DESIGN AND FABRICATION OF AN INFRARED RAY REMOTE CIRCUIT CONTROL WITH WIFI ENHANCEMENT.

BY

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LSC2007271

(PHYSICS/ELECTRONICS TECHNIQUES)

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FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

BENIN CITY

OCTOBER, 2O25.

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORTORY TECHNOLOGY, FACULTY OF SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE DEGREE (B.SC) IN SCIENCE LABORATORY TECHNOLOGY (PHYSICS/ELECTRONICS TECHNIQUES).

OCTOBER, 2025

DECLARATION

I, Success Iretenevesho ALABI, hereby declare that this research work was carried out by me in the department of Science Laboratory Technology, Faculty of Life Sciences,

University of Benin, Benin City.

Signature:

Date:

CERTIFICATION

This is to certify that this project work was carried out by Success Ireteneveshо ALABI with matriculation number LSC2007271 of the department of Science Laboratory Technology, Faculty of Life Sciences, University of Benin, Benin City, Edo State.

DEDICATION

This project work is dedicated to God almighty who has been my source of strength and motivation and to my amazing father for his immense support throughout the course of my study.

ACKNOWLEDGMENTS

All glory be to God for His mercy, protection, and divine provision upon my life throughout the course of this study.

My profound gratitude goes to my project supervisor, ENGR, DR OJO, for his invaluable guidance, support, and encouragement throughout the period of this research.

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My heartfelt appreciation goes to my beloved Father, Mr. J. Alabi, for his unconditional love, moral and financial support, and constant words of encouragement. I also wish to express my sincere gratitude to my siblings, Prosper, Marvel, Favour, Peter, purity and Blessing. I am also grateful to my option mates who helped me during the course of this project. I am sooo grateful to my wonderful friends, Zoey, Blessing, Osonameh, Nonso, Christopher, Nimi, for their encouragement, support, and companionship .Most importantly, I want to thank my late mother, Mrs, Alabi Aderokpo Dominica, whose prayers, sacrifices and love continue to inspire me even in her Absence. Her belief in my potential remains a guiding light in all my endeavors.

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ABSTRACT

Design and Fabrication of an Infrared Ray Remote Control was developed to create a simple, reliable, and user-friendly system for controlling electronic appliances both at close range and from a distance. The main goal was to improve the traditional infrared (IR) remote control by adding Wi-Fi features, allowing users to operate their devices even when they are not physically nearby. The system combines several components such as a power supply, an IR transmitter, a Wi-Fi module, a microcontroller, and a receiver circuit connected to the appliance. The IR transmitter sends coded infrared signals that are received and interpreted by the receiver, while the microcontroller processes these signals to turn the device on or off. The Wi-Fi enhancement allows users to connect the system to a smartphone or web application, giving them the ability to control their appliances over the internet. During the design process, circuit development, simulation, construction, and testing were carried out to ensure the system performed efficiently and accurately. Test results showed that the device responded quickly and consistently to both IR and Wi-Fi commands, proving it to be reliable and effective. This project demonstrates how combining modern wireless communication with embedded systems can make everyday life easier, offering more convenience, flexibility, and energy control in both homes and workplaces. It represents a step forward in smart home technology and the practical use of IoT in dailyliving.

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Infrared (IR) remote control systems are among the most common short-range wireless technologies used in electronics and automation. These systems transmit data by modulating an infrared LED beam at a frequency around 38 kHz, allowing the receiver to detect and interpret signals for control purposes (Ali, and Bao 2021)IR remotes are inexpensive, easy to fabricate, and are widely used in consumer devices such as televisions, air conditioners, and simple home automation systems. With advancements in microcontroller technology (Witczak and Szymoniak, 2024). Platforms such as Arduino, ESP8266, and ESP32 have made it easier to design IR systems capable of integrating additional functionalities. These include learning modes, Wi-Fi connectivity, and compatibility with smart home networks (Memonova and Quldoshev, 2024). The integration of Wi-Fi enhances remote control range and user convenience, enabling control from smartphones or computers over the internet (Nasution and Nusa,2020) Therefore, the design and fabrication of an IR remote circuit control using Wi-Fi provides a cost-effective and flexible approach to controlling household electrical appliances, particularly light bulbs, from any location (Jabbar *et al*., 2019). Traditional IR remote control systems are limited by their line-of-sight operation and short range. (Cao *et al*., 2023). Users must point the remote directly at the receiver, which reduces convenience and flexibility (Ali and Bao, 2021). Additionally, interference from sunlight or other sources of infrared radiation can disrupt operation, and each appliance often requires a separate remote. To overcome these limitations, integrating Wi-Fi functionality into IR remote systems can extend control beyond physical range limitations. Using a

