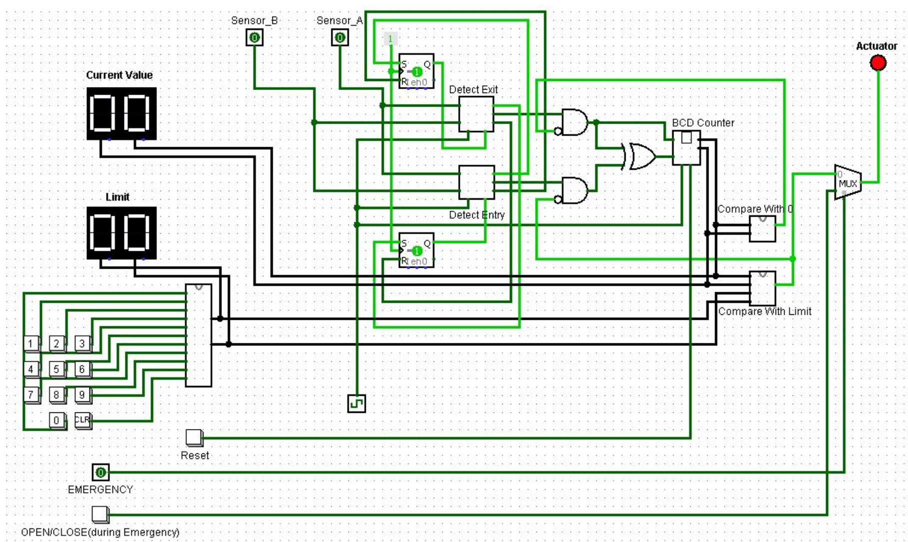
CS F215(Digital Design)
Design Assignment

Group 96

Problem Statement:

Design a system to count the number of people that enter a room. It should automatically close the doors when the pre-set number of people is reached.



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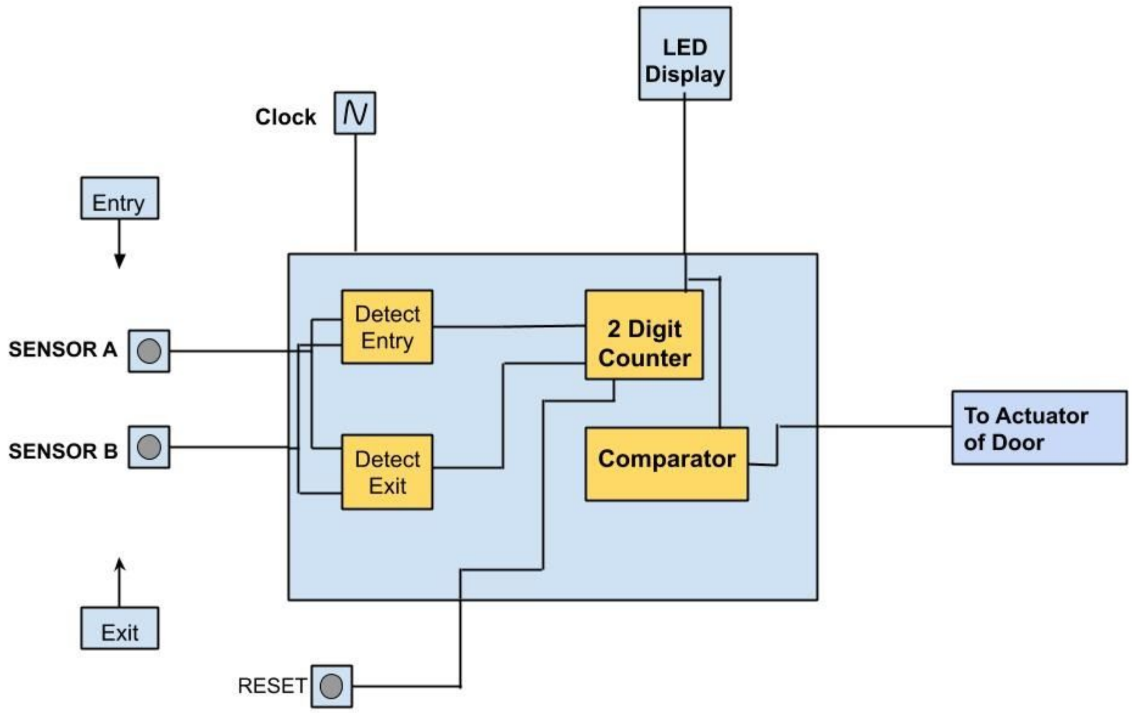
Top Level Block Diagram:



Inputs:

1. **Input from IR sensor A:**
   returns 0 when no obstacle detected , 1 when obstacle detected
2. **Input from IR sensor B:**
   returns 0 when no obstacle detected , 1 when obstacle detected
3. **Clock input**
   design is a sequential circuit, clock frequency should be preferably high
4. **Reset**
   To reset the count recorded till present

Outputs:

1. **2 4-bit BCD outputs from counter:**
   The counter can count upto 2 digits(in decimal). The BCD outputs of each digit (units and tens place) are sent to Hex Digit Display to display the current count
2. **Output to actuator:**
   If a preset number of people have entered the room the output becomes high making the actuator close the door. If count is less than the limit, output is low.

Assumptions made w.r.t the design:

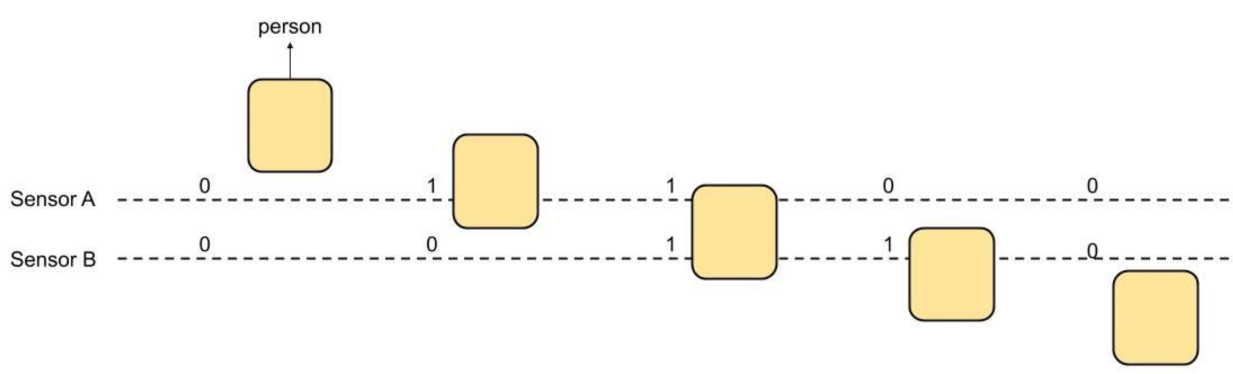
1. A person who has once passed through the first sensor from either side, or is standing in front of both the IR sensors, he/she cannot make a U-Turn to return back.
2. Not more than one person can pass through the door at a time i.e. only if a person has exited/entered completely can the next person enter/exit.
3. Two people cannot come from either side of the door simultaneously.

Design Approach and Methodology:

The requirement of the given design problem is to detect motion through the door and most importantly direction of motion. It is because of the latter requirement that we require two IR sensors, to gauge the direction of motion through the door, in order to classify it as an exit or an entrance. Accordingly we can give input to the counter to increase or decrease the count.

The circuit is designed as a sequential circuit. Since, we have no control over the time when a person walks in/out through the door, it is imperative that the circuit be operated at a high clock frequency. This is to prevent the case where there is a spike in the input (input changes and returns back to original value) between two clock pulses. And also, the circuit should take in input from the sensors at each and every moment. However since that is not possible practically, having a high clock frequency shall suffice and meet the requirements of the design problem.

Path of entry:



*The signals from the sensor are also mentioned for a particular instant beside the person block.

The above diagram illustrates how an entry can be detected from the signals of the sensor. Similarly, in the reverse motion, one can detect the exit of a person.

Therefore, we divide the circuit into four main subparts:

1. **Detect Entry:**
   The function of this subcircuit is to output a “HIGH” when a person enters the room.
2. **Detect Exit:**
   The function of this subcircuit is to output a “HIGH” when a person exits the room.
3. **Counter:**
   The counter is basically a cascade of ‘n’ BCD decade up/down counters in order to count a ‘n’ - digit decimal number. For simplicity in circuit and implementation, all simulations for this design will be for 2 digit decimal numbers.
4. **Comparator:**
   The comparator will check if the current count is equal to or exceeding the preset limit. If it is exceeding it outputs a HIGH signal which is sent to the actuator to close the door.

