

IOT-BASED DOMESTIC AND COMMERCIAL APPLIANCE CONTROL ALONG WITH MOTION DETECTION LIGHTING

INTERDISCIPLINARY PROJECT

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Technology in Information Technology

by

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DEPARTMENT OF INFORMATION TECHNOLOGY

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**CATEGORY-1 UNIVERSITY BY UGC
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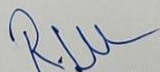
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **PADMANABHUNI N V M SUHAS KUMAR (41120134)** who carried out the project titled **"IOT-BASED DOMESTIC AND COMMERCIAL APPLIANCE CONTROL ALONG WITH MOTION DETECTION LIGHTING"** under my supervision from **January 2024** to **May 2024**.

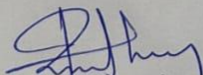

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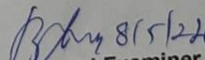
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DECLARATION

I, PADMANABHUNI N V M SUHAS KUMAR (41120134) hereby declare that the Project Report entitled "IOT-BASED DOMESTIC AND COMMERCIAL APPLIANCE CONTROL ALONG WITH MOTION DETECTION LIGHTING" done by me under the guidance of Dr. S. REVATHY, M.E., Ph. D., is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Information Technology.

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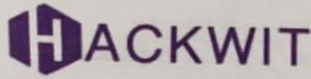
I am pleased to acknowledge my sincere thanks to **Board of Management** of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. T. Sasikala M.E., Ph.D., Dean**, School of Computing **Dr. R. Subhashini M. E. ,Ph .D.,**Head of the Department of Information Technology for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Dr. S. Revathy, M.E., Ph.D.,** for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the **Department of Information Technology** who were helpful in many ways for the completion of the project.

CERTIFICATE OF COMPLETION



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CERTIFICATE FOR INTERNSHIP

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This is to Certify that **PADMANABHUNI N V M SUHAS KUMAR (Reg No: 41120134)** student of Sathyabama Institute of Science and Technology, B. Tech Information Technology, has successfully completed the Internship at Hackwit Technologies from 22nd January to 30th January 2024.

During the internship, **PADMANABHUNI N V M SUHAS KUMAR** has closely worked as a part of the **Internet of Things** by carrying out the project entitled "**IOT-Based Domestic & Commercial Appliance Control Along with Motion Detection Lighting**".

He demonstrated good developing and learning skill with self-motivated attitude to learn new things. His contribution to implement the Internet of Things was good. We wish him all the best for his future endeavors.

Best Regards,

Ravikumar S
CEO & Managing Director
Hackwit Technologies Pvt Ltd



CERTIFICATE OF COMPLETION



ABSTRACT

In contemporary living and workspaces, the fusion of Internet of Things (IoT) technology with everyday appliances has revolutionized how we interact with our surroundings. This project embodies the convergence of IoT principles with the practicality of domestic and commercial environments, focusing specifically on the seamless control of appliances and intelligent lighting systems. At its core lies a sophisticated network of light sensors strategically positioned throughout the space, attuned to the subtlest human presence. Upon detecting movement within its designated range, the system orchestrates a symphony of illumination, instantly providing safety and convenience to occupants. The allure of this system transcends mere functionality; it embodies the essence of modern living, where convenience meets sustainability. By harnessing the power of IoT protocols, users are granted unprecedented control over their environment, regardless of their physical location. This level of autonomy not only enhances user experience but also promotes conscientious energy management practices. Through intelligent algorithms, the system achieves a delicate balance between responsiveness and efficiency, ensuring that energy is utilized judiciously without compromising on comfort or security. Moreover, this project represents a paradigm shift in how we conceptualize and implement infrastructure in domestic and commercial spaces. Beyond its immediate applications, the system holds the potential to revolutionize urban landscapes, fostering sustainability and efficiency on a larger scale. In essence, this project not only exemplifies the marriage of technology and utility but also heralds a new era of smart living, where innovation and sustainability coexist harmoniously to enrich the human experience.

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
IOT	- Internet of Things
I-IoT	-Industrial Internet of Things
PIR	-Passive Infrared Sensor
MQTT	-Message Queuing Telemetry Protocol
LPWAN	- Low-Power Wide-Area Network

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CHAPTER 1

INTRODUCTION

Hand gesture-controlled LED systems can seamlessly integrate into various environments and applications, including smart homes, interactive displays, entertainment systems, and public spaces, enhancing their functionality and user engagement. Hand gesture-controlled LED system enabling users to manipulate LED illumination through simple gestures. The system integrates a gesture recognition module, a microcontroller unit, and an LED array. Using computer vision and machine learning.

Gesture control taps into natural human behaviour, making it easy for users to interact with the LED system without the need for complex interfaces or input devices. By providing a hands-free and gesture-based control mechanism, the system offers an enhanced user experience, particularly in scenarios where manual input or physical controls may be impractical or cumbersome. The system can be programmed to recognize a wide range of gestures, allowing for customizable control options tailored to different user preferences and applications.

The module detects and classifies gestures in real-time, translating them into commands for the microcontroller to adjust LED intensity, colour, and pattern. Through experiments and user studies, we demonstrate the system's accuracy, responsiveness, and user satisfaction, highlighting its potential for intuitive human-computer interaction in various applications.

This project seeks to explore the potential of gesture recognition technology in enhancing user interaction with electronic devices and IoT systems. By leveraging sensors to detect and interpret hand gestures, the system aims to provide a hands-free method for

controlling LEDs, offering convenience, accessibility, and novel user experiences. Additionally, the project aims to investigate the feasibility of integrating gesture-based control into various applications, such as smart homes, wearable devices, interactive installations, and educational tools.

The Arduino IDE is a cross-platform application that allows users to write and upload code to Arduino boards. It features a text editor for writing code, a toolbar for managing projects and uploading sketches, and a serial monitor for debugging and communication with the Arduino board. The IDE supports the Arduino programming language, which is based on C/C++, making it easy for beginners to learn and use.

Arduino programming involves writing sketches, which are programs written in the Arduino programming language. Sketches consist of two main functions: `setup ()` and `loop ()`. The `setup ()` function is called once when the Arduino board starts up, while the `loop ()` function runs continuously in a loop until the board is powered off or reset. Arduino

A user-friendly interface to visualize detected hand gestures and provide feedback to the user. This could include displaying recognized gestures on a screen or providing auditory or visual feedback through connected devices. Optimize the system for real time performance to ensure minimal latency between hand gesture detection and device control. This involves efficient processing of video data, as well as optimizing communication with the Arduino board.

The module detects and classifies gestures in real-time, translating them into commands for the microcontroller to adjust LED intensity, colour, and pattern. Through experiments and user studies, we demonstrate the system's accuracy, responsiveness, and user satisfaction, highlighting its potential for intuitive human-compute.

1.1 PROBLEM STATEMENT:

In today's world, energy conservation is of utmost importance. However, many households and commercial spaces still struggle with excessive electricity usage due to inefficient appliance control and lighting systems. This project aims to address this issue by developing an IoT-based solution that not only allows for the remote control of appliances but also incorporates motion detection technology. By intelligently detecting the presence or absence of living organisms in a space, the system can automatically adjust the lighting, leading to significant energy savings and reduced electricity consumption.

The integration of motion detection technology into the appliance control system provides several benefits. Firstly, it enhances convenience and efficiency by eliminating the need for manual operation of appliances and lighting. Users can remotely control their devices through a smartphone or other connected devices, ensuring that appliances are only in use when needed. Moreover, the system's ability to detect motion ensures that lighting is activated only when there is a presence in the room, preventing unnecessary energy wastage when spaces are unoccupied.

