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Assignment Cover Sheet

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ASSIGNMENT DETAILS

Unit Code	COS10004	Unit Title	COMPUTER SYSTEMS
Tutorial/Lab Group	Group 8	Lecturer/Tutor Name	Mark Tee Kit Tsun
Assignment Title	Design Logic Circuits Using CEDAR		
Due date	11/01/2019	Date Received	

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Total Mark		Marker's Signature		Date	

EXTENSION CERTIFICATE

This assignment has been given an extension by

Unit Convenor			
Extended due date		Date Received	

COS10004 – COMPUTER SYSTEMS

DESIGN LOGIC CIRCUITS USING CEDAR

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1. Introduction

A smart home system is a home setup where the appliances and devices within the house are automated and remotely controlled through the Internet (Chen 2018). They are connected to each other through a central hub, which controls all the smart devices and handles the inter-communication between the devices. This relates to the concept of Internet of Things (IoT), where a network of smart devices work together and communicate data with one another to automate certain tasks (Liu 2019).

Different smart home systems make use of different gimmicks and technologies, but they all generally have the same idea behind how they function. They integrate four different components; sensors/devices, connections, data processing, and the user interface (McClelland 2017). The sensors/devices continuously collect data from their surroundings, which are then sent to the cloud for processing. The output can then be notified to the user, or be used by other devices to automate certain processes. This automated system of obtaining data, processing, and producing output is what makes a smart home system “smart”, as it can function autonomously without the need for human supervision.

This concept of networking devices together has existed for quite some time, going as far back as 1982. A modified Coke vending machine was the first Internet-connected appliance, capable of reporting its inventory and the temperature of its drinks through the Internet (Palermo 2014). From then, various technological developments and innovations have helped in the development of IoT and eventually smart home systems. From toasters, to LGs smart fridge, to Amazon Echo and artificial intelligence (Braun 2019), IoT has grown to become a vital part in today’s world, helping improve a multitude of aspects in multiple different areas, and that includes creating efficient and convenient smart home systems.

2. Research Survey

2.1. Existing Smart Home Systems/Devices

2.1.1. Amazon Alexa

Amazon Alexa, also known as Alexa, is a cloud-based voice-enabled virtual assistant that is developed by Amazon (Amazon Alexa). It is capable of performing various functions, such as scheduling, taking notes, music playback, providing online information and many more through voice-input, which is handled and processed in the cloud. As of the year 2019, many third-party organizations have integrated Alexa into their devices, with over 20000 third-party integrations with Alexa (Forsey 2019), which makes Alexa the smart system that is compatible with the most third-party devices.

There are two ways that Alexa can be integrated into the devices. The first method is by utilizing Alexa Skills, which function like apps for Alexa (Amazon Alexa). With this, developers can create Alexa Skills that interact with their device, which allows their device to be controlled voice-input via Amazon Alexa. Another way is to integrate Alexa directly into the device, with Alexa Voice Service. If the device can handle voice input and output, then they can make use of the Alexa Voice Service, which allows these devices to basically act like Amazon Echo devices.

In order to connect any smart devices to Alexa, the devices must be on the same WiFi network as Amazon Echo devices, so that they can communicate with each other on the same network. The devices also have to be setup through the methods provided by the manufacturer, then only can they be discovered and connected to Alexa through voice-input or the app.

Once connected, the smart home devices can be interacted with through Amazon Echo devices with voice-input. These smart home devices can also be grouped together to form "Routines" (Amazon), which allows Alexa to perform a series of actions with one command.

2.1.2. Wink Hub 2

Wink Hub allows management of connected devices under one single app called The Wink App, allowing simpler control and monitor(Wink). In addition to its own variety of smart products, Wink works with devices from many other brands such as Philips, Honeywell, Nest, Kwikset and Leviton.

A special feature of Wink is the implementation of “Robots”. Robots allows users to customize interactions between different products, like giving the house a mind of its own. According to Duncan (2017), this means automation for tasks the users can set, whether it is trigger events, time of the day or chaining multiple actions with a single input. To set up a robot, or the automation, is easy. From the app’s interface, the user can link up devices and choose the conditions for the desired action.

Wink also has a shortcut feature within the app, allowing control to entire systems with a single swipe. Convenient for actions and interactions that users do frequently. There are two types of shortcuts, the normal shortcuts and Google Now using Google Assistant. This can be combined with schedules and robots to open up more possibilities.

Wink tracks the power usage of the house and notifies the user the bill in real time. Wink knows exactly the activities of each device in the building, and in addition, can help save power by controlling them.

2.1.3. Samsung SmartThings

Samsung SmartThings is Samsung's own brand of smart devices that include smart sensors, outlets, buttons, cameras, and many more, that serve to interact with other smart devices to create a more complex and intricate smart home system.

At the center of a SmartThings smart home system is the SmartThings Hub. It uses WiFi to connect to the network in order to interact with the various smart devices that it is compatible with. Once connected, the smart devices can be monitored and controlled using a single SmartThings app. It also has a scheduling feature called SmartThings Routines which allows the user to automate their smart home devices according to the time of day (SmartThings).

Then, there are the devices that allow for greater control over the automation of a smart home system. WIth the use of SmartThings cameras, sensors, and buttons, various smart devices can be automated based on the input from these SmartThings devices, such as switching on the lights when a person is detected in the room with a sensor. This allows devices that otherwise have no capability of automation to be controlled and automated with sensors and cameras.

Samsung, by themselves, do not have a large quantity of smart home devices, which is where their extensive compatibility with over 100s of devices from various organizations and companies allows them to create intricate smart homes (Samsung). They are compatible with devices from companies such as Ecobee, Philips, Ring and many more.

2.1.4. Ecobee Smart Thermostat with Voice Control

Ecobee Smart Thermostat (Ecobee) is an Alexa voice-enabled thermostat that is capable of regulating internal house temperature for comfort or energy-saving. It is built with occupancy sensors that detects the presence of a person within a room, which provides the thermostat with various useful features such as the Smart Home/Away or the Follow Me Mode. This functionality is extended across multiple rooms by using SmartSensors, which can be placed in different rooms and spots. This allows the thermostat to adjust the internal house temperature for comfort when someone is at home, or vice versa, and even "follows" the person around the house by adjusting the temperature of the rooms based on where the person is.

Because of this automatic regulation of the internal house temperature, it prides itself for its energy saving capabilities. Since the temperature of the entire house is taken into consideration with the use of multiple sensors in multiple rooms unlike ordinary thermostats, it is able to control the Heating, Ventilation and Cooling (HVAC) system more optimally and efficiently. It also comes with a Thermal Protect capability, which prevents the HVAC system from excessive runtime by ignoring sensors that greatly diverge from the other sensors.

On top of all of that, Alexa is built into every SmartSensor, and not just the thermostat, which extends Alexa functionality throughout the entire house. It also sends notifications and reports to the user's phone, which shows various useful information such as energy saving rate, performance, and other statistics.

2.1.5. TP-Link HS200

TP-Link HS200 (TP-Link) is a smart light switch that is capable of remote operation through the smartphone or tablet. With the use of the Kasa app, the user can control their home lighting from anywhere, as long as they are connected to the Internet. Thus, the user can monitor their home lighting and control it whenever and wherever. It is also compatible with Amazon Alexa, thus the user can conveniently use their voice to control their home lighting, without the need for any manual input.

The smart switch also comes with scheduling functionality, which allows the user to automate their home lighting based on the time of day. For example, they can have it set so that the lights in their room switch on during their waking hours, or only activate the lights in certain areas during sunset. With this, the user can automate their lighting system so that they do not have to manually toggle the lights whenever they need to.

The Kasa app is also capable of grouping together multiple different switches as one, so that the user is able to toggle multiple light switches with just one tap. This can be utilized in a variety of different ways, such as setting up different “lighting modes”, or switching all the lights in a single room.

There is also an Away Mode, as a form of security feature. Whenever the user is not home, the smart light switch can take over the lighting system and randomly switch them on and off, to give the appearance that someone is at home to deter any potential criminals.

Since the HS200 still allows for manual toggling of the switches, it has built in LED indicator that allows the user to find the switch, even when all the lights are switched off during night time.

2.2. Limitations

Although these existing smart home devices are very convenient and capable, there are still some limitations or features that have not been implemented or utilized to their full extent.

Firstly, the Ecobee Smart Thermostat system makes use of occupancy sensors that detect the presence of someone in the room. In the context of the Smart Thermostat, it is used to determine which part of the HVAC system to enable in the house. This can be utilized further by other devices that could benefit from this automatic detection, such as to automatically activate devices when someone enters a room.

Secondly, existing coloured smart bulbs do not seem to implement the feature of being controlled by the temperature. These bulbs seem to be able to controlled by the weather, images, and various other methods, but temperature does not seem to be one of them. This is an interesting feature that should be explored as it may be utilized to good effect, such as to "display" the temperature of a device without having to monitor it on a screen.

3. Design Flowchart

3.1. Follow-Me Room Activation System

This system utilizes occupancy sensors to detect the presence of a person in the room. If a person is detected, appliances such as Smart Plugs, the HVAC system, or anything switchable via WiFi within the room will be switched on. The user will be able to configure which devices can be activated through their phone, so that unneeded devices are not activated unnecessarily/important devices are deactivated accidentally when entering/leaving a room.

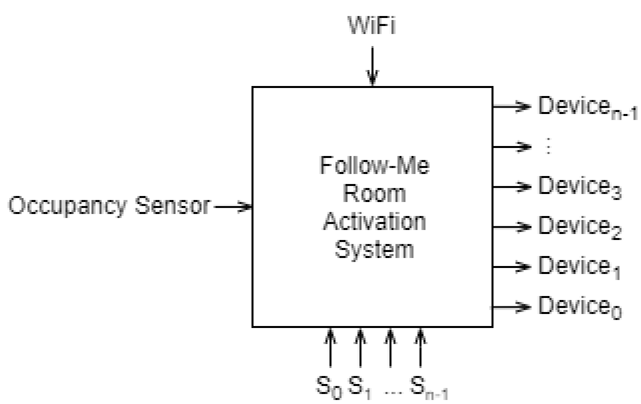

Figure 1: Block diagram for Follow-Me Room Activation System

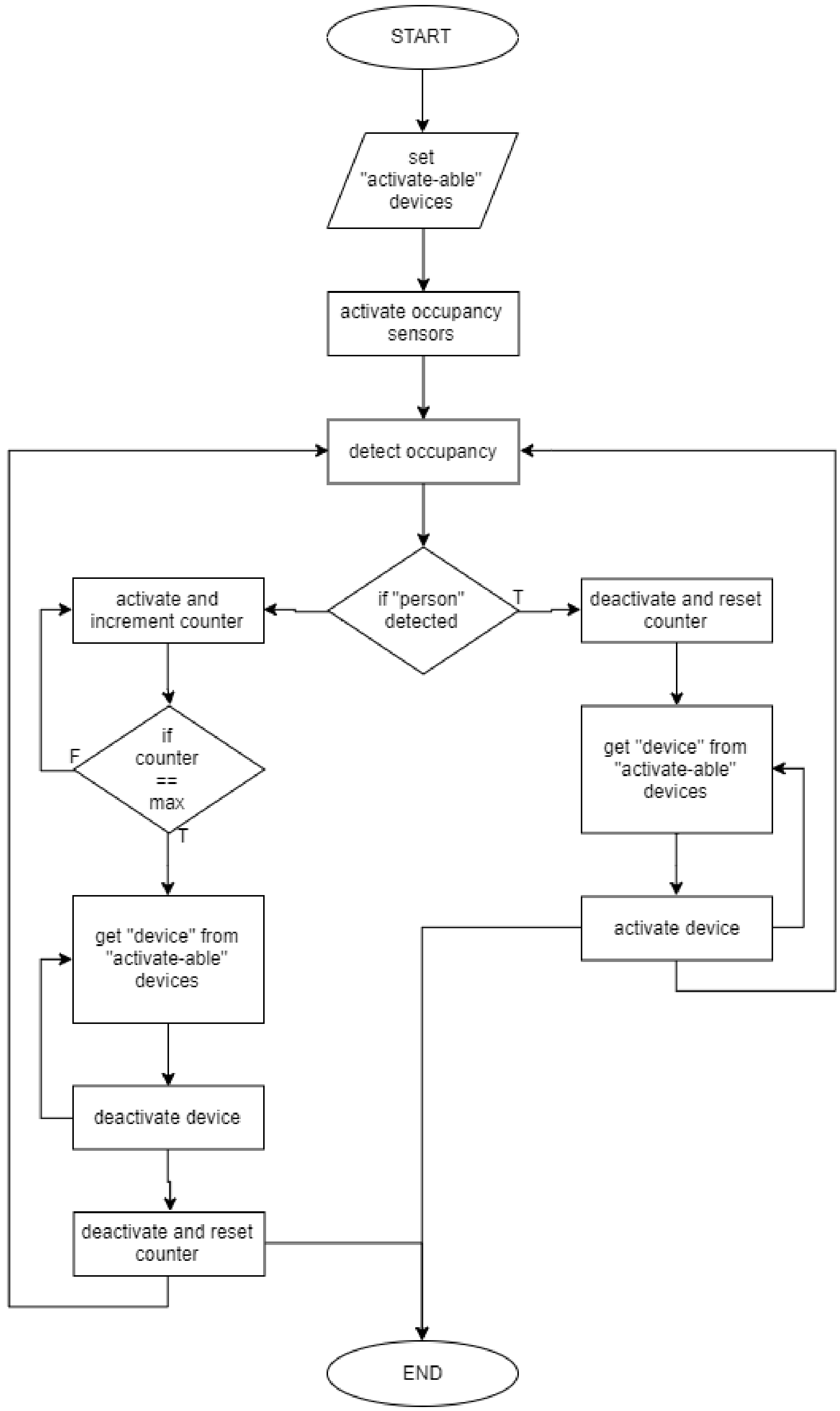

Figure 2: Flowchart for Follow-Me Room Activation System

3.2. Security System

The doors of the house have magnetic locks fitted onto them, which serve as a way to prevent traditional forms of burglary. These doors, if broken into by force, will trigger the security. There are also sound sensors, which are triggered by sudden, loud sounds such as windows breaking. The sound sensors are only activated when the user is not at home, so that there are no false alarms in the event of an accident. Occupancy sensors in the house also detect any unexpected intruders that managed to sneak into the house, which will also trigger the security.

