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EE 231 – Logic Circuit Design

Smart Home Control System

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Abstract

Our project will provide an exceptional implementation of a control system using logic gates. In addition, the information that we studied in this course will be adequately used. This control system is related to the intelligent home system but simpler for this level because it is constructed in a simplistic form to distinguish particular ideas and become a beneficial application of our study. All the work will be done by hardwired components, Multisim, and Tinkercad. The truth table, K-maps, circuit diagrams, our analysis, and possible future development suggestions will be provided.

The Content

Introduction

A lot of us heard about control systems, this common term in the electrical engineering field. However, it is an essential part of any modern house or organization. These days, many of us might see or read about the smart home. These unique types of institutions are very satisfying, helpful, beneficial, and attractive. In our project, we want to give a simple representation of some of the features of these intelligent systems, including an AC, Curtains, check-in/out, Coffee Maker, and any other possible application related. The following section will be a theoretical part that explains our ideas and clarify them. Then, we will use logic gates in our designs. We will provide their truth tables, K-maps, and logical expressions. All that will be done in a simulation using Multisim, Tinkercad, and hardwired components. In the end, we will provide some suggestions for some future characteristics that could be added to this project.

Theory

We will discuss in this section what is our input, output, and what functions are used.

- ### Input

The input of this project will be referring to a certain logic value that is measured differently, maybe a sensor, a push-button, a timer, or any other procedure. And our inputs are:

1- Door Button: it will be 1 if the person changes the switch button to the (check-in) side, and 0 if it is on the (check-out) side. So, a switch button could be used. In addition, it has a lock that can be activated using a save button that works as a clock switch to save the password of the lock.

2- Time: it is 1 when the sun rises until the sunset, and 0 if the reversed. It can be controlled by a light sensor or a programmable timer. Any device used to control the time needs to be adjustable by the user.

3- Temp: it becomes 1 when the temperature is equal to or above the specific value (25 Celsius as an example) and 0 when under it. The specific value can be commanded by the owner or the renter. This temperature can be determined by a temperature sensor from any wanted type.

- ### Output

Our outputs are shown in form of a digital lamp, but in a real, complete, and modern intelligent system, they will be presented appropriately. And the outputs are:

1) Lights: the lights of the house shines when it is 1. Contrary, they will be off when the value is 0. They can be presented using LEDs or any lighting tool.
2) AC: it refers to the air conditioning system. It will be on 1 when the person is in the house. Also, the temperature is 1. It will be 0 otherwise. Its working function can be edited as needed.
3) Curtains: 1 value means they will be open. So, 0 will mean that they are closed. They can be any kind of curtains, and the procedure characteristics can be changed as needed (time of opening or closing, one side or two sides, etc.).
4) Coffee Maker: It will make the coffee (1 value) when the person is in the house and at the sunrise (when the time is 1), and vice versa. The

making time can be controlled manually if any other time is preferred.

- Truth Table

Inputs			Outputs			
Door Button	Time	Temp	Lights	AC	Curtains	Coffee Maker
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	0	0	0
1	0	0	1	0	0	0
1	0	1	1	1	0	0
1	1	0	0	0	1	1
1	1	1	0	1	1	1

Table 1 – Inputs & Outputs

- K-maps

Door Button = X, Time = Y		
Lights (K-map)		
X\Y	0	1
0	0	0
1	1	0
Lights = XY'		

Table 2 – Lights K-map

Door Button = X, Time = Y		
Curtains (K-map)		
X\Y	0	1
0	0	0
1	0	1
Curtains = XY		

Table 3 – Curtains K-map

Door Button = X, Time = Y, Temperature = Z				
AC (K-map)				
X\YZ	00	01	11	10
0	0	0	0	0
1	0	1	1	0
AC = XZ				

Table 4 – AC K-map

Door Button = X, Time = Y		
Coffee Maker (K-map)		
X\Y	0	1
0	0	0
1	0	1
Coffee Maker = XY		

