1. Introduction

1.1 Purpose of the Project

The purpose of this project is to design and implement a smart home automation system that enhances convenience, energy efficiency, and security by integrating sensor-based control for lighting, temperature regulation, and motion detection. This system uses logic circuits with sensors to automatically adjust environmental settings, improving overall comfort and reducing energy consumption in homes.

1.2 Scope of the Project

- **Automated Lighting:** Using a light-dependent resistor (LDR) to control lighting based on the surrounding light conditions, automatically turning lights on in darkness and off in sufficient daylight.
- **Temperature-Controlled Fan:** A fan system that automatically adjusts its operation based on the ambient temperature, ensuring optimal comfort and energy efficiency.
- **Motion Detection:** A motion sensor integrated with logic circuits to detect movement in a room and control devices like lighting or security systems, enhancing home security and convenience.
- **Integration of Logic Circuits:** The project focuses on using basic logic gates and circuits to manage sensor inputs, providing a cost-effective and reliable solution for home automation.
- **Energy Efficiency:** By automating control based on real-time conditions (light, temperature, motion), the system contributes to reducing unnecessary power consumption

1.3 Objectives

- **Design an automated lighting system** using an LDR to control light switches based on the presence or absence of natural light.
- **Develop a temperature-controlled fan** that adjusts its speed or state (on/off) based on ambient temperature readings.
- **Incorporate a motion detector** to automate home appliances and security systems, turning on lights or activating alarms based on detected movement.

- **Implement logic circuits** to efficiently manage sensor inputs and control the automation processes.
- **Ensure energy conservation** by minimizing the use of electrical appliances when they are not needed, thus promoting sustainable living.
- **Enhance user comfort and convenience** by automating routine tasks, reducing the need for manual control of lights, fans, and security features.

2. Brief Relevant Theory

2.1 Background Information

In this project, we developed a smart home system, **Smart Nest**, incorporating core digital logic concepts to automate home functions using sensors and logic circuits. The project integrates an LDR for light automation, a temperature-controlled fan, and a motion detector for security and efficiency, all powered by digital logic gates. The goal was to apply theoretical knowledge from digital logic circuits into practical, meaningful use, creating an efficient and user-friendly smart home environment that responds intelligently to environmental changes and human presence.

2.2 Previous Work in the Field

Several previous works have utilized digital logic circuits for home automation, especially in controlling lights, fans, and motion detection systems:

1. Motion Detector Circuit with 555 Timer: This project used the well-known 555 timer IC along with an IR sensor to detect motion and control AC loads like lights and fans. The circuit utilized a relay to switch devices on and off based on motion detection, demonstrating the application of simple digital logic for home automation.

2. Motion Sensor Light Switch using CD4017: Another notable project employed the CD4017 decade counter IC with an IR sensor to automate light control. The motion detection triggered changes in the state of the digital logic circuit, demonstrating the versatility of digital ICs in automation.

3. 8051 Microcontroller-Based Intelligent Home Automation: This system used the 8051 microcontrollers along with sensors like motion detectors and light sensors to control appliances. The project emphasized the cost-effectiveness of using digital logic circuits and microcontrollers for scalable home automation solutions.

These works illustrate the practical application of digital logic circuits in automating key household functions, providing a foundation for your SmartNest project.

2.3 Components Name

1) ***Light Dependent Resistor***

- LDR
- Resistor (330-ohm,6.8kiloohm)
- Battery (9 V)
- NAND (7403)
- LED (red)

2) Temperature Controlled Fan

- NAND gate (7403)
- AND (7408)
- DC fan (12 V)
- NTC (10 Kilo ohm)
- Potentiometer (10 kiloohm,100kiloohm)
- Battery (9V)
- Battery Connector

3) Motion Counting Detector

- 4026 IC (Johnson counter)
- Resistors
- 7 Segment Display
- Battery

2.4 Working Principle/Methodology

Automatic Night Light:

This circuit demonstrates a simple automated lighting control system using an LDR (Light Dependent Resistor) and a NAND gate. The LDR, along with a resistor (R1), forms a voltage divider that controls one of the inputs to the NAND gate (U1). The other input is connected directly to a fixed voltage.

LDR (LDR1): Its resistance decreases with increased light intensity. In darkness, its resistance is high, which affects the voltage at the NAND gate input.

NAND(U1): This logic gate outputs a high voltage only when both inputs are low. When it is dark (high resistance in LDR), one input is low, and the output is high, turning on the LED (D1).