There are a number of actions that are undertaken when the security is triggered. Firstly, a high priority notification is sent to the user's mobile phone to inform them of the event, to first check if it a false alarm or it is the user's own doing. If it is indeed an intrusion, the nearest authorities are contacted and an alarm will be triggered. The user can also view the state of their home through cameras that are placed around the house, and initiate voice conversation with the intruder, to perhaps threaten and scare him away.

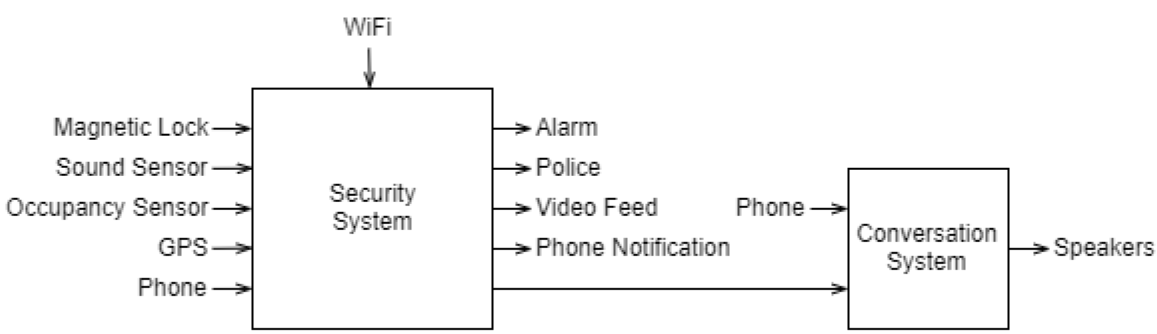

Figure 3: Block diagram for Security System

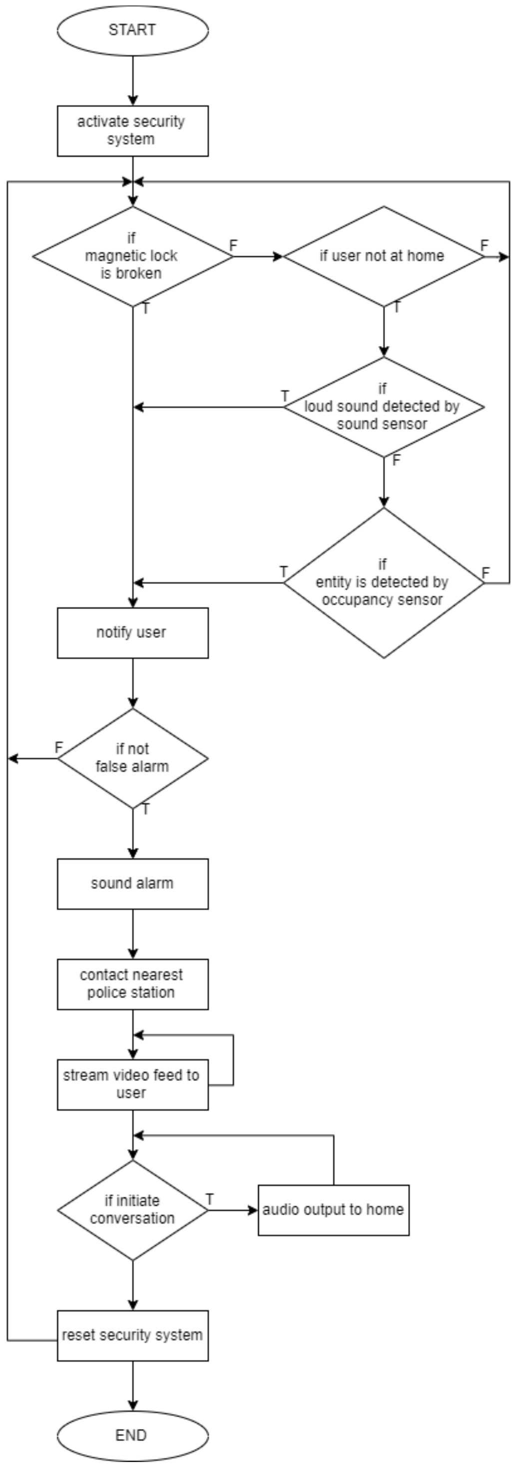

Figure 4: Flowchart for Security System

3.3. Privacy Blinds

The house is fitted with light sensors on the inside and the outside of the house, and the blinds will have varying levels of "shutting", based on the difference between the light levels inside and outside the house. If there is a big difference between the light levels, then the blinds will be completely shut, and conversely, the blinds will be completely open if there is no difference between the light levels, and everything in between.

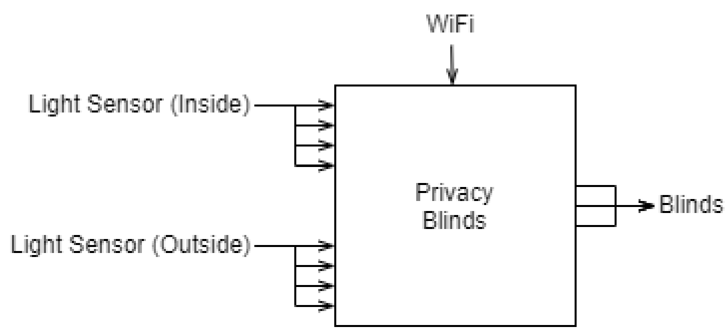

Figure 5: Block diagram for Privacy Blinds

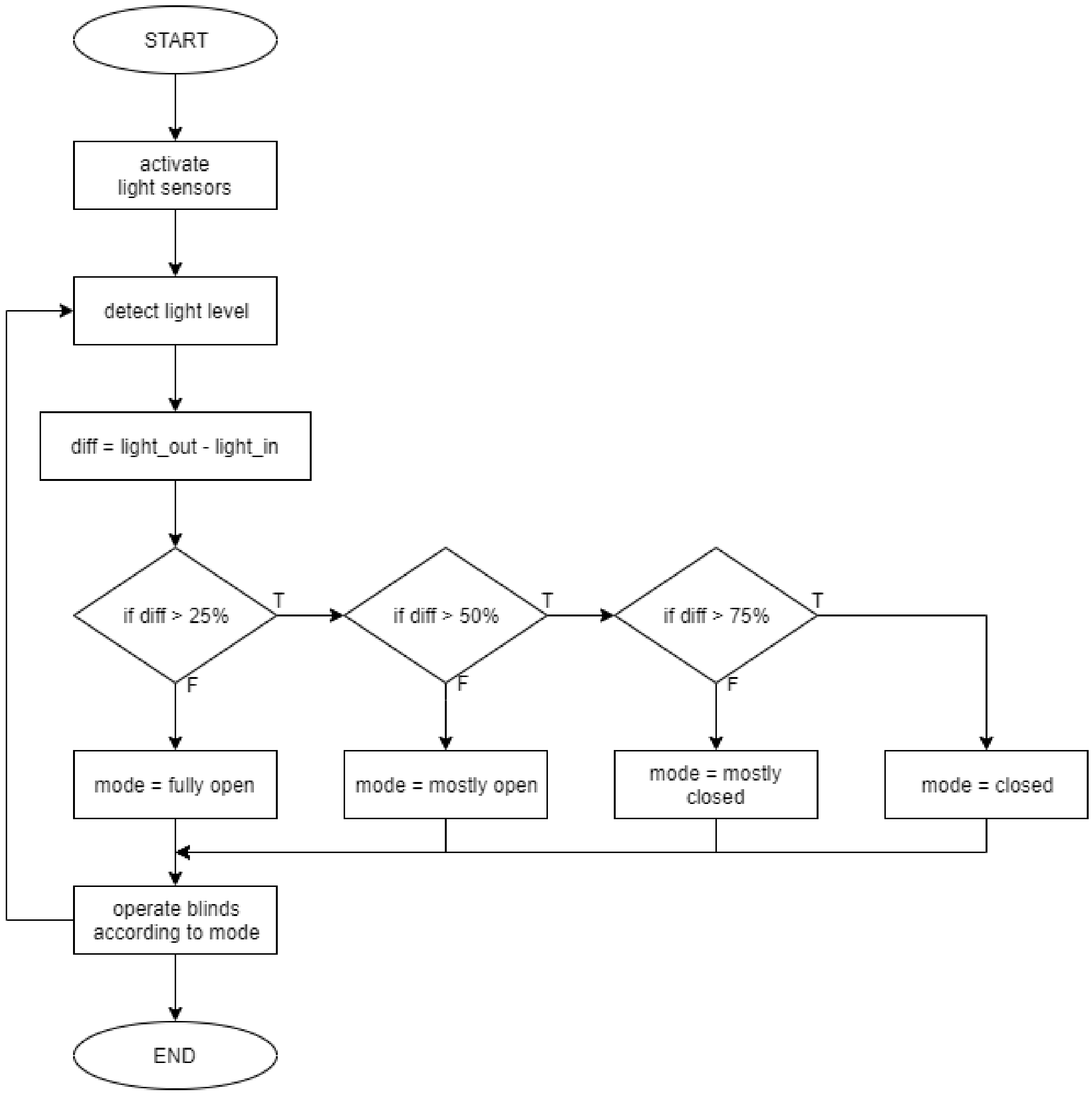

Figure 6: Flowchart for Privacy Blinds

3.4. Temperature-Colored Bulbs

Another use of thermometers that's not popular in the market is to connect them to a light source. The Temperature-Colored Bulbs is a suitable product to pair and work with a smart thermometer. The thermometer outputs the change in temperature, and the hue bulb receives input in RGB format. Since the output and input format of the thermometer and the lights are different, an intermediate design circuit will be required to convert the values and allow communication between the two devices.

We also assume that the bulb only outputs either 1 or 0 for increase and decrease respectively, whenever there is one, while the bulb has three sets of 8bit inputs, for each color.

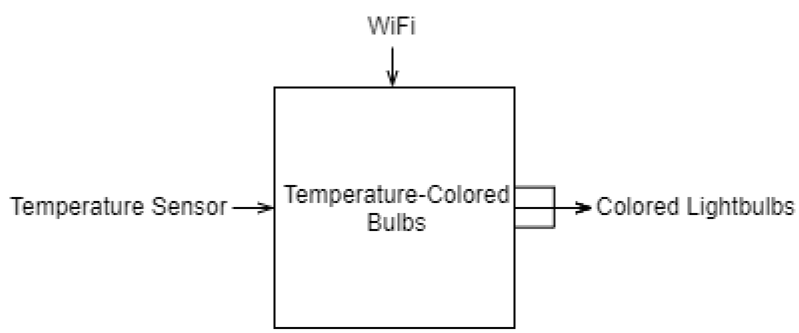

Figure 7: Block diagram for Temperature-Colored Bulbs

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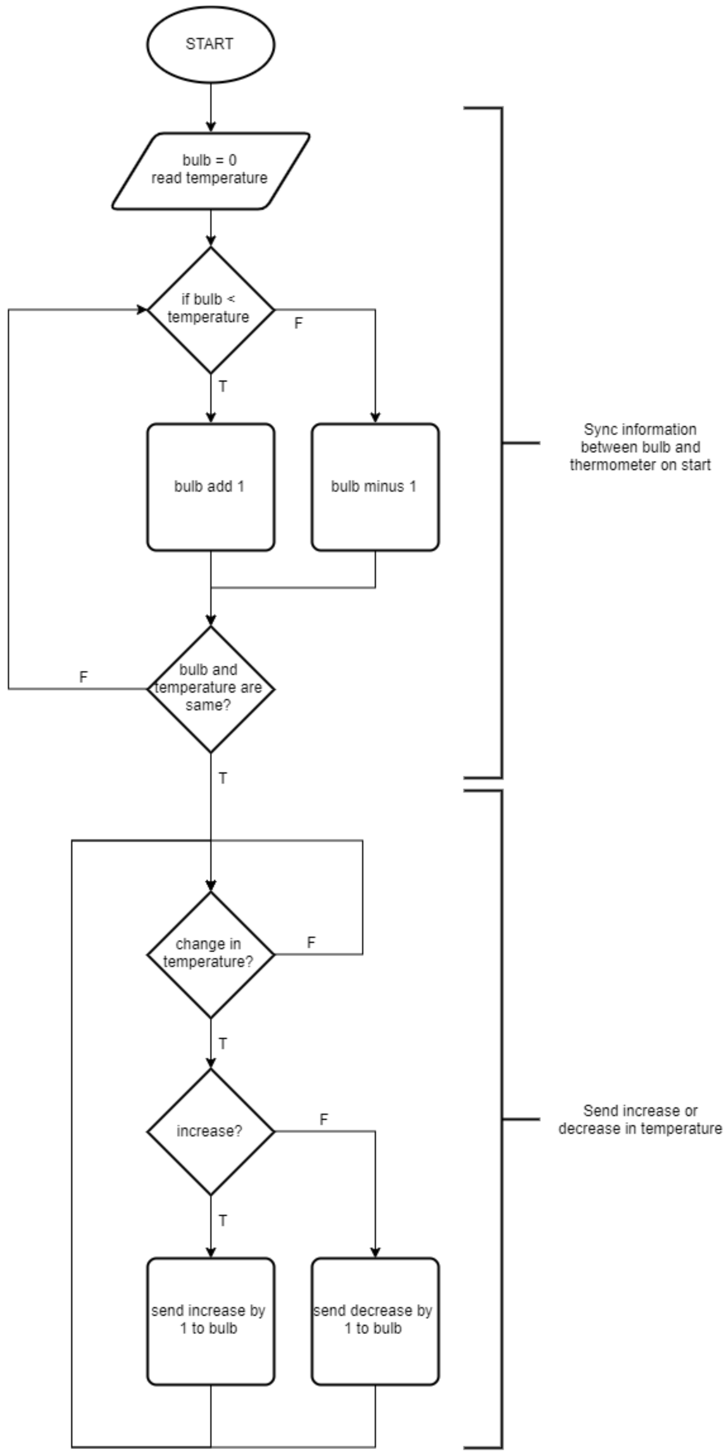


Figure 8: Flowchart for Temperature-Colored Bulbs

3.5. Notification Lights

The Notification Lights connects regular everyday notifications to the lights around the house. These notifications can come from anything that is connected to the hub, such as the doorbell, microwave, phone calls and notifications, and washing machines. This is especially useful when the user is focused on something or listening to music and are unable to hear the sounds from their appliances/devices. For versatility and customizability, the system can store up to a certain amount of custom colors and change them whenever required.