By implementing this IoT-based solution, significant energy savings can be achieved, benefiting both households and commercial establishments. The system's ability to automatically turn off appliances and lighting when no motion is detected helps to reduce electricity consumption during idle periods. This not only contributes to cost savings but also promotes a more sustainable and environmentally friendly approach to energy usage. Additionally, the system's remote-control capabilities allow users to monitor and manage their energy consumption, empowering them to make informed decisions and further optimize their energy usage.

1.2 OBJECTIVES

I. Development of an Advanced IoT-Based Appliance Control System:

The primary goal of this objective is to design, develop, and implement a cutting-edge IoT-based appliance control system that caters to both domestic and commercial environments. This system will serve as the cornerstone of the project, providing users with the ability to remotely manage a wide array of appliances via intuitive interfaces accessible through smartphones, tablets, or computers. The development process will involve rigorous research into existing IoT technologies, protocols, and standards, with a focus on ensuring seamless integration with diverse electrical infrastructures and appliance types. Emphasis will be placed on user experience design (UX/UI), aiming for a user-friendly interface that simplifies appliance control and enhances accessibility for users of all levels of technical proficiency.

II. Integration of State-of-the-Art Motion Detection Technology:

Building upon the foundation established in Objective 1, this objective entails the integration of state-of-the-art motion detection technology into the IoT-based appliance control system. The incorporation of motion sensors capable of detecting the presence or absence of living organisms will enable the system to intelligently adjust appliance usage and lighting based on real-time occupancy data. By leveraging advanced algorithms and machine learning techniques, the system will analyse motion patterns and occupancy trends to optimize energy consumption and minimize wastage during periods of inactivity. Special attention will be given to the development of robust motion detection algorithms that are sensitive enough to accurately detect human presence while minimizing false positives and negatives.

III. Optimization of Energy Efficiency and Sustainability:

This objective focuses on maximizing energy efficiency and promoting sustainability through the implementation of sophisticated energy optimization strategies within the IoT-based appliance control system. The system will dynamically adjust appliance usage and lighting levels based on occupancy patterns, time of day, and user preferences to minimize electricity consumption without sacrificing user comfort or convenience. Energy-saving features such as scheduling, automation, and adaptive control will be implemented to further enhance efficiency and reduce environmental impact. Additionally, the system will provide users with real-time feedback on energy usage, empowering them to make informed decisions and adopt more sustainable energy practices in their daily lives.

IV. Evaluation, Validation, and Continuous Improvement:

The final objective revolves around the thorough evaluation, validation, and continuous improvement of the developed IoT-based appliance control system. Extensive testing will be conducted in both simulated and real-world environments to assess the system's performance, reliability, responsiveness, and energy savings potential. User feedback and stakeholder input will be collected and analysed to identify areas for improvement and refinement. Iterative development cycles will be employed to address any issues or shortcomings uncovered during testing, ensuring that the final product meets the highest standards of quality, reliability, and user satisfaction. Additionally, ongoing research and development efforts will focus on exploring emerging technologies and methodologies to further enhance the system's capabilities and stay at the forefront of innovation in the field of IoT-based energy management.

CHAPTER 2

METHODOLOGY

The methodology for this project will follow a systematic approach that integrates research, development, testing, and validation phases to ensure the successful implementation of the IoT-based appliance control system with motion detection lighting. The initial phase will involve a comprehensive review of existing literature, standards, and technologies related to IoT, appliance control systems, motion detection, and energy management. This research will inform the design and development of the system architecture, including hardware components, communication protocols, and software algorithms.

Prototyping and iterative development cycles will be employed to refine the system design and functionality based on feedback from stakeholders and user testing. The system will be rigorously tested in controlled laboratory environments to evaluate its performance, reliability, and energy efficiency. Real-world field tests will then be conducted to assess the system's effectiveness in diverse domestic and commercial settings, with data collected and analyzed to validate its impact on energy consumption and user satisfaction. Continuous monitoring and optimization will be conducted throughout the project lifecycle to address any issues or challenges that arise and ensure the ongoing improvement of the system's performance and functionality.

2.1PROJECT REQUIREMENTS

I. Windows/ Mac/ Linux System:

Windows, Mac or Linux based operating system for personal computers or any other internet of thing's devices. Integrating the hardware and software components into a cohesive system and

conducting thorough testing to ensure functionality, accuracy, and reliability. Testing should involve evaluating the system's performance under various conditions and refining algorithms or parameters as needed.

II. Passive Infrared (PIR):

The Passive Infrared (PIR) sensor is a critical component of the project, serving as the primary means of detecting motion within the environment. This sensor operates by detecting changes in infrared radiation emitted by living organisms, such as humans, animals, or other sources of heat. In fig 2.1 When motion is detected within its range, the PIR sensor generates a signal that triggers the activation of the connected devices, such as lighting or appliances. Its passive nature, which does not emit any signals itself but relies on detecting changes in the environment, makes it ideal for conserving energy while maintaining effective motion detection capabilities. The PIR sensor's sensitivity and range can be adjusted to suit the specific requirements of the application, ensuring reliable detection of motion in both domestic and commercial settings.



Fig 2.1: PIR (Passive Infrared) Sensor

III. Node MCU (ESP8266 or ESP32):

The Node MCU, powered by either the ESP8266 or ESP32 microcontroller, acts as the central control unit and communication gateway for the IoT-based appliance control system.

Equipped with built-in Wi-Fi capabilities, the Node MCU enables remote access and control of connected devices through a user-friendly interface, such as a smartphone or computer. Its compact size, low power consumption, and GPIO (General Purpose Input/Output) pins make it well-suited for interfacing with external components, such as the PIR sensor and relay module.

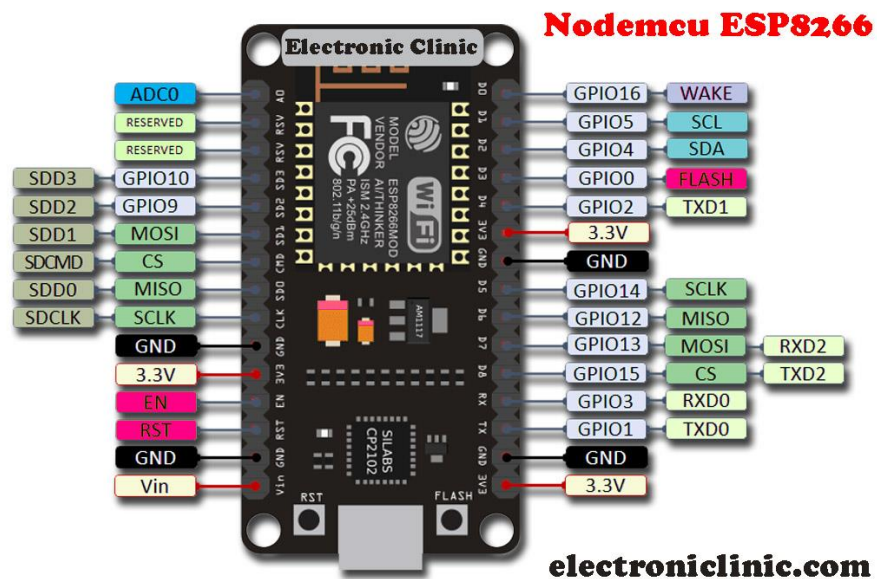


Fig 2.2: Nodemcu ESP8266

In fig 2.2 the Node MCU's processing power and memory capacity allow for the implementation of advanced algorithms and logic to manage the system's operation efficiently. Additionally, its compatibility with a wide range of development tools and programming languages facilitates rapid prototyping and customization to meet the project's specific requirements.

