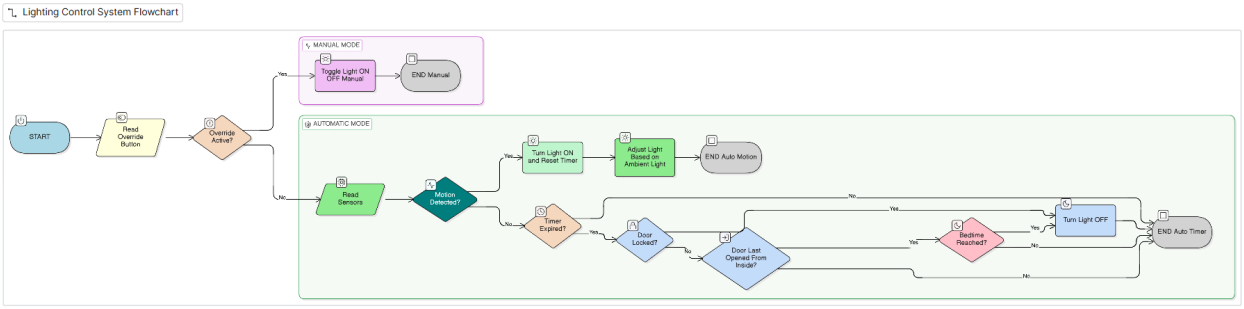
# Smart Home Motion-Based Lighting System

## Introduction

Automation systems play a critical role in modern engineering by improving efficiency, comfort, safety, and energy management. One common and practical example is a **smart home lighting system** that automatically controls lights based on human presence and predefined conditions. This project focuses on the design and simulation of a **motion-based smart lighting system** using an Arduino microcontroller, a PIR motion sensor, an override button, and an RGB LED.

The system is designed to automatically turn lights on when motion is detected and turn them off after a period of inactivity, while also including a manual override feature and a simulated bedtime shutoff. This report explains **how the system works, why it works, its real-world relevance, and its importance**, while also discussing design decisions and limitations.

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## 2. System Overview

The smart lighting system consists of the following main components:

- **Arduino Uno** – Acts as the brain of the system, executing control logic.
- **PIR Motion Sensor** – Detects human movement within the room.
- **RGB LED** – Represents the room light and allows control over light color.
- **Push Button (Override Button)** – Allows manual control of the lighting system.
- **Resistors** – Protect the LED from excessive current.

The system operates in two main modes:

1. **Automatic Mode** – Light control based on motion detection and timers.
2. **Manual Override Mode** – User directly controls the light regardless of sensor input.

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# 3. How the System Works

## 3.1 Automatic Lighting Operation

In automatic mode, the system continuously monitors the PIR motion sensor. When motion is detected, the Arduino turns the RGB LED on and records the time of the last detected movement. As long as motion continues to be detected within the specified timeout period, the light remains on.

If no motion is detected for a predefined duration (15 seconds in the simulation), the system assumes the room is unoccupied and automatically turns the light off. This logic prevents energy wastage and mimics real smart lighting behavior.

Additionally, a simulated **bedtime condition** is implemented. After a fixed duration from system startup, the lights are forced off regardless of motion. This represents scheduled lighting control commonly found in smart homes.

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## 3.2 Manual Override Functionality

The override button allows the user to take full control of the lighting system. When the button is pressed:

- The system toggles between automatic mode and override mode.
- In override mode, the PIR sensor and timers are ignored.
- The user can turn the light on or off manually.

To ensure reliable operation, the button uses the Arduino's **internal pull-up resistor**, meaning the button reads HIGH by default and LOW when pressed. This eliminates floating input issues and ensures consistent button behavior.

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## 3.3 Lighting Output

The RGB LED is programmed to emit a soft warm-white color with RGB values:

- Red: 255
- Green: 245

- Blue: 205

This color was chosen to resemble comfortable indoor lighting rather than harsh white light. When the system turns the light off, all RGB values are set to zero, fully disabling the LED.

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# 4. Real-World Applications

Smart lighting systems similar to this project are widely used in:

- **Homes** – Automatic hallway, bathroom, and bedroom lighting.
- **Offices** – Energy-efficient lighting in meeting rooms and corridors.
- **Hospitals** – Hands-free lighting control for hygiene and convenience.
- **Hotels** – Automated lighting based on room occupancy.
- **Public Buildings** – Reducing electricity waste in restrooms and stairwells.

These systems significantly reduce energy consumption while improving user comfort.

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# 5. Importance of Smart Lighting Systems

Smart lighting systems are important for several reasons:

- **Energy Efficiency** – Lights operate only when needed.
- **Cost Reduction** – Lower electricity bills over time.
- **User Convenience** – No need for manual switching.
- **Safety** – Automatic lighting reduces accidents in dark environments.
- **Sustainability** – Supports environmental conservation efforts.

As smart cities and IoT technologies continue to grow, systems like this form the foundation of intelligent infrastructure.

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# 6. Conclusion

This project successfully demonstrates the design and implementation of a **smart motion-based lighting system** using basic electronic components and microcontroller logic. Through the integration of motion sensing, timing logic, and manual override control, the system reflects real-world smart home solutions.

The project highlights key engineering concepts such as automation, digital input handling, timing control, and system reliability. Most importantly, it provides a strong foundation for more advanced smart home and IoT-based projects.