Resistors (R1, R2): R1 sets the sensitivity of the LDR circuit, while R2 limits the current to the LED, protecting it from damage.

LED (D1): The LED lights up when the output of the NAND gate is high, indicating darkness.

This circuit is typically used in smart home applications for automatic lighting, where the light turns on in low light conditions.

Temperature Controlled Fan

In this automatic fan design, we used two **NAND gates (7403)** and one **AND gate** to control the fan speed based on logic inputs. The design includes three speed conditions: **High**, **Medium**, and **Low**.

- We set the **S input** of the NAND gate to a fixed value while varying the **R input** to the second NAND gate.
- The output from these NAND gates feeds into the **AND gate**, determining whether the fan should be **on** or **off**. When the AND gate's output is **1**, the fan starts running, and when it's **0**, the fan is turned off.
- A unique behavior is observed when the circuit reaches a middle state, where the fan enters an ambiguous zone. In this case, the fan runs at **medium speed**, as the circuit does not have a clear high or low command. This design allows for basic control of fan

operation using digital logic, effectively implementing a simple automation system with adjustable speeds.

Motion Counting Detector

In the provided circuit, the 4026 IC is being used as a counter (Johnson Counter), which drives a seven-segment display to show numerical values. The circuit operates by counting pulses received from the clock input. The clock is triggered by pressing the switch connected to the 12V battery. Each time the switch is pressed, a pulse is sent to the clock input (pin 1) of the 4026 IC, which increments the counter. The output pins (A-G) of the IC are connected to the corresponding segments of the seven-segment display, which updates to show the new count. Resistor R1 helps limit current, and the reset mechanism ensures that the counter can be reset to zero if needed. (here we have used an Op-Amp extra in our hardware circuit to increase the already inputted voltage to meet our desired voltage level)

2.5 Detailed Schematics of three circuits:

<u>Automatic Night Light</u>

<u>A) When atmosphere is dark, light is on</u>

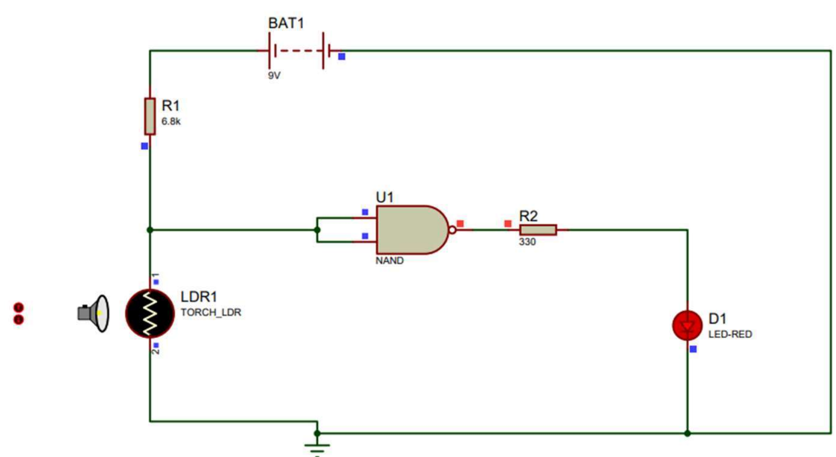

Fig 1: Automatic Night light (when atmosphere is dark)

B) When atmosphere is bright, light is off

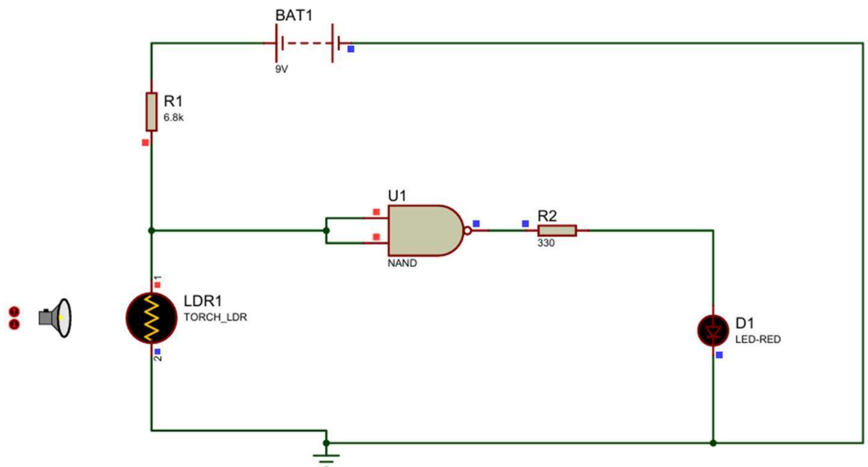

Fig 2: Automatic Night light (when atmosphere is bright

Truth Table:

Input (LDR)	Output(Light)
0	1
1	0

Table 01: Automatic Night Bulb

Temperature Controlled Fan

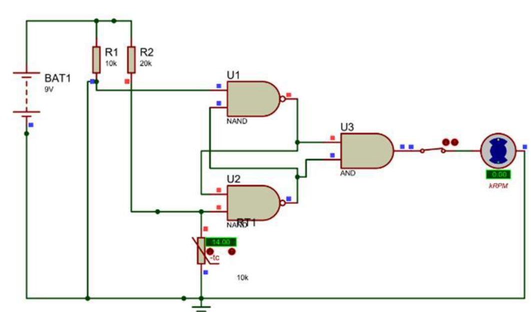

Fig 3: Temperature Controlled Fan (when Temperature is low)

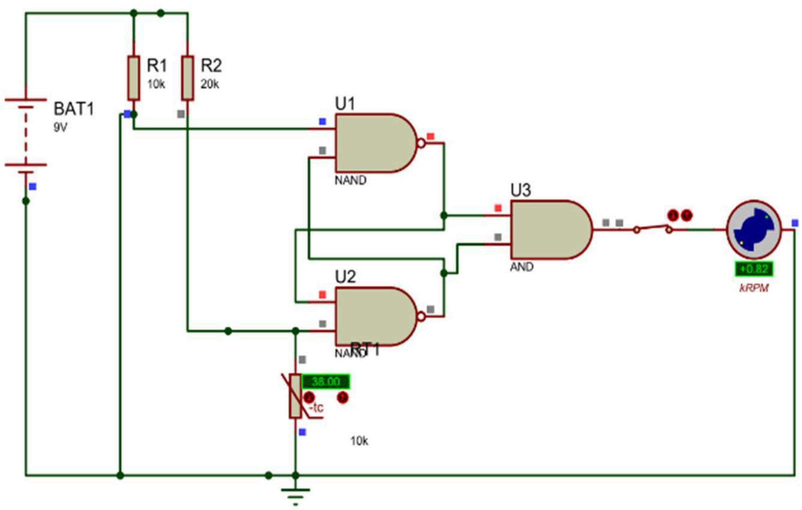

Fig 4: Temperature Controlled Fan (when Temperature is medium)

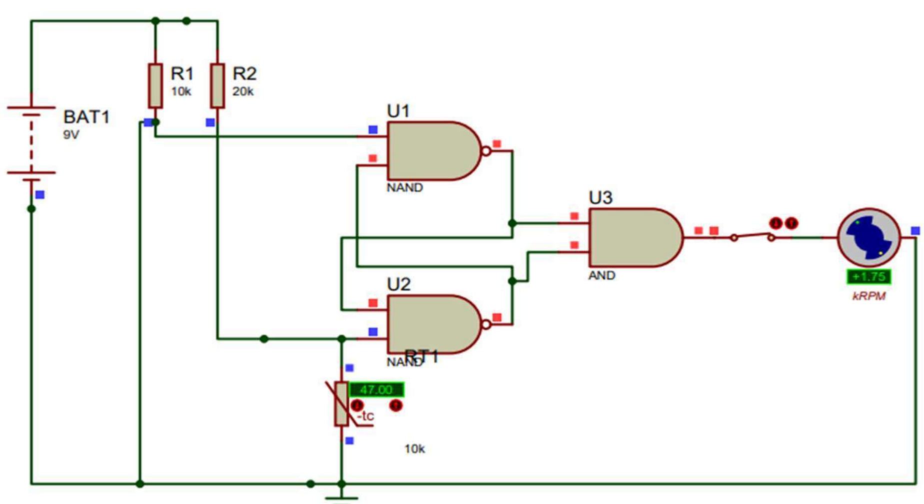

Fig 5: Temperature Controlled Fan (when Temperature is High)

Truth Table:

Input 1(GND)	**Input 2(NTC)**	**Q**	**$\bar{Q}$**	**AND Output**	**Fan State**
0	**1**	**1**	**0**	**0**	**Off**
0	**?**	**1**	**? (0/1)**	**? (0/1)**	**Medium**
0	**0**	**1**	**1**	**1**	**High**