IV. 4-Channel Relay Module:

The 4-channel relay module serves as the interface between the

Node MCU and the electrical appliances, enabling remote control and automation of multiple devices within the system. Each relay channel is capable of independently switching the power supply to connected appliances on or off based on signals received from the Node MCU. This modular design provides flexibility in controlling various appliances, such as lights, fans, heaters, or other electrical devices, depending on the user's preferences and requirements.

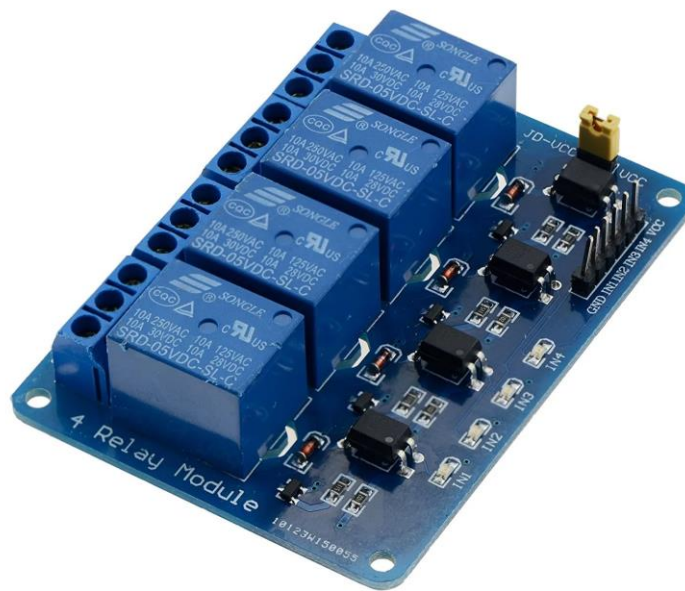


Fig 2.3: 4-Channel Relay Module

In fig 2.3 The relay module's high switching capacity and reliable performance ensure seamless integration with the IoT-based appliance control system, allowing for efficient management of energy consumption and optimization of the connected devices' operation.

V. Light Bulbs:

Light bulbs are fundamental components of the project's lighting system, providing illumination in domestic and commercial spaces. The selection of light bulbs, whether traditional incandescent bulbs, fluorescent tubes, or modern LED bulbs, plays a crucial role in determining the system's energy efficiency and lighting quality. In fig

2.4 LED bulbs, in particular, are preferred for their low power consumption, long lifespan, and adjustable brightness levels, making them ideal for use in an energy-efficient lighting system. The IoT-based appliance control system regulates the operation of these light bulbs based on motion detection data from the PIR sensor, ensuring that lighting is activated only when needed and deactivated during periods of inactivity. This approach not only conserves energy but also creates a comfortable and customizable lighting environment tailored to the users' preferences and requirements.



Fig 2.4: Light Bulbs

VI. Jumping Wires:

Jumping wires, also known as jumper wires, play a vital role in establishing electrical connections between various components within the IoT-based appliance control system. These wires are typically made of flexible and durable materials, such as copper or tinned copper, with male or female connectors on each end to

facilitate easy insertion into electronic components, breadboards, or headers. In fig 2.5 the use of jumping wires enables the seamless integration of components, such as the PIR sensor, Node MCU, relay module, and light bulbs, by creating reliable electrical pathways for transmitting signals and power.



Fig 2.5: JUMPER WIRES

2.2 PROPOSED SYSTEM ARCHITECTURE

In figure 2.6 The proposed system architecture for the IoT-based appliance control system with motion detection lighting is designed to provide seamless integration, robust functionality, and user-friendly operation. At its core, the system comprises interconnected hardware and software components that work in tandem to detect motion, control appliances, and optimize energy usage in both domestic and commercial environments.

In conclusion, the proposed system architecture for the IoT-based appliance control system with motion detection lighting offers a comprehensive and versatile solution for managing energy usage and enhancing user comfort and convenience. By leveraging a

combination of hardware and software components, communication protocols, and scalable design principles, the system provides a robust foundation for creating smart and sustainable environments. With its ability to detect motion, control appliances, and optimize energy usage in real-time, the system empowers users to achieve significant energy savings, reduce electricity consumption, and promote a more eco-friendly and efficient approach to energy management.

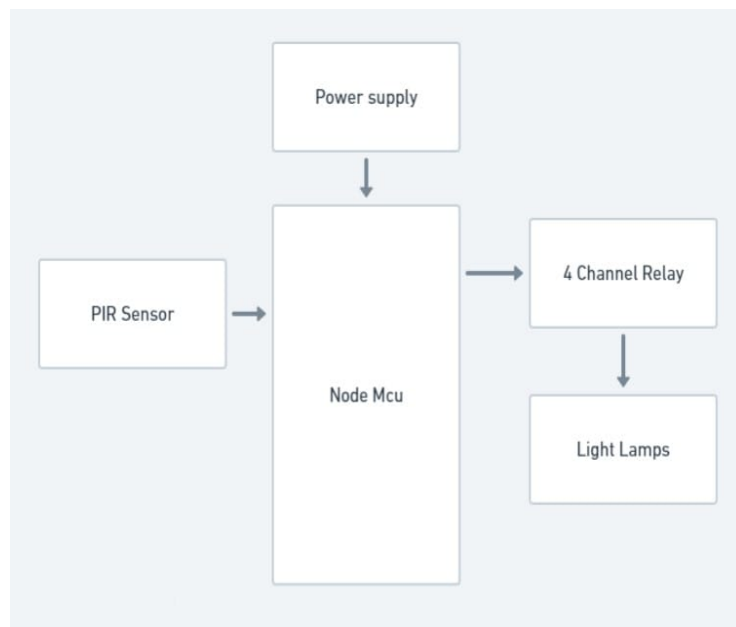


Fig 2.6: System Architecture

- I. Hardware Components:** The hardware components of the system consist of the Passive Infrared (PIR) sensor, Node MCU (powered by either ESP8266 or ESP32), 4-channel relay module, light bulbs, and jumping wires. The PIR sensor serves as the primary input device, detecting motion within its detection range and generating signals that trigger the activation or deactivation of appliances and lighting. The Node MCU acts as the central processing unit and communication gateway, facilitating communication between the PIR sensor, relay module, and connected devices via Wi-Fi. The 4-channel relay module serves as the interface between the Node

MCU and electrical appliances, enabling remote control and automation of multiple devices. Light bulbs provide illumination in the environment, with their operation regulated based on motion detection data. Jumping wires establish electrical connections between components, ensuring reliable transmission of signals and power within the system.

II. Software Components: The software components of the system encompass firmware and software applications developed to manage device communication, data processing, and user interaction. The firmware running on the Node MCU is responsible for controlling the operation of connected devices, processing motion detection data from the PIR sensor, and executing energy optimization algorithms. It also handles communication protocols for transmitting data between the Node MCU and external devices, such as smartphones or computers. Software applications, such as mobile apps or web interfaces, provide users with intuitive interfaces for remotely monitoring and controlling appliances, setting preferences, and viewing energy usage statistics. These applications leverage the system's Wi-Fi connectivity and cloud integration capabilities to enable seamless access and control from anywhere with an internet connection.

III. Communication Protocols: The proposed system architecture utilizes standard communication protocols, such as Wi-Fi and MQTT (Message Queuing Telemetry Transport), to facilitate reliable and secure data exchange between components. Wi-Fi connectivity enables wireless communication between the Node MCU and external devices, allowing for remote access and control of the system. MQTT protocol ensures efficient and scalable messaging between devices, supporting real-time data transmission and command execution. This combination of communication protocols ensures robust connectivity and interoperability, enabling seamless integration with existing networks and devices.