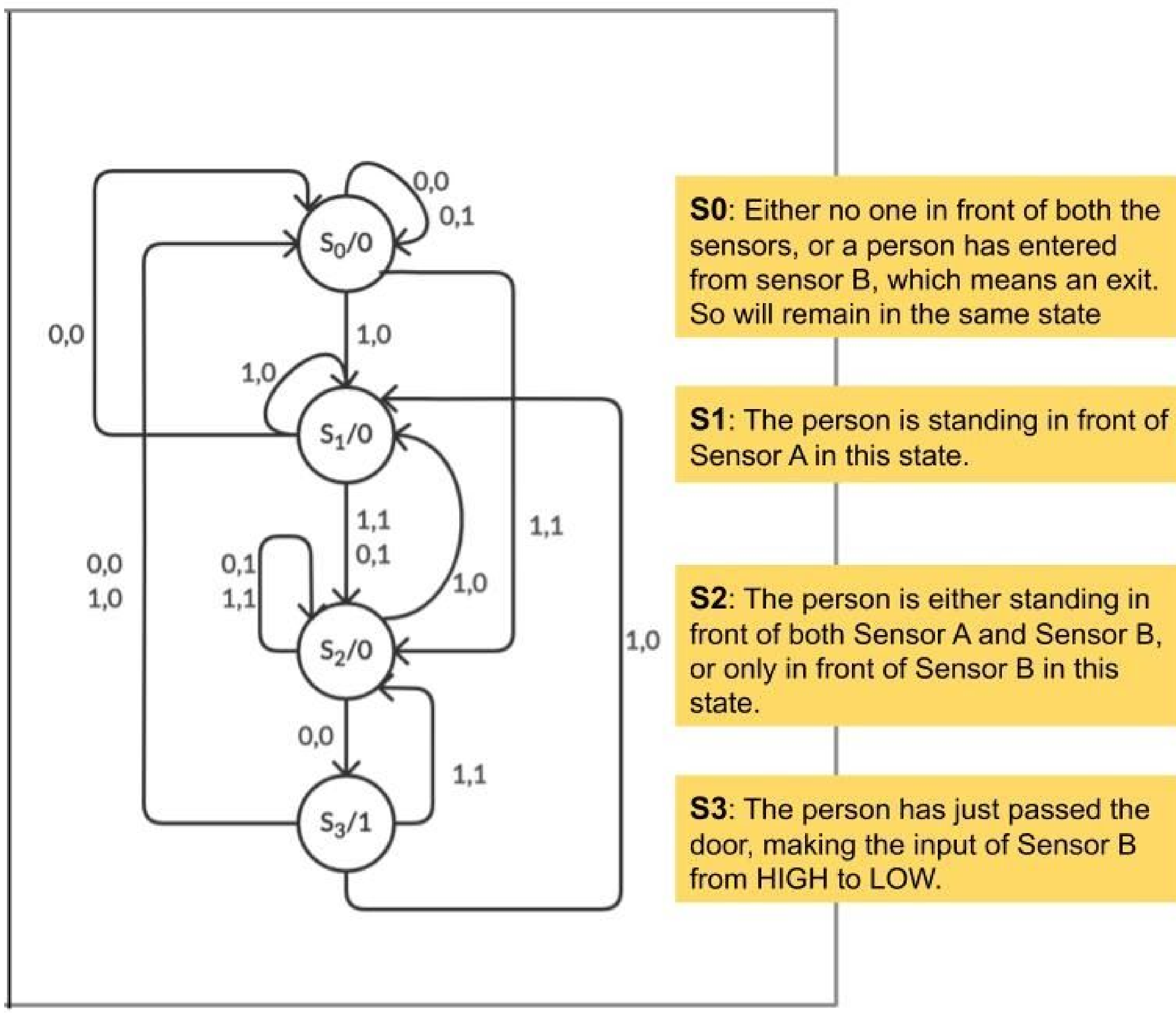
   Also, another comparator checks if the current count is zero. If it is, then our design ensures that even if there is some malfunction which results in an EXIT signal the counter won’t count down.

   Similarly, when the current count is equal to the preset limit, and if there is some malfunction which results in an ENTRY signal the counter won’t count up.

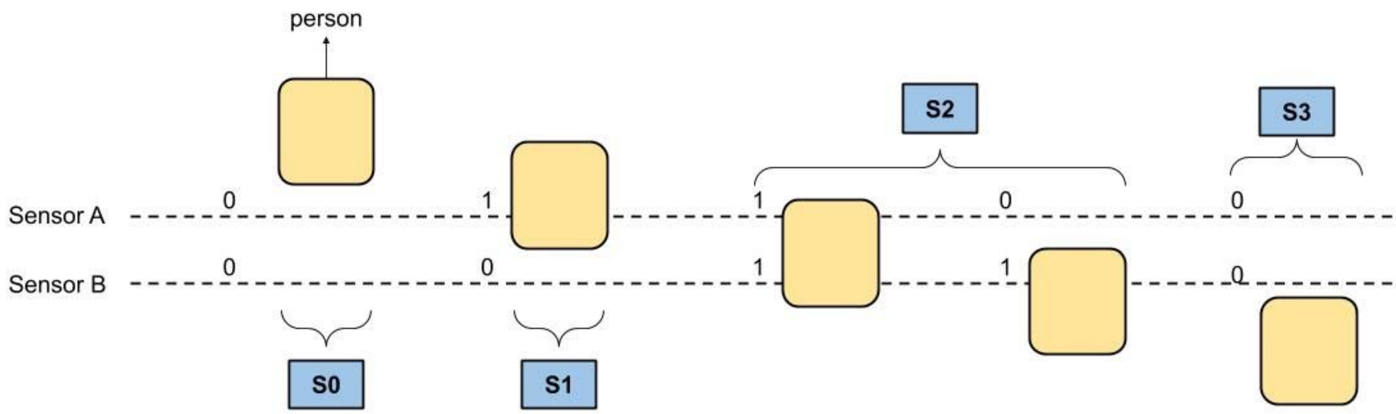
State Diagrams: (Moore implementation)

1. **State Diagram for Detect Entry module:**
   Input to the module:
   a. Output of Sensor A
   b. Output of Sensor B
   c. Clock

   Output:
   HIGH when an entry takes place through the door.
   LOW otherwise



Path of entry:



*The signals from the sensor are also mentioned for a particular instant beside the person block.

Transition of states and input explanation:

S0 to S1:
Since, the state S1 denotes the scenario where the person is standing in front of only Sensor_A, S0 to S1 transition occurs when inputs go from 00 to 10.

S1 to S2:
S2 denotes the state when the person stands in front of either both or only Sensor B. So if the inputs go from 10 to 11, or directly from 10 to 01(which is slightly improbable if the clock frequency is high) the state should change to S2.

If the inputs go back to 00, it means the person came in front of A, but decided to turn back. So, we go back to state S0.

S2 to S3:
S3 is the state where entry has finally been detected i.e. the inputs go from 01 to 00, the person standing in front of B has moved ahead and has entered the room.

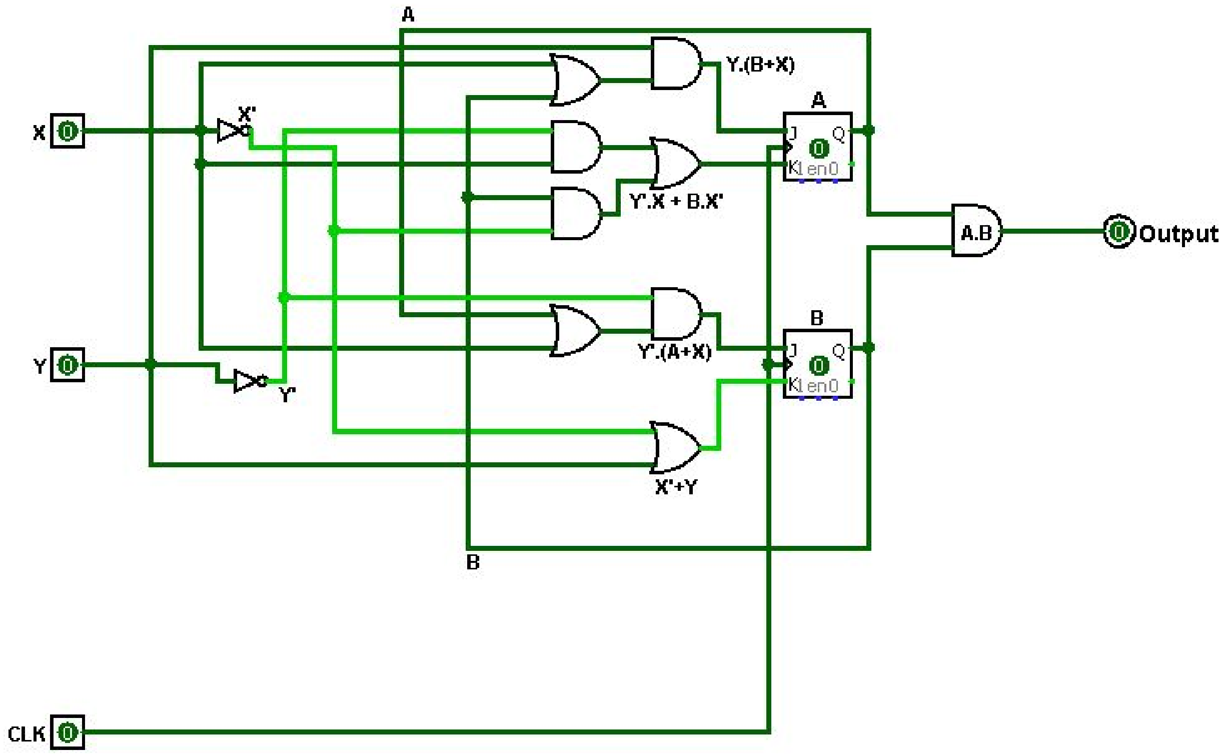
S3 and further:
Now, if the inputs received at S3, i.e.just one clock cycle after the last person has entered, are 00 or 10(not important for entry) we go to S0, are 10 we go to S1.