When the notifications are received, dedicated lights will change their colors from their current ones to the set color for a brief moment, before turning back.

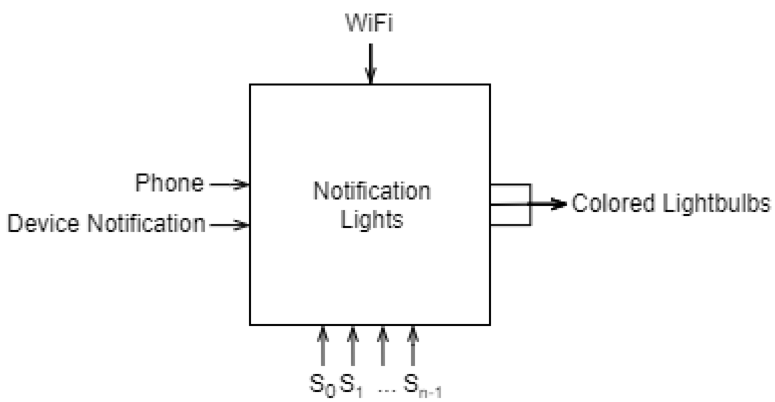


Figure 9: Block diagram for Notification Lights

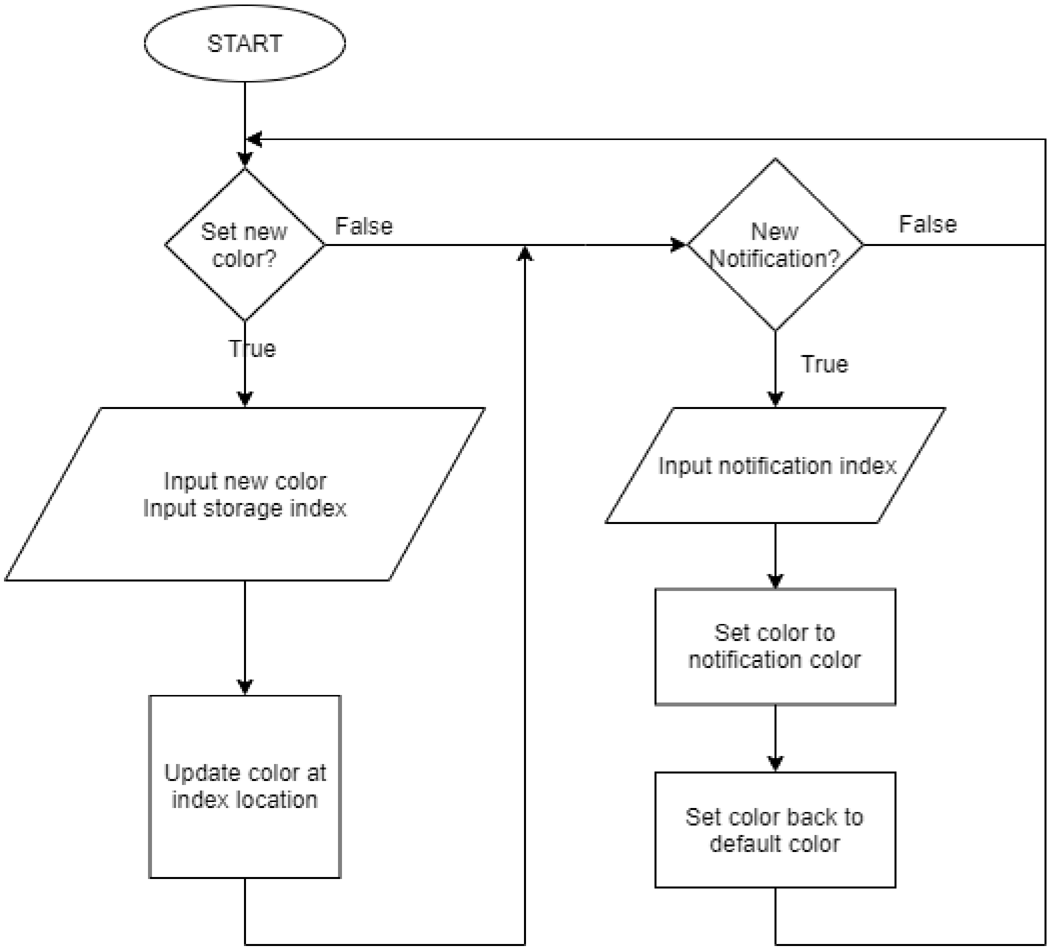


Figure 10: Flowchart for Notification Lights

4. Circuit Design Description

4.1. Follow-Me Room Activation System

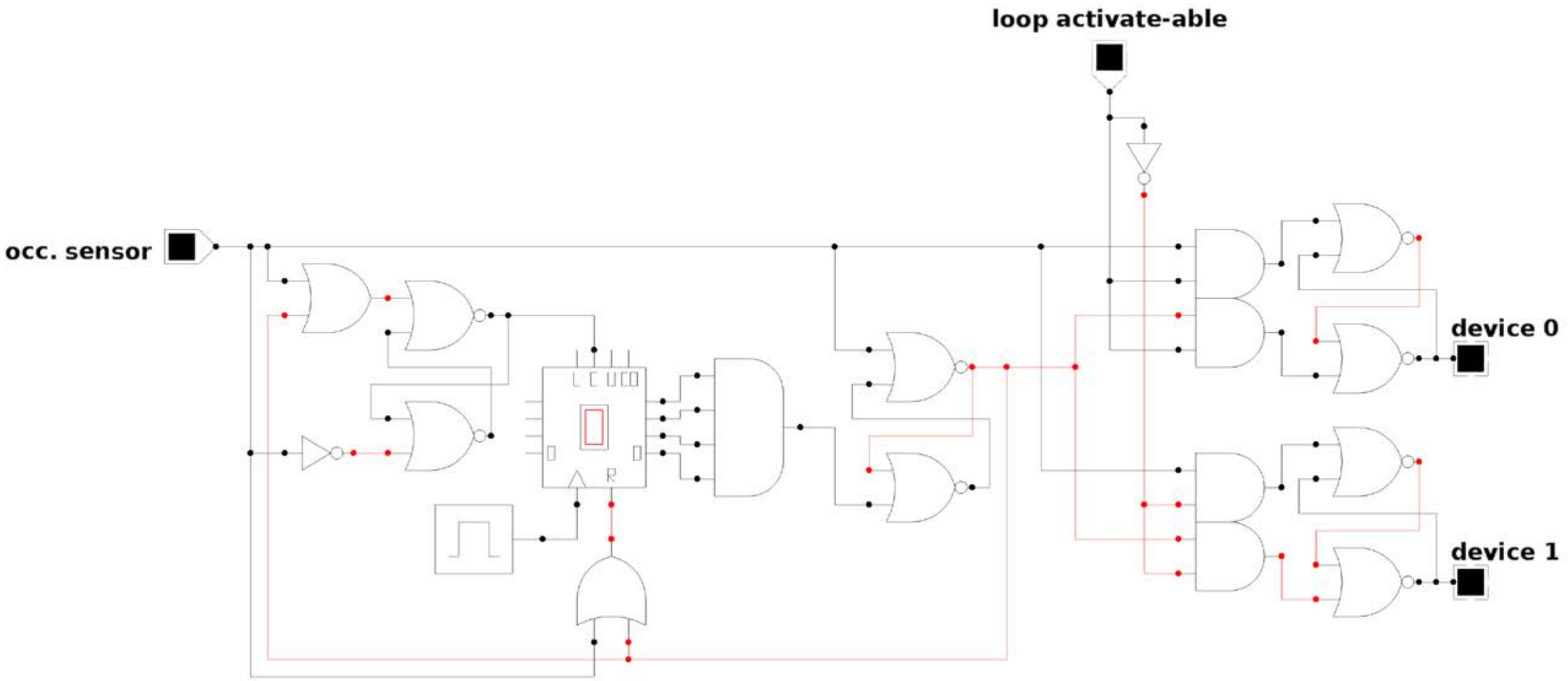


Figure 11: Full circuit for Follow-Me Room Activation System

This system can be split up into 3 parts, the trigger, the reset and the demultiplexer.

The trigger is simple. If the occupancy sensor detects someone, it will output a 1 and switch on the devices in the room with the help of the demultiplexer and SR latches that are attached before the devices. The demultiplexer loops through the “activate-able” devices that the user set in the program, and routes the input to the correct devices to activate them. In this circuit, a 1:2 demultiplexer was used for simplicity, but in practice, a larger demultiplexer will be used to accommodate the large number of devices in a room.

Occupancy Sensor	Activate-able	Device 0	Device 1
0	0	Q	0
0	1	0	Q
1	0	Q	1
1	1	1	Q

At the same time when the occupancy sensor outputs a 1, the “counter” latch and the counter itself will be reset to 0.

When the person leaves the room, the reset comes into play. The moment the occupancy sensor outputs a 0, the “counter” latch will be set to 1 and the counter will start counting up. When the counter reaches the maximum value, the “disabler” latch that comes before the multiplexer is set to 1. The output of this latch is then multiplexed to the different devices, resetting the device latches (the ones before the devices) to 0. At the same time when the “disabler” latch is set to 1, the “counter” latch and the counter itself is reset to 0.

Occupancy Sensor	“Counter” Latch	Counter Bits	“Disabler” Latch	Devices
0	1	0000 - 1110	0	Q
0	1 (before reset)	1111	1	0
0	0 (after reset)	0000	1	0
1	0	0000	0	Q

4.2. Security System

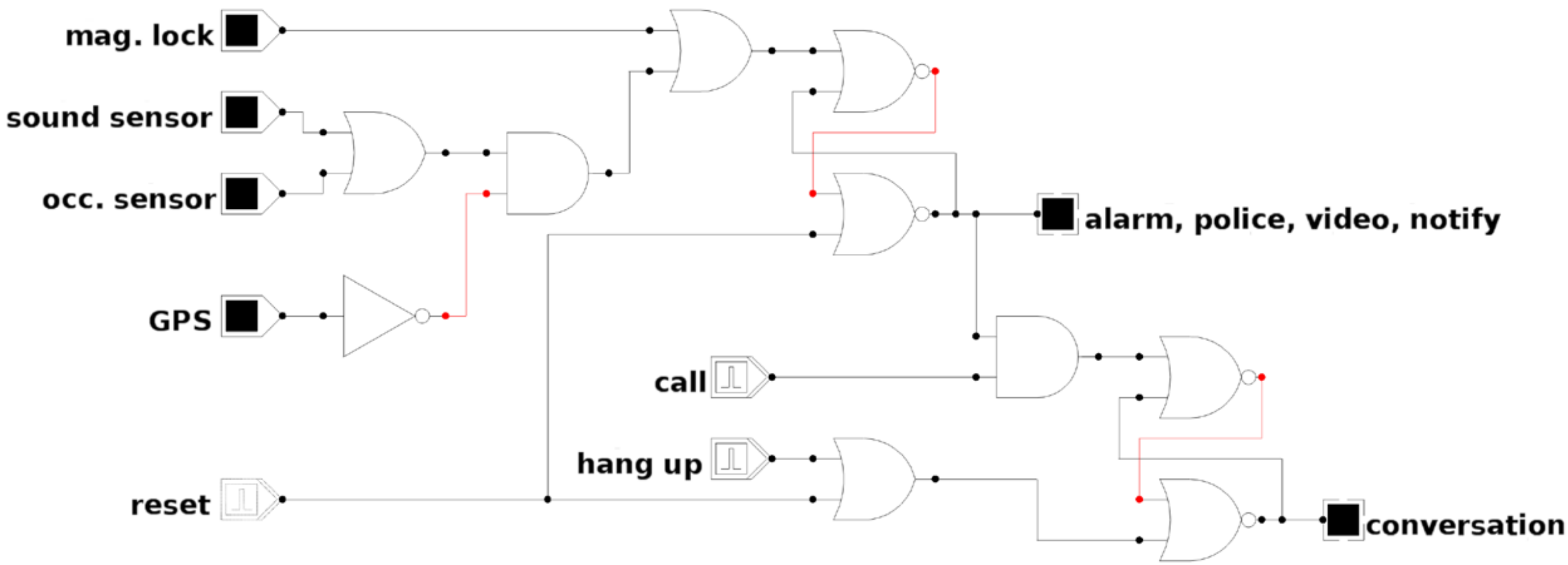


Figure 12: Full circuit for Security System

The circuit can be broken down into 3 parts: the trigger system, the “conversation” system, and the reset system.