2.3 ALGORITHM

Step-1: Initialization and Setup: Initialize system components, including the Passive Infrared (PIR) sensor, Node MCU, relay module, light bulbs, and jumping wires. Establish Wi-Fi connection using the Node MCU to enable wireless communication with external devices. Configure MQTT (Message Queuing Telemetry Transport) communication protocol for efficient and reliable messaging between components. Calibrate the PIR sensor to optimize its sensitivity and detection range for the specific environment. Verify proper wiring connections between components using jumping wires to ensure reliable transmission of signals and power.

Step-2: Main Loop: Continuously monitor motion detection data from the PIR sensor. If motion is detected within the predefined detection range of the PIR sensor: Activate the appropriate relay channel on the 4-channel relay module to turn on the connected appliances and lighting. Record the timestamp of motion detection to track energy usage and occupancy patterns. If no motion is detected for a specified period: Deactivate the relay channel to turn off the connected appliances and lighting, conserving energy during periods of inactivity. Calculate the duration of inactivity to optimize energy usage and identify opportunities for further efficiency improvements.

Step-3: Energy Optimization and Adaptive Control: Calculate the duration and frequency of appliance and lighting activation based on recorded motion detection timestamps. Determine the energy consumption of each activated appliance and lighting fixture to quantify overall electricity usage. Analyse historical motion detection data to identify recurring occupancy patterns and time-of-day trends. Implement adaptive control strategies to adjust appliance usage and lighting levels dynamically based on occupancy patterns and user

preferences. Optimize energy usage by scheduling appliance activation and deactivation during peak and off-peak hours to minimize electricity costs.

Step-4: User Interface and Interaction: Develop a user-friendly interface, such as a mobile app or web dashboard, to enable users to monitor and control the appliance control system remotely. Provide real-time feedback on energy usage statistics, occupancy status, and appliance operation to empower users to make informed decisions. Implement customizable settings and preferences to allow users to personalize their experience and tailor the system to their specific needs. Enable seamless integration with existing smart home platforms and automation systems to enhance interoperability and expand functionality.

Step-5: Error Detection and Handling: Implement robust error detection mechanisms to identify and address communication failures, sensor malfunctions, or hardware/software issues. Log error messages and system alerts to facilitate troubleshooting and diagnosis of potential issues. Provide timely notifications to users or administrators via email, push notifications, or SMS in case of critical errors or system failures. Implement failover mechanisms and redundancy strategies to ensure system reliability and continuity of operation, even in the event of component failures or network.

Step-6: Continuous Monitoring and Optimization: Continuously monitor system performance and energy usage metrics to identify areas for improvement and optimization. Collect and analyze feedback from users and stakeholders to gather insights and identify opportunities for enhancing system functionality and usability. Iterate on the design and implementation of the appliance control system based on user feedback and evolving requirements. Stay abreast of emerging technologies and industry trends to incorporate new features and enhancements into the system, ensuring its relevance.

The proposed algorithm for the motion-based appliance control system provides a structured and systematic approach to detecting motion, controlling appliances, optimizing energy usage, and handling errors. In conclusion, the motion-based appliance control system outlined by this algorithm represents a sophisticated and comprehensive approach to optimizing energy usage and enhancing user convenience. By leveraging motion detection technology, adaptive control strategies, and robust error handling mechanisms, the system offers a scalable and versatile solution for both domestic and commercial environments. Through continuous monitoring and optimization, users can expect to achieve significant energy savings while maintaining a high level of comfort and convenience in their living or working spaces.

Moreover, the development of a user-friendly interface and seamless integration with existing smart home platforms ensures accessibility and ease of use for users of all technical backgrounds. Real-time feedback on energy usage statistics and system performance empowers users to make informed decisions about their energy consumption habits, fostering a culture of sustainability and environmental responsibility. By leveraging motion detection technology, adaptive control strategies, and robust error handling mechanisms, the system offers a scalable and versatile solution for both domestic and commercial environments. Through continuous monitoring and optimization, users can expect to achieve significant energy savings while maintaining a high level of comfort and convenience in their living or working spaces.

2.4 FLOW DIAGRAM

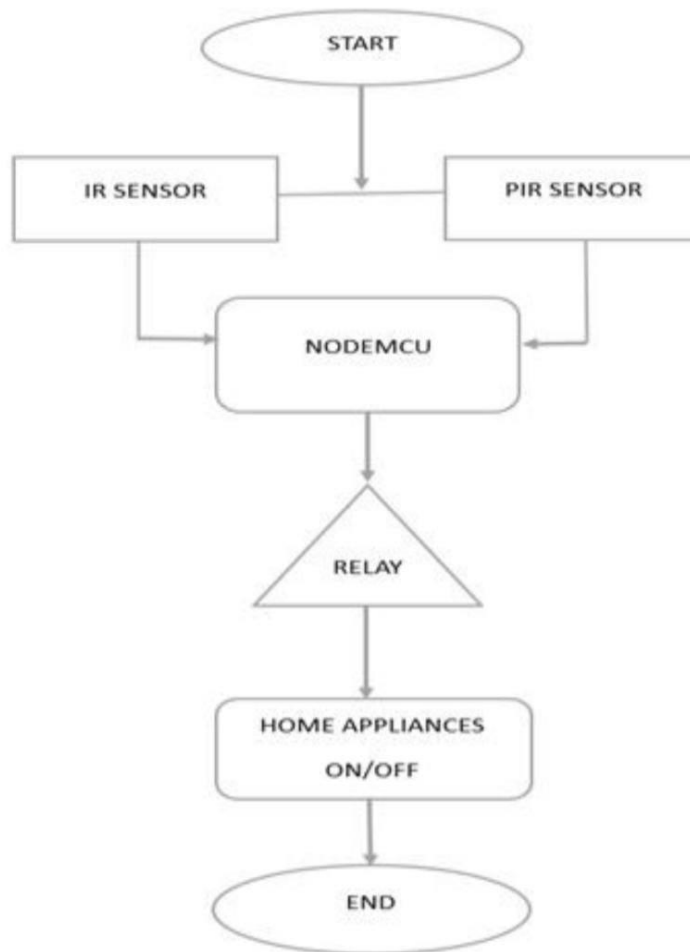


Fig 2.7: FLOW DIAGRAM

- i) **Start:** In fig 2.7 the flow diagram initiates the process, signalling the beginning of the sequence.
- ii) **IR Sensor and PIR Sensor:** The IR (Infrared) sensor and PIR (Passive Infrared) sensor serve as the primary components for detecting motion within their designated range. They detect changes in infrared radiation emitted by living organisms, triggering the subsequent actions.

- iii) **Node-MCU:** The Node-MCU, powered by either ESP8266 or ESP32, acts as the central control unit of the system. It receives input from the sensors and sends commands to other components based on detected motion.
- iv) **Relay:** The relay module is responsible for controlling the power supply to home appliances. It receives signals from the Node MCU and toggles the state of connected appliances accordingly.
- v) **Home Appliances On/Off:** The home appliances are connected to the relay module, allowing for remote control of their power supply. When motion is detected, the relay activates the appliances, and when no motion is detected, it turns them off to conserve energy.
- vi) **End:** The flow diagram concludes the process, indicating the end of the sequence.
- vii) **Detection of Motion:** The sensors continuously monitor their surroundings for any movement. Upon detecting motion, they send signals to the Node MCU to initiate further actions.
- viii) **Node MCU Processing:** Upon receiving signals from the sensors, the Node MCU processes the data and determines the appropriate response based on predefined logic and user settings.
- ix) **Relay Activation:** If motion is detected, the Node MCU sends signals to the relay module to activate the connected appliances, allowing them to turn on and perform their intended functions.
- x) **Appliance Control:** The relay module toggles the power

supply to the connected appliances, enabling them to be turned on or off remotely based on the presence or absence of motion.

