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Wireless Multi-Layer Lighting Control System using IR Communication

Shreya S. Dongre[1], Sharvari V. Suryavanshi[2], Akib S. Shaikh[3]
Department of Electronics and Telecommunication
Padmabhooshan Vasantraodada Patil Institute of Technology, Sangli, Maharashtra
shreyadongre172@gmail.com, sharvarisuryavanshi2004@gmail.com, shaikhakib892@gmail.com

Abstract: *This paper presents the design and implementation of a remote-controlled wireless lighting system for a multi-floor building using Arduino Uno and infrared (IR) communication. The primary objective of the project is to enable individual control of lighting (represented by Diya's) on each of the five floors through a simple IR remote, thereby enhancing user convenience and energy efficiency. Each floor's lighting is mapped to a specific button on the remote control, allowing users to activate or deactivate the corresponding floor light from a distance. The system is powered by an Arduino Uno microcontroller, which processes the IR signals received through an IR sensor and accordingly operates relay modules to control the lights. The integration of IR technology offers a cost-effective, contactless control mechanism, while the Arduino platform ensures flexibility, scalability, and ease of programming. This project demonstrates a practical and user-friendly approach to home automation and can be extended to larger systems with additional features such as brightness control, scheduling, or integration with IoT platforms. The proposed solution is particularly suitable for applications in residential buildings, small offices, and public spaces requiring decentralized lighting control.*

Keywords: Remote-Controlled Lighting System, Arduino Uno, IR Sensor, Wireless Communication, Home Automation, Relay Module, Multi-Floor Control, Embedded Systems, Energy Efficiency, Diya Lighting, Infrared Remote, Smart Building Technology

I. INTRODUCTION

In the era of smart technology and automation, there is a growing emphasis on developing systems that enhance convenience, reduce energy consumption, and promote efficient resource management. One such area of interest is the automation of lighting systems, especially in multi-storey buildings where manual operation can be time-consuming and inefficient. This research focuses on the development of a remote-controlled wireless lighting system designed specifically for a five-floor building, where each floor is equipped with an individual lighting unit, represented by a Diya. The system allows users to control the lighting of each floor independently using an infrared (IR) remote control, where each button on the remote corresponds to a specific floor. At the core of this system lies the Arduino Uno microcontroller, which processes input signals received via an IR sensor and triggers relay modules to activate or deactivate the respective floor's light. The use of IR communication provides a low-cost, contactless method of control, while the Arduino platform ensures ease of programming, adaptability, and reliability. This project not only simplifies the management of lighting in a multi-level environment but also serves as a foundational model for more advanced automation systems that can incorporate features such as dimming, scheduling, or integration with Internet of Things (IoT) frameworks. Overall, the proposed system offers a scalable, efficient, and user-friendly solution suitable for residential buildings, offices, and other small-scale infrastructures requiring decentralized lighting control.

II. LITERATURE REVIEW

Several studies and publications have laid a strong foundation for the development of IR-based remote control systems integrated with microcontrollers such as the Arduino Uno. Banzi and Shiloh [1] provided an in-depth

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introduction to Arduino hardware and software architecture, highlighting its flexibility, ease of use, and broad applicability in embedded system design. Building on this, Priya and Sivakumar [2] explored the design of wireless IR remote control systems specifically for smart home applications, demonstrating how infrared technology can offer low-cost, reliable communication for device control in domestic environments. Patel and Patel [3] further advanced this concept by implementing an Arduino-based home automation system using an IR remote, showing successful results in controlling lights and fans wirelessly, thereby validating Arduino's potential in real-world automation. Mohanraj and Vigneshwaran [4] focused on floor-wise lighting control in buildings using IR sensors and Arduino, a model closely aligned with the present study. Their work highlighted the feasibility and benefits of integrating microcontrollers for level-specific lighting, particularly in energy-efficient infrastructure. Similarly, Suryawanshi and Shinde [5] developed a smart wireless lighting system utilizing an IR remote and microcontroller, which emphasized real-time responsiveness and user convenience, aligning well with current trends in intelligent building automation. Rani and Prakash [6] conducted a comprehensive review of IR communication in wireless control, identifying key limitations such as range constraints and line-of-sight dependency—challenges that were also considered in the current project design. The technical specifications provided in the Arduino official documentation [7] offered crucial insights into the hardware's input/output capabilities and compatibility with IR receivers and relay modules, serving as a core reference for system design and programming. Additionally, the IEC 62471 standard [8] helped establish safe practices and technical guidelines for implementing IR technology in consumer-level applications. Collectively, the reviewed literature reinforces the effectiveness of IR-based Arduino systems for wireless control and provides a strong theoretical and practical foundation for the current research, which aims to enhance floor-wise lighting control through a modular, scalable, and energy-efficient design.