Table 02: Temperature Controlled Fan

Motion Counting Detector

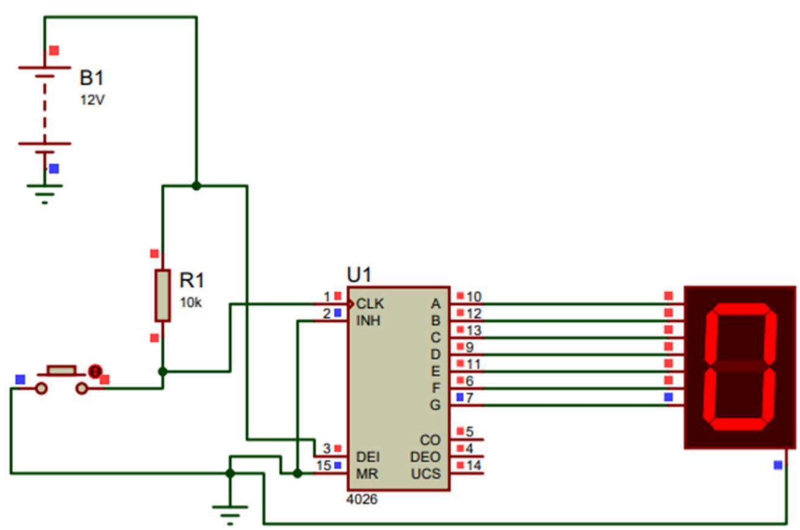

Fig 6: Motion Counting Detector

Truth Table:

Clock Input (Motion Detected)	Display Output (7-Segment)	Count Output
0	**0**	**0000**
1	**1**	**0001**
0	**1**	**0001**
1	**2**	**0010**
0	**2**	**0010**
1	**3**	**0011**
0	**3**	**0011**
1	**4**	**0100**
0	**4**	**0100**
1	**5**	**0101**
0	**5**	**0101**
1	**6**	**0110**
0	**6**	**0110**
1	**7**	**0111**
0	**7**	**0111**
1	**8**	**1000**
0	**8**	**1000**
1	**9**	**1001**
0	**9**	**1001**
1	**0 (Reset to 0)**	**0000**

Table 03: Motion Counting Detector

2.6 Flow Chart

Automatic Night Light

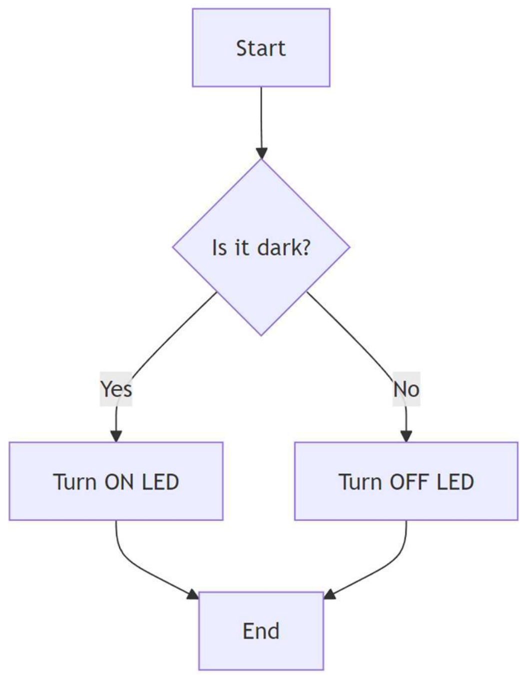

Fig 7: Flowchart for Automatic Night Light

This flowchart represents the decision-making process for an automatic lighting system:

1. Start : The system Begins operation.
2. Check if it's dark: A sensor (like an LDR) checks if the surrounding light level is low (dark).
3. Yes (It is dark): If it's dark, the LED (light) is turned ON.
4. No (It is not dark): If it's not dark, the LED (light) remains OFF.
5. End : The process concludes, and the system continuously repeats the decision-making loop.

This simple logic controls the automatic turning on/off lights based on ambient conditions.