State Table for Flip Flop input equations:

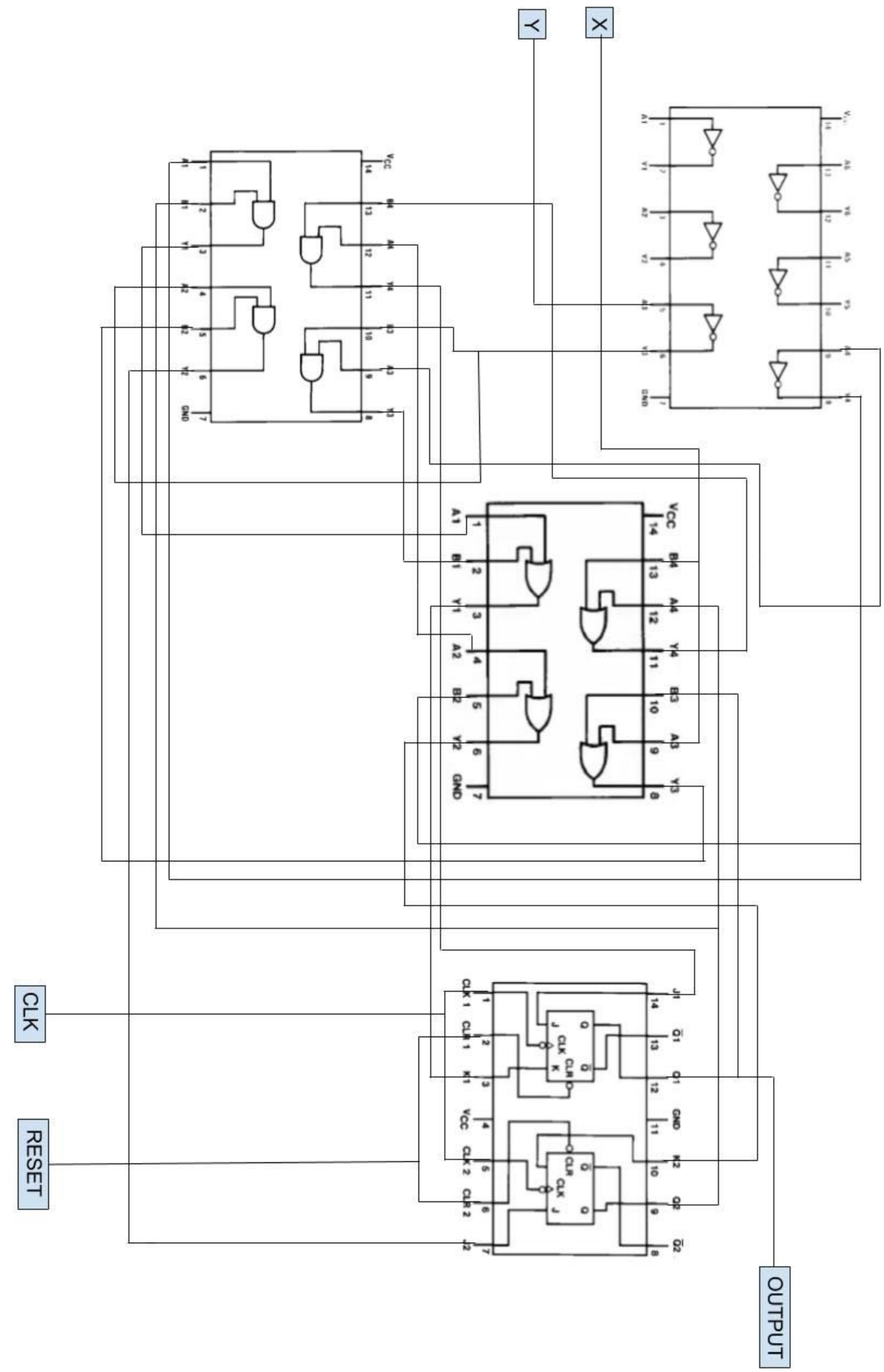
State Table Entry Circuit

Present State			Input		Next State		JK Flip Flops			
A	B		x	y	A(t+1)	B(t+1)	Ja	Ka	Jb	Kb
0	0		0	0	0	0	0	X	0	X
0	0		0	1	0	0	0	X	0	X
0	0		1	0	0	1	0	X	1	X
0	0		1	1	1	0	1	X	0	X
0	1		0	0	0	0	0	X	X	1
0	1		0	1	1	0	1	X	X	1
0	1		1	0	0	1	0	X	X	0
0	1		1	1	1	0	1	X	X	1
1	0		0	0	1	1	X	0	1	X
1	0		0	1	1	0	X	0	0	X
1	0		1	0	0	1	X	1	1	X
1	0		1	1	1	0	X	0	0	X
1	1		0	0	0	0	X	1	X	1
1	1		0	1	0	0	X	1	X	1
1	1		1	0	0	1	X	1	X	0
1	1		1	1	1	0	X	0	X	1

Logisim implementation of ENTRY DETECT module:



Pin-Out Diagram of ENTRY DETECT: (IC Used: DM7432(1),DM7408(1), 74AHC74(1), DM7404(1))



2. State Diagram for Detect Exit module:

Input to the module:

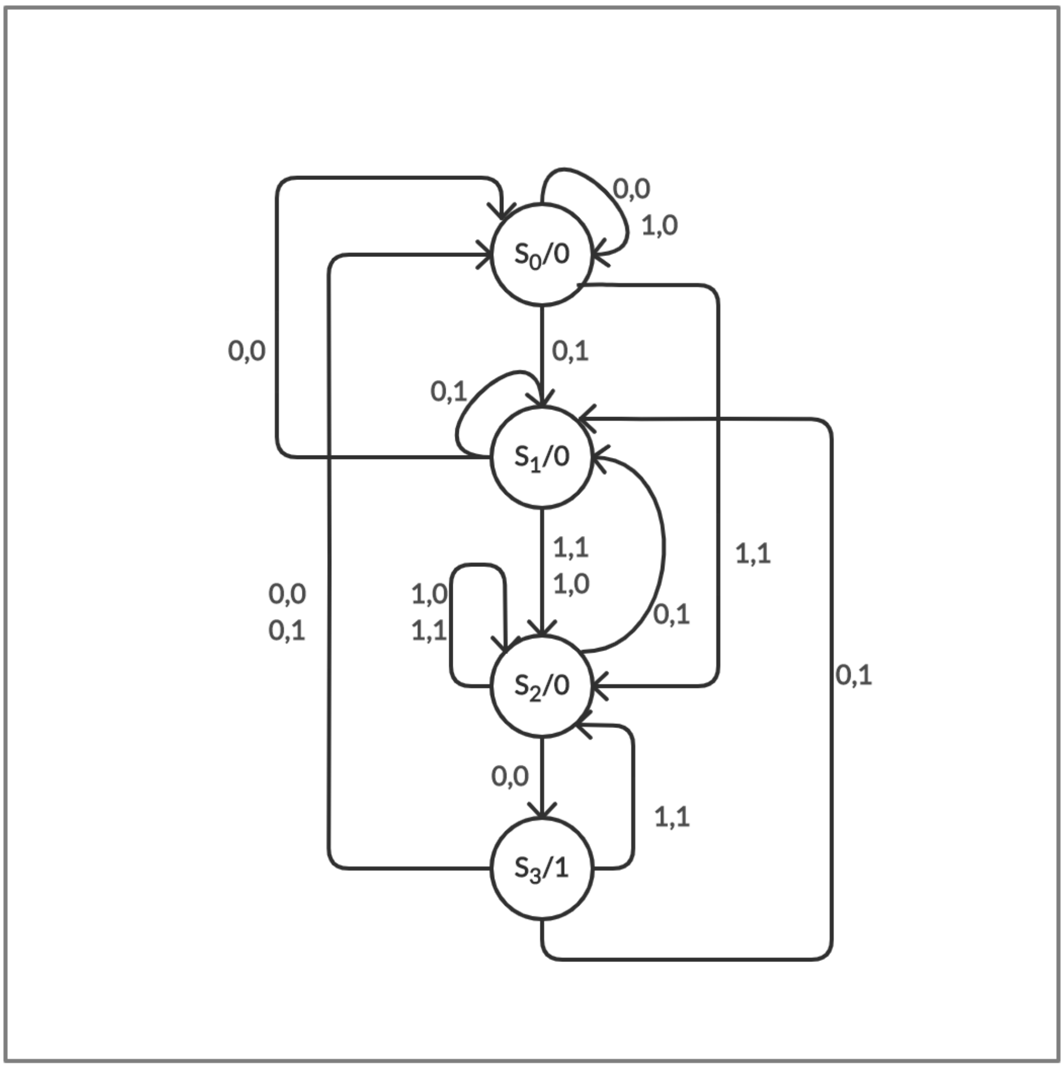
d. Output of Sensor A
e. Output of Sensor B
f. Clock

Output:

HIGH when an exit takes place through the door.