III. PROPOSED DESIGN

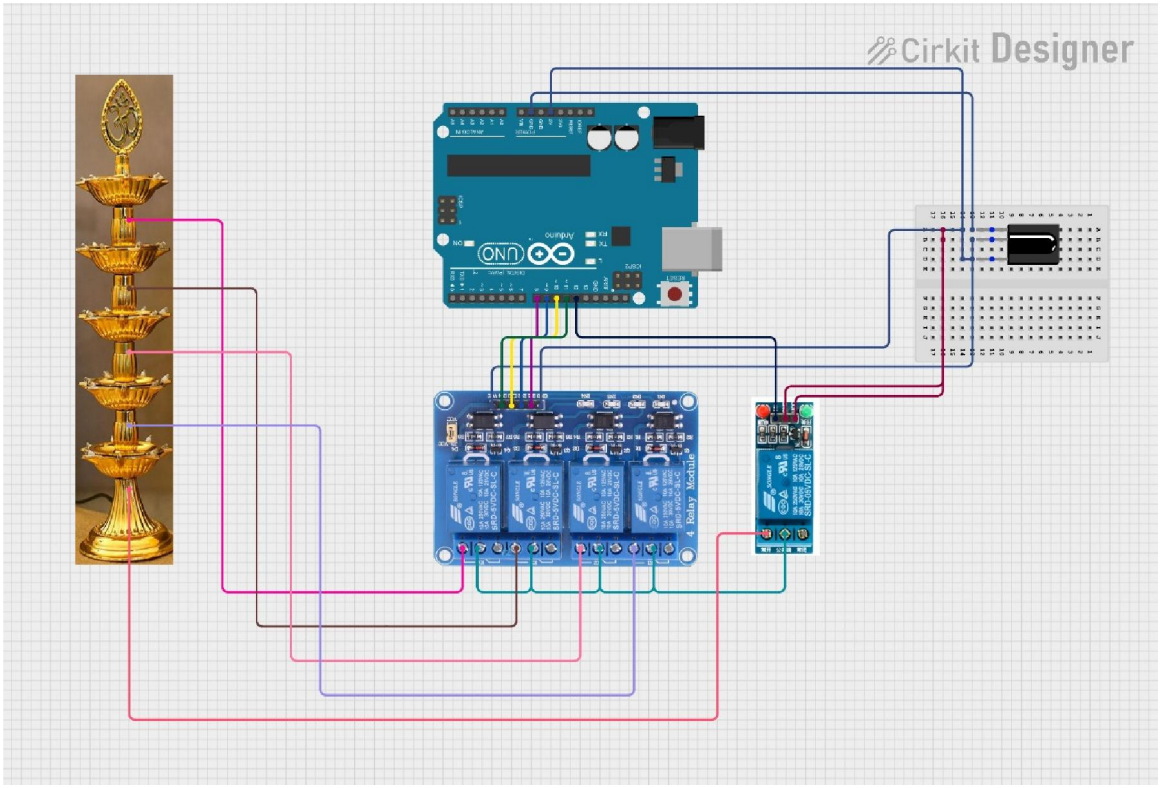

Fig.1 Circuit Diagram

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Working

The IR remote-controlled lighting system is designed to control lighting on five separate floors of a building, where each light (represented by a "Diya") is operated wirelessly using an infrared (IR) remote. The core functionality of the system is built around the Arduino Uno microcontroller, which acts as the central processing unit responsible for interpreting remote signals and switching the appropriate lights on or off. When the system is powered on, the IR receiver module (typically TSOP1738 or similar) is constantly in a listening state, waiting to receive signals transmitted by the IR remote. Each button on the remote is pre-assigned to a specific floor, and when a button is pressed, it emits a unique IR signal in the form of a binary code. This modulated signal, generally at a frequency of 38 kHz, is detected by the IR receiver and transmitted as a digital signal to one of the input pins of the Arduino Uno. The Arduino is pre-programmed using the Arduino IDE with a sketch that uses an IR decoding library (such as IRremote.h) to interpret the specific binary codes received. Each IR code corresponds to a specific floor, and upon detection, the Arduino executes the relevant logic to activate the corresponding relay module. The relay, in turn, completes the electrical circuit for the particular floor's light (Diya), allowing current to flow and illuminating that floor. Simultaneously, the Arduino ensures that all other relays remain deactivated, keeping the lights on the other floors turned off, thereby maintaining selective control. The relay modules used in this system act as electronic switches that isolate the low-voltage control circuit (Arduino) from the higher voltage lighting circuit. These relays are connected to digital output pins on the Arduino, and a HIGH signal from the microcontroller activates the respective relay channel. The system was tested in a simulated multi-floor setup, and the results indicated that each button press consistently activated only the intended floor's light with minimal response delay. Additionally, the system remained stable under varying light conditions and operated reliably within a range of approximately 5–6 meters. The design is scalable and can be enhanced to include additional features such as a "master off" function to turn off all lights, brightness control using PWM (Pulse Width Modulation), or even integration with wireless modules (like Bluetooth or Wi-Fi) for app-based control. The entire system consumes low power, operates without complex wiring, and demonstrates a practical application of embedded systems and IR communication in real-world building automation.