Table 5 – Coffee Maker K-map

- Logical Expressions

After writing down the K-map for each output we conclude the following equations:

- **Lights** = Time'*Door
- **AC** = Temp*Door
- **Curtains** = Time*Door
- **Coffee maker** = Time*Door

- Door Lock

When we finished planning, we have added a door lock to the system to make more beneficial and its features are the following:

1- The Function Table:

Save	Code0 to Code4 (any combination)	Door Button
0	X	0
1	A specific combination	1
0 or 1	The same combination	1
0 or 1	A different combination	0

Table 6 – Door Lock function table

2- The Logical Expression:

Door Button = (C0⊕Q1)' * (C1⊕Q2)' * (C2⊕Q3)' * (C3⊕Q4)'

Multisim Simulation

Using the logical equations that we have got from the previous part; we were able to set up this simulation using Multisim.

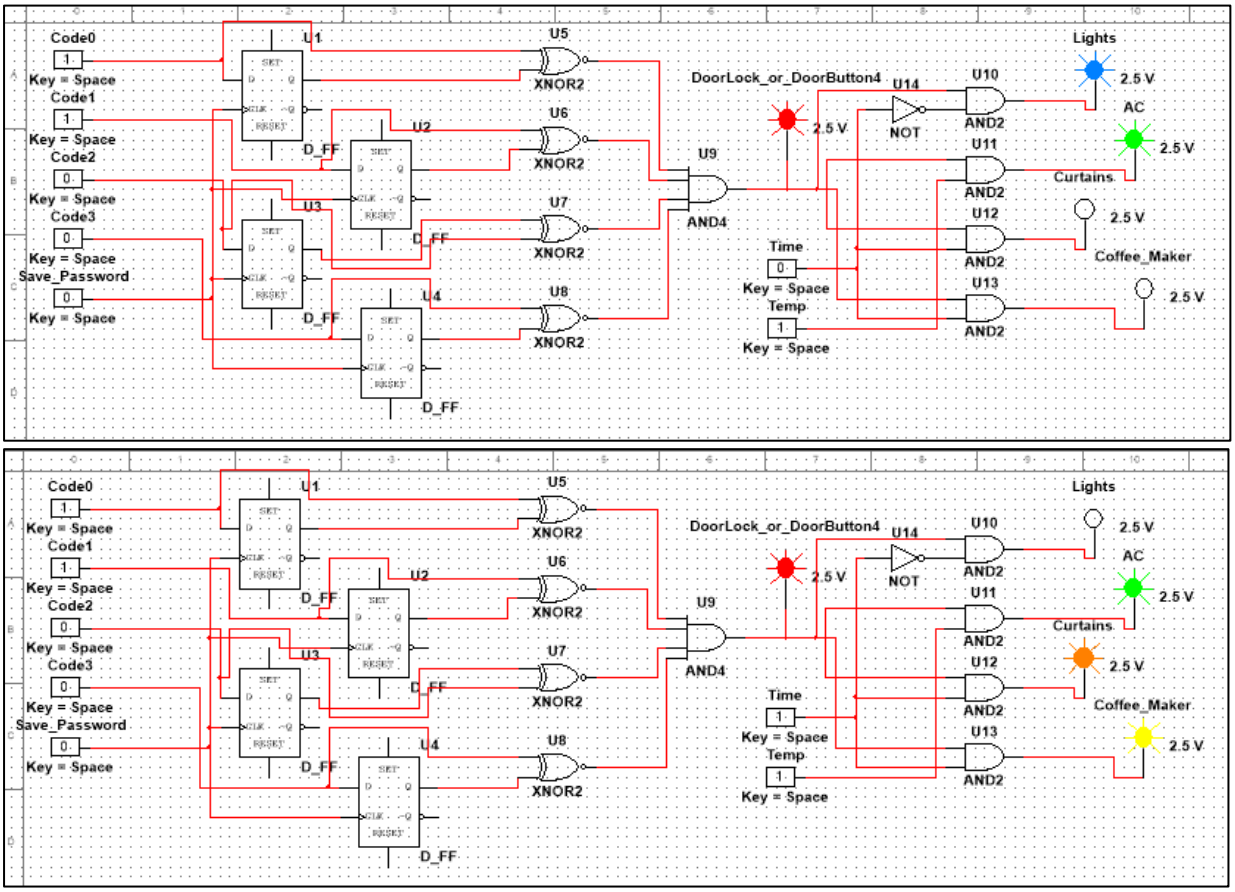

Figure 1 –Multisim Simulation of the Project – with Door Lock

Hardwired Components

After the simulation, we were able to construct a hardwired circuit using multiple gates, switches for the inputs, and small lights for the outputs. Due to some limitations, we could not set up the whole circuit like the simulations. However, here is what we have created:

- Hardwired Set-up

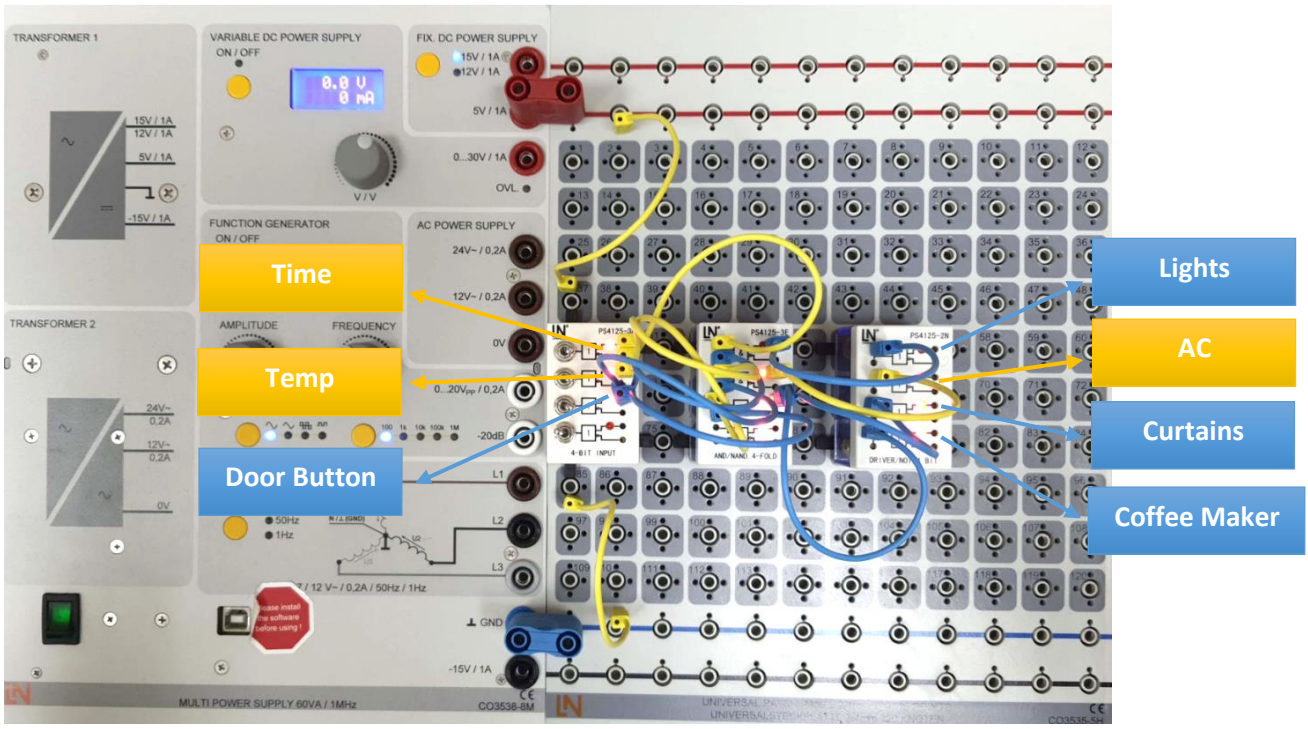

Figure 2 - A top-down picture showing how the circuit was set up

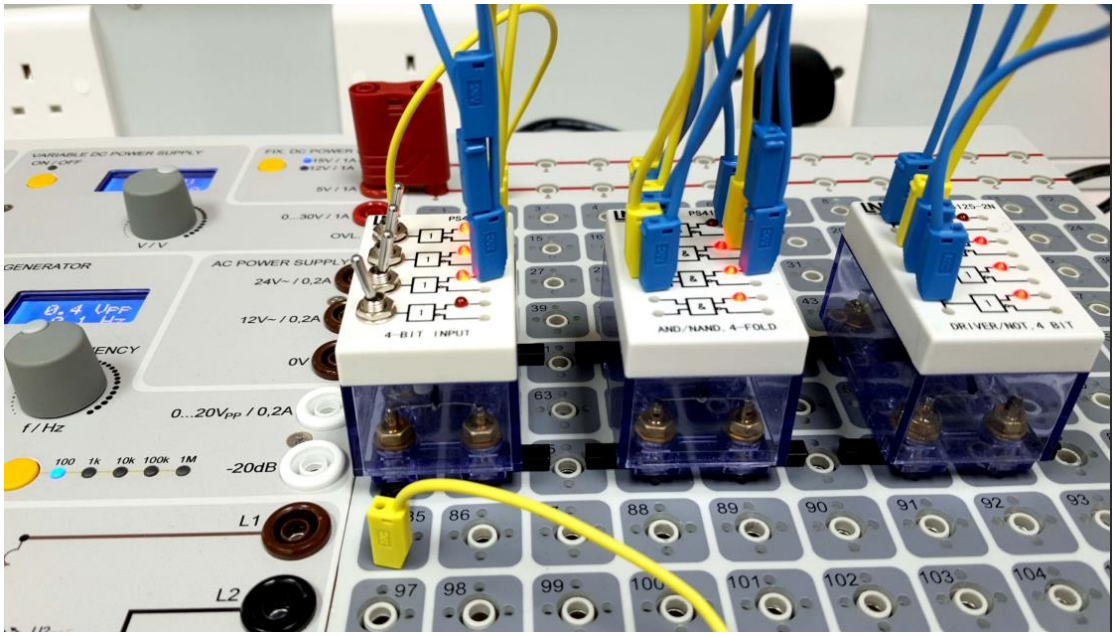

Figure 3 - A side-view picture showing all the inputs and outputs

Tinkercad Simulation

In this section, we will represent our project simulation in Tinkercad to make it more realistic and more applicable. The following figures demonstrate our words:

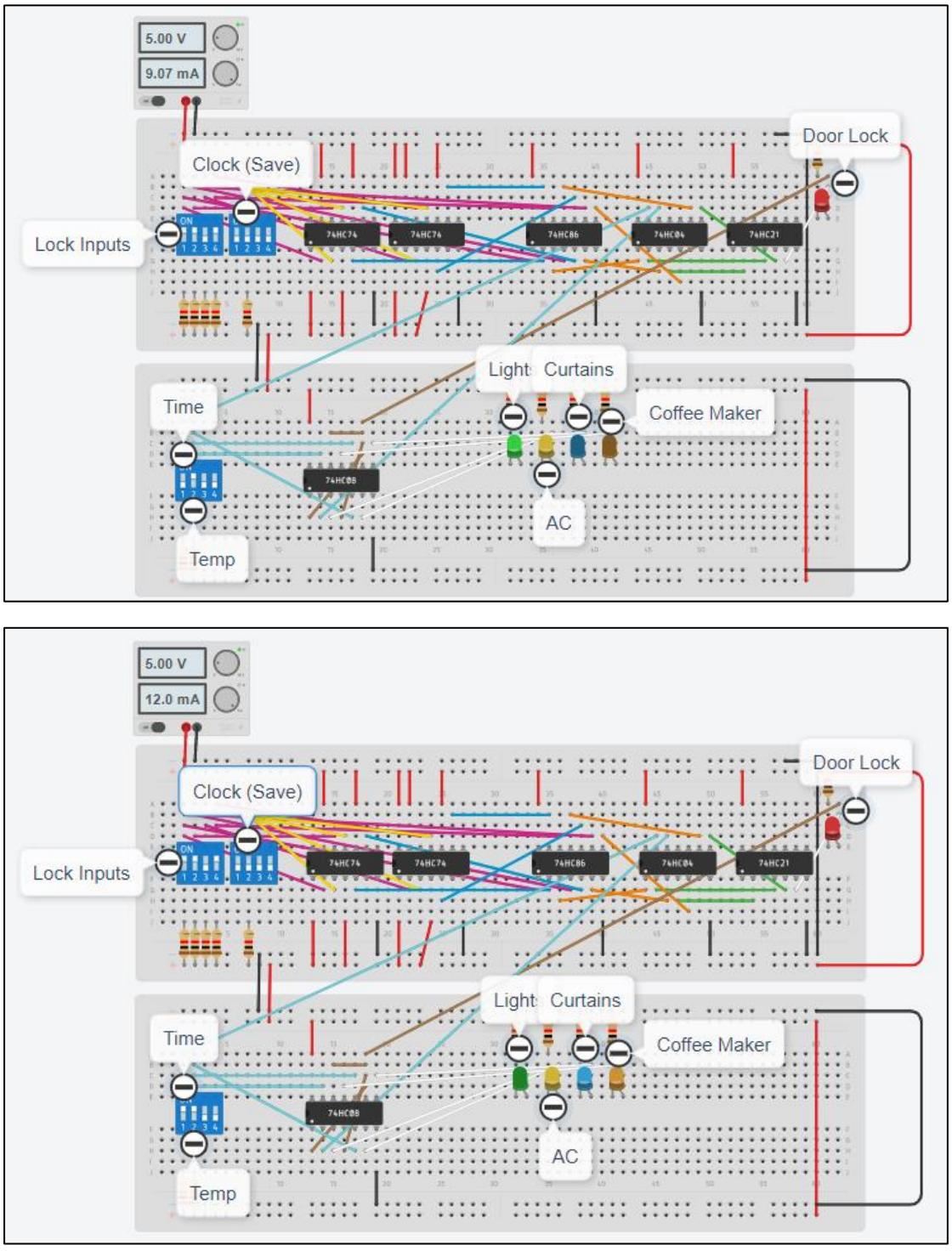

Figure 4 – Tinkercad Simulation of the project

Development suggestions

After working on this project for some time, we have had a few extra ideas that we wanted to implement into the project, but we could not do it either because of lack of time or because the idea was too complex for the project.

1- Our first idea was to replace the Time input with a timer that would count down from 0 to 23 to simulate real-time hours. We would have done this by using flip-flops to create a 32-bit counter and have it reset at value “23”. We did not use this idea because a light sensor made more sense for our outputs.

2- We had other ideas for our outputs. For example, add an alarm to the timer that would go off during a specific time, or add a radiator that would turn on when the temperature is too low.

3- Someone could add more inputs to the system to allow for better flexibility with the outputs.

Conclusion

In this project, we wanted to create a system using our knowledge of logic gates. The system had to be practical and useful to other people in their lives as well as be simple to set up and use. That is the reason why we chose to create a smart home control system. Currently, it is very basic, however, we have a lot of ideas to expand and make the system more helpful and secure by adding new features. Such as, a passcode to the door that will lock the system and increase the number of inputs and outputs to add more functions to the system. All in all, we hope to continue working on this project in the future to make it better and see it implemented in the real world.