Temperature Controlled Fan:

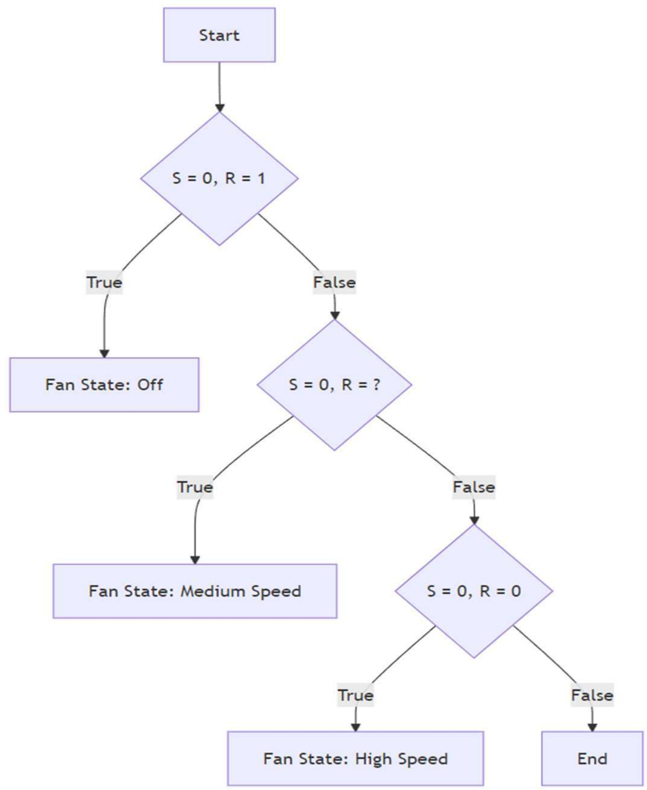

Fig 8: Flow chart for Temperature Controlled fan

This flowchart illustrates the control logic for a fan with three possible states (Off, Medium Speed, High Speed) based on the values of two inputs, \`S\` (possibly speed selection) and \`R\` (reset or another control signal):

1. Start: The process begins.

2. Check S = 0 and R = 1:

   - True: The fan state is set to Off.

   - False: The process checks the next condition.

3. Check S = 0 and \`R =? (some condition for R):

   - True: The fan state is set to Medium Speed.

   - False: The process continues to the next check.

4. Check S = 0 and R = 0:

- True: The fan state is set to High Speed.

- False: The process ends, with no change to the fan state.

This flowchart represents the decision-making process for adjusting the fan speed based on the values of S and R.

Motion Counting Detector

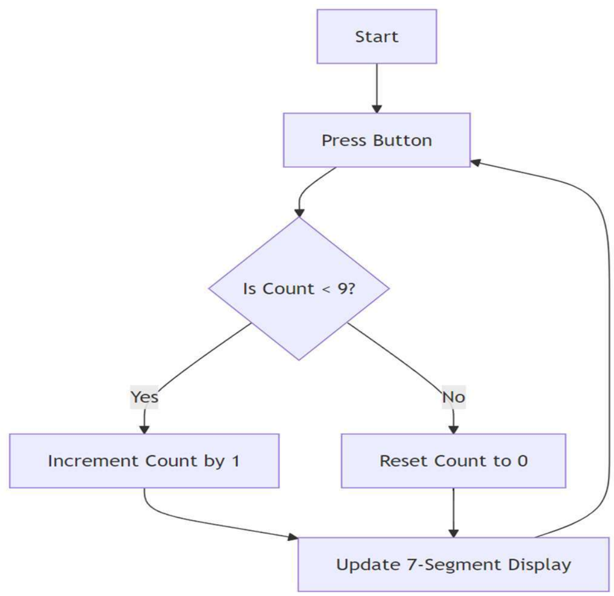

Fig 9: Flow chart for Motion Counting Detector

This flowchart describes the process of incrementing a counter and displaying the result on a 7-segment display:

1. Start: The system is initialized.

2. Press Button: The user presses a button to trigger an action.

3. Check if the Count is less than 9:

- Yes: If the count is less than 9, increment the count by 1.

- No: If the count reaches 9, reset the count to 0.

4. Update 7-Segment Display: The 7-segment display is updated to reflect the current count.

5. The process then loops back to await another button press.

This flowchart represents a basic counter system with a button-triggered increment function, where the count is reset after reaching 9.