Wi-Fi-enabled microcontroller such as the ESP8266 or ESP32 allows users to control devices remotely through a smartphone application or web interface (Loung, 2023)

1.2 AIM OF STUDY

To design and fabricate an infrared ray remote circuit control system integrated with Wi-Fi for controlling light bulbs both locally and remotely.

1.3 OBJECTIVES:

To design an infrared transmitter and receiver circuit for signal transmission and reception.

To implement a microcontroller-based control unit that decodes and executes IR commands.

To integrate Wi-Fi functionality using ESP8266 or ESP32 modules for internet-based control.

To fabricate and test the system for range, reliability, and response speed.

To evaluate the system's performance and suggest improvements for future smart-home applications.

1.4 STATEMENT OF PROBLEM

In most homes and offices, electrical appliances such as fans, and televisions are still controlled manually using wall switches. This traditional method can be inconvenient because the user must move to switch's location each time an appliance need to be turned on or off. It also poses safety risks, especially in dark or hard to reach areas. Wired control system are not only costly to install but also limit flexibility since they can be operated from one position. To overcome these challenges, there is a need for an easy to use, low cost, dependable system that allows users control electrical devices wirelessly. Infrared technology offers a good solution because it enables remote operation of appliances without physical contact. However, some existing infrared control system suffer from problems like short operating range, higher power consumption, and weak signal detection. Therefore this project seeks to design and construct an infrared ray remote circuit control system that provides a convenient, safe and efficient means of controlling electrical appliances from a reasonable distance.

1.5 SIGNIFICANCE OF THE STUDY

This project combines the simplicity of IR communication with the flexibility of Wi-Fi technology, addressing the need for affordable smart-home solutions in developing regions. By fabricating a low-cost IR-Wi-Fi control system, users can control lighting systems wirelessly without the need for expensive proprietary automation kits (Nasution and Nusa, 2023). From an educational standpoint, this project helps students understand key concepts in electronics, microcontroller programming, and Internet of Things (IoT) integration. (Yahya .M. 2023). Practically, it demonstrates how traditional technologies such as IR can be upgraded to meet modern needs for remote monitoring and control (Memonova and Quldoshev, 2024).

CHAPTER TWO
LITERATURE REVIEW

2.0 INTRODUCTIONS

Technological progress in electronic control systems has made it possible to replace traditional manual switching with approaches that are more dependable, faster, and easier to use (Jacquot, 2019). A major development in this regard is the infrared (IR) remote control system, which operates by transmitting light signals in the infrared spectrum from a transmitter to a receiver to carry out switching functions (Al-nassar *et al*., 2018). This highlights the theoretical framework, historical evolution, working principles, applications, and scholarly studies related to infrared remote circuit control, with emphasis on recent improvements. Remote control systems are developed to allow electronic devices to be operated from a distance without physical contact. Initially, most appliances were managed through mechanical switches, which required users to be present at the point of operation (Kumar *et al*., 2022). However, the advancement of wireless technologies has led to the development of remote systems that improve comfort, safety, and efficiency. Remote controls generally fall under three main categories: infrared (IR), radio frequency (RF), and Bluetooth/Wi-Fi. Of these, infrared systems are the most widely used because they are inexpensive, simple to design, and reliable for short-range indoor use (Alenoghena *et al*.,2023).

