SECR1013-02 DIGITAL LOGIC PROJECT

Elevator Controller System

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Group Members:

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Dedication and Acknowledgement

This project is dedicated to our lecturer, Dr. Zuriahati, for her guidance and mentorship on the subject Digital Logic throughout the first semester, which bought us a deeper understanding in the vast world of knowledge regarding computer science.

We would like to express our greatest gratitude to each of our group members, which we worked together to propose, ideate, amend, and finalized the project together. Additionally, we want to thank Dr. Zuriahati for her expertise and constructive feedback given to our project. Special thanks to all our classmates who provided support and help along the way.

Contents

Overview

As technology advances, the demand for an elevator inside buildings is increasing rapidly nowadays to sustain the high paced life in crowded cities. The critical factor that must be considered for spreading such technologies will be the efficiency, safety and security of the elevator. By simulating an imaginary case study, our group is presenting a design of the elevator controller system using a sequential logic circuit which allows user to choose to ascend or descend to the desired floor, scan NFC hotel card to activate elevator. Additionally, users are given the choice to input passcode as an alternative to the NFC hotel card. All simulations in the project are done using Deeds (Digital Circuit Simulator) software.

Problem Statement

Inside a hotel, we want to emphasize on the security and royalty of the customers. Hence, the design of the elevator control system includes a verification feature to either input passcode or tap NFC hotel card to verify the identity of user. This eliminates the worry of intruders and give our customers a sense of privacy where none other people will have access to the elevator.

Solution

When the user has entered the elevator, the door will close. The user should turn on the power switch of the elevator. In the elevator, the user should choose the desired floor number using 4-bit Input Hex Digit, starting from ground floor (0) to seventh floor (7) and decide whether the elevator should ascend or descend. Next, the user should tap their room card if they are a customer, or input passcode set if they are staff member. Both actions will activate the lift and bring the user to their desired floor. There are LED bulbs to let the user know if they successfully tapped a card or entered the passcode correctly. The HEX LED display will show the consecutive floor number as they ascend or descend and stop once it reaches the respective floor. The door will open for the user to move out of the elevator. If there is no room card tapped and the passcode is wrong, the elevator will not be activated. The 4-bit Input Hex Digit is connected to the comparator, to compare the current floor and the user input and count up/count down until the value is the same as user input, meaning that the elevator has arrived at the desired floor. If the current floor and user input are the same, the door will remain open and the elevator will not start to function.

We have designed a complete system solution for the problem.

Counter (COUNT UP/DOWN)

State Diagram

Figure 1 shows a saturated counter. From a practical point of view, it is impossible for the user to go directly from the 7th floor to the ground floor without passing through other floors.

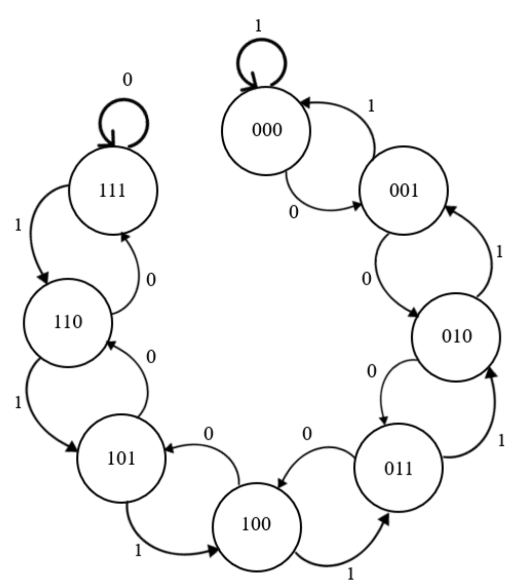


Figure 1

State Table

Table 1 shows the next state table for the counter.

Table 1

Input (X)	Present State			Next State		
	Q2	Q1	Q0	Q2+	Q1+	Q0+
0	0	0	0	0	0	1
0	0	0	1	0	1	0
0	0	1	0	0	1	1
0	0	1	1	1	0	0
0	1	0	0	1	0	1
0	1	0	1	1	1	0
0	1	1	0	1	1	1
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	0	0	1
1	0	1	1	0	1	0
1	1	0	0	0	1	1
1	1	0	1	1	0	0
1	1	1	0	1	0	1
1	1	1	1	1	1	0

Flip-Flop Transition Table

Table 2 shows JK Flip Flop transition table which created from its excitation table (Figure 2).

Figure 2

Present State	Next State	FF State	
Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

J-K flip-flop

Table 2

Input (X)	Present State			Next State			Flip Flop					
	Q2	Q1	Q0	Q2+	Q1+	Q0+	J2	K2	J1	K1	J0	K0
0	0	0	0	0	0	1	0	X	0	X	1	X
0	0	0	1	0	1	0	0	X	1	X	X	1
0	0	1	0	0	1	1	0	X	X	0	1	X
0	0	1	1	1	0	0	1	X	X	1	X	1
0	1	0	0	1	0	1	X	0	0	X	1	X
0	1	0	1	1	1	0	X	0	1	X	X	1
0	1	1	0	1	1	1	X	0	X	0	1	X
0	1	1	1	1	1	1	X	0	X	0	X	0
1	0	0	0	0	0	0	0	X	0	X	0	X
1	0	0	1	0	0	0	0	X	0	X	X	1
1	0	1	0	0	0	1	0	X	X	1	1	X
1	0	1	1	0	1	0	0	X	X	0	X	1
1	1	0	0	0	1	1	X	1	1	X	1	X
1	1	0	1	1	0	0	X	0	0	X	X	1
1	1	1	0	1	0	1	X	0	X	1	1	X
1	1	1	1	1	1	0	X	0	X	0	X	1

K-map

Figure 3 is K-map generated from table 2 in order to form the expression for our circuit.