The trigger system takes 3 sensor inputs, the state of the magnetic lock, the sound sensor, and the occupancy sensor. The GPS input functions as an enabler for the sound sensor and occupancy sensor. Below are the definitions of the values:

Magnetic Lock:	0 = Not broken in	1 = Broken in
Sound Sensor:	0 = No loud sound	1 = Loud sound detected
Occ. Sensor:	0 = No presence	1 = Presence detected
GPS:	0 = Not at home	1 = At home

Only when the GPS is at 0 (user is not at home), will the sound sensor and occupancy sensor have any effect, in which case any one of them will trigger the security. The magnetic lock, if broken into, will always trigger the security regardless of the other inputs. Once triggered, the state is memorized in the SR Latch, so that it stays activated even if the inputs change.

Magnetic Lock	Sound Sensor	Occupancy Sensor	GPS	Trigger
0	0	0	0	Q
0	0	0	1	Q
0	0	1	0	1
0	0	1	1	Q
0	1	0	0	1
0	1	0	1	Q
0	1	1	0	1
0	1	1	1	Q
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

The “conversation” system is dependent on two values, the trigger and the “call” which comes from user input when they are notified of the intrusion. Only when the security is triggered and the user agrees to call, then will the “conversation” be started, else there will be no change to the “conversation”.

Trigger	Call	Conversation
0	0	Q
0	1	Q
1	0	Q
1	1	1

The reset system takes two inputs, which are the “reset” and “hang up”. “Hang up” only functions to stop the “conversation” if it was initiated before, while “reset” un-triggers the security system and stops the “conversation” in the process.

Reset	Hang Up	Trigger	Conversation
0	0	Q	Q
0	1	Q	0
1	0	0	0
1	1	0	0

4.3. Privacy Blinds

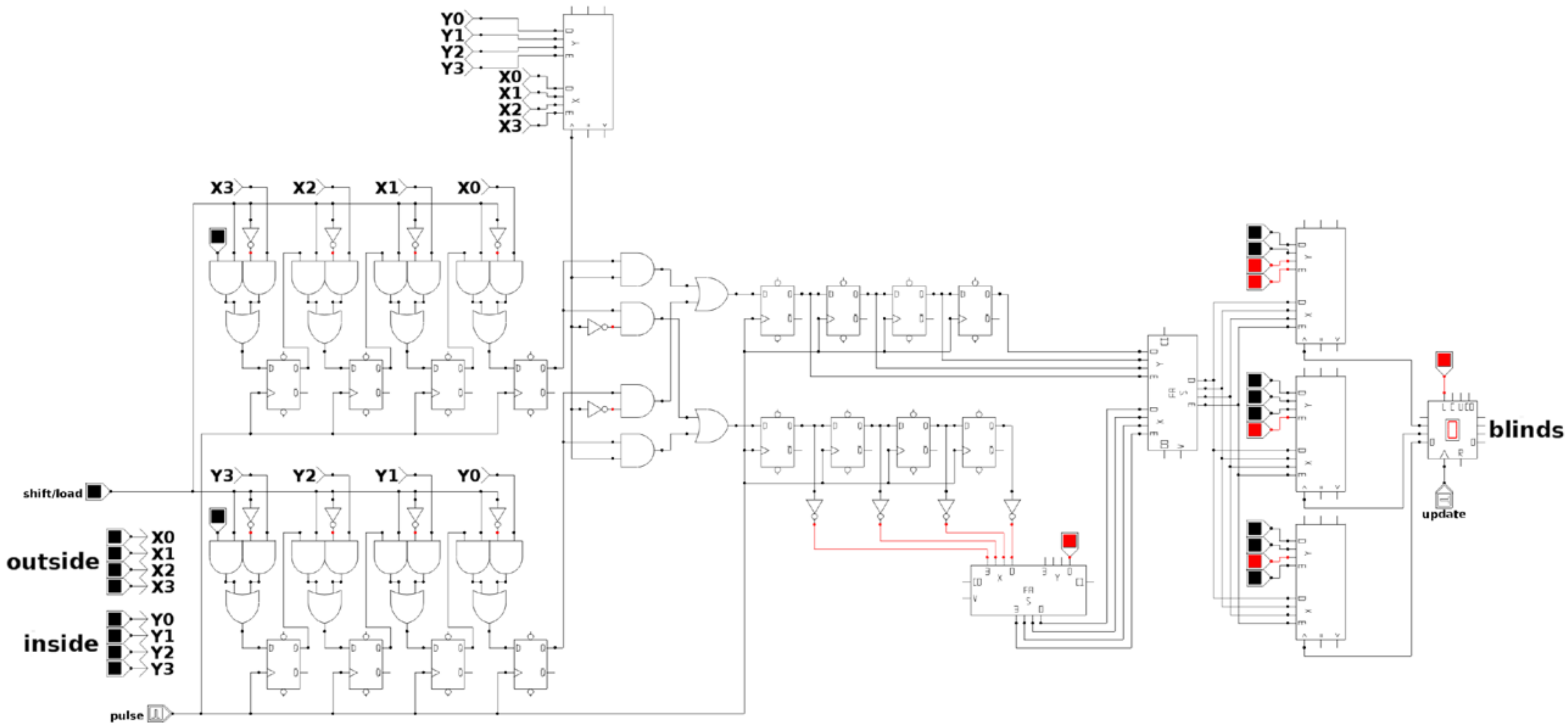


Figure 13: Full circuit for Privacy Blinds

The privacy blinds consist of various different sections: the PISO section, the demultiplexer section, the subtraction section and the comparison section.

The circuit accepts input as parallel, and converts it into serial output using the following PISO converter circuitry. The input is first loaded all at once into the D Flip Flops, and then the circuit is changed into shift mode, where the data will be outputted one bit at a time, in accordance with the ticks from the “pulse” input.

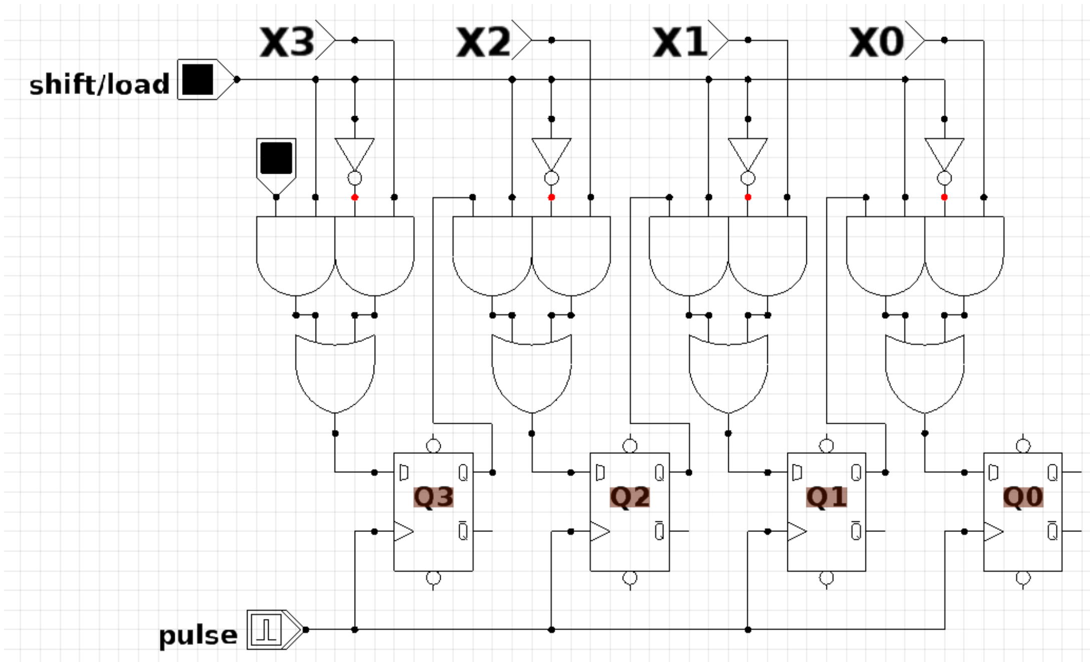


Figure 14: PISO Converter

Shift/Load	Pulse	Q0	Q1	Q2	Q3
0	0	Q0	Q1	Q2	Q3
0	1	X0	X1	X2	X3
1	0	Q0	Q1	Q2	Q3
1	1	Q1	Q2	Q3	0

The output from the PISO converter is then passed into the demultiplexer, which redirects the two different serial input, X and Y, into one of the two lines. The comparator will compare whether X is greater than Y, and the result acts as a selector for the demultiplexer. The larger number will be redirected to the top line, while the smaller number will be redirected to the bottom line.

Greater Than: 0 = X less than or equal to Y 1 = X greater than Y

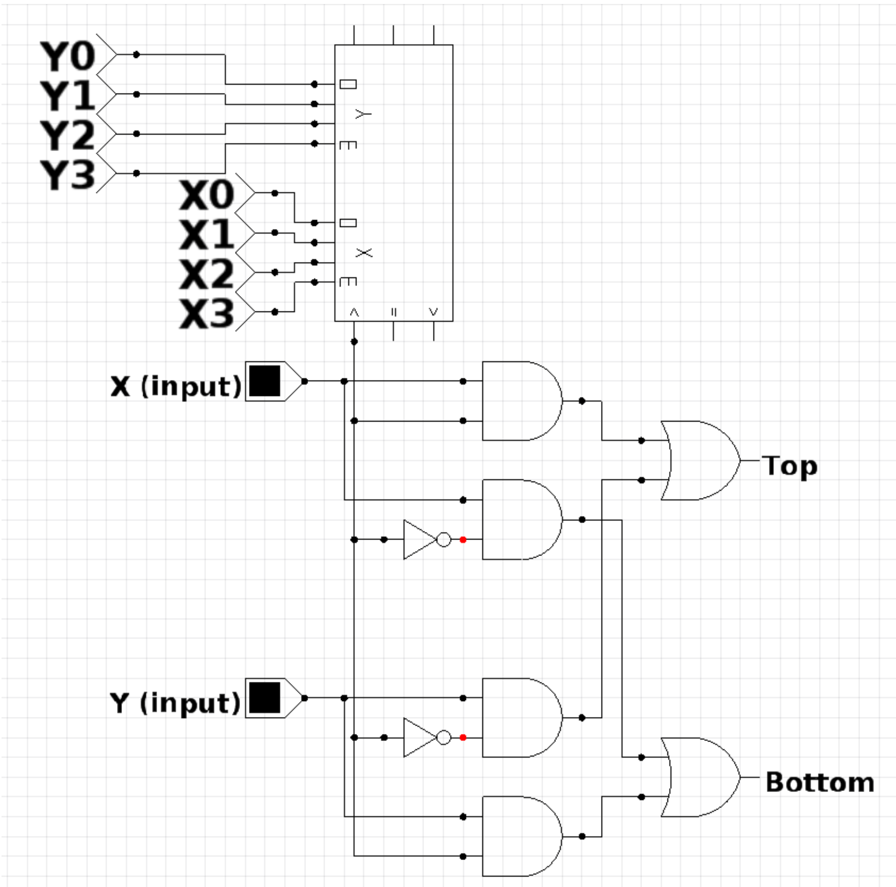


Figure 15: 1:2 Demultiplexer

X (Compare)	Y (Compare)	Greater Than	Top Line	Bottom Line
0000	0000	0	Y (input)	X (input)
0000 - 1110	1111	0	Y (input)	X (input)
1111	0000 - 1110	1	X (input)	Y (input)

The subtractor section functions to calculate the difference between the values that came from the two sensors. The two numbers are first converted from serial to parallel. The values are loaded in from the left, one bit at a time, and at the fourth tick, all the values would be loaded into the D Flip-flops. Two's complement is applied to the smaller number on the bottom line, before it is then added to the bigger number to calculate the difference between the two values.