LOW otherwise

(explanation is analogous to detect entry just, replacing B by will suffice)

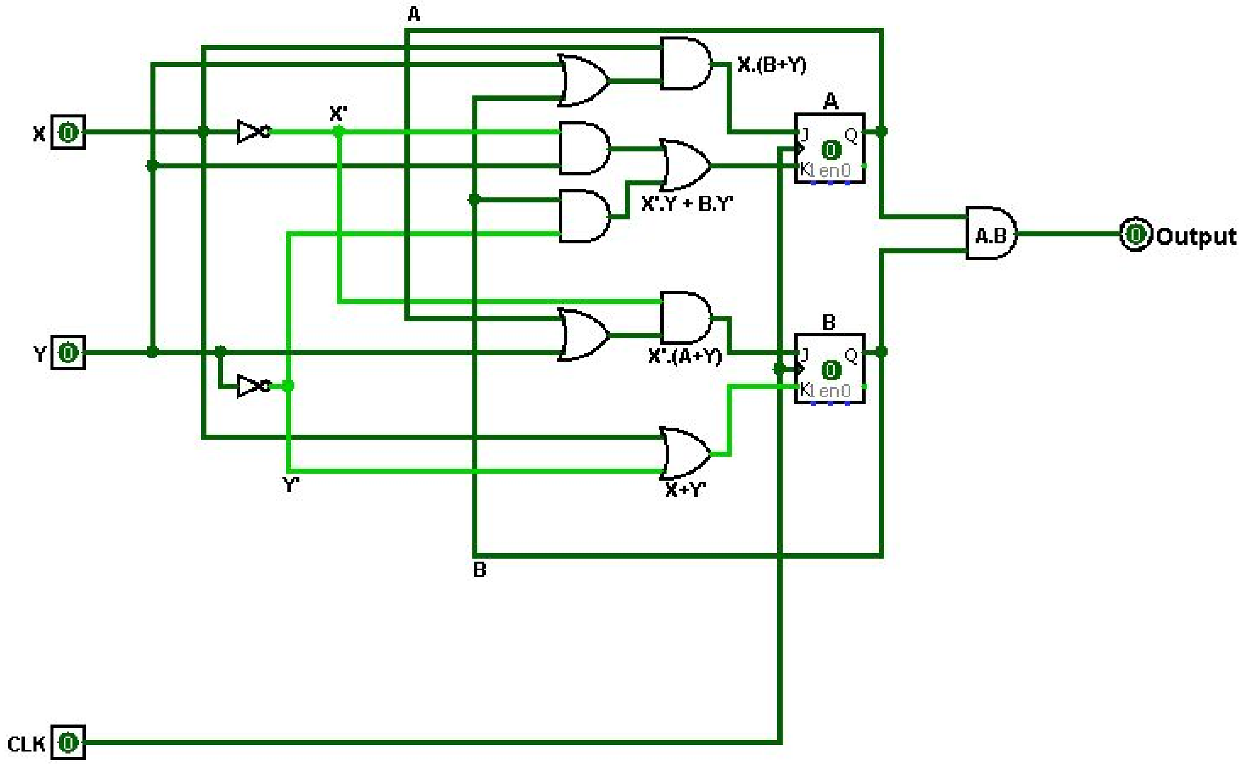


State Table for Flip Flop input equations:

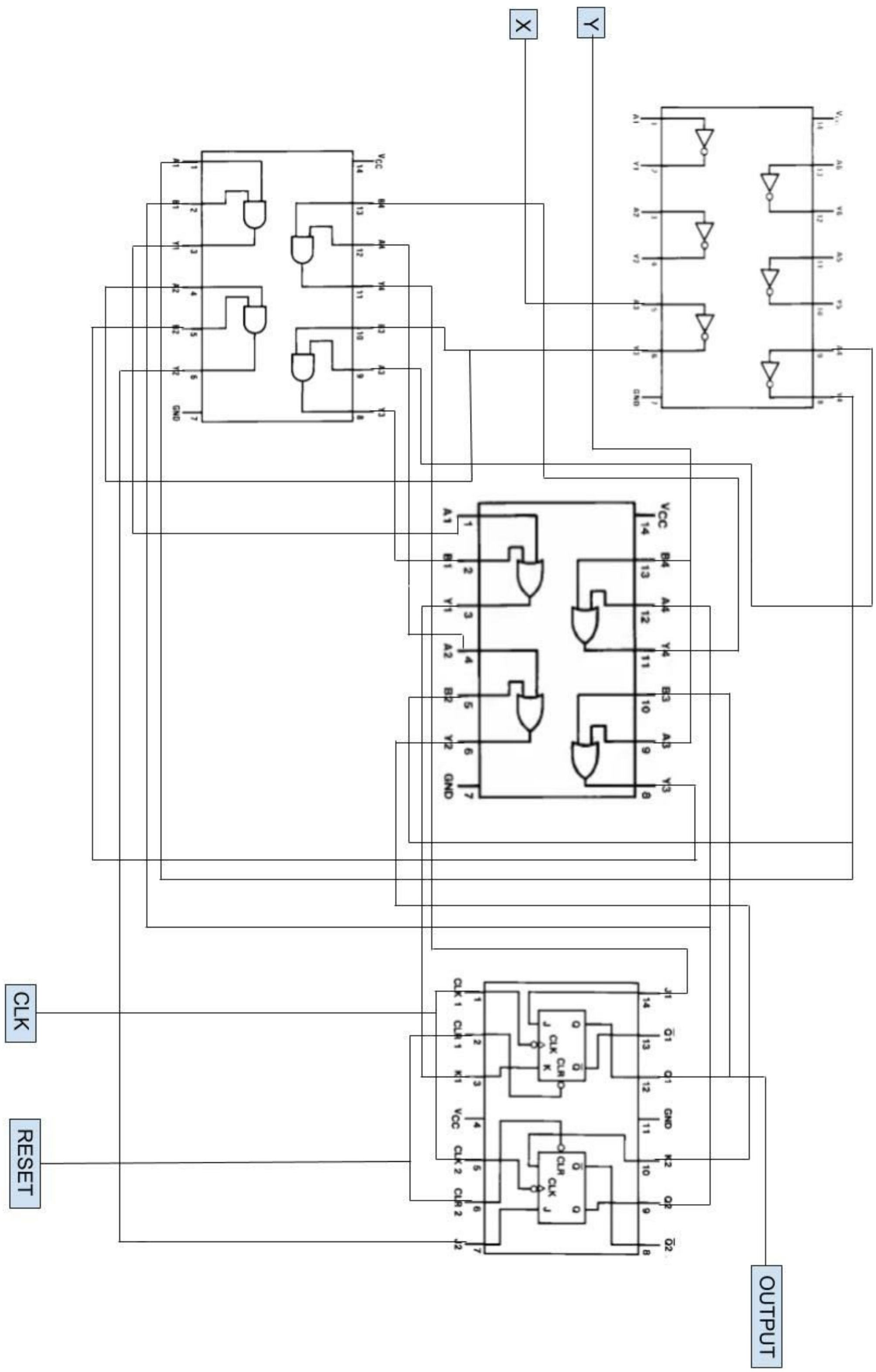
State Table Exit Circuit

Present State			Input		Next State		JK Flip Flops			
A	B		x	y	A(t+1)	B(t+1)	Ja	Ka	Jb	Kb
0	0		0	0	0	0	0	X	0	X
0	0		0	1	0	1	0	X	1	X
0	0		1	0	0	0	0	X	0	X
0	0		1	1	1	0	1	X	0	X
0	1		0	0	0	0	0	X	X	1
0	1		0	1	0	1	0	X	X	0
0	1		1	0	1	0	1	X	X	1
0	1		1	1	1	0	1	X	X	1
1	0		0	0	1	1	X	0	1	X
1	0		0	1	0	1	X	1	1	X
1	0		1	0	1	0	X	0	0	X
1	0		1	1	1	0	X	0	0	X
1	1		0	0	0	0	X	1	X	1
1	1		0	1	0	1	X	1	X	0
1	1		1	0	0	0	X	1	X	1
1	1		1	1	1	0	X	0	X	1

Logisim implementation of EXIT DETECT module:



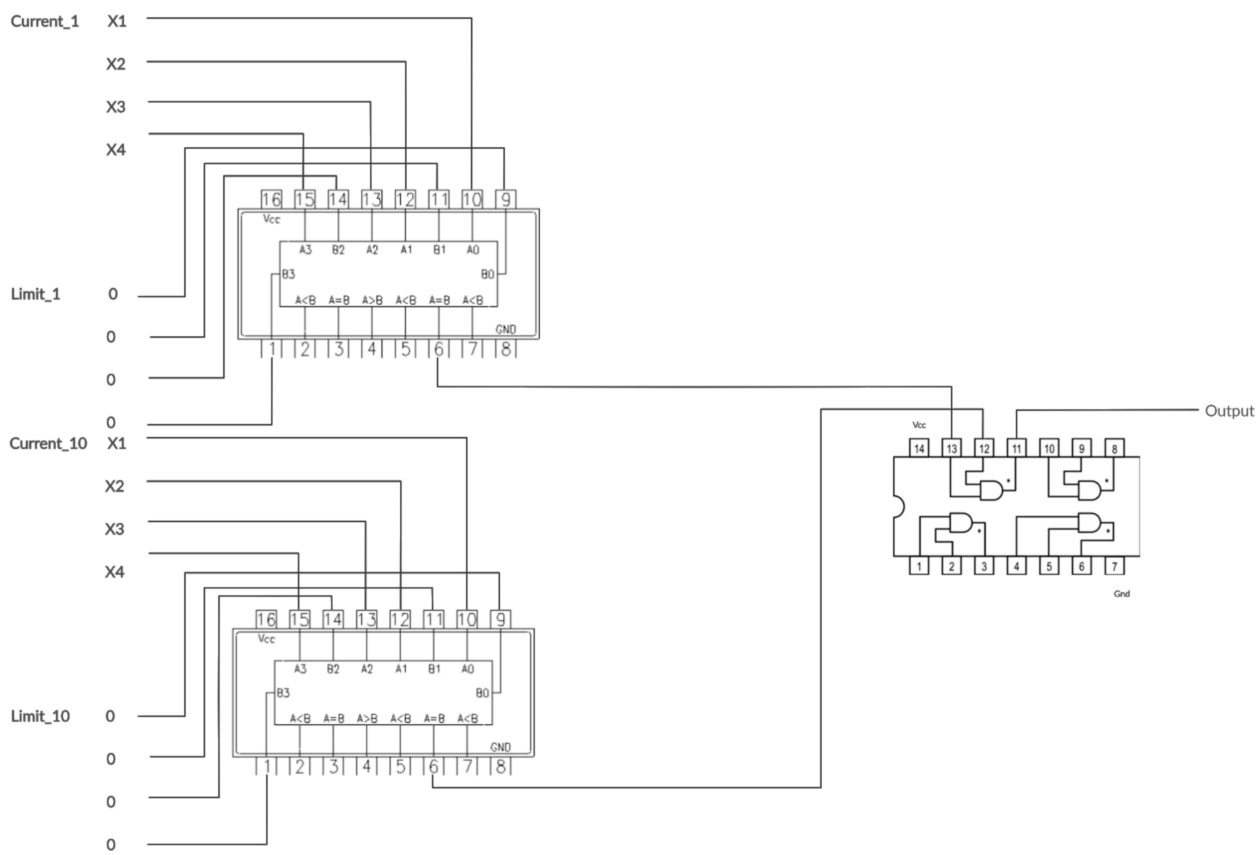
Pin-Out Diagram of EXIT DETECT: (IC Used: DM7432(1),DM7408(1), 74AHC74(1), DM7404(1))



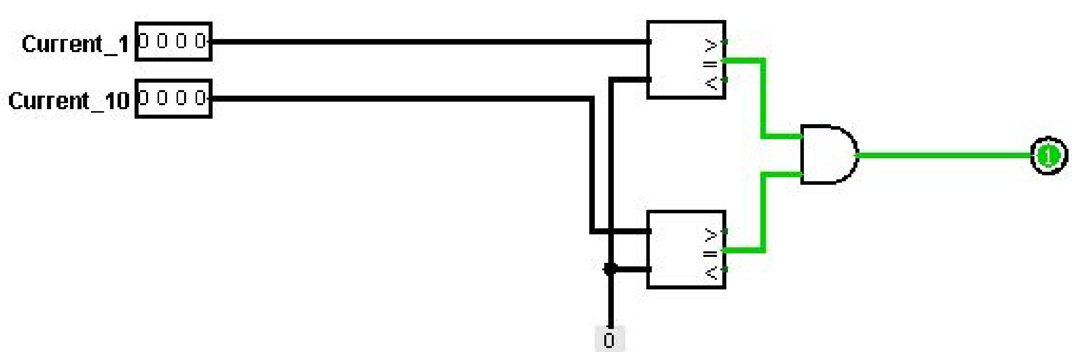
Pin-Out Diagrams and Logisim implementation for Comparator:

1. **Comparator 1:**
   To compare with zero

   Pin-Out: (IC used: DM74LS85(2), DM7408(1))

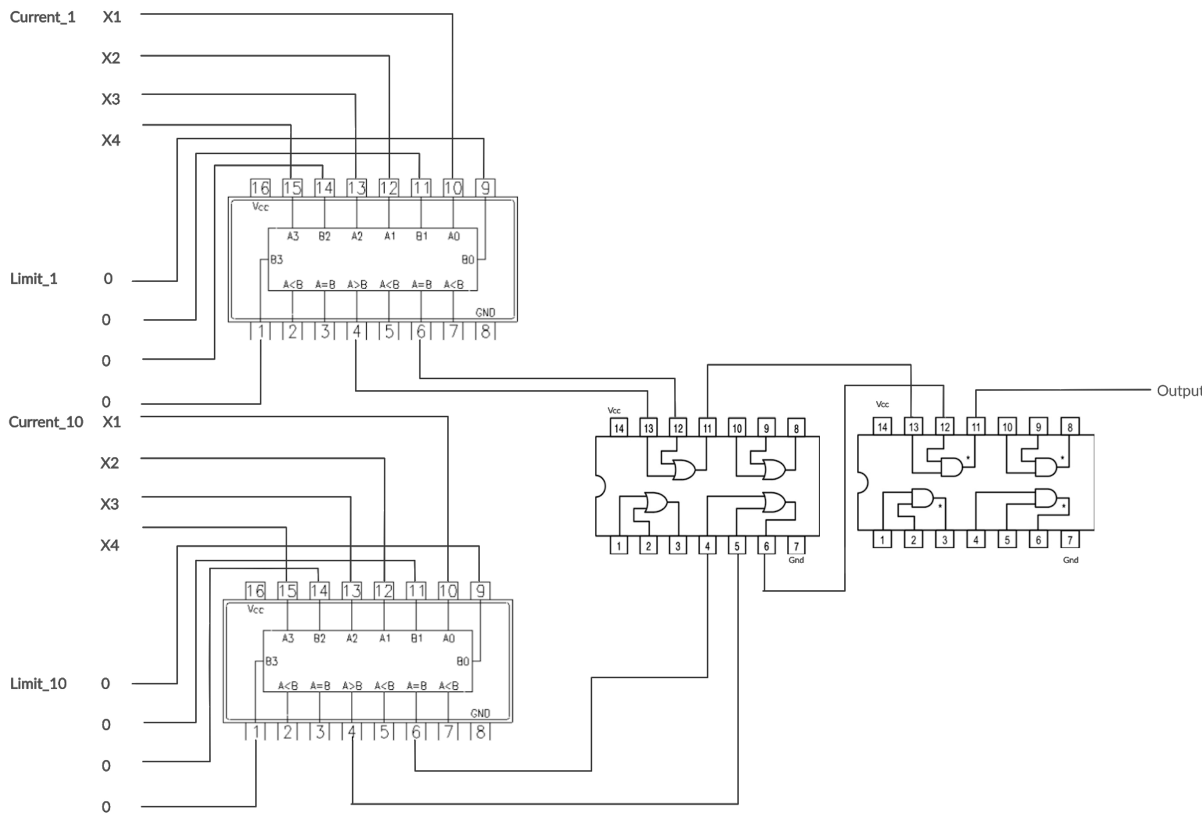


Logisim:

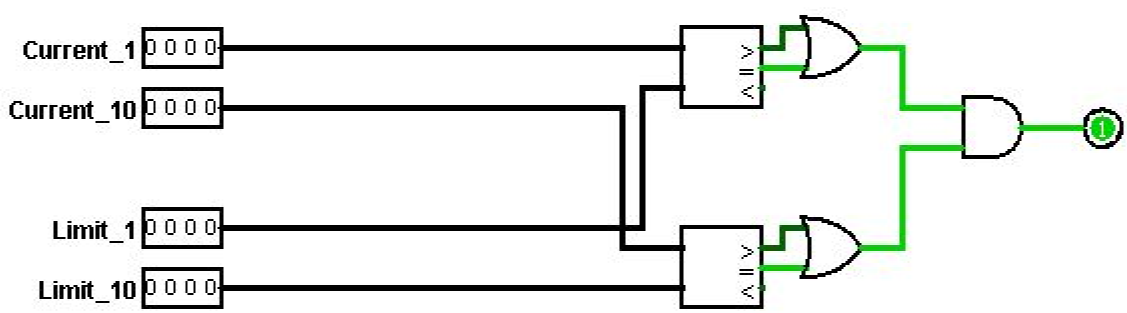


2. **Comparator 2:**
   To compare with preset value

   Pin-Out: (IC used: DM74LS85(2), DM7408(1), DM7432(1))