J_2

XQ_2 \ Q_1Q_0	00	01	11	10
00	0	0	1	0
01	X	X	X	X
11	X	X	X	X
10	0	0	0	0

$$J_2 = \bar{X}\, Q_1 Q_0$$

K_2

XQ_2 \ Q_1Q_0	00	01	11	10
00	X	X	X	X
01	0	0	0	0
11	1	0	0	0
10	X	X	X	X

$$K_2 = X\, \overline{Q_1}\, \overline{Q_0}$$

J_1

XQ_2 \ Q_1Q_0	00	01	11	10
00	0	1	X	X
01	0	1	X	X
11	1	0	X	X
10	0	0	X	X

$$J_1 = \bar{X}\, Q_0 + X\, Q_2 \overline{Q_0}$$

K_1

XQ_2 \ Q_1Q_0	00	01	11	10
00	X	X	1	0
01	X	X	0	0
11	X	X	0	1
10	X	X	0	1

$$K_1 = X\, \overline{Q_0} + \bar{X}\, \overline{Q_2}\, Q_0$$

J_0

XQ_2 \ Q_1Q_0	00	01	11	10
00	1	X	X	1
01	1	X	X	1
11	1	X	X	1
10	0	X	X	1

$$J_0 = \bar{X} + Q_2 + Q_1$$

K_0

XQ_2 \ Q_1Q_0	00	01	11	10
00	X	1	1	X
01	X	1	0	X
11	X	1	1	X
10	X	1	1	X

$$K_0 = \overline{Q_2} + \overline{Q_1} + X$$

Figure 3

Room Card Detector and Passcode Detector

For room card detector, to ensure that every hotel guest can use our elevators, we designed a room card detector by an Active-HIGH S-R Latches. Table 3 shows the active-HIGH table for S-R Latches. We will receive low input from comparator to R which is the initial condition for the elevator to function (Current Floor of elevator ≠ User key-in Floor). When user tapped their card, S will receive high input makes the Latch SET and output, Q = 1.

For passcode detector, we will same receive low input from comparator to R and when user enter the passcode using respective input switch, the SET of that S-R Latches will receive high input, 1 and the output, Q = 1.

Table 3

S (SET)	R (RESET)	Output	Comment
0	0	NC	Latch remains in present state.
0	1	Q=0 (RESET)	Latch RESET
1	0	Q=1 (SET)	Latch SET
1	1	Invalid	Invalid Condition

Comparator

In our system solution, we use comparator from NOR and NAND gates to confirm that the floor user wants to go to is different from the current floor. When the user input and current floor is unequal, the output of comparator will be high (1) to send high signal to clock controller and the inverter will send low (0) to RESET of the S-R Latches.

For example, in Table 4, the Current Floor (CF) is ground floor (0) and the user entered floor (EF) is 2 floor (2). After compare each of the binary digit with each other using NOR gate, we will have two low (0). Then, all of the result from NOR should go to NAND gate to compare. Since there is low (0) input for the NAND gate, if we look at the NAND truth table in Table 5, we see that whenever one of the inputs is 0, the output will be 1.

Table 4

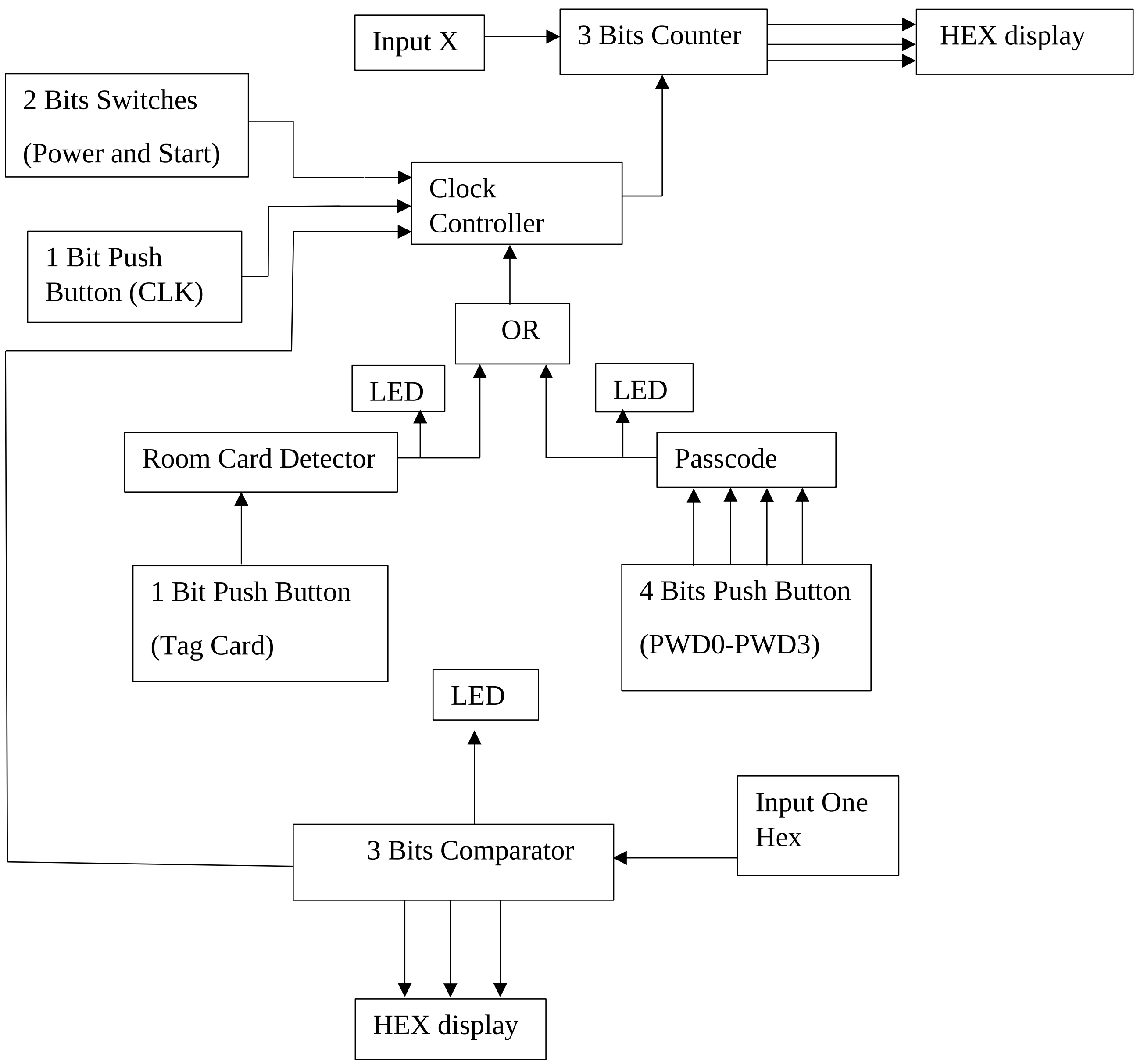
	CF	EF	$\overline{CF + EF}$
Q_2	0	0	1
Q_1	0	1	0
Q_0	1	0	0