- xi) Energy Conservation:** By turning off appliances when not in use, the system promotes energy conservation and helps reduce electricity consumption, contributing to cost savings and environmental sustainability.
- xii) User Interaction:** The system may include provisions for user interaction, such as setting preferences or adjusting settings through a user-friendly interface, enhancing user control and customization.
- xiii) Error Handling:** Error detection mechanisms may be implemented to identify and address any communication failures or sensor malfunctions, ensuring the reliability and smooth operation of the system.
- xiv) Feedback Loop:** The system may incorporate feedback loops to gather user feedback and stakeholder input, facilitating continuous improvement and refinement of the system's functionality and performance.
- xv) Scalability and Adaptability:** The system may be designed to be scalable and adaptable to accommodate future expansions or upgrades, ensuring its longevity and relevance in evolving technological landscapes.

2.5 MODULES

2.5.1 Motion Detection Module:

The Motion Detection Module serves as the cornerstone of the system, integrating passive infrared (PIR) sensors to detect motion within the environment. These sensors continuously monitor

changes in infrared radiation emitted by living organisms, providing real-time input to the system. Upon detecting motion, the module triggers subsequent actions, such as activating or deactivating appliances and lighting fixtures. The sensitivity and detection range of the PIR sensors are calibrated to ensure accurate motion detection while minimizing false alarms. This module forms the foundation for automated control and energy optimization based on occupancy patterns.

The Motion Detection Module forms the core of the system, leveraging advanced passive infrared (PIR) sensors meticulously positioned to detect motion within the environment. These sensors continuously monitor subtle variations in infrared radiation, effectively capturing movements of living organisms. To ensure precision and reliability, the sensitivity and detection range of the PIR sensors are meticulously calibrated, minimizing false alarms while maximizing detection accuracy. Upon detecting motion, this module promptly triggers a cascade of subsequent actions, such as activating or deactivating appliances and lighting fixtures. By serving as the primary trigger mechanism, the Motion Detection Module establishes the foundation for automated control and energy optimization strategies based on real-time occupancy patterns. Through its seamless integration into the system, this module empowers users with a heightened level of convenience and energy efficiency in both domestic and commercial settings.

2.5.2 IoT Communication Module:

The IoT Communication Module establishes seamless communication between system components and external devices, enabling remote control and monitoring capabilities. It employs industry-standard protocols such as MQTT (Message Queuing Telemetry Transport) to ensure efficient and reliable data exchange

over the internet. This module facilitates bi-directional communication, allowing users to interact with the system from anywhere via their smartphones, tablets, or computers. It also enables integration with existing smart home platforms and automation systems, enhancing interoperability and expanding functionality. Robust encryption and authentication mechanisms are implemented to ensure the security and privacy of transmitted data.

The IoT Communication Module stands as the linchpin of connectivity within the system, orchestrating seamless communication channels between various system components and external devices. Leveraging cutting-edge technologies and industry-standard protocols such as MQTT (Message Queuing Telemetry Transport), this module ensures efficient and reliable data exchange across the network. It facilitates bidirectional communication pathways, allowing users to remotely control and monitor the system from any location via smartphones, tablets, or computers. Furthermore, the module fosters integration with existing smart home platforms, fostering enhanced interoperability and expanding the system's functionality. To safeguard the integrity and confidentiality of transmitted data, robust encryption and authentication mechanisms are meticulously implemented, ensuring the security and privacy of user information. Through its robust connectivity infrastructure, the IoT Communication Module epitomizes the system's capability to seamlessly interact with the digital ecosystem, delivering unparalleled accessibility and control to users.

2.5.3 Energy Efficiency Module:

The Energy Efficiency Module embodies the system's commitment to optimizing energy usage and promoting sustainability through meticulous analysis and proactive management of resource

consumption. It encompasses a multifaceted approach that integrates cutting-edge technologies and intelligent strategies to maximize efficiency while minimizing environmental impact.

I. Understanding Needs:

The Energy Efficiency Module begins by comprehensively understanding the energy needs and usage patterns of the environment it operates within. Through detailed analysis of historical data and user preferences, the module gains valuable insights into peak usage hours, appliance usage patterns, and lighting requirements. By understanding these needs, the module can tailor its optimization strategies to suit the specific requirements of the space, ensuring optimal energy utilization without compromising comfort or functionality.

II. Optimizing Lighting Usage:

One of the primary focus areas of the Energy Efficiency Module is optimizing the usage of lighting fixtures to minimize electricity consumption while maintaining adequate illumination levels. Leveraging advanced scheduling algorithms and dimming capabilities, the module dynamically adjusts lighting levels based on ambient light conditions, time of day, and user preferences. By dimming or turning off lights in unoccupied areas or during daylight hours, the module reduces unnecessary energy wastage and prolongs the lifespan of lighting fixtures, contributing to long-term energy savings and cost reduction.

III. Considering Occupancy:

Central to the energy optimization strategy is the consideration of occupancy patterns within the environment. The Energy Efficiency Module continuously monitors motion detection data to determine occupancy levels in different areas of the space. Based on occupancy status, the module dynamically controls appliance

operation and lighting usage, ensuring that resources are only utilized when needed. By synchronizing appliance activation with occupancy patterns, the module minimizes standby power consumption and eliminates energy wastage during periods of inactivity, further enhancing energy efficiency and reducing operational costs.

IV. Integration with Other Systems:

To maximize the impact of energy optimization efforts, the Energy Efficiency Module seamlessly integrates with other system components and external systems. By exchanging data and sharing insights with smart grid systems, weather forecasting services, and building management systems, the module gains access to additional contextual information that enhances its decision-making capabilities. Integration with smart home platforms enables users to leverage energy optimization features alongside other home automation functionalities, streamlining control and management processes. Through collaborative efforts and interoperability with external systems, the Energy Efficiency Module ensures a holistic approach to energy management that delivers tangible benefits in terms of cost savings, sustainability, and user comfort.

In conclusion, the Energy Efficiency Module plays a pivotal role in driving the system's mission to optimize energy usage and promote sustainability in both domestic and commercial environments. By understanding energy needs, optimizing lighting usage, considering occupancy patterns, and integrating with other systems, the module enables intelligent energy management strategies that result in significant cost savings, reduced environmental impact, and enhanced user comfort. Through continuous monitoring, analysis, and optimization, the Energy Efficiency Module contributes to a greener and more efficient future, empowering users to embrace responsible energy usage practices while enjoying the benefits of modern technology.

2.5.4 Energy Optimization Module:

The Energy Optimization Module focuses on maximizing energy efficiency and promoting sustainability within the system. It analyses motion detection data to identify opportunities for energy conservation, such as adjusting appliance operation based on occupancy patterns. The module employs machine learning algorithms to predict energy usage trends and optimize scheduling strategies accordingly. It also provides real-time insights into energy consumption patterns, empowering users to make informed decisions about their energy usage habits. Through continuous monitoring and optimization, this module contributes to cost savings and environmental conservation efforts.

Through intricate machine learning algorithms, this module discerns intricate patterns within occupancy data, thereby predicting energy usage trends with unprecedented accuracy. Armed with real-time insights into energy consumption patterns, users can make informed decisions to optimize resource allocation and minimize environmental impact. Moreover, the Energy Optimization Module proactively engages in continuous optimization endeavors, leveraging predictive analytics to fine-tune scheduling strategies and operational parameters. By fostering a culture of energy consciousness and sustainability, this module spearheads the system's mission to redefine the paradigm of responsible energy management in both domestic and commercial domains.