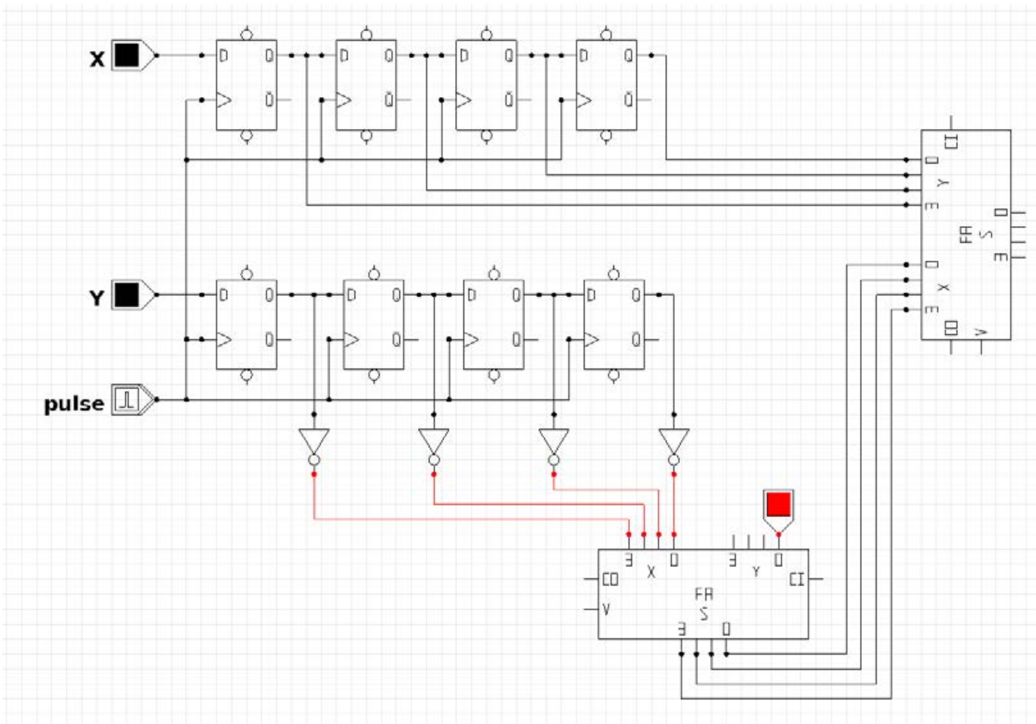


Figure 16: 4-bit Subtractor

Some example truth tables:

X	Y	2's Comp Y	Difference
0000	0000	0000	0000
0110	0011	1101	0110 + 1101 = 0011
1101	1011	0101	1101 + 0101 = 0010
1111	1111	0001	1111 + 0001 = 0000
1111	0000	0000	1111 + 0000 = 1111

In the comparator section, the difference between the values from the sensors are compared with preset values that determine the blinds “shutting” level. If the difference is larger than any of these values, then a 1 will be outputted for that specific level. Expected outputs are 000, 001, 011, 111.

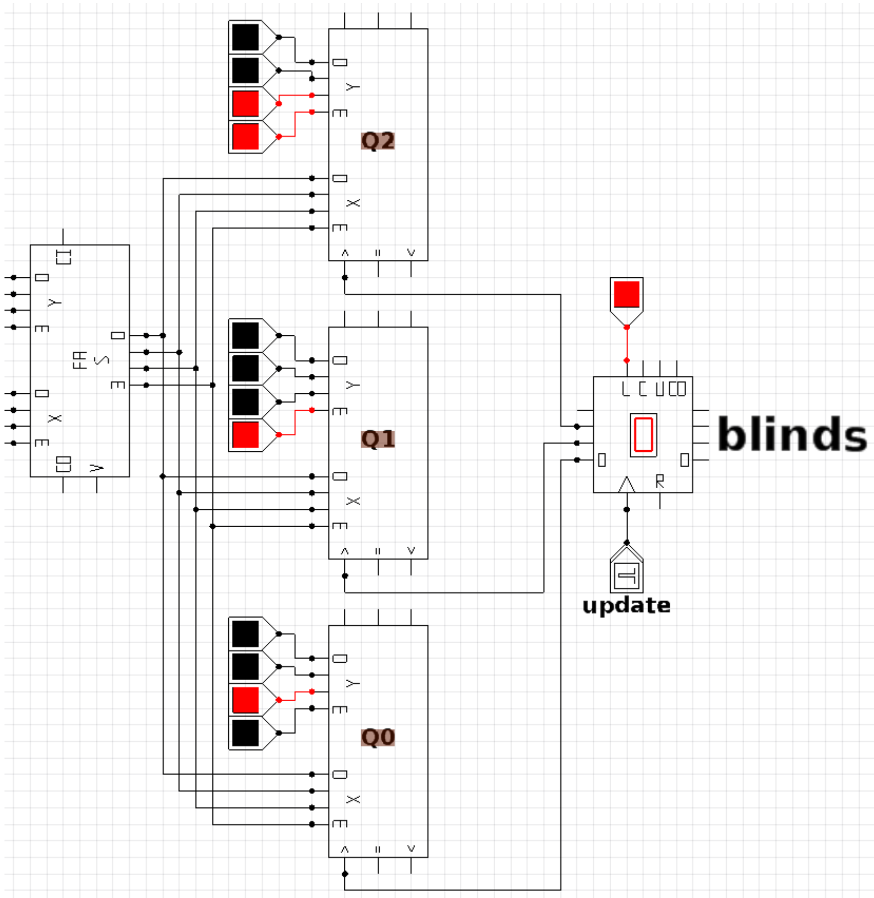


Figure 17: Comparator

Difference	Q0	Q1	Q2
0000 - 0100	0	0	0
0101 - 1000	1	0	0
1001 - 1100	1	1	0
1101 - 1111	1	1	1

4.4. Temperature-Colored Bulbs

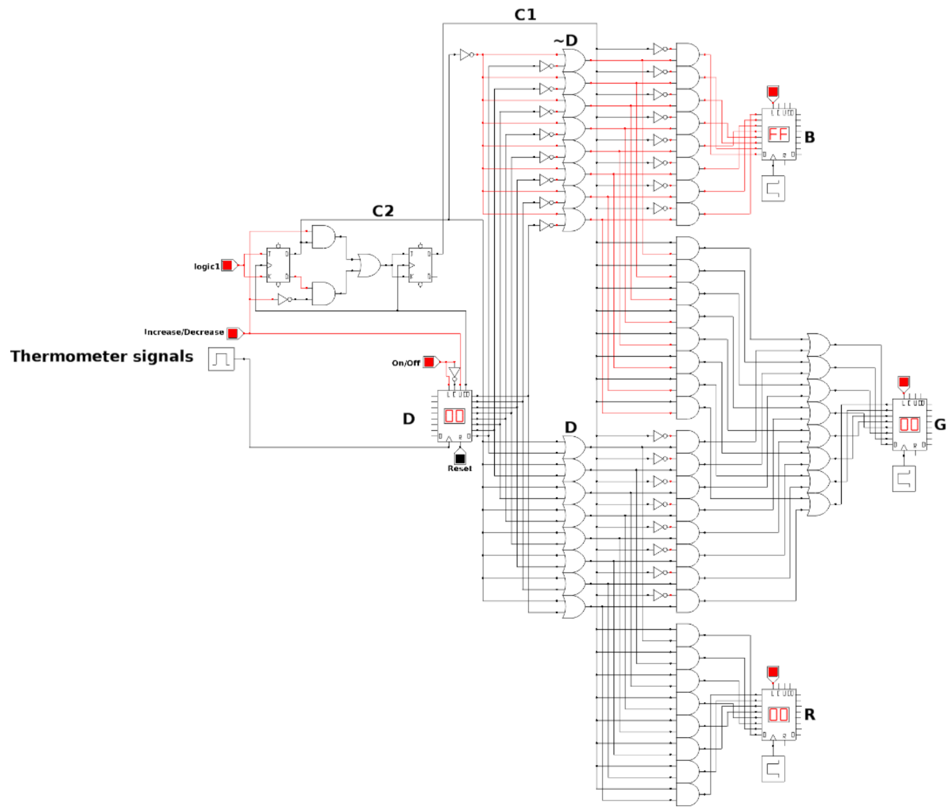


Figure 18: Full circuit for Temperature-Colored Bulbs

For the Temperature-Colored Bulbs, the colors are inputted in RGB, which are 256x256x256 color coded. The input will be 3 sets of 8 lines of inputs that will set the color. The output from the temperature sensor is 10 bits. There are 1024 unique inputs. The sensor sends 2 signals, a control bit of 1 when there is a change, and another bit which has 0 for “decrease”, and 1 for “increase”. There are three parts in this circuit: the register, the channel shifter, and the RGB value selector.

The 10 bits for temperature are separated into 3 parts: Control1, Control2 and Data.

C1	C2	D							
0	0	0	0	0	0	0	0	0	0

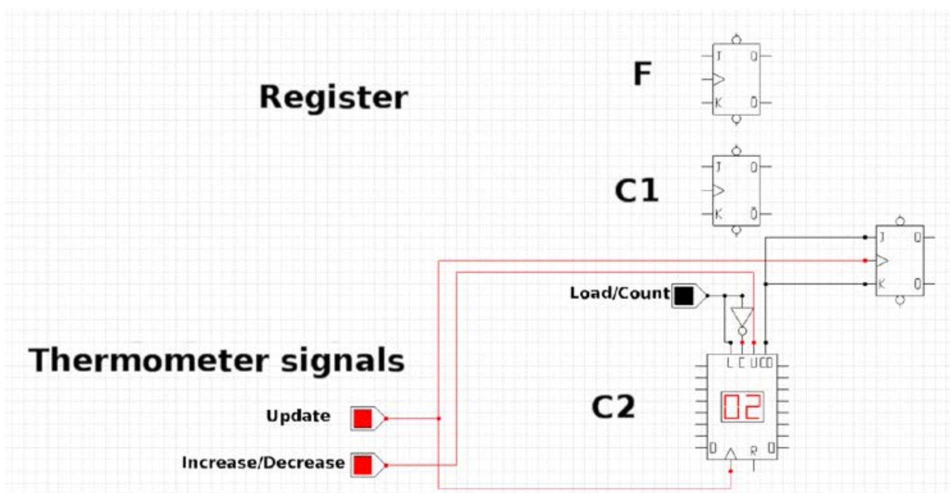


Figure 19: Register

The register keeps track of the current temperature in 10 bits. This is done with an 8-bit register that stores the last 8 bits, and a bidirectional counter that calculates and stores the first two bits. The inputs are updates of increase or decrease. The “logic1” refers to a signal that’s always on.

The register has the load and count modes that are controlled by an input. The load mode is used to reset, as nothing is connected to its input side, while the count mode, along with the Up/Down mode, is used to count up/down the register value to match the temperature. The

Up/Down mode, indicated by “U” in the register, is controlled by the input of Increase (1) or Decrease (0). An overflow triggers a 1 in the CO output, which is connected to the bidirectional counter.

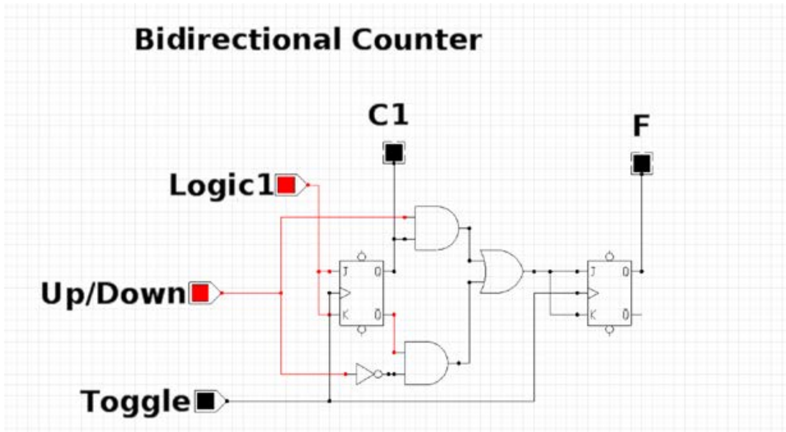


Figure 20: Bidirectional Counter

The bidirectional counter, or Up/Down counter, is a counter that can count both up and down. It receives an enable toggle input that counts the current value up/down through the flip-flops’ enable inputs. The Up/Down input controls whether the counter will increase or decrease. This design uses two T flip-flops. The first T flip-flop will always receive a logic 1 input, so every enable toggles the output.

The second T flip-flop takes in an input of 1 when the next toggle will cause an overflow. To find out whether the next toggle will do so, AND gates were used between the output of the first T flip-flop and the up/down mode input.

If the output of the first T flip-flop is 1 and the counter is on Up count, the next toggle will cause an overflow. Similarly, if the output of the T flip-flop is 0 and the counter is on Down count, there would be an overflow as well.

Up = 1 Down = 0

Q	Up/Down	Q1
0	0	1
0	1	0
1	0	0
1	1	1

The second T flip-flop will toggle only if the input to it is 1 when the clock pulses. The previous overflow section determines if this input will have a signal of 0 or 1, so the second T flip-flop will count when there is an overflow.

The output of the first T flip-flop is connected to C2, and the output of the second T flip-flop is C1. The counter and register are chained together for storing 10 bits. The CO from the register representing the overflow activates the enable for the counter, causing a count. The increase/decrease signal is the same for both parts.