Table 5

X	**Y**	$\overline{XY}$
0	0	1
0	1	1
1	0	1
1	1	0

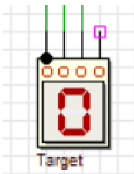
When the floor entered by the user is the same as the current floor, the output of the comparator will be low (0) and it will be sent to clock controller so that the elevator will not function. Then, we also use inverter to make it high. Therefore, the high input (1) will be transfer to room card detector and passcode detector to make the Latches RESET.

Block Diagram



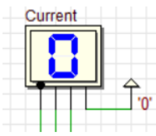
The Requirement

Input HEX digit (4 bits)



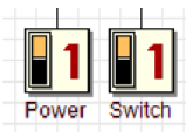
The user can enter the desired floor that they want to go to.

HEX display



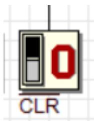
To display the current floor that the elevator is on.

Power button and Switch



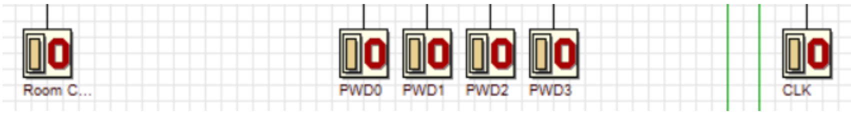
The power button input switch allows the user to switch on the elevator to make it function.

Clear button



In Counter part, when switched on (1), the elevator starts function and when switched off (0), the elevator will descend to ground floor. In Passcode part, when switched on (1), the user can enter the passcode and when switched off (0), the passcode entered will be cleared.

Input Push-Button



As a room card detector, passcode function and clock of the elevator system. Pressing the room card detector push button means that the user has tagged the room card. Click on the passcode push button indicates the passcode that have entered by the user. Otherwise, pressing the clock push button controls the elevator to ascend or descend.

LED

Bright when the door is closed, the users have tagged their room card, the passcode entered is correct and the clock is function. The LED also shows whether the elevator is going up or down,

3-bit Synchronous Counter

Support 8 floors hotel elevator to ascend and descend.

Clock Controller

To let the elevator start to operate when all the operating conditions is met, that is, when the power is turned on, the elevator is switched on, and the room card or passcode is correctly detected.

Room Card Detector

Detect the room card that tagged by the user.