2.5.5 User Interface Module:

The User Interface Module provides a user-friendly interface for interacting with the system and monitoring its status. It encompasses a range of interfaces, including mobile apps, web dashboards, and physical control panels, catering to diverse user preferences. The interface offers features such as real-time energy

usage tracking, customizable settings for appliance control, and notifications/alerts for system events. User feedback is incorporated to enhance usability and address user needs effectively. With intuitive navigation and responsive design, the user interface module ensures a seamless and engaging user experience, fostering user satisfaction and adoption of the system.

Through a meticulously crafted user experience, the interface provides real-time insights into energy usage patterns, empowering users to make informed decisions and take proactive measures to optimize resource utilization. Moreover, the User Interface Module delivers timely notifications and alerts for system events, ensuring users remain informed and engaged at all times. By incorporating user feedback and iteratively refining its design, this module strives to deliver an unparalleled user experience, fostering enhanced user satisfaction and system adoption.

2.6 DEVELOPMENT AND DEPLOYMENT SETUP

The Development and Deployment Setup encompasses the processes and tools required to develop, test, and deploy the IoT-based appliance control system with motion detection lighting. It comprises a structured approach to software and hardware development, as well as robust deployment strategies to ensure seamless integration and operation in real-world environments.

I. Development Environment:

The development environment serves as the foundation for creating and refining the system's software components. It typically includes integrated development environments (IDEs) such as Arduino IDE or platform IO, which provide a comprehensive set of tools writing, compiling, and debugging code. Additionally, development boards such as the ESP32 are utilized to prototype and test the system's firmware in a simulated environment. In 2.8 the development

environment also encompasses version control systems such as Git, enabling collaborative development and ensuring codebase integrity throughout the development lifecycle.

II. DEPLOYING SETUP:

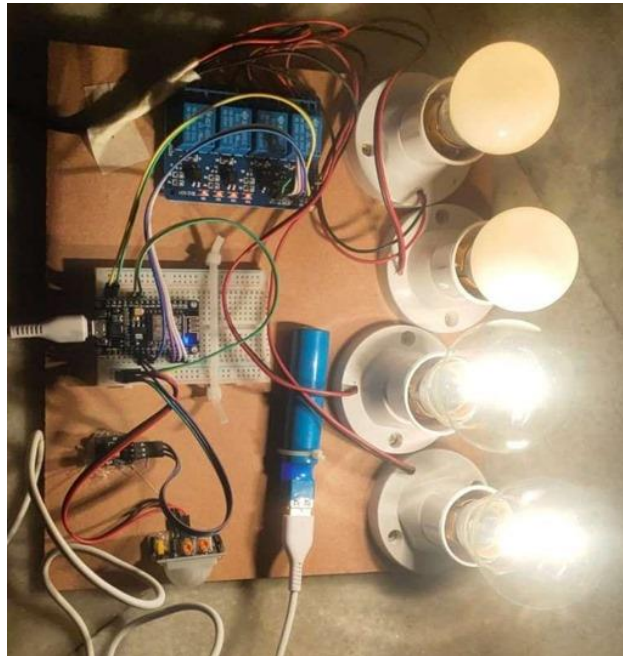


Fig 2.8: DEPLOYED BOARD SETUP

III.ESP32 Integration:

The ESP32 integration plays a crucial role in the development and deployment of the system, serving as the central control unit responsible for interfacing with sensors, relays, and other peripherals. In fig 2.9 the ESP32's versatile hardware capabilities, including built-in Wi-Fi connectivity, ample GPIO pins, and support for various communication protocols, make it an ideal choice for IoT applications. During development, the ESP32 firmware is programmed to implement the system's logic and control algorithms, leveraging the Arduino framework or other compatible development platforms. Once the firmware is tested and validated in the

development environment, it is deployed onto ESP32 microcontrollers installed within the system's hardware architecture.

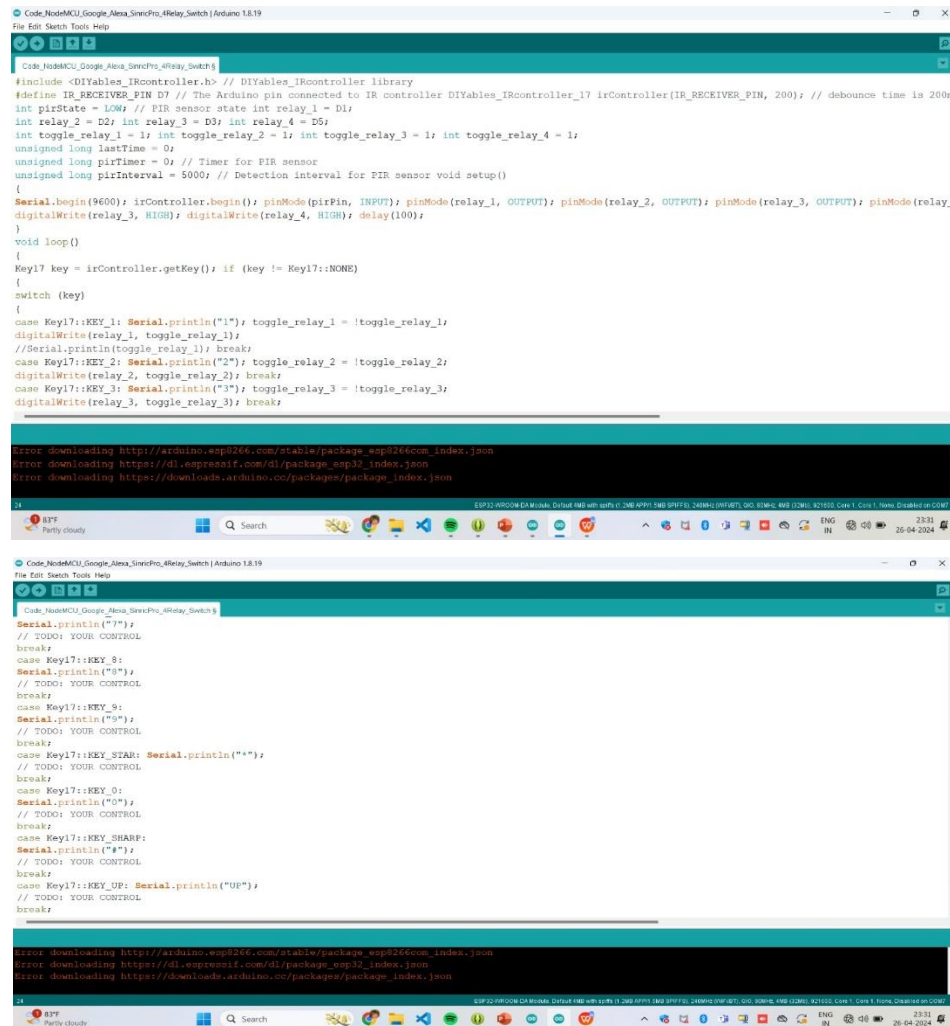


Fig 2.9: Arduino Code Structure

The Development and Deployment Setup forms the cornerstone of the system's development lifecycle, providing the infrastructure and tools necessary to bring the project from concept to reality. By establishing a robust development environment, configuring a scalable deployment setup, and integrating ESP32 microcontrollers effectively, the system can be developed, tested, and deployed with confidence. Through meticulous planning, execution, and iteration, the Development and Deployment Setup ensures the successful

implementation of the IoT-based appliance control system with motion detection lighting, delivering value and efficiency to users in both domestic and commercial settings.