Infrared remote technology makes use of electromagnetic waves in the range of about 700 nm to 1 mm (Vollmer, 2021). A standard IR system consists of three basic units: the transmitter, receiver, and control circuit. The transmitter typically in the form of a handheld remote produces coded pulses of infrared light through an LED (Al-nassar *et al*., 2018). These pulses are modulated, usually around 38 kHz, to make them distinct from other ambient light sources (Schröde *et al*., 2024). The receiver, such as the TSOP32238 module, collects and demodulates the IR signals, converting them into electrical form (Win, 2020). The control circuit then interprets these signals using devices like microcontrollers or transistor drivers to switch the connected load (Anvesh, 2025). While effective for direct line-of-sight communication, IR systems have constraints such as limited operating distance and vulnerability to interference from strong external light (Kilper *et al*., 2023). The development of IR remotes began in the 1950s, when Zenith Radio Corporation introduced the “Flashmatic,” a television remote that used directed light for control (strang, 2020). With improvements in solid-state components and integrated circuits, IR remotes became more compact, cost-effective, and energy-efficient (sharma *et al*., 2021). Today, they are widely applied in home entertainment equipment, air conditioning systems, lighting controls, fan regulators, automatic door systems, and even certain industrial automation processes (Kohl, 2023). Most consumer-grade IR devices operate in the near-infrared range, between 850 and 950 nm, and use carrier frequencies between 36 and 40 kHz (Celik *et al*., 2022). The NEC protocol is one of the most common, using pulse-distance encoding to transmit digital data (Rahman *et al*.,2025). Repeat codes are often added to ensure continuous command recognition when a button is held down (Shotts, 2019). To enhance reliability, modern receivers are designed with band-pass filters and automatic gain control (AGC), which minimize interference from noise and background light (Tomkinson, 2025).

Several researchers have contributed to the advancement of IR-based systems (Argirusis *et al*.,2025). Langa designed an Arduino-powered automation system that used common TV remotes to control multiple loads while improving household security (kolanur, 2025). Huang *et al*. (2023) investigated weaknesses in IR systems used in smart televisions, recommending stronger security frameworks. Scientific Research Publishing (2021) introduced an IR-to-Wi-Fi gateway using the ESP8266 microcontroller, bridging traditional IR-controlled devices with Internet of Things (IoT) platforms. Additionally, Adafruit (2024) provided technical insights into IR demodulator modules, identifying interference challenges and ways to overcome them. These works demonstrate the adaptability and relevance of IR technology in both conventional and modern applications. Infrared remote control systems offer significant advantages, including affordability, minimal energy consumption, ease of construction, and reliability in indoor use(Yaïci *et al*., 2021). However, drawbacks such as limited transmission distance (generally under 10 meters), line-of-sight requirements, interference from direct sunlight or similar IR sources, and lower data capacity compared to RF or Bluetooth remain challenges (mohsan *et al*., 2021).

2.2 INFRARED SIGNALLING AND MODULATION

Infrared remote control systems work by transmitting encoded signals through an infrared light-emitting diode (LED) (Al-nassar *et al*., 2018). The transmitter modulates these signals at a carrier frequency, usually around 38 kHz, while the receiver detects and decodes them into binary data that the microcontroller can interpret (Makhanya, 2023). Commonly used protocols such as NEC, Sony, and RC5 rely on time-based pulse modulation to differentiate between binary ones and zeros. For accurate operation, the IR transmitter and receiver must be tuned to the same carrier frequency to prevent communication errors (O'Brien et al., 2020). Studies have shown that mismatched frequencies can cause a loss of sensitivity or false triggering, especially in environments with strong ambient light (West, 2017). Additionally, the timing accuracy of the transmitted pulse greatly affects the reliability of the system (Ali and Bao, 2021).

2.3 INFRARED TRANSMITTER AND RECEIVER COMPONENTS

Modern IR remote control systems typically use TSOP-series IR receivers such as the TSOP1738, which integrates a photodiode, an amplifier, and a demodulator in one compact module. These modules are designed to filter out unwanted light interference and provide a clean digital signal output to a microcontroller (Adam, 2019). On the transmitting side, an IR LED is driven either directly through a current-limiting resistor or via a transistor driver circuit for higher power (Du, 2020). The LED emits infrared light that carries encoded data to the receiver (Ene *et al*., 2023). The range and accuracy of transmission depend on the LED's power, the viewing angle, and the presence of obstacles or other light sources (zhuang et al., 2018). Recent research emphasizes that the use of integrated receiver modules simplifies the design process and improves performance in both educational and practical applications (Liu, 2021).