Passcode 4-bit Comparator

Compare the passcode entered by user with the corresponding passcode

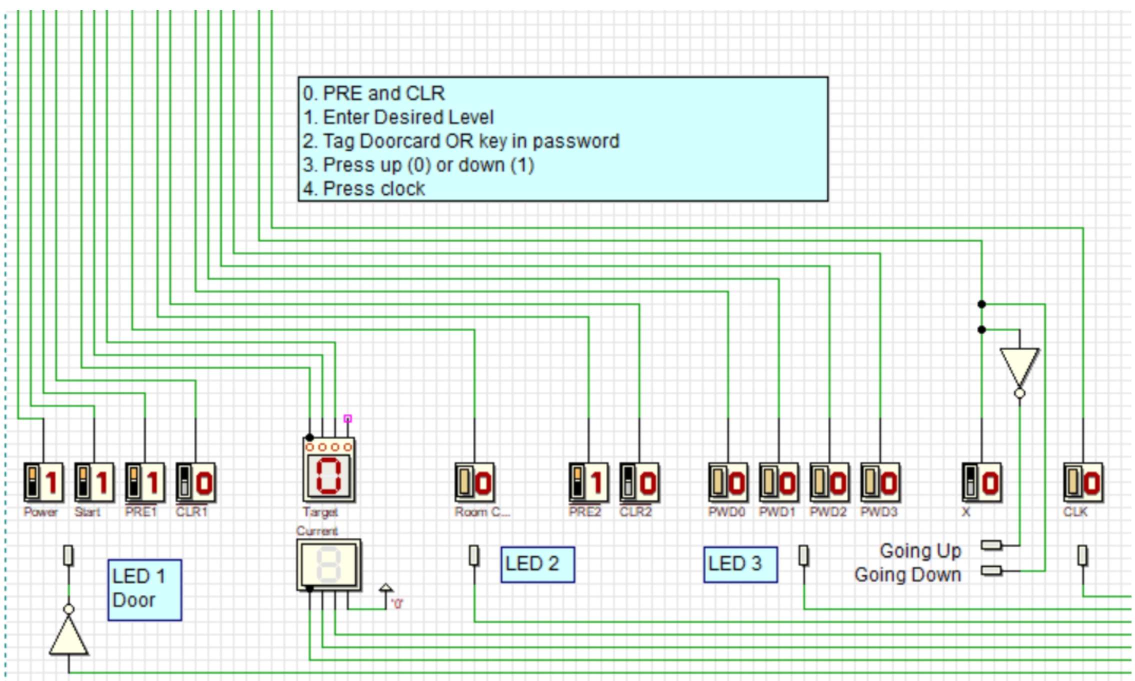
3-bit Comparator

Compare the current floor and the desired floor entered by the user. If it is the same, the door will stay open.

System Implementation

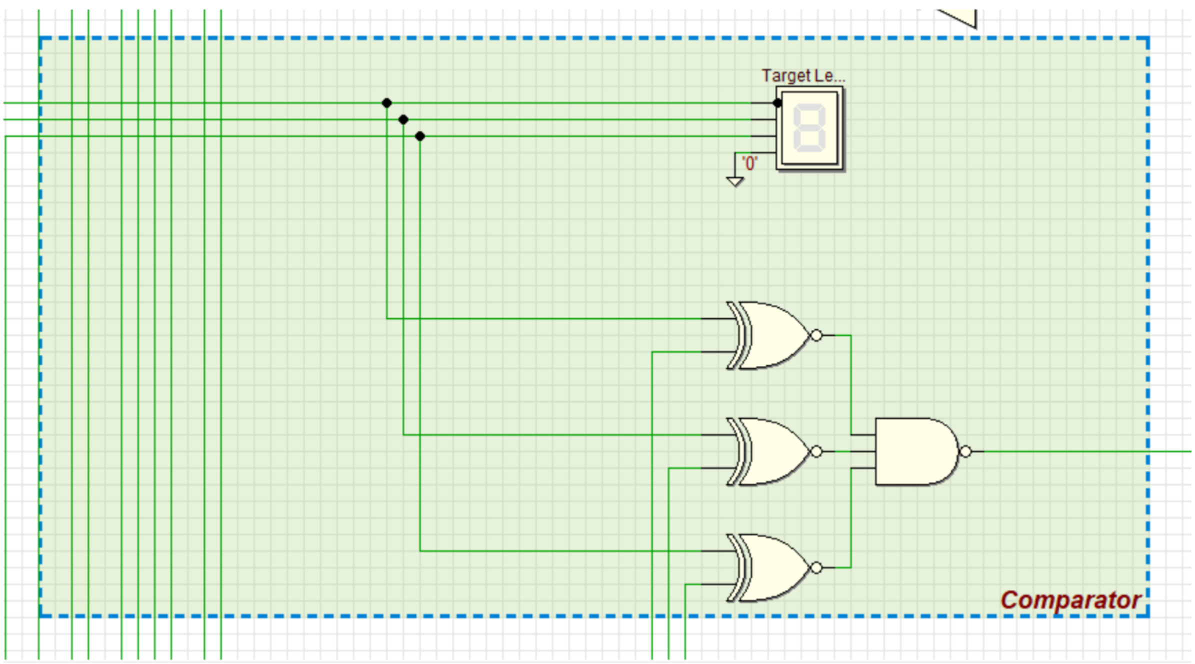
1. Input

Firstly, the elevator is connected to the POWER switches which connect to the voltage and START switches which start up the whole machine of the lift. Then, users can specify the desired floor level with a single hex digit ranging from 0 to 7. Only when the desired level is different from the current level will the elevator function. If not, it will stay unchanged. When the user goes to a different level, the door automatically closes and LED 1 lights up. After users activate the push button (Room Card) by tagging their room card, LED 2 will light up, showing that the lift will only operate if the users have a room card. In addition, the passcode input has four switches (PWD0 - PWD3). Employees who require this elevator for work purposes are designated by these switches. LED 3 will light up and the lift will function once all four passcodes are entered correctly. The $\overline{CLR2}$ switch can be used to clear all passcodes and enter the correct passcode again if staff members accidentally enter the wrong ones. The elevator 's direction can then be determined using the X switch. For instance, the elevator will rise, and the going up LED will light up when X = 0, or vice versa. The elevator can be operated level by level by pressing the CLK push button.