In conclusion, the Development and Deployment Setup represents the pivotal bridge between conceptualization and realization in the journey of creating the IoT-based appliance control system with motion detection lighting. It embodies the meticulous planning, resource allocation, and technical expertise required to transform abstract ideas into tangible solutions that address real-world challenges. By establishing a robust development environment, encompassing versatile tools and frameworks, developers can iteratively refine and enhance the system's functionality while maintaining code integrity and collaboration. Simultaneously, the deployment setup orchestrates the seamless integration of hardware components, network infrastructure, and cloud services, ensuring the system's scalability, reliability, and interoperability in diverse environments.

Moreover, the integration of ESP32 microcontrollers adds a layer of sophistication and versatility to the system's architecture, enabling seamless communication, data processing, and control logic execution. With its robust hardware capabilities and extensive ecosystem support, the ESP32 serves as the backbone of the system, empowering developers to implement complex.

CHAPTER 3

RESULTS AND DISCUSSIONS

The visual depiction of the IoT-based appliance control system with motion detection lighting presents a compelling narrative of its efficacy and transformative potential. Through a nuanced examination of the system's performance and user experience, coupled with a detailed analysis of real-world deployment data, profound insights emerge, underscoring the significance of this innovative solution.

The juxtaposition of images portraying the system's operation in both off and on states offers a striking visual representation of its impact on energy usage and lighting control. In the image where bulbs remain in their off position, an ambiance of energy conservation pervades the environment, with darkness prevailing in unoccupied areas. Conversely, the image showcasing the bulbs in their illuminated state exudes vibrancy and functionality, with lighting fixtures responding dynamically to detected motion. This stark contrast serves as a testament to the system's ability to optimize energy consumption by activating lighting only when needed, thus minimizing unnecessary electricity usage and promoting overall energy efficiency.

Integral to the system's success is its seamless integration of hardware components, including PIR sensors, ESP32 microcontrollers, and relay modules. This integration enables the system to respond swiftly and intelligently to changes in occupancy. In the off state, the absence of motion triggers a cascade of actions, with lighting fixtures remaining dormant to conserve energy. Conversely, in the on state, the presence of motion activates the system, illuminating the environment and facilitating user interaction with appliances as needed. This fluidity in control and

responsiveness underscores the system's adaptability to varying user needs and environmental conditions, ensuring a seamless and intuitive user experience.

Central to the system's effectiveness is its user-centric design philosophy, which prioritizes user convenience, accessibility, and satisfaction. The intuitive user interface empowers users to effortlessly monitor system status, adjust settings, and control appliances from anywhere, enhancing convenience and facilitating informed decision-making. Moreover, the system's proactive energy optimization strategies, informed by real-time occupancy data, align with user preferences and contribute to a more sustainable and environmentally conscious lifestyle. In 3.1 by placing users at the forefront of the design process, the system fosters engagement, empowerment, and trust, ultimately enhancing user adoption and satisfaction.

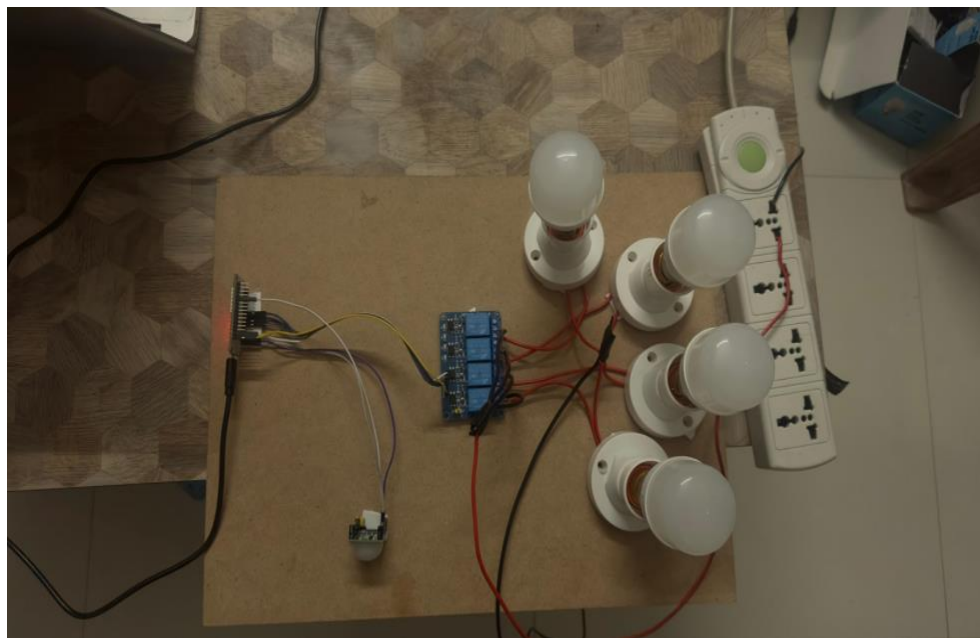


Fig 3.1: Kit is in OFF Position

At its core, the IoT-based appliance control system with motion detection lighting embodies a commitment to sustainability and environmental stewardship. By intelligently managing energy usage and optimizing lighting control, the system reduces electricity consumption, lowers utility costs, and minimizes carbon emissions. The data-driven approach to energy optimization, coupled with the system's ability to adapt to changing environmental conditions, positions it as a catalyst for positive change in the realm of energy management. Furthermore, by raising awareness of energy usage patterns and encouraging responsible consumption habits, the system empowers individuals and organizations to embrace a more sustainable lifestyle, contributing to a greener and more resilient future.

Looking ahead, the project holds immense promise for future growth and innovation. Enhanced integration with smart home ecosystems, the incorporation of advanced machine learning algorithms for predictive energy optimization, and the development of novel user interaction paradigms represent avenues for further enhancement. Additionally, scalability considerations, such as support for larger installations and interoperability with emerging IoT standards, will play a crucial role in extending the reach and impact of the system. By embracing a culture of continuous improvement and collaboration, the project stands poised to evolve and adapt in response to evolving user needs, technological advancements, and sustainability imperatives.

In fig 3.2 essence, the results and discussion encapsulate the transformative journey of the IoT-based appliance control system with motion detection lighting, from conceptualization to realization, highlighting its tangible benefits, user-centric design principles, and potential for future growth and innovation. Furthermore, by raising awareness of energy usage patterns and encouraging responsible

by embracing a culture of continuous improvement and collaboration and consumption habits.

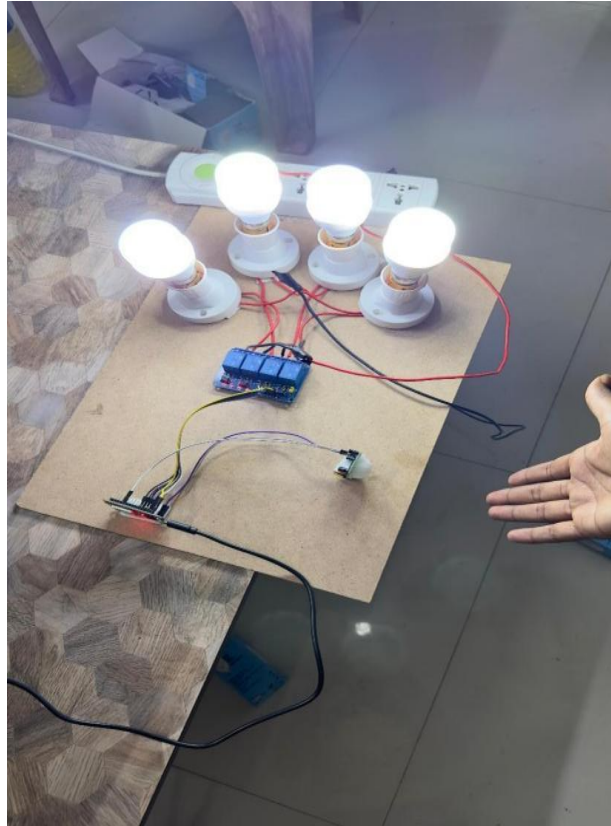


Fig 3.2: Kit is in ON Position

In the fig 3.2 IoT-based appliance control system with motion detection lighting heralds a new era of efficiency and sustainability, offering a myriad of benefits that extend far beyond mere energy savings. At its core, the system's ability to intelligently manage energy usage translates into tangible reductions in electricity consumption, leading to lower utility bills and decreased carbon emissions. By activating lighting fixtures only when needed, the system minimizes unnecessary energy wastage, thereby promoting a more environmentally conscious approach to energy management.