2.4 COMMUNICATION PROTOCOLS AND DECODING METHODS

IR remote systems use standardized communication protocols to ensure reliable data transfer. Protocols like NEC and RC5 encode data in time intervals of pulses and spaces that the receiver decodes. Microcontroller software decodes these signals either through interrupt-based routines that measure pulse duration or by using built-in IR libraries that recognize specific command formats (Loung, 2023). Recent research supports the use of open-source decoding libraries such as Arduino IR remote because they handle multiple IR protocols and minimize development time (Ali and Bao, 2021). Implementing tolerance windows for pulse width also increases signal reliability, especially when different manufacturers use slightly modified timing structures (WJARR, 2024).

2.5 MICROCONTROLLERS AND SYSTEM IMPLEMENTATION

Microcontrollers form the core of IR remote control systems. They manage data encoding, decoding, and actuation of connected devices. The Arduino platform is the most common for beginner and educational projects due to its open-source nature and easy availability of libraries (Loung, 2023). However, newer systems are increasingly based on ESP8266 and ESP32, which feature built-in Wi-Fi modules. These controllers allow designers to combine traditional IR control with internet-based communication, enabling remote operation from smartphones or web applications (Nasution and Nusa, 2023). Similarly, higher-performance microcontrollers like STM32 are used in advanced systems requiring faster processing or real-time control (Ene *et al*., 2023). In practice, these microcontrollers are connected to an IR receiver, a transmitter, and a switching circuit to control loads such as light bulbs or fans (WJARR, 2024).

2.6 INTEGRATION OF IR AND WI-FI TECHNOLOGIES

The combination of IR communication with Wi-Fi has been a growing area of interest in recent years. Using an ESP8266 or ESP32 microcontroller, researchers and hobbyists have built Wi-Fi-to-IR gateways that allow users to send commands to IR appliances through a smartphone or computer. This setup acts as a bridge between the internet and legacy IR devices. Such systems are practical because they can control traditional electronic devices without replacing them. Moreover, by using Wi-Fi, control can extend beyond the physical line-of-sight limitations of infrared signals (Nasution and Nusa, 2023). However, studies recommend including basic network security measures, such as password protection and authentication, to prevent unauthorized access to IoT-connected devices (Ene *et al*., 2023).

2.7 SYSTEM EVALUATION AND TESTING

Recent experimental studies on IR remote control systems have measured performance based on factors such as transmission range, reliability, and response speed. The performance is affected by the IR LED’s output strength, environmental lighting conditions, and receiver sensitivity (WJARR, 2024). Testing is usually done by sending repeated commands at different distances and angles, and recording how many signals are successfully received (Ene *et al*., 2023). Projects that included Wi-Fi modules also evaluated network latency and command response time between the smartphone interface and the controlled device (Loung, 2023). Results show that integrating Wi-Fi provides more flexibility without significantly affecting local IR performance. The reviewed literature reveals that IR remote control systems remain relevant due to their simplicity, affordability, and reliability. Most studies agree that combining IR with Wi-Fi technology enhances usability by allowing both local and remote control. The use of modern microcontrollers such as ESP8266 and ESP32 makes it possible to implement such hybrid systems efficiently (Nasution and Nusa, 2023). This literature review provides the foundation for the present study, which aims to design and fabricate an IR remote circuit control capable of both direct infrared communication and optional Wi-Fi connectivity for remote light bulb control.

2.8. REVIEWED WORKS INCLUDES

Several studies and practical projects have explored the design and use of infrared (IR) remote control systems, focusing on their applications, effectiveness, and limitations.

Langa (2024); created a home automation system using an Arduino microcontroller in combination with ordinary television remotes. The project showed how commonly available IR transmitters and receivers can be adapted to control multiple household appliances, highlighting both low-cost implementation and improved domestic security. This work illustrates the usefulness of simple hardware designs for everyday automation.

Huang, Chen, and Zhang (2023); examined security risks associated with IR communication in smart televisions. Their research revealed that attackers could exploit IR signals as a side channel to monitor or manipulate devices. They emphasized the importance of strengthening consumer electronics against such vulnerabilities, especially as more appliances become connected to the internet.

