y} + XY$$

X	Y	Z
0	0	1
0	1	1
1	0	1
1	1	1