2.7 Codes (Verilog Code)

Light Dependent Resistor

The Code:

```
module light (
    input wire A,       // First input
    output wire Y       // Output
);

assign Y = ~(A & A);   // NAND operation

endmodule
```

Fig 9: Verilog code for Automatic night Bulb

Output:

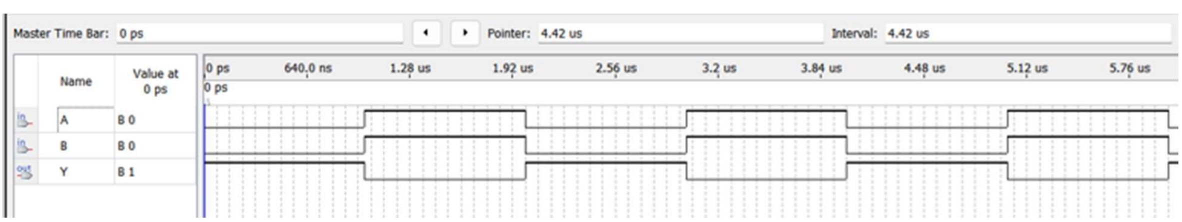

Fig 10: Verilog output for Automatic night Bulb

Temperature Controlled Fan

The Code:

```
module tempfan(
      input S,     // Set input
      input R,     // Reset input
      output Q,    // Output
      output Qn,      // Complementary output
      output f
);

// NAND gate logic for SR latch
wire S_nand, R_nand;

assign S_nand = ~(S & Qn);  // First NAND gate
assign R_nand = ~(R & Q);   // Second NAND gate

assign Q = S_nand;          // Q output
assign Qn = R_nand;         // Q complement output

assign f= (Q & Qn);

endmodule
```

Fig 11: Verilog code for Temperature Controlled Fan

Output:

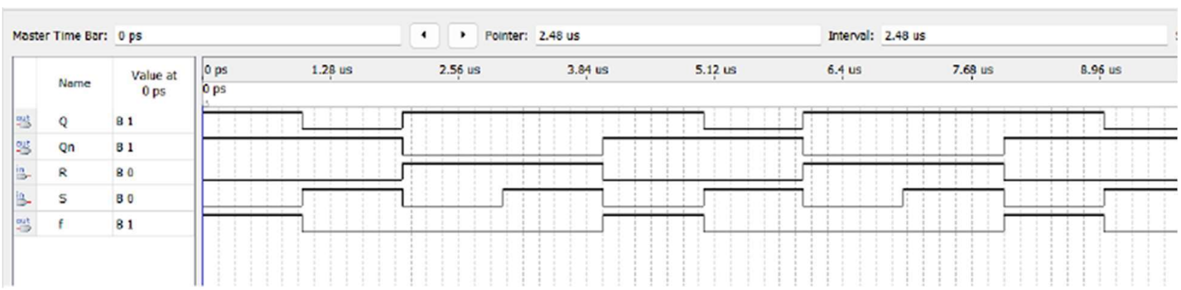

Fig 12: Verilog output for Temperature Controlled Fan

Motion Counting Detector

The Code:

```
module counter(
    input clk,          // Clock input
    input reset,        // Reset input
    output reg [3:0] q // 4-bit output
);

// Sequential logic for the Johnson counter
always @ (posedge clk or posedge reset) begin
    if (reset)
        q <= 4'b0000;           // Reset the counter to 0
    else
        q <= {~q[0], q[3:1]};  // Shift the bits and feed the complement of q[0] into q[3]
end

endmodule
```

Fig 13: Verilog code for Motion counting Detector

Output:

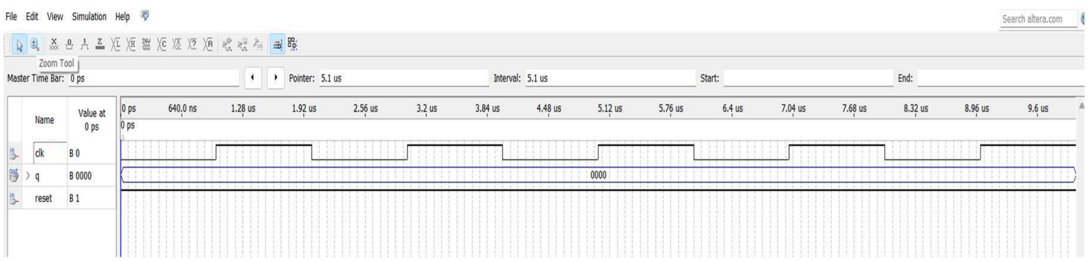

Fig 14: Verilog output for Motion counting Detector

3.Application, Prospects and Ethical Aspects

Real-Life Implications of the Smart Home Automation Project

3.1 Practical Applications of the Project

The smart home automation system designed in this project can significantly enhance daily living through various practical applications:

1. **Enhanced Comfort and Convenience**:
   a. Automated lighting adjusts according to natural light levels, ensuring rooms are well-lit during the evening while conserving energy during the day.
   b. Temperature-controlled fans provide optimal air circulation, enhancing comfort in different weather conditions without manual adjustments.
2. **Improved Security**:
   a. Motion detectors can trigger alarms or send notifications to homeowners when unauthorized movement is detected, increasing security and peace of mind.
3. **Energy Efficiency**:
   a. By automating the control of lights and appliances, the system minimizes unnecessary energy consumption, leading to lower utility bills and a reduced carbon footprint.

4. **Integration with Smart Devices**:
    a. The automation system can be integrated with other smart devices (e.g., smart speakers, security cameras) to create a comprehensive smart home environment, enhancing overall functionality.
5. **Remote Access and Control**:
    a. Future enhancements could enable remote control of the system via smartphones or tablets, allowing users to manage home settings from anywhere.

3.2 Potential Market and Users

The target market for this smart home automation system includes:

1. **Homeowners**:
    a. Individuals seeking to improve their home's comfort, convenience, and security are primary users. This system appeals to tech-savvy homeowners interested in modernizing their living spaces.
2. **Renters**:
    a. Renters looking for temporary solutions to enhance their living conditions may find the system beneficial without making permanent changes to their properties.
3. **Senior Citizens**:
    a. The automation system can significantly aid elderly individuals, providing them with enhanced safety features (like motion detection) and reducing the need for manual operation of lights and appliances.
4. **Real Estate Developers**:
    a. Developers looking to incorporate smart technology into new homes or renovations can utilize this project as a selling point, attracting environmentally conscious and tech-oriented buyers.
5. **Energy Companies**:
    a. Utilities and energy providers may collaborate with homeowners to incentivize the use of energy-efficient solutions, promoting the project as part of energy-saving initiatives.

3.3 Ethical Aspects

- **Energy Conservation**: Automating lights and fans based on environmental conditions (light levels, temperature, motion) reduces unnecessary electricity consumption, contributing to more efficient energy use and lowering carbon footprints.

- **Reducing Environmental Pollution**: By minimizing energy waste, the system helps reduce demand on power plants, which in turn decreases greenhouse gas emissions and other pollutants, supporting a cleaner environment.

- **Promoting Sustainability**: Automation encourages sustainable living by integrating eco-friendly technology into daily routines, fostering long-term environmental responsibility.

- **Cost Savings**: Energy-efficient homes lead to reduced electricity bills, making green technology more accessible and incentivizing wider adoption, thus supporting the global shift toward renewable energy sources.

- **Ethical Use of Resources**: By conserving energy, the system promotes responsible use of finite natural resources, addressing the ethical challenge of balancing comfort with environmental protection.

4.Conclusion and Discussion

Discussion

The SmartNest project demonstrates how simple digital logic circuits can automate key household functions. We have designed the circuits applying the knowledge we have about digital logic gates and circuits. Besides, we have run also implemented it via Verilog Code. After running the code, we found our desired outputs and timing diagrams Automatic Night bulb, using an LDR and NAND gates, efficiently controls lights based on ambient light, reducing energy usage and without anyone having to control it. The temperature-controlled fan, regulated by NAND and AND gates, adjusts its speed according to room temperature, ensuring comfort while conserving energy. The motion detection system, using the 4026 IC and counter, detects the movement of anyone entering the room/home and counts it and displays it on a & segment display. It enhances security and reduces manual effort.

The project highlights how basic logic circuits and sensors can create a cost-effective, energy-efficient smart home system, offering practical automation solutions without the need for complex programming or microcontrollers.

Conclusion

SmartNest has effectively demonstrated the use of digital logic circuits to automate essential aspects of home management, such as lighting, temperature-controlled fan, and security systems by automatic counting. By continuously adapting to real-time conditions, it optimizes energy efficiency and enhances user convenience. The reliance on simple and cost-effective components like logic gates and sensors makes SmartNest an accessible and practical solution for homeowners. Additionally, its flexible design allows room for future upgrades, offering immense potential for scaling and improving the system with more advanced technologies. This positions SmartNest as an appealing option in the growing home automation market.

5.References:

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