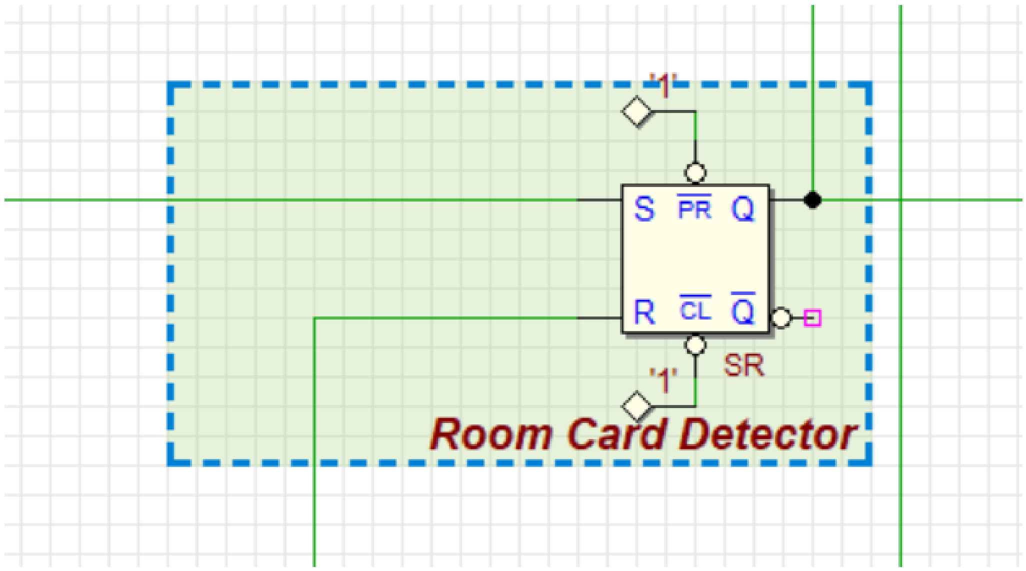
2. 3 bit-Comparator

Comparator is set up by three 2-input XNOR gates and a 3-input NAND gate. It is used to compare the users' entered target level with the current level. The least significant bit (LSB) of the two sources is compared using the first XNOR gate. The output of an XNOR gate will be 0 or vice versa if the target level and the current level are different. The second and third XNOR gates operate on the same principle. After that, a NAND gate will receive the signal from all three gates and convert it into the opposite signal (1). As a result, the NAND gate will provide an output of 1 to the clock controller to initiate the elevator when it gets the low input (0) provided by the input switches.



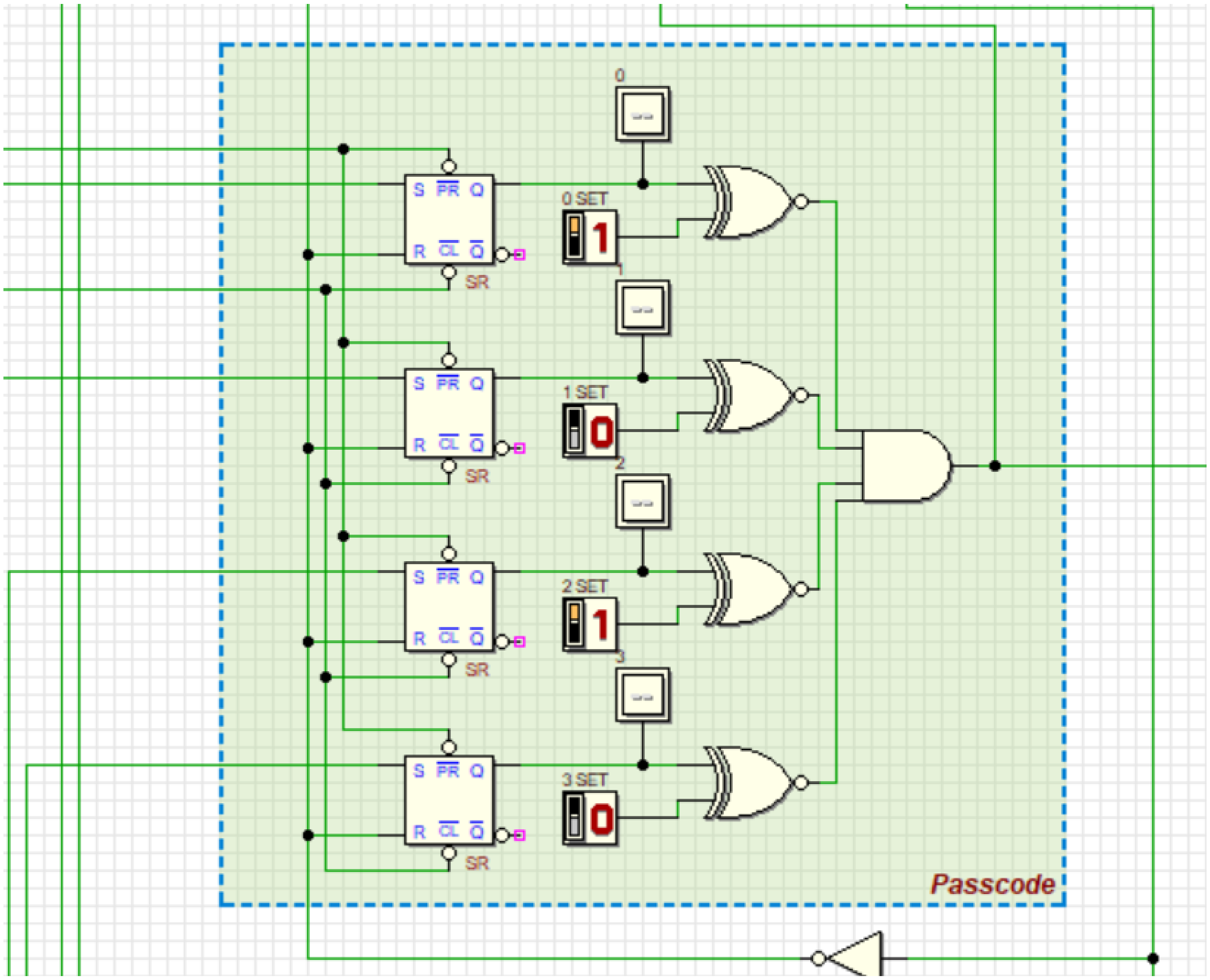
3. Room Card Detector

To determine if the user has tagged his card or not, we are using an active HIGH SR latch. PRE and CLR should always be HIGH (1) to allow for the SR latch's SET and RESET to respond freely. When the user tags his card, the input signal (1) from the room card push button is received by the SR latch's SET. The NAND gate, which is connected to the NOT gate, simultaneously sends the opposite signal (0) to the SR latch's RESET, when the target level is different from the current level. As a result, the SR latch's SET and RESET will never be the same. If someone tags the card accidentally before entering the target level, the door remains open and the elevator at that level stays the same. After that, the SR latch output will be delivered to the clock controller.