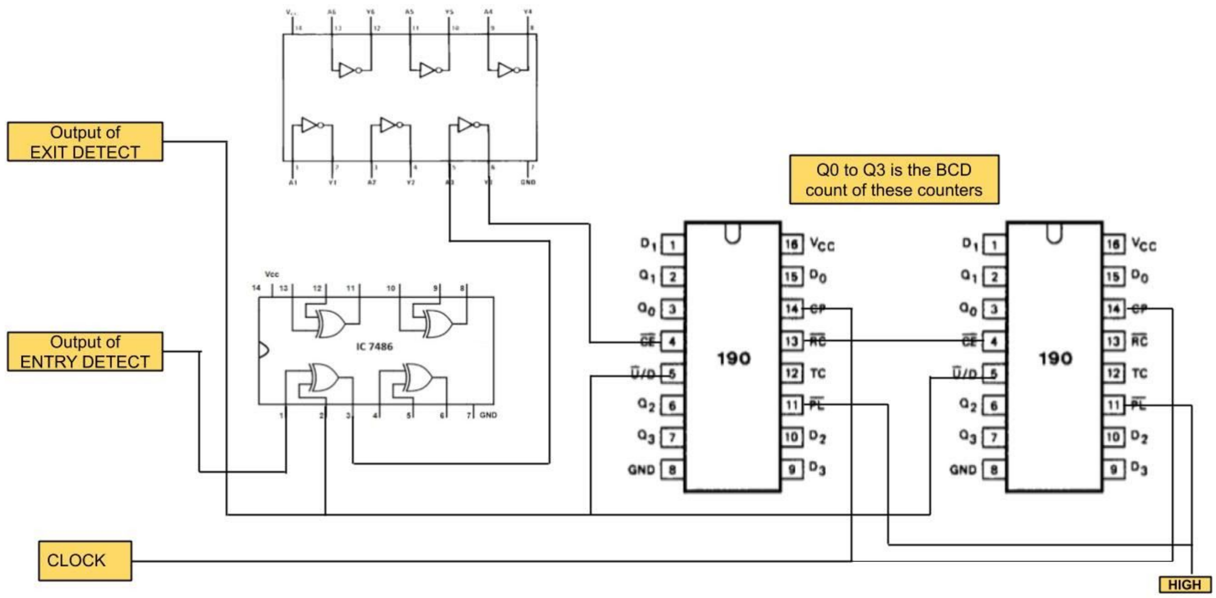


   Logisim implementation:

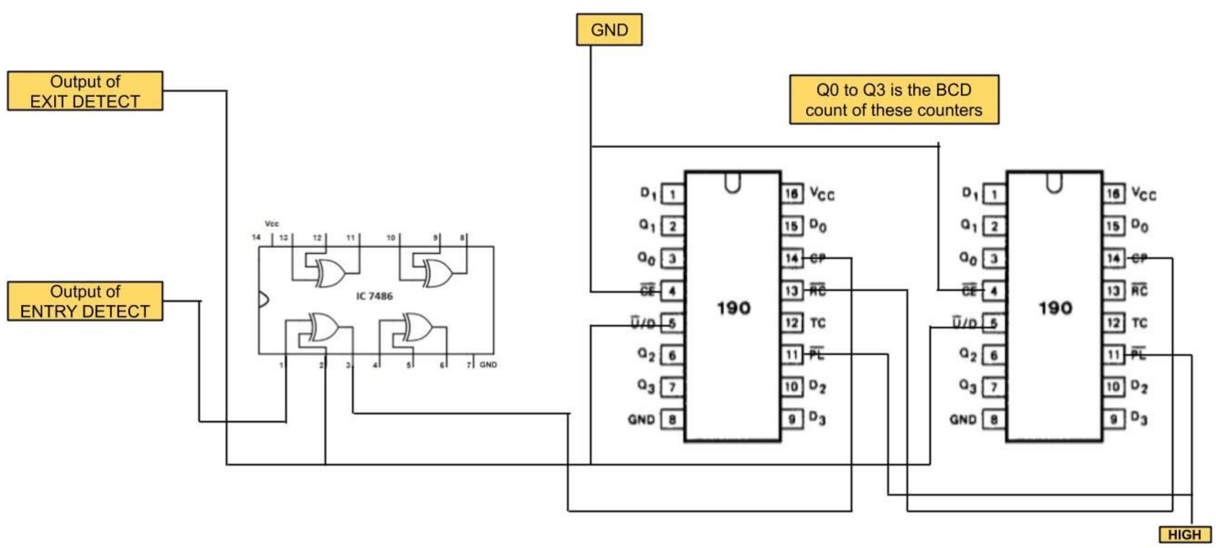


Pin-Out Diagram for Counter:(IC used, 74HC190)

(Synchronous design of counter)



(Asynchronous design of counter)

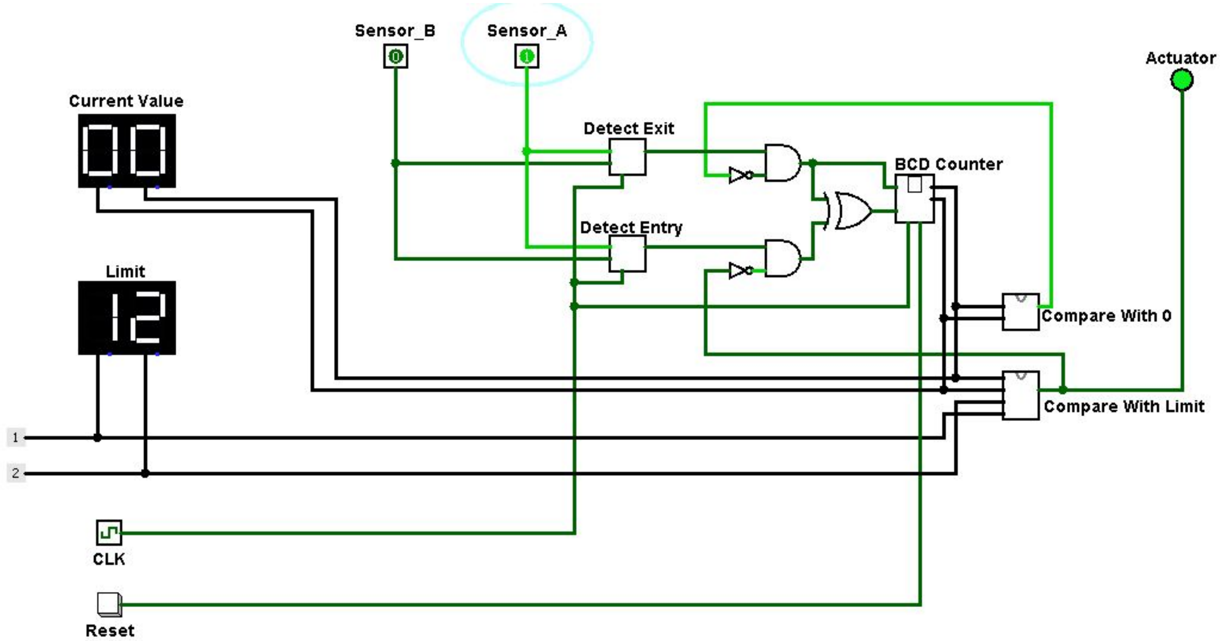


One Sample I/O combination:

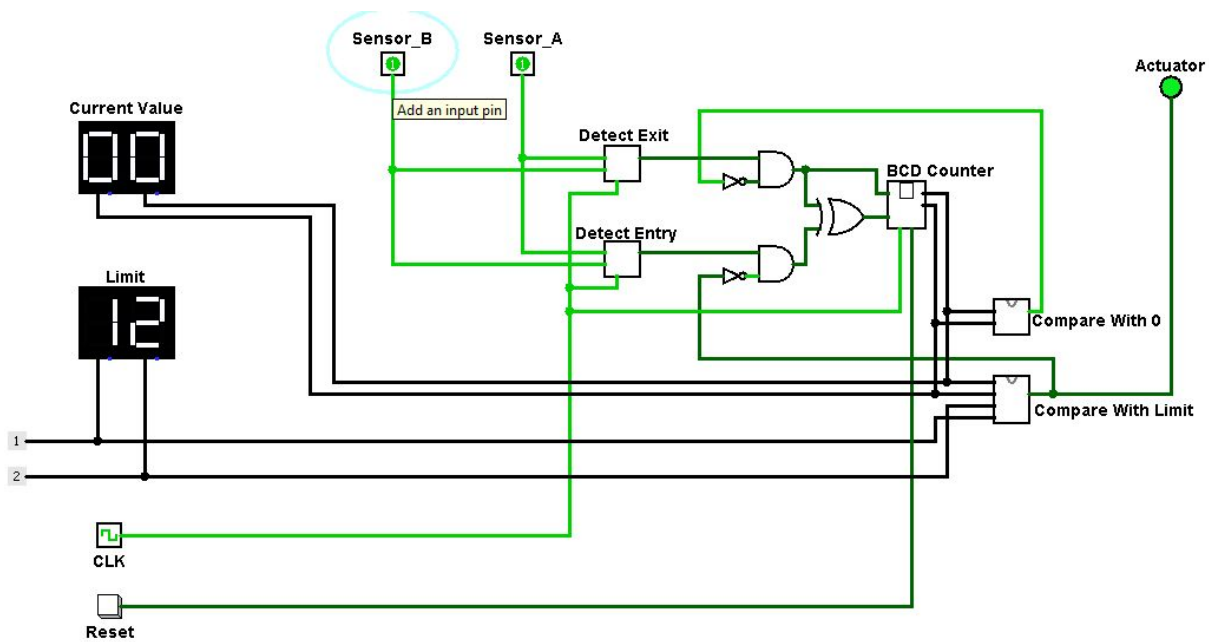
(a detailed description of all other combinations will be explained in the Viva since, it is cumbersome to include so many images, also another pdf file in the zip folder includes some other combinations)