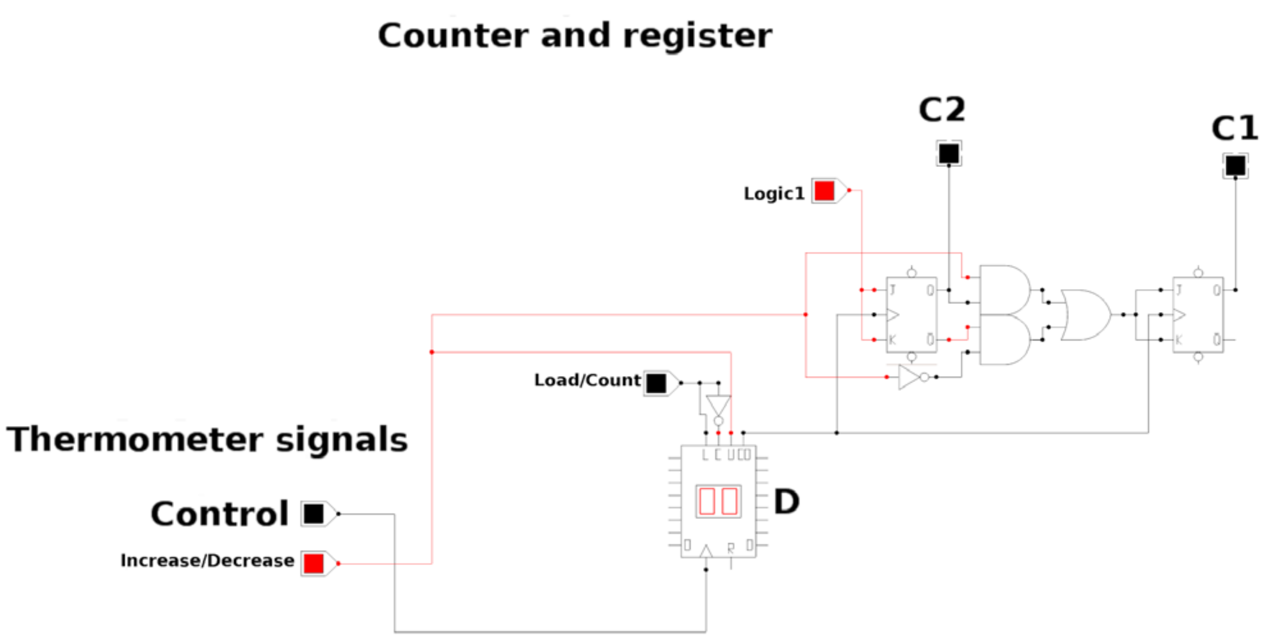
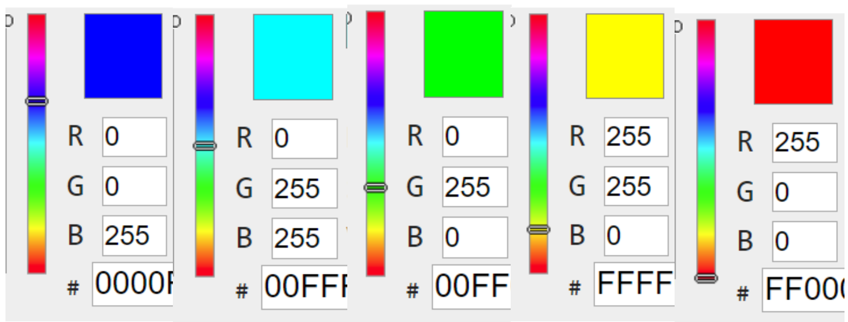


Figure 21: Counter and Register

The colors range from cool to warm, following the color theory. The two extremes, blue and red, are chosen to clearly demonstrate the contrast in temperature, while everything in between mixes with green.



Thermostat	R	G	B
0|0|00000000	00000000	00000000	11111111
0|0|00000001	00000000	00000001	11111111
0|0|00000010	00000000	00000010	11111111
...	...	....	...
0|1|00000000	00000000	11111111	11111111
0|1|00000001	00000000	1111111	11111110
...	...	...	...
0|1|11111111	00000000	11111111	00000000
1|0|00000000	00000000	11111111	00000000
1|0|00000001	00000001	11111111	00000000
1|0|00000010	00000010	11111111	00000000
...	...	...	...
1|0|11111110	11111111	11111111	00000000
1|1|11111111	11111111	00000000	00000000

A few observations were made.

- There are always only two colors that will contain non-zero values. Therefore, only two color channels need to be linked to the input at the same time. The other channel will remain at 0.
- At least one color will always be at full value, while another color will increase/decrease for every increase/decrease in temperature.

The rules for change in color values in each channel:

1. Blue starts with 255, Green and Red starts with 0.
2. Every increase in temperature directly translates to Green.
3. If Green reaches 255, Blue starts decreasing for every increase in temperature.
4. If Blue reaches 0, Red increases for every increase in the temperature.
5. If Red reaches 255, Green decreases with every increase in temperature.

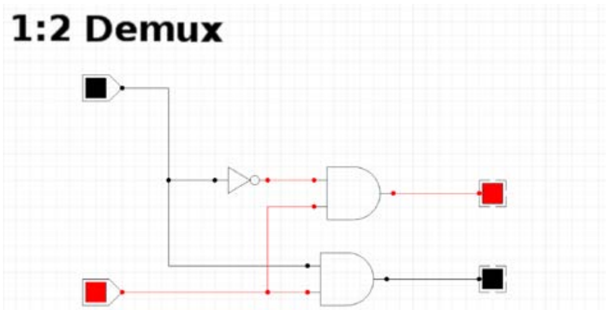


Figure 22: 1:2 Demultiplexer

The “channel shifter” changes the output into the correct color channels. This is done with a variation of 1:2 Demultiplexer that takes in 8 bits as input instead of 1. The demux is used twice for two inputs, both using the same selector input. Finally, the two middle outputs are connected to OR gates to direct the inputs between Blue-Green and Red-Green.

D	C1	R	G	B
X	0	0	X	~X
X	1	X	~X	0

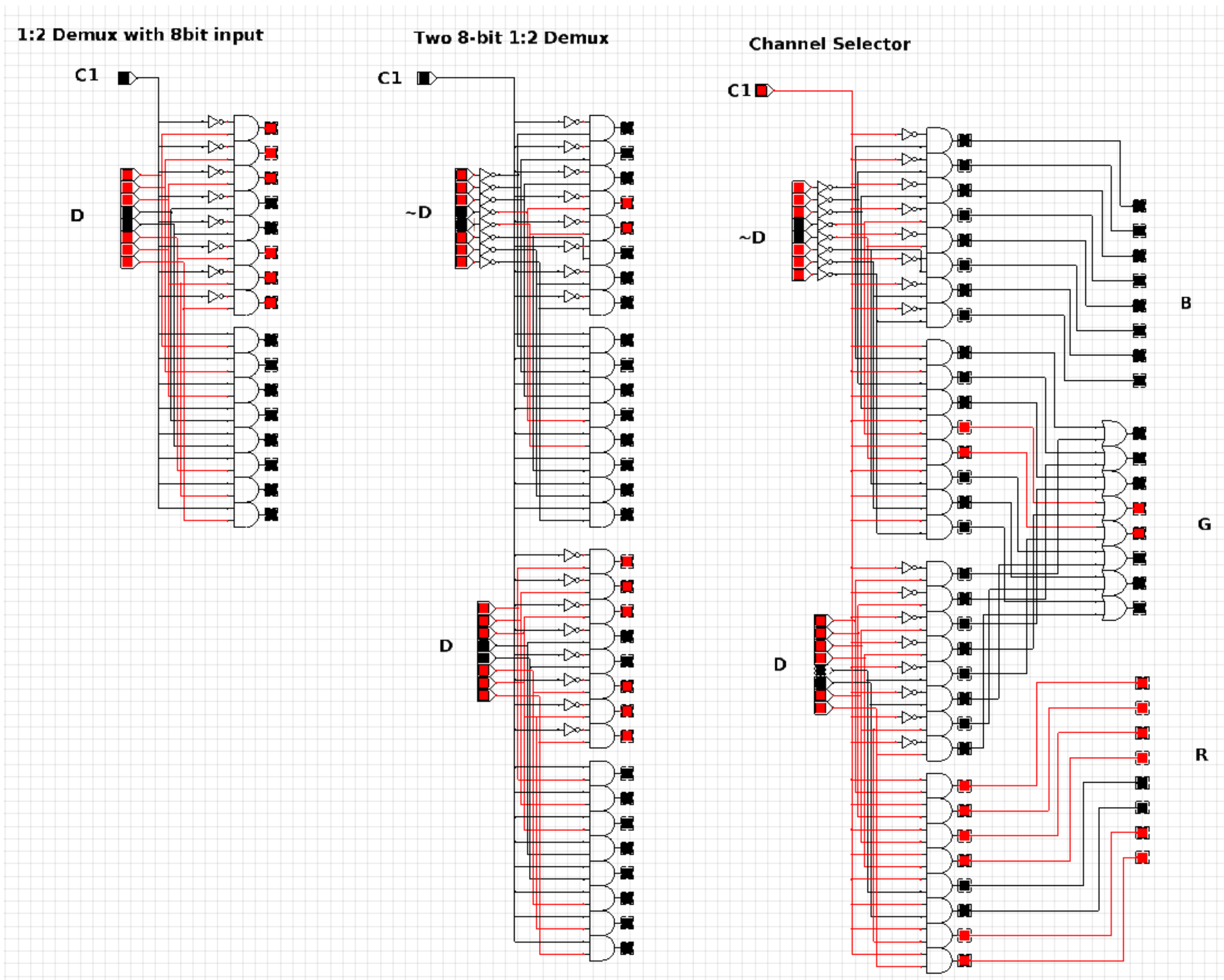


Figure 23: Channel selector

The “RGB value selector” calculates the color value for two channels dependending on the input from the register. This is done with NOT and OR gates between the last 8 bits(D) and the 9th bit(C2). The upper channel’s input can either be the inverse of C2 or inverse of D, while the lower channel can be either C1 or D.

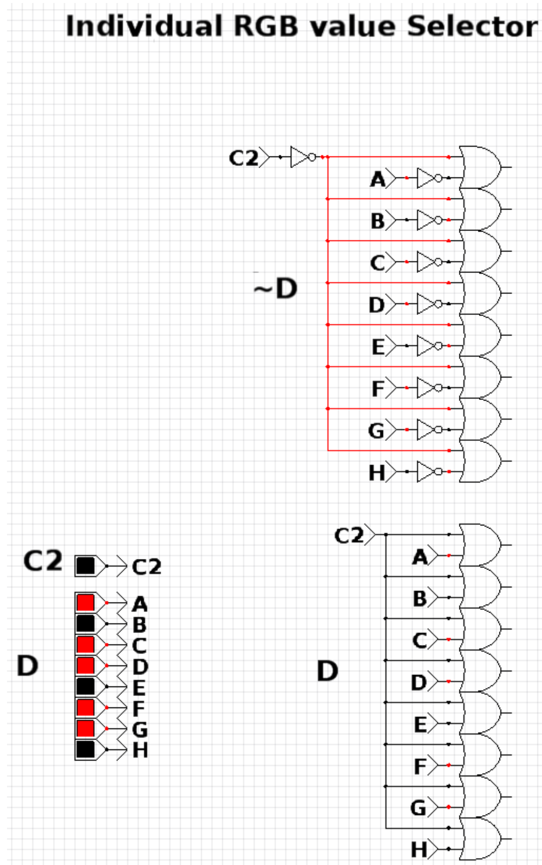


Figure 24: RGB Selector Module

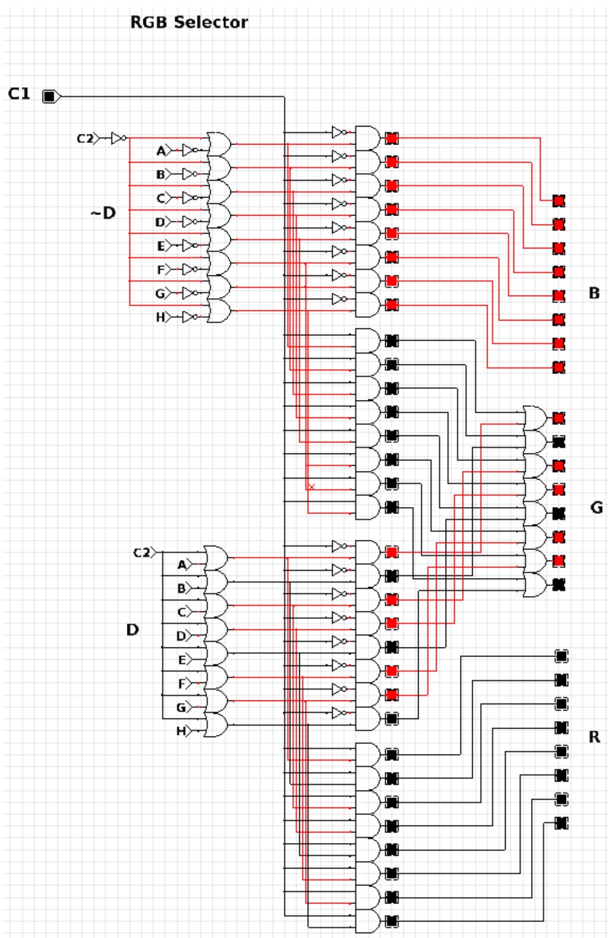


Figure 25: Full RGB Selector

Then, combining with the “channel selector” previously explained, the 10th bit(C1) switches the channels. This means the upper channel and the lower channel can result to B and G respectively, or to G and R respectively.