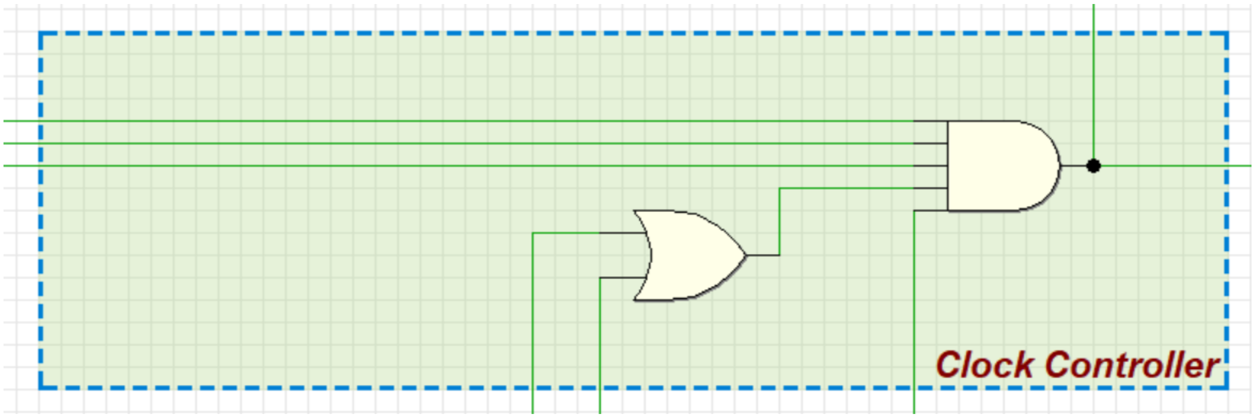
4. Passcode

The passcode system is made up of four SR latches, four XNOR gates, and one AND gate. It is designed for users who must use the elevator for work-related activities but didn't bring their room card, such as employees, security guards, and others. The purpose of the passcode function is to check user-entered passcodes with the correct passcode (1010). The first SR latch and XNOR gate are used to compare the passcode's least significant bit (LSB). The output will be HIGH (1) if the passcode entered by the users matches the correct passcode (1), or vice versa. The second, third, and fourth SR latches, and the XNOR gates, work on the same concept. After that, every output from every XNOR gate is received by the AND gate. When the output is HIGH (1), it indicates that the users' passcode is accurate, and the elevator will be working.



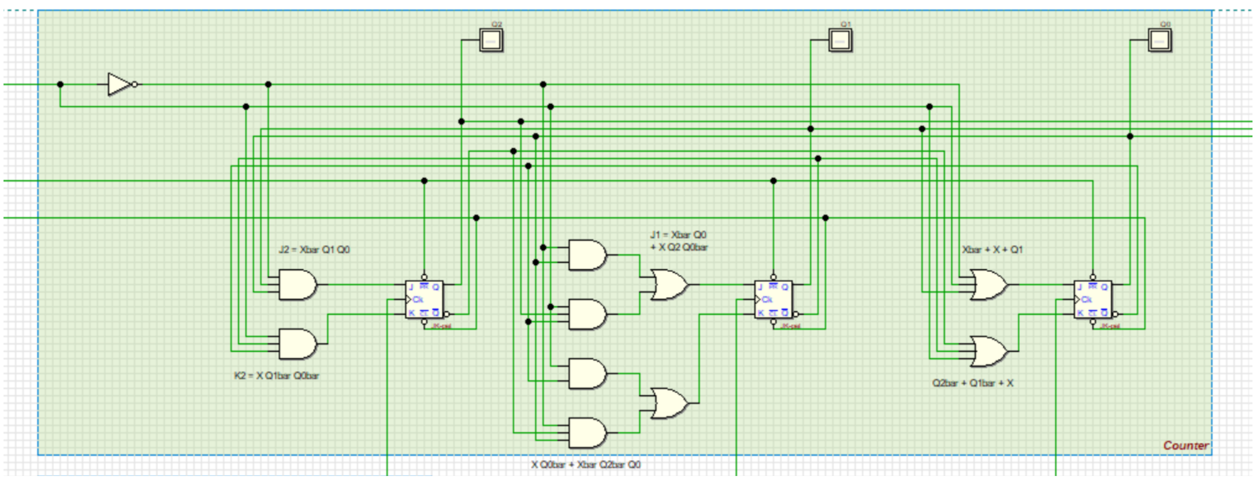
5. Clock controller

Before the elevator operates, the clock controller must ensure that all requirements are fulfilled, including turning on the power, selecting the target level, and tagging the room card or entering the passcode. It consists of a 5-input AND gate and a 2-input OR gate. The OR gate receives the signal from the system passcode and room card detectors, showing that either the passcode or the room card is required to operate the elevator. Then, two of the AND gate's inputs are connected to the POWER and START switches, one is connected to an OR gate, one is connected to a 3-bit comparator, which is used to determine the level target, and the other is connected to a CLK switch, which is used to control the elevator's level-by-level movement. All these requirements are HIGH (1) and must be fulfilled to activate the elevator. The clock controller's output will then be sent to the counter for operation.