Entry Sequence simulation:

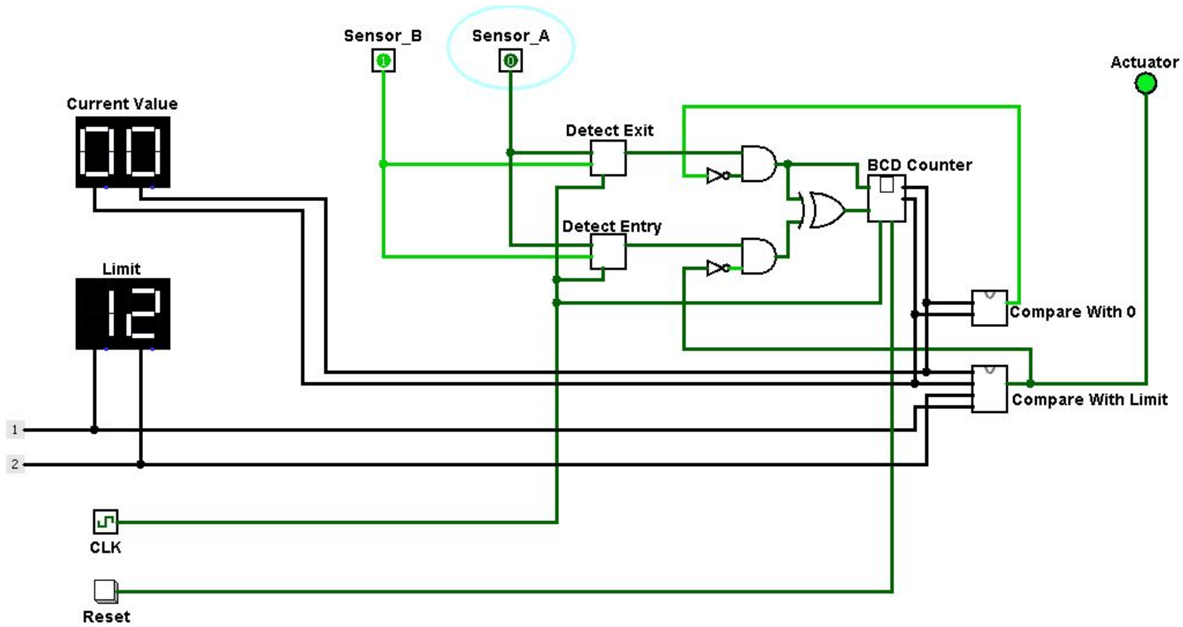
<u>Sensor A:</u> HIGH <u>Sensor B:</u>LOW



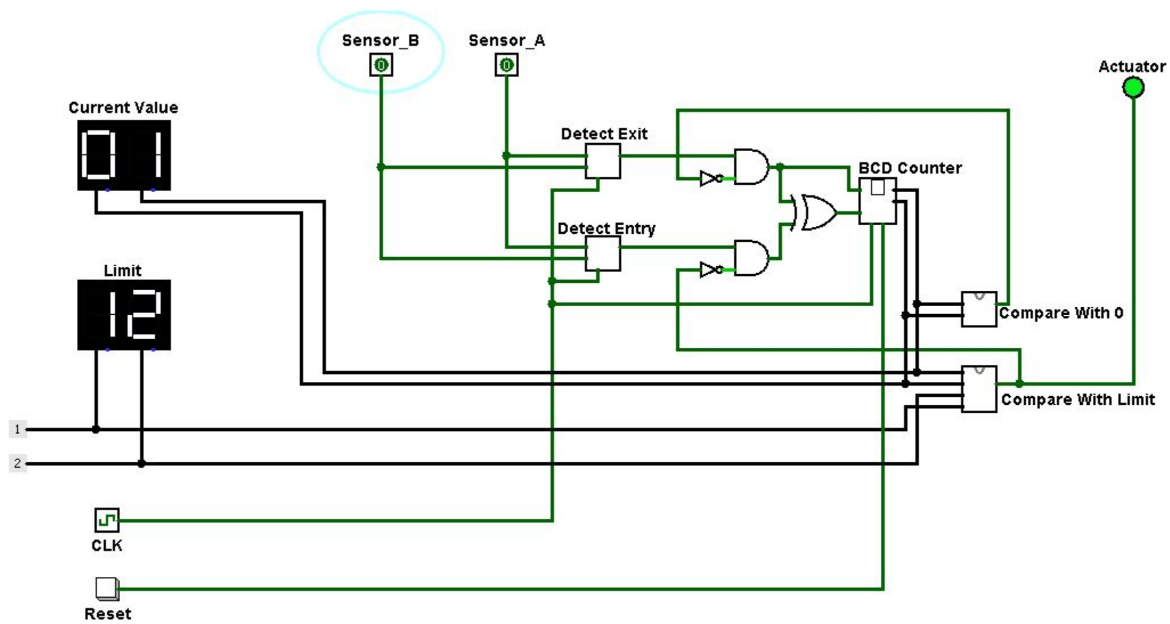
<u>Sensor A:</u> HIGH <u>Sensor B:</u> HIGH



<u>Sensor A:</u> LOW <u>Sensor B:</u> HIGH



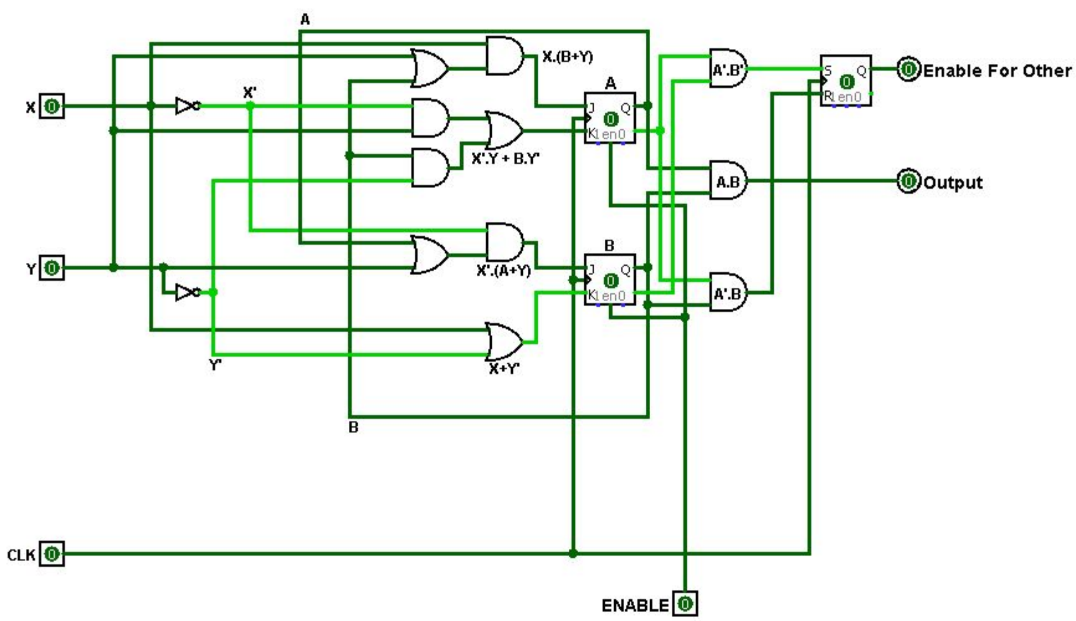
<u>Sensor A:</u> LOW <u>Sensor B:</u> LOW (Entry detected, count increases by 1)



Additional Functionalities:

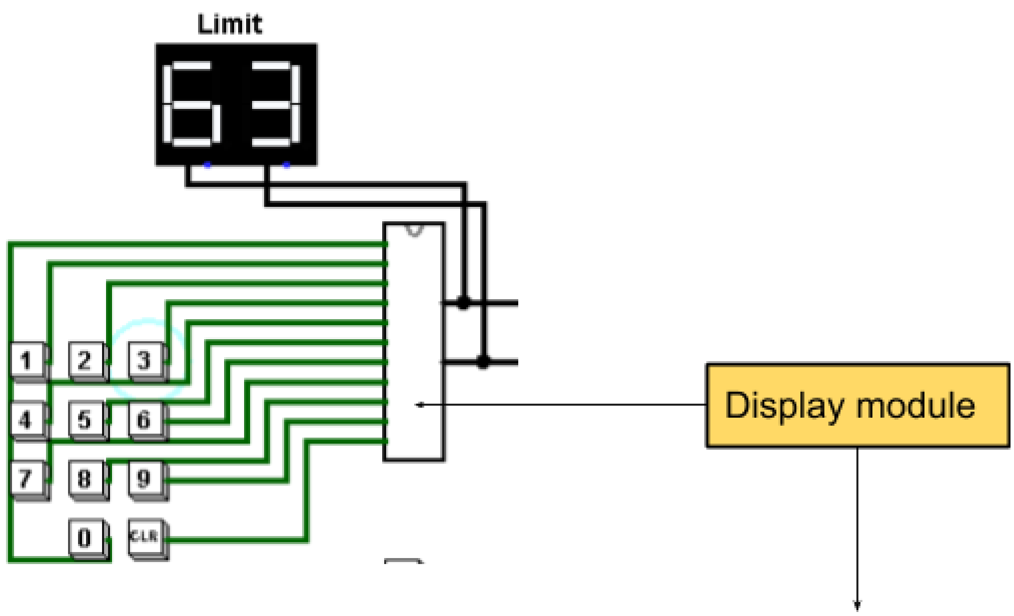
1. **Detect U-Turn:**
   The design will identify whether a person has made a U-Turn or not. In the basic design, if a person who has entered from outside the door (is making an entrance) decides to return back outside midway, the counter will count down, thinking it is an exit.
   However, this problem/assumption has been addressed in the additional design wherein, if a person makes a U-turn the counter value won't change.
   This design was implemented using the SR Latch. The underlying principle used is that if the Sensor A goes to HIGH first, the Exit Detect module should be disabled, and if the Sensor B goes to HIGH first the entry detect module should be disabled.
   So, the concept used is that when the state of Entry Detect Module goes to S1, it means that either an entry will occur or a U-Turn will occur, but an Exit is impossible unless both Sensors return HIGH, i.e. reach reset state.

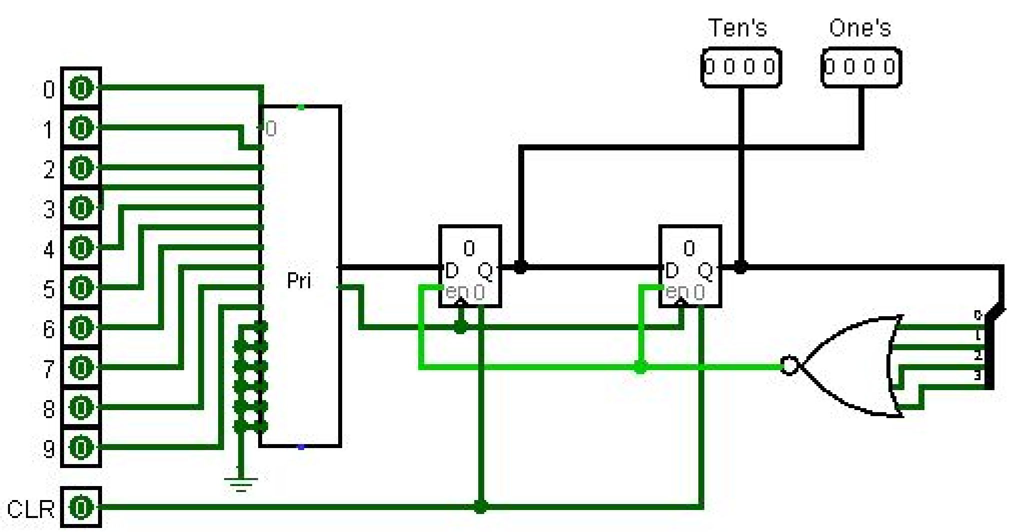
   Therefore, we use an SR Latch whose output will serve as the enable for the other module. For the Entry Detect module, we must set the latch when the state is S0 and we must Reset the latch when the state is S1(a person is standing in front of Sensor A).



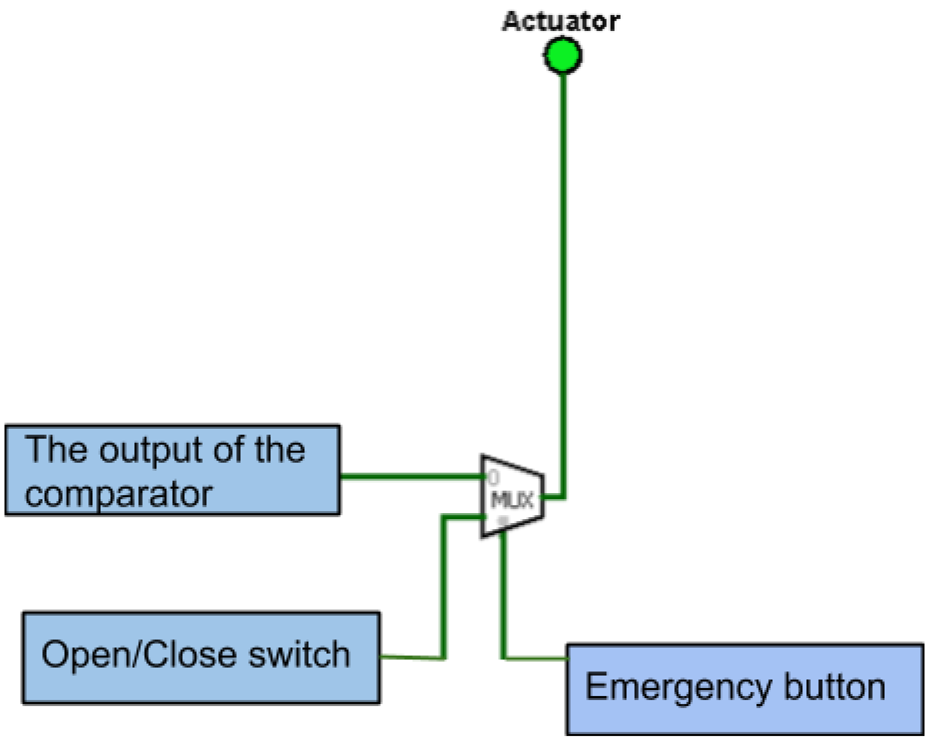
The exit detect module using the SR Latch to enable/disable the entry detect module

2. **Take input from the user for the limit of people the circuit should count to:**
   This feature of our design empowers the user to set the limit for the maximum number of people that can be present in the room. The user inputs the limit (in decimal) from a keypad and a display shows the corresponding number. Hence, if the application of our design is for a mall or shopping complex during this pandemic, the owner can reduce the limit on Sundays owing to the rush and can increase the limit on weekdays. Registers and a priority encoder were used for this design.





3. **Emergency OPEN/CLOSE button:**
   This additional feature facilitates opening and closing of the door during emergency situations like a fire/earthquake, where people may need shelter inside the room or may have to exit the room to save themselves. The design is implemented using a simple 2:1 Multiplexer. An emergency button decides whether the design must function in normal mode or emergency mode. If the emergency button is HIGH, then another open/close switch will be activated using which the handler can open or close the door.



4. **ENTRY/EXIT indicator:**
   Since, the design does not stay accountable for the case where more than one people enter through the door at the same time, it is necessary to add an indicator that is GREEN when the next person can pass through and is RED when a person is in the process of exiting/entering.

List and quantity of all datasheets used:

IC	Function of the IC	Quantity
DM7408	2-input AND	4
DM7432	2-input OR	3
DM7404	Inverter	3
DM7486	2-input XOR	1
DM7476	JK Flip Flops	2
DM74LS85	4-bit Comparator	4
74HC190	Presettable Synchronous BCD Decade Up/down Counter	2

Appendix:

(links to all datasheets)

2 input AND:
https://www.jameco.com/Jameco/Products/ProdDS/872095.pdf

2 input OR:
http://ee-classes.usc.edu/ee459/library/datasheets/DM74LS32.pdf

Inverter:
https://www.electroschematics.com/wp-content/uploads/2013/07/dm7404-datasheet.pdf

2 input XOR:
https://www.jameco.com/Jameco/Products/ProdDS/48098.pdf

JK Flipflops:
http://www4.ujaen.es/~gnofuen/Hoja%20caracteristicas%207476.pdf

4-bit comparator:
http://ee-classes.usc.edu/ee459/library/datasheets/DM74LS85.pdf

Presettable Synchronous BCD Decade Up/down Counter:
https://www.digchip.com/datasheets/parts/datasheet/364/74HCT190.php