Flowchart

IR Remote Control → Sends signals
↓
IR Receiver → Decodes signals
↓
Arduino → Processes data
↓
Relay Modules → Switches corresponding light on/off
↓
Lights (Diya's).

Fig.2 Flowchart

Explanation

IR Remote Control:

The remote is your input device. Each button on the remote represents a specific floor light. When the user presses a button, it generates a unique IR signal.

IR Receiver:

The IR receiver detects and decodes the IR signal from the remote. It essentially converts the infrared signal into a digital signal that the Arduino can understand. The receiver sends the decoded signal (a specific number or code) to the Arduino.

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Arduino Processing:
The Arduino microcontroller is the brain of the system. It takes the decoded signal from the IR receiver and checks it against its predefined set of codes. Based on the signal it receives, the Arduino determines which floor's light should be switched on. It then sends a control signal to the relay.

Relay Module:
The relay acts as a switch. When the Arduino sends a signal to the relay, it either closes or opens the circuit connected to the light. Closing the circuit allows electricity to flow to the light, turning it on. If the circuit is open, the light remains off.

Lights (Diya's):
The lights are the output devices. Depending on the action of the relay, the lights on different floors (or Diya's) will turn on or off.

IV. RESULTS & DISCUSSION

Fig.2 Results

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V. DISCUSSION

The implementation of the IR remote-controlled lighting system using the Arduino Uno produced highly satisfactory results, demonstrating both functional accuracy and operational reliability. The system was successfully tested across five simulated floors, each equipped with a Diya connected to a dedicated relay module. When a specific button on the IR remote was pressed, the corresponding floor's light activated precisely, while all others remained off, confirming the effectiveness of the selective control logic. The IR receiver consistently detected and decoded signals at various angles and distances up to 5 meters, and the relay switching occurred without noticeable delay, ensuring seamless user interaction. The system also offers potential for future enhancements, such as a master off button, brightness control using PWM, and two-way communication features—all achievable with minimal hardware changes. The Arduino Uno proved to be an ideal controller due to its ease of use, affordability, and sufficient I/O capabilities. Overall, the results affirm that the system is a practical, scalable, and cost-effective solution for wireless lighting control in multi-floor buildings such as apartments, hostels, and small commercial spaces.