4.5. Notification Lights

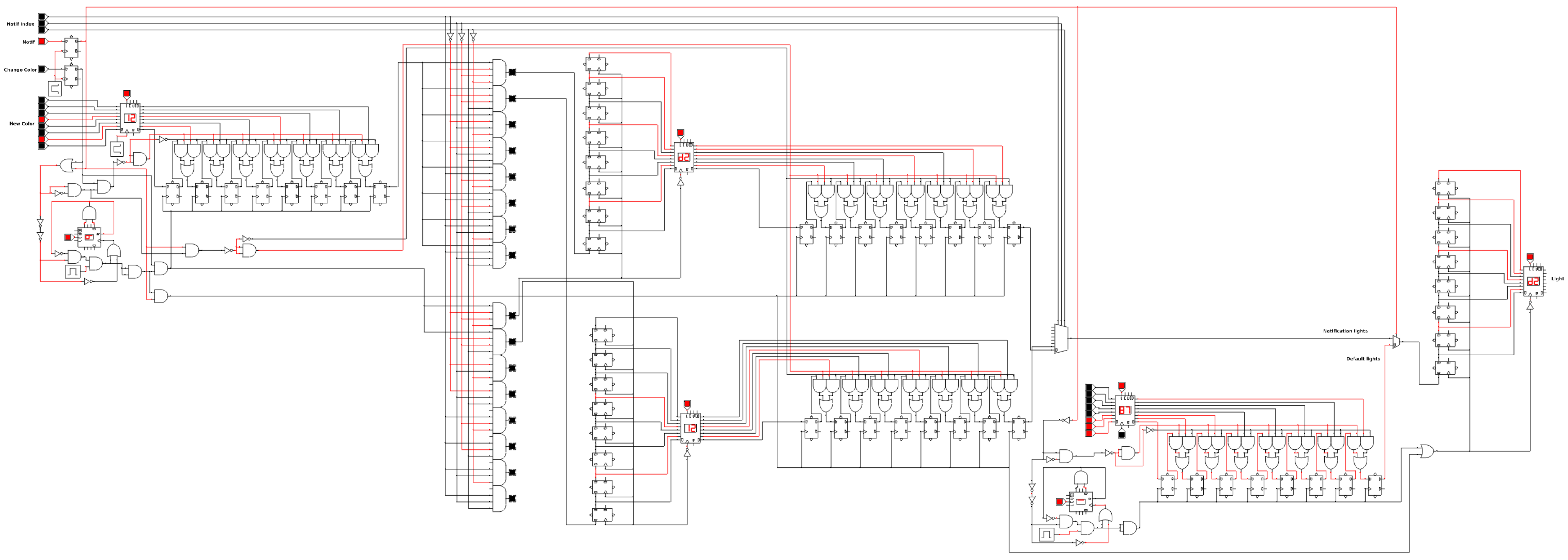


Figure 26: Full circuit for Notification Lights

The three inputs are the notification alert (notif), the index of where the color for the notification is stored in (notification index), and the new color in 8 bits. For simplicity, all colors are stored in only 8-bits RGB instead of 24-bits, one for every three colors. There will be two parts for the circuit, the “color storage” and the “notification alert”.

For converting between parallel and serial, 8-bit SIPOs and PISOs converters were used.

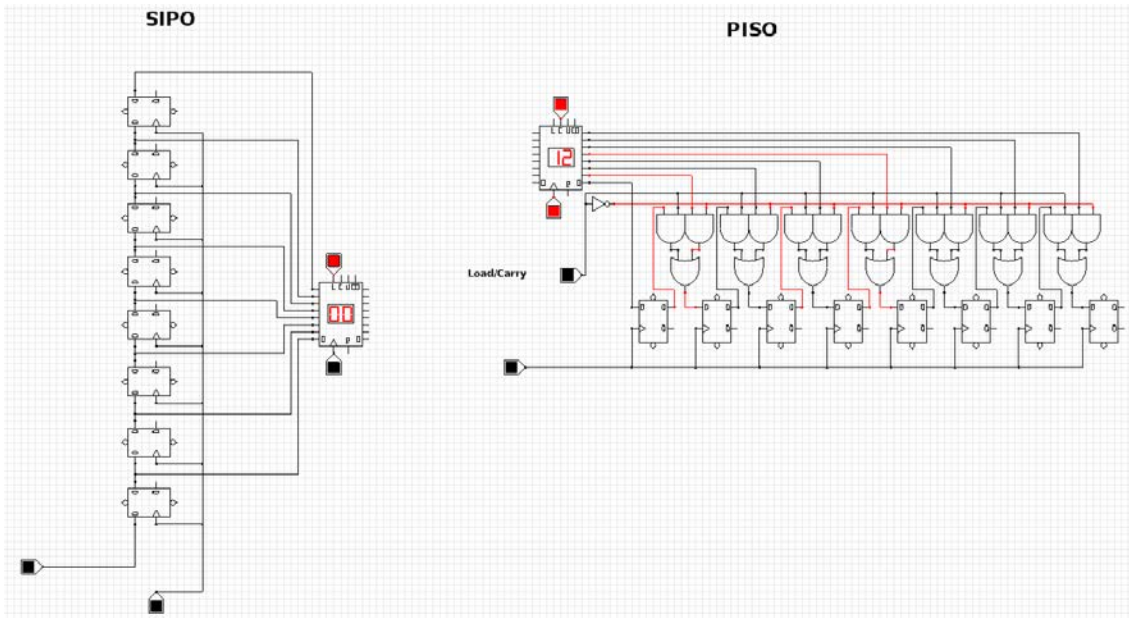


Figure 27: 8-bit SIPO and PISO converters

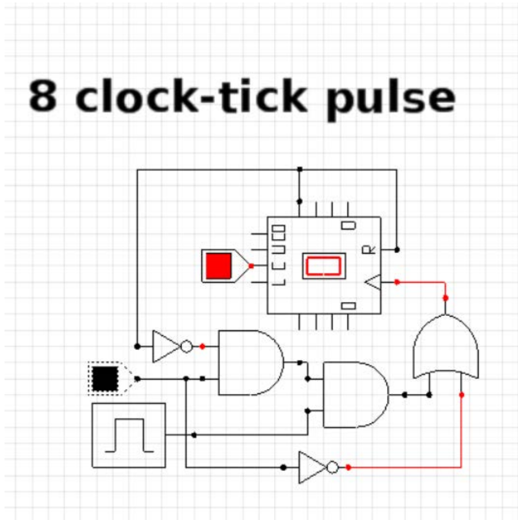
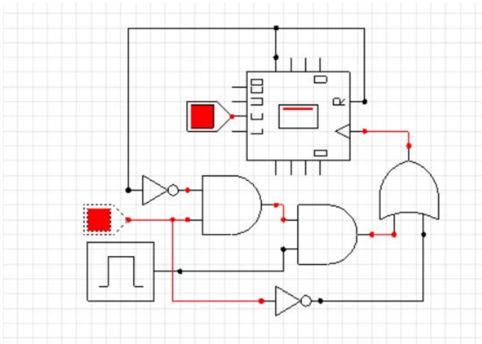


Figure 28: 8-pulse generator

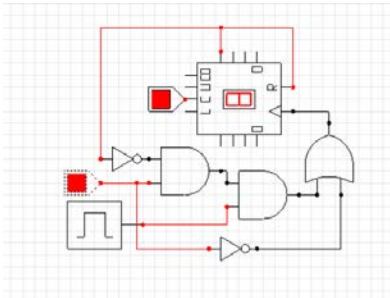
The 8-pulse generator, will send a maximum of 8 pulses before it stops. In order to activate the generator, the counter must be at a value less than 8, and the “activator” input must output a 1. Only then, will the clock be able to update and increase the counter, in accordance with the clock pulses. Once the counter reaches the “maximum”, which is 8 in this case, the output from the counter will deactivate itself and enable the counter’s reset mode. In this state, when the “activator” is switched to 0, the counter will be updated and reset to 0.

Counter	Activator	Clock	Counter	Counter Reset
0000 - 0111	0	0	Q	0
0000 - 0111	0	1	Q	0
0000 - 0111	1	0	Q	0
0000 - 0111	1	1	Q + 1	0
1000	0	0	Q	1
1000	0	1	Q	1
1000	1	0	Q	1
1000	1	1	Q	1

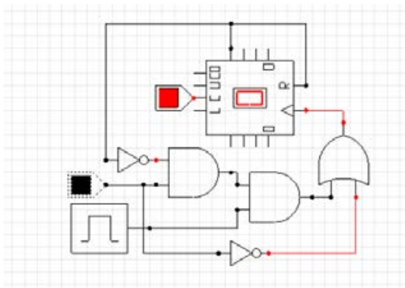
Counter Reset	Activator	Counter
1	0	1000
1	1	1000
1	0	0000



Pulse generator counting at 1 by activating register.



Pulse generator reached max value, reset mode is on, input is blocked.



Pulse generator when input just turned 0, register activated and reset. Input is no longer blocked

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For the "color storage", the new color input goes through the 1:8 demultiplexer to 8 different registers as storage memory for when a notification appears. The notification index acts as a selector for which register the new color will go to. Only two registers are shown for simplification.

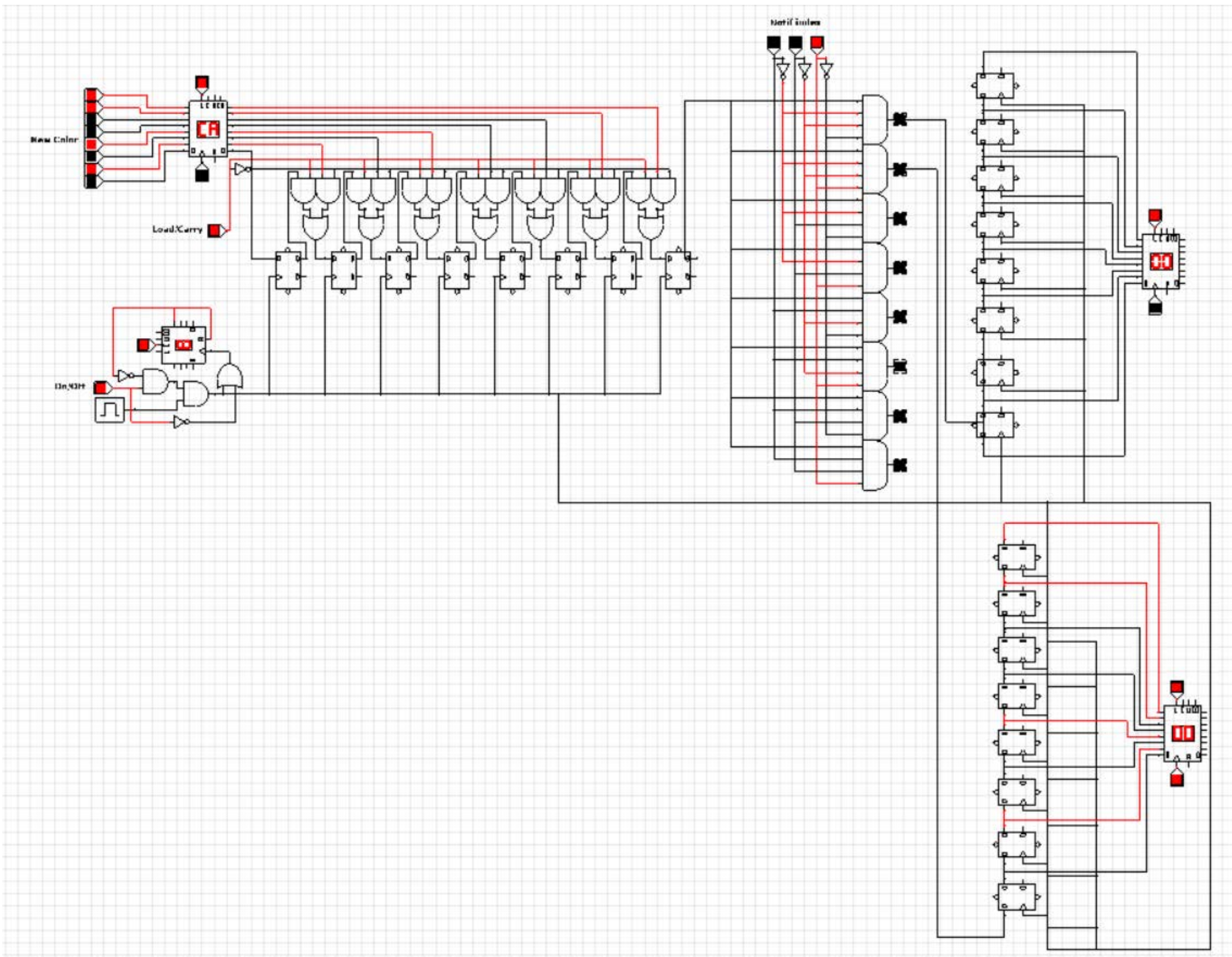

Figure 29: 1:8 Demultiplexer

Whenever there is a notification, the color selector uses a 2:1 multiplexer to choose between the default color and the custom notification color. The notification index selects which color will be chosen with an 8:1 multiplexer.