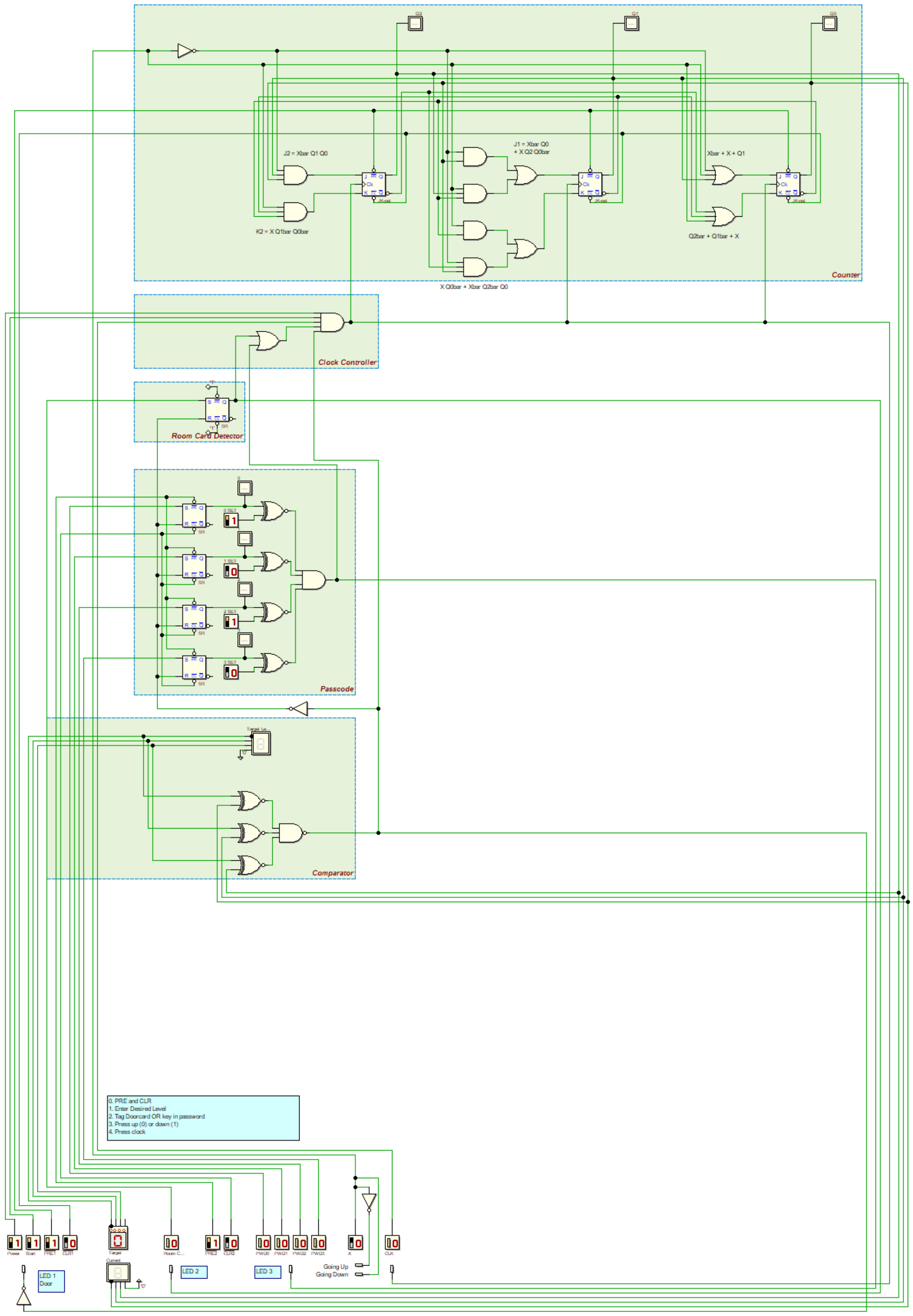


6. Counter

Three-bit JK positive edge count-up counters make up the counter. A connection exists between the clock controller and every CLK of the JK flip-flop. The elevator only operates when the clock controller's output is HIGH (1). The PRESET (PRE) switch is always in the HIGH position (1). However, only when the elevator is required to be used, the CLEAR (CLR) switch be set to HIGH (1). For instance, CLR should be LOW (0) to descend the elevator to ground level for maintenance purposes if there is an emergency. In addition, the Boolean expression obtained from the K-map is used to connect J_2, K_2, J_1, K_1, J_0, and K_0. [1]



Full Deeds Circuit



Conclusion and Reflections

As a conclusion, the problem is successfully solved by the elevator system that we designed. The circuit can be break down into several important parts, each parts withhold a different operating function, mainly Counter, Clock controller, Room Card Detector, Passcode Detector and the Comparator, made from components such as Input HEX digit (4 bits), HEX display, Power button and Switch, Clear button, Input Push-Button, LED Display, 3- bit Synchronous Counter, Clock Controller, Comparator and flip flops.

The usage of Hotel Card in our system is relatively simple to provide customers of the hotel with great experience using the elevator while also preventing other people from using the lift. By implementing the passcode system, it eases the process in the future when maintenance is required, such that a staff will have direct access to the elevator without the need of having a customer only Hotel Card, since both actions can be applied to operate the elevator.