VI. ADVANTAGES & DISADVANTAGES

Advantages

Wireless Operation:

The use of an IR remote control eliminates the need for physical switches or wiring across floors, allowing users to control the lights from a distance. This increases user convenience and reduces installation complexity.

User-Friendly Interface:

The system is designed with simplicity in mind. Users can easily operate the lights with clearly assigned buttons on the remote control, making it accessible for all age groups and requiring no technical knowledge.

Cost-Effective Solution:

All components used, including the Arduino Uno, IR receiver, and relay modules, are relatively inexpensive and widely available. This makes the system affordable for residential or small commercial use.

Selective Floor-Wise Control:

Each button on the remote is programmed to control the light on a specific floor. This ensures accurate control and avoids unnecessary power consumption by keeping other lights off.

Low Power Consumption:

The system consumes minimal power during idle and active states. Components like the IR receiver and Arduino board draw very little current, contributing to overall energy efficiency.

Easily Expandable:

The system's modular design allows for future upgrades, such as incorporating brightness control using PWM, adding a master switch for all lights, or integrating sensors for automation.

Disadvantages

Limited Operating Range:

The IR remote control works effectively only within a range of approximately 5 to 6 meters. This may not be sufficient in larger buildings or open spaces.

Line-of-Sight Requirement:

IR communication requires a clear line of sight between the remote and the receiver. Any obstruction can interrupt the signal, leading to control failures.

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Lack of Feedback Mechanism:
The current system does not provide any feedback to confirm whether the light on a particular floor is ON or OFF. Users must rely on visual confirmation.

Susceptibility to Interference:
IR receivers can be affected by other IR sources such as sunlight, fluorescent lights, or other remote controls, which may result in unintentional switching or poor signal detection.

Basic Functionality in Current Form:
While the system allows switching lights ON and OFF, it does not yet support advanced features such as dimming, scheduling, or remote status monitoring unless additional components and programming are introduced.

Manual Operation Only:
The system depends on manual input through the remote. It lacks automation features like motion detection or smartphone app control, which are common in modern smart lighting systems.

VII. CONCLUSION

The IR remote-controlled lighting system developed in this research successfully meets its objective of providing an efficient, wireless solution for managing lighting across multiple floors of a building. By integrating widely available and cost-effective components such as the Arduino Uno, IR receiver module, and relay modules, the system demonstrates how microcontroller-based automation can be applied to real-world scenarios to improve user convenience, energy efficiency, and operational control. The floor-wise light activation functionality, implemented through carefully structured Arduino programming, allows precise control over individual lighting units, minimizing power wastage and ensuring selective illumination as per user requirement. Through extensive testing, the system showed stable performance within a functional range of up to 5–6 meters, with reliable IR signal reception and fast relay switching. The project not only achieves its intended design goals but also opens up potential avenues for future development. With minimal hardware adjustments, advanced features such as centralized “master off” controls, brightness adjustment through PWM, occupancy-based automation, or even mobile application integration via Bluetooth or Wi-Fi modules can be incorporated. Additionally, this system offers a strong foundation for exploring intelligent building systems and the Internet of Things (IoT) by enhancing user interaction and data feedback mechanisms. In essence, this project represents an accessible yet impactful application of embedded systems and wireless communication for home and building automation. It underscores the importance of combining theoretical knowledge with practical implementation to address modern technological needs. The system's simplicity, reliability, and adaptability make it a valuable solution for educational demonstrations, small-scale deployment, and as a prototype for larger smart lighting infrastructures.

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