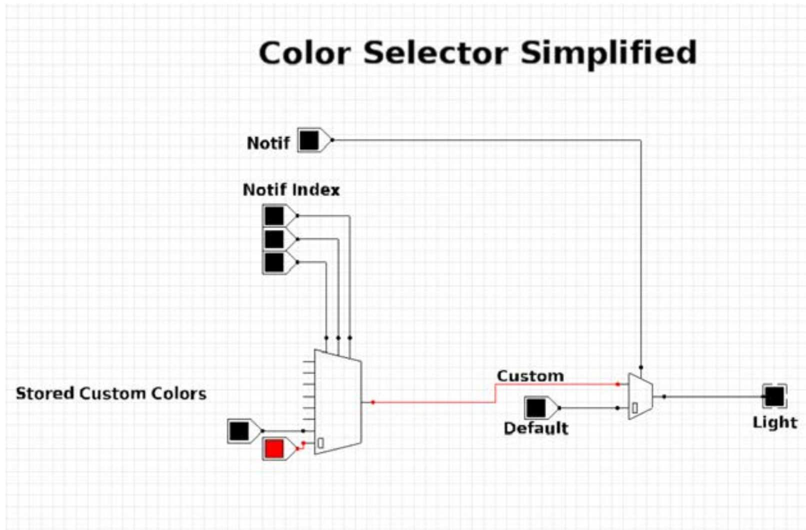

Figure 30: Simplified Color Selector

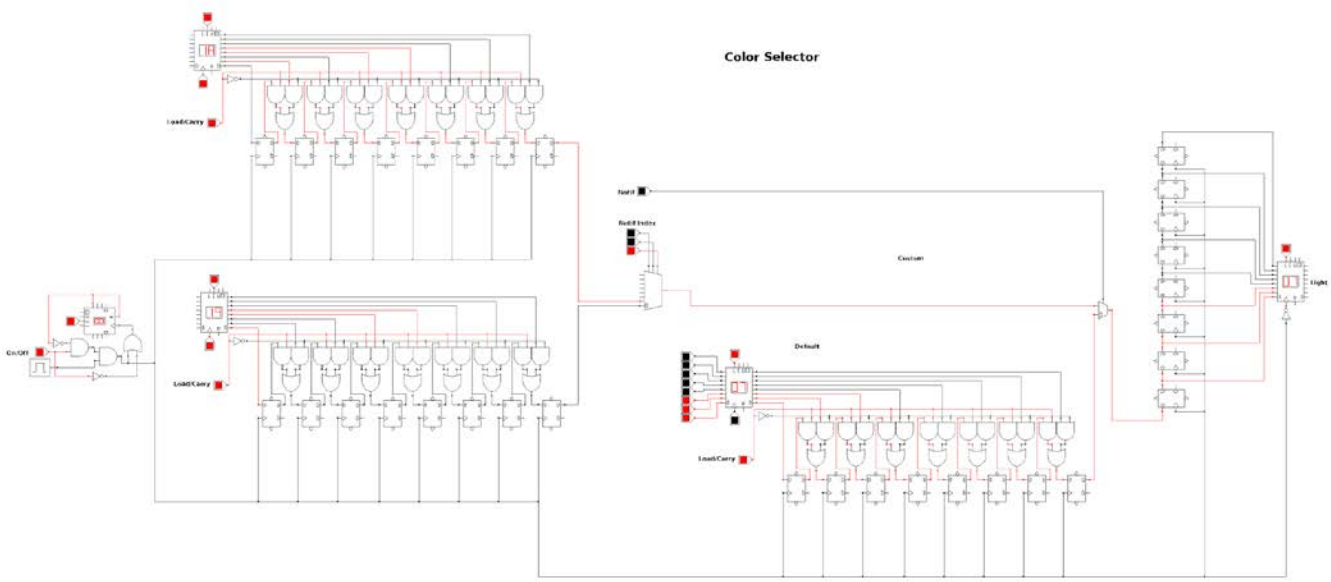

Figure 31: Color Selector Implementation

Improvements were made for the input by chaining the clock (pulse generator) and control(load/carry) to the notification input. The process is set to load mode, clock pulse once, set to carry mode, pulse 8 times. To accommodate this, the pulse generator is changed to a 9 pulse. The 9 pulse generator has an AND gate to check if the register has counted up to 9 instead of 8.

Double NOT gates and AND gates are used to time the input to the correct timing, as every gate will cause one delay each. Timing in this circuit is very crucial. The serial and parallel data may not work correctly if the timing is even slightly off.

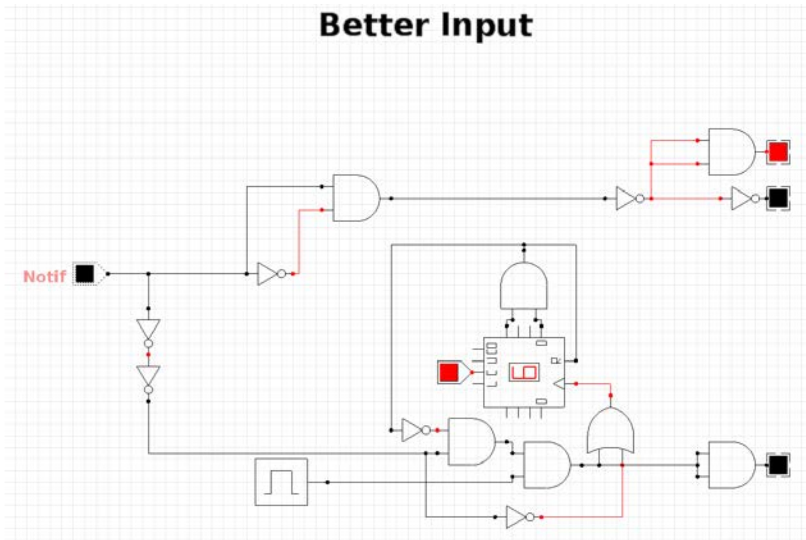

Figure 32: Improved input

At the top middle, a single pulse generator is used. This generates a single pulse only at the UP cycle of the input. Initially, the notif signal is at 0, with its inverse of 1, goes to the AND gate with an output of 0. The instant the notif signal gets to 1, the NOT gate's output is one tick behind, but the top signal reaches the AND gate instantaneously. This outputs a 1 before the NOT gate catches up in the next tick, outputting a 0 to the AND gate, causing the final output to go back to 0. This means only one tick of the signal is allowed through, creating a single pulse.

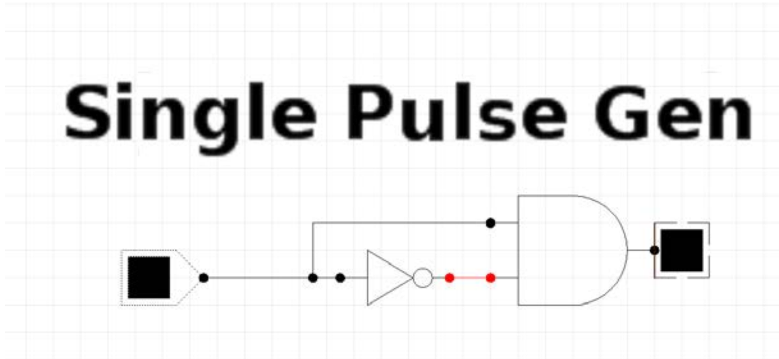

Figure 33: Single pulse generator

Sequence	Input	Output
1	0	0
2	1	1
3	1	0

The top right of the circuit in this diagram outputs to the load/carry, which needs to happen within one pulse at the same time. It receives the single pulse from the one pulse generator. An AND gate is used to slow down and match the speed of the top output with the inversion that goes through a NOT gate. The registers are on load mode for a tick before they turn into carry mode.

Two NOT gates are used for the signal going towards the pulse generator. This delays the signal by 2 ticks, which is exactly 1 tick behind the signal to load/carry, but results in the output signals going at the exact same tick. This means one tick of load, followed by 8 ticks of carry, one right after the other.

The final circuit contains 2 pulse generators, one for when a notification is received and the other for when the notification ends. The color storage and selector are combined together, sharing the first clock for two different actions at different parts of the circuits.

5. Final Circuit

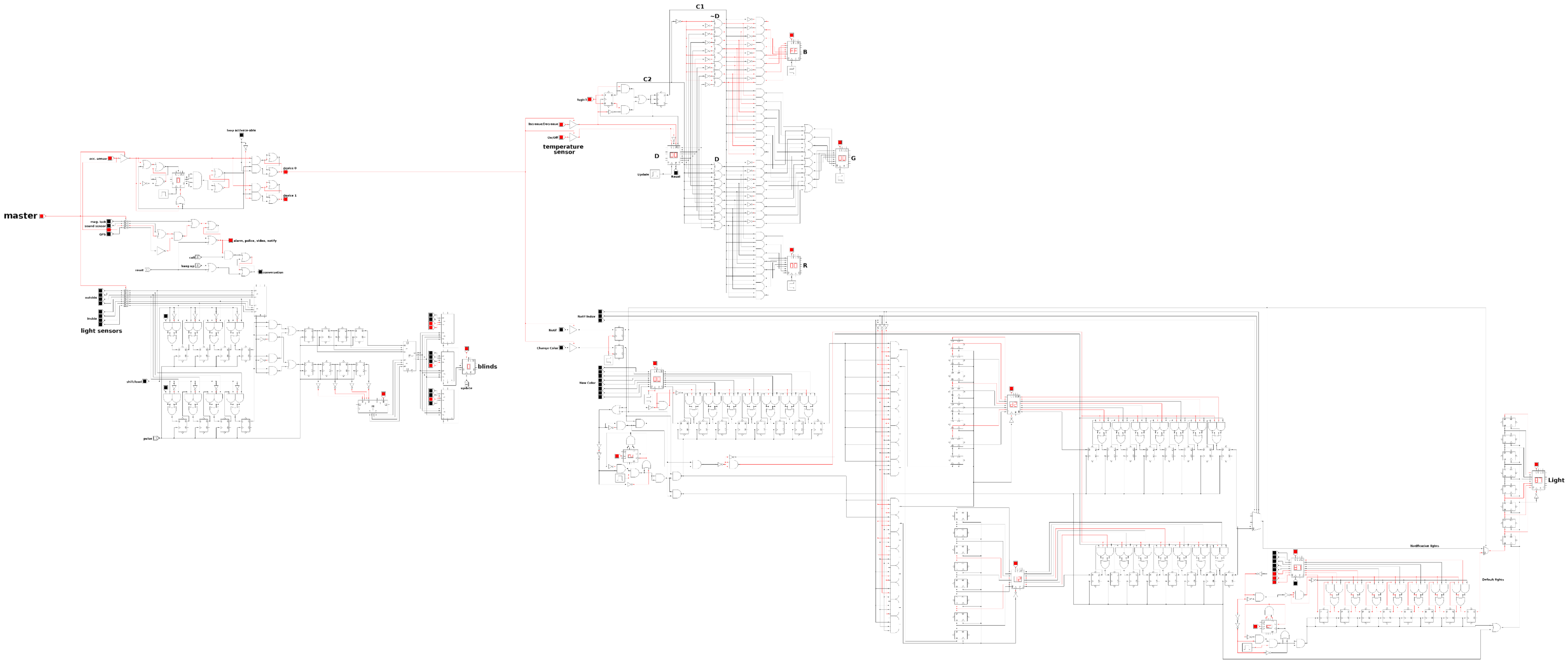

Figure 34: Final complete circuit

As the subsystems all have varying input and output except for a select few, they do not have much intercommunication between each other. Even so, they are all connected to one "master" switch, which is the phone input which can activate or deactivate the entire smart home system, with the exception of the Notification Lights and the Temperature-Colored Bulbs, which are connected to the Follow-Me Room Activation System so that they function only when the user is nearby and can see them. This is done by connecting the inputs of the subsystems to tri-state buses, which has the feature of allowing/disallowing circuit connections with one input. This allows the user to deactivate the entire system with just one input.

6. Assumptions

Firstly, it is assumed that the devices that are connected to these circuits are capable of parallel input and output. This is because some of these circuits utilize parallel input and output, such as the Temperature Color LED and the Notification Lights, as it is easier to visualize than a stream of serial inputs.

Secondly, some of the circuits were simplified and were connected to only a few devices. In reality, these circuits would be duplicated across multiple rooms and are connected to multiple different output devices. For example, the Follow-Me Room Activation System is only connected to two output devices which would not be practical in reality, but is presented as such for simplicity.

Thirdly, it is assumed that the output devices understand and are able to process the data from the circuit. For example, the Privacy Blinds circuit outputs values in parallel in the form of 000, 001, 011, and 111 for the different levels of "shutting" , and it is assumed that the mechanism that controls the blinds understands this kind of input and is able to operate the blinds accordingly.

7. Unresolved Problems

Some of the circuits that were designed are rather complex, utilizing features such as parallel input/output and clocks. As a result, the size of these circuits are rather large compared to some other simpler circuits, and the circuitry is also rather complicated. It may be possible to further simplify these circuits to produce a more efficient and smaller circuit, but due to a lack of knowledge in the field, these circuits were not simplified.

The temperature color light does not allow any other hues and saturation of colors. Due to how the circuit is designed, there can only be at most a mixture between two different colors when representing the values from the temperature sensor. This may not be a huge problem, but it is still a limitation and restricts the total number of possibilities which may impede the execution of certain ideas/implementations.

Due to the sheer size of the circuits, they may be prone to bugs and miscalculations. Large quantities of connections are required to make the circuits work, and it is highly likely that unforeseen occurrences will happen when running the circuits. Certain combinations of inputs or settings may cause bugs within the circuits, or perhaps certain intended features do not work as well as intended.

8. Conclusion

Smart homes systems are capable of drastically improving the quality-of-life and comfort of one's life, by automating repetitive and mundane tasks with the use of computers and circuitry. It is growing to become a huge industry, with countless numbers of companies and organizations competing to innovate and develop new and interesting smart home devices and systems. Though this may be the case, there are still some limitations and features that have not been implemented which may be prove useful.

Thus, a variety of designs for smart home systems were proposed: the "Follow-Me Room Activation System", the "Security System", the "Privacy Blinds", the "Temperature-Coloured Bulbs" and the "Notification Lights". These systems make use of a variety of basic, combinational and sequential circuits, such as full-adders, multiplexers and flip-flops, to name a few. These circuits perform simple functions, but when combined into a larger circuit, interesting features can be implemented and different devices can be made to work together, which results in convenient smart home devices and systems.

From this research, many challenges were faced and creative solutions had to be thought up to solve these problems. Thus, the team gained great amounts of knowledge and experience in circuit designing, and obtained insight to how smart home systems worked on a lower level, which resulted in greater appreciation of the contributions of technology to society.

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Each group is expected to submit a signed copy of this form with their assignment documentation. You are asked to assess the percentage contribution of each team member to the assignment. The total percentage should equal 100% (or almost) so, for example, in a group of 4 where each person is agreed to have played an equal part, the figure would be 20% against each name.

Name of team member	% contribution to assignment
Wong Kah Heng	33%
Jonathan Seng Yaw Tong	33%
Jeffery Sia Ming Hong	33%

Signatures of team members: ________________

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