However, this system is only applicable by the assumption of there is only one person inside the elevator at a time. In the future, we wish to further enhance our design by adding the function for selecting multiple destination floor at one time, and the ability to set priority to each floor by determining the shortest time travel between floors.

References

(1) Abd. Bahrim Yusoff, Mazleena Salleh, Mohd Fo'ad Rohani, Ismail Fauzi Isnin. (2013). Digital Logic Module (Fifth Edition). Faculty of Computing, Universiti Teknologi Malaysia.

Appendices

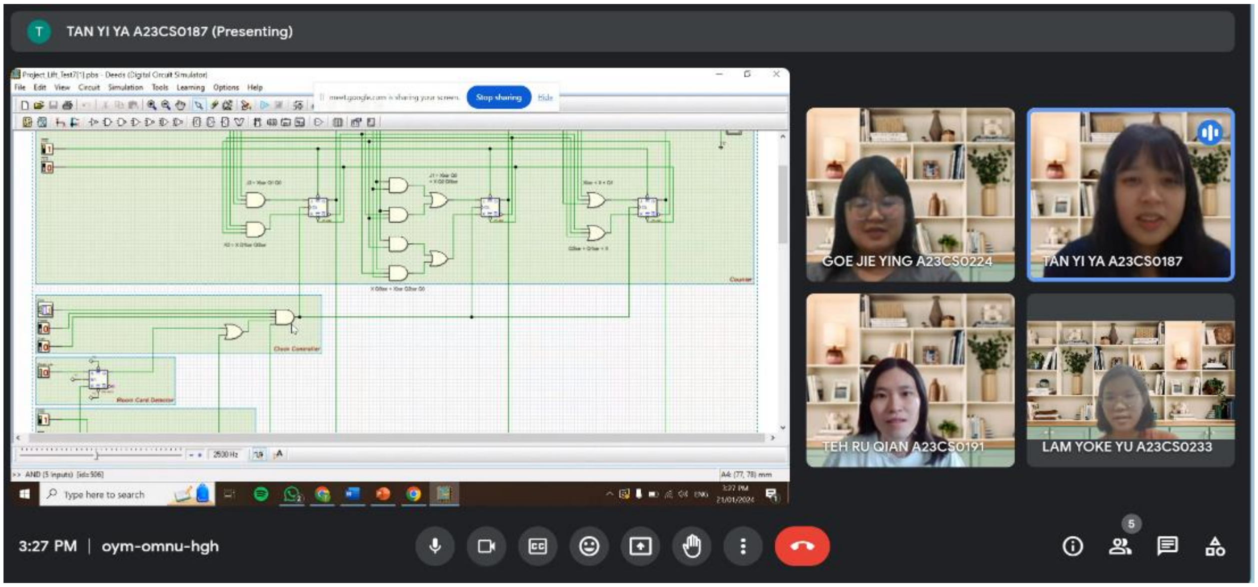
Task Distribution

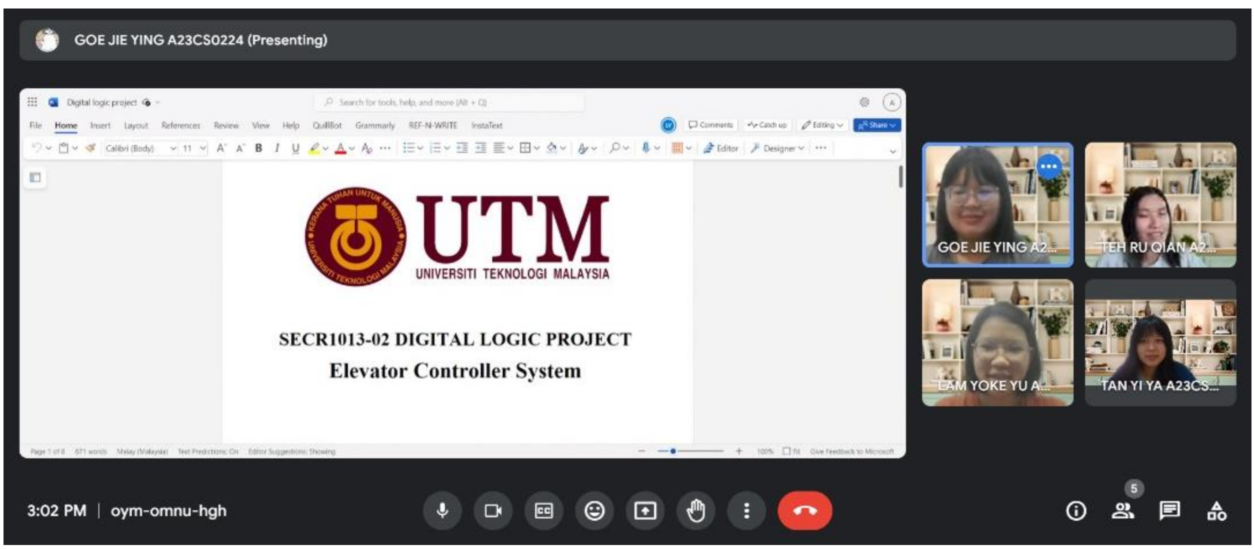
Task	Member
Background / overview	Tan Yi Ya
Problem Statement	Tan Yi Ya
Suggested Solution	Goe Jie Ying
System implementation	Teh Ru Qian
Conclusion and Reflection	Tan Yi Ya
Video	Lam Yoke Yu
Deeds Circuit	All members

Photos

Group Discussion on 17/1/2024

Group Discussion on 21/1/2024





Demonstration video link:

https://www.youtube.com/watch?v=yMGTg36wHTQ