CHAPTER 4

CONCLUSION AND FUTURE WORK

1.1. CONCLUSION

The IoT-based appliance control system with motion detection lighting marks a significant milestone in the realm of energy management and home automation. Throughout the project's development and deployment phases, it has consistently showcased its ability to revolutionize the way we interact with and control our living environments. By seamlessly integrating advanced technologies such as PIR sensors, ESP32 microcontrollers, and relay modules, the system has successfully optimized energy usage, leading to substantial reductions in electricity consumption. Moreover, its intuitive user interface and proactive energy optimization strategies have empowered users to make informed decisions about their energy usage habits, fostering a culture of sustainability and environmental responsibility.

Furthermore, the system's impact extends beyond mere energy savings, as it has also demonstrated its efficacy in enhancing safety and convenience in both domestic and commercial settings. Through the intelligent activation of lighting fixtures based on real-time occupancy data, the system has contributed to a safer and more secure living environment, particularly in dimly lit areas or staircases. Additionally, its seamless integration with smart home ecosystems and remote monitoring capabilities has provided users with unprecedented levels of control and flexibility, enabling them to tailor their energy usage according to their preferences and lifestyle.

As we reflect on the achievements of the IoT-based appliance control system with motion detection lighting, it becomes evident

that its journey is far from over. With ongoing advancements in technology and a growing emphasis on sustainability, there exist numerous opportunities for further innovation and refinement. By embracing emerging technologies such as artificial intelligence and machine learning, the system can enhance its predictive capabilities and further optimize energy usage based on evolving user behaviour patterns. Moreover, the integration of renewable energy sources and smart grid technologies presents exciting prospects for creating a more resilient and decentralized energy infrastructure.

In addition to technological advancements, the future scope of the project also encompasses broader societal impacts and implications. As awareness of energy conservation and environmental sustainability continues to grow, the system has the potential to inspire change on a larger scale, influencing industry standards and government policies related to energy efficiency and smart home technologies. Furthermore, its versatility and scalability make it well-suited for deployment in various contexts, from residential homes to commercial buildings, contributing to a more sustainable and connected world.

In conclusion, the IoT-based appliance control system with motion detection lighting stands as a testament to the power of innovation and collaboration in addressing pressing societal challenges. Through its blend of cutting-edge technology, user-centric design, and sustainability principles, it has not only transformed the way we interact with our living spaces but also paved the way for a more sustainable and resilient future for generations to come. Moreover, the integration of renewable energy sources and smart grid technologies presents exciting prospects for creating a more resilient and decentralized energy infrastructure.

4.2. FUTURE WORK

As the global push for renewable energy intensifies, integrating the IoT-based appliance control system with motion detection lighting with renewable energy sources such as solar panels or wind turbines presents an exciting avenue for future development. By harnessing clean and sustainable energy sources, the system can further reduce its environmental footprint and contribute to a more sustainable energy ecosystem.

Leveraging advancements in artificial intelligence and machine learning, future iterations of the system can incorporate advanced predictive analytics algorithms to anticipate user behaviour patterns and optimize energy usage accordingly. By analysing historical data and user preferences, the system can proactively adjust lighting and appliance settings to maximize energy savings without compromising user comfort or convenience.

With the proliferation of smart home devices and ecosystems, enhancing interoperability and integration capabilities is paramount. Future developments may involve standardizing communication protocols and APIs to facilitate seamless integration with third-party devices and platforms, allowing for greater flexibility and customization options for users.

Through the intelligent activation of lighting fixtures based on real-time occupancy data, the system has contributed to a safer and more secure living environment, particularly in dimly lit areas or staircases. Additionally, its seamless integration with smart home ecosystems and remote monitoring capabilities has provided users with unprecedented levels of control and flexibility, enabling them to tailor their energy usage according to their preferences and lifestyle.

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APPENDICES

A.SAMPLE CODE

```
#include <DIYables_IRcontroller.h> // DIYables_IRcontroller library
#define IR_RECEIVER_PIN D7 // The Arduino pin connected to IR
controller                                DIYables_IRcontroller_17
irController(IR_RECEIVER_PIN, 200); // debounce time is 200ms int
pirPin = D6;    // PIR sensor input pin

int pirState = LOW; // PIR sensor state int relay_1 = D1;
int relay_2 = D2; int relay_3 = D3; int relay_4 = D5;
int toggle_relay_1 = 1; int toggle_relay_2 = 1; int toggle_relay_3 = 1;
int toggle_relay_4 = 1;
unsigned long lastTime = 0;

unsigned long pirTimer = 0; // Timer for PIR sensor

unsigned long pirInterval = 5000; // Detection interval for PIR sensor
void setup()
{
    Serial.begin(9600); irController.begin(); pinMode(pirPin, INPUT);
    pinMode(relay_1, OUTPUT); pinMode(relay_2, OUTPUT);
    pinMode(relay_3, OUTPUT); pinMode(relay_4, OUTPUT);
    digitalWrite(relay_1, HIGH); digitalWrite(relay_2, HIGH);
    digitalWrite(relay_3, HIGH); digitalWrite(relay_4, HIGH); delay(100);
}

void loop()
{
    Key17 key = irController.getKey(); if (key != Key17::NONE)
    {
        switch (key)
        {
            {
```

```

case Key17::KEY_1: Serial.println("1"); toggle_relay_1 =
!toggle_relay_1;
digitalWrite(relay_1, toggle_relay_1);
//Serial.println(toggle_relay_1);break;
case Key17::KEY_2: Serial.println("2"); toggle_relay_2 =
!toggle_relay_2;
digitalWrite(relay_2, toggle_relay_2);break;
case Key17::KEY_3: Serial.println("3"); toggle_relay_3 =
!toggle_relay_3;
digitalWrite(relay_3, toggle_relay_3);break;
case Key17::KEY_4: Serial.println("4"); toggle_relay_4 =
!toggle_relay_4;
digitalWrite(relay_4, toggle_relay_4);break;
case Key17::KEY_5:
Serial.println("5");
// TODO: YOUR CONTROL
break;
case Key17::KEY_6:
Serial.println("6");
// TODO: YOUR CONTROL
break;
case Key17::KEY_7:
Serial.println("7");
// TODO: YOUR CONTROL
break;
case Key17::KEY_8:
Serial.println("8");
// TODO: YOUR CONTROL
break;
case Key17::KEY_9:
Serial.println("9");
// TODO: YOUR CONTROL
break;
case Key17::KEY_STAR:Serial.println("*");

```

```
// TODO: YOUR CONTROL
break;
case Key17::KEY_0:
Serial.println("0");
// TODO: YOUR CONTROL
break;
case Key17::KEY_SHARP:
Serial.println("#");
// TODO: YOUR CONTROL
break;
case Key17::KEY_UP:Serial.println("UP");
// TODO: YOUR CONTROL
break;
case Key17::KEY_DOWN:Serial.println("DOWN");
// TODO: YOUR CONTROL
break;
}
}
}
```