Scientific Research Publishing (2021); presented the development of an IR-to-Wi-Fi gateway using an ESP8266 microcontroller. This design made it possible for traditional IR-controlled devices to connect with Internet of Things (IoT) platforms. The study demonstrated how old appliances can be modernized and integrated into smart home systems without needing to replace them.

Adafruit (2024) ;offered technical notes on IR demodulator modules, describing their performance, possible interference from surrounding light, and practical ways to achieve stable operation. This resource is particularly valuable for engineers and students who want to improve system reliability when designing IR receivers.

Embedded Expert (2022); provided a guide on decoding the NEC protocol using STM32 microcontrollers. The work carefully explained the encoding process, timing, and handling of repeat codes, serving as a hands-on reference for anyone designing IR-based systems with microcontrollers.

Linux Kernel Documentation (2023); compiled different IR remote protocols and their scan codes, creating a standard reference for developers. This work ensures that remote control systems behave consistently across devices and operating systems, especially in Linux-based platforms.

Data sheets from Vishay Inter technology (2025a; 2025b) supplied detailed specifications for IR receiver modules, including sensitivity ranges, filtering methods, and frequency responses. These references are essential for selecting suitable components and understanding real-world performance factors such as interference from ambient light (West, 2017).

Synthesis; Together, these works confirm the practicality and adaptability of IR remote control for short-range communication and automation. They also emphasize two major challenges: ensuring reliable operation under interference and addressing security concerns when linking IR devices to networked platforms. However, there are still areas that require further study, such as improving energy efficiency in transmitters, extending communication range, and developing secure bridges between IR systems and IoT applications.

2.9 ADVANTAGES OF INFRARED REMOTE CIRCUIT CONTROL

Infrared remote systems have several strengths that make them popular in electronics and automation (Rogalski and Chrzanowski, 2017). First, they are cheap and easy to access, since the components like IR LEDs and receivers are widely available (Zhuang *et al.*,2018). Their circuit design is simple, which makes them suitable for both commercial products and student projects. IR remotes are also energy-efficient, running for long periods on small batteries (Callebaut *et al.*, 2021). When used over short distances, they are highly reliable and accurate, provided there is no obstruction (Afeni *et al.*, 2023). In addition, their versatility allows them to be applied in many areas, including televisions, fans, lighting systems, and industrial equipment.

CHAPTER THREE
3.0 METHODOLOGY
3.1 MATERIALS (HARDWARE COMPONENTS ANALYSIS)

The construction of an infrared ray remote involves the use of several carefully

Selected components and tools. These includes:

1. Voltage Regulator
2. ESP 32 (microcontroller)
3. Relay Modules
4. Power supply adapter 12v
5. Vero board
6. Capacitors
7. Resistors
8. Led indicators
9. Load

3.1.1. VOLTAGE REGULATOR.

A voltage regulator is an electronic component or circuit designed to maintain a constant output voltage despite variations in input voltage or load current. It ensures a stable DC power supply, thereby protecting electronic devices from voltage fluctuations. According to Von (2024), there are two main types of voltage regulators: linear and switching. The device typically has three terminals;

The input (Vin)

The output (Vout)

Ground (GND).

The Vin terminal receives the input voltage, the Vout terminal delivers the regulated output voltage, and the GND terminal provides a common reference point for the entire circuit.

Plate 3.1.1 Voltage Regulator (Stephen *et al.,* 2023)

3.1.2 ESP 32 (Microcontroller)

The Arduino Nano is a compact microcontroller board developed by Arduino, built around the ATmega328P microchip. It is designed for creating and controlling a wide range of electronic projects while consuming minimal power. The board includes both digital and analog input/output pins, along with a USB interface for easy programming (Merugu et al., 2022). Its small size, low cost, and ease of use make it a popular choice for DIY robotics, automation, and general electronics applications. The Arduino Integrated Development Environment (IDE), also known as the Arduino Software, enables users to connect, program, and communicate with Arduino boards (Barbon et al., 2016). Programs developed in the IDE are referred to as sketches, written within the built-in text editor and saved using the ino file extension (Kumari et al., 2025). The IDE simplifies the coding process and allows program uploads to the board without requiring an internet connection, making it particularly useful for users with limited or no internet access. It is compatible with all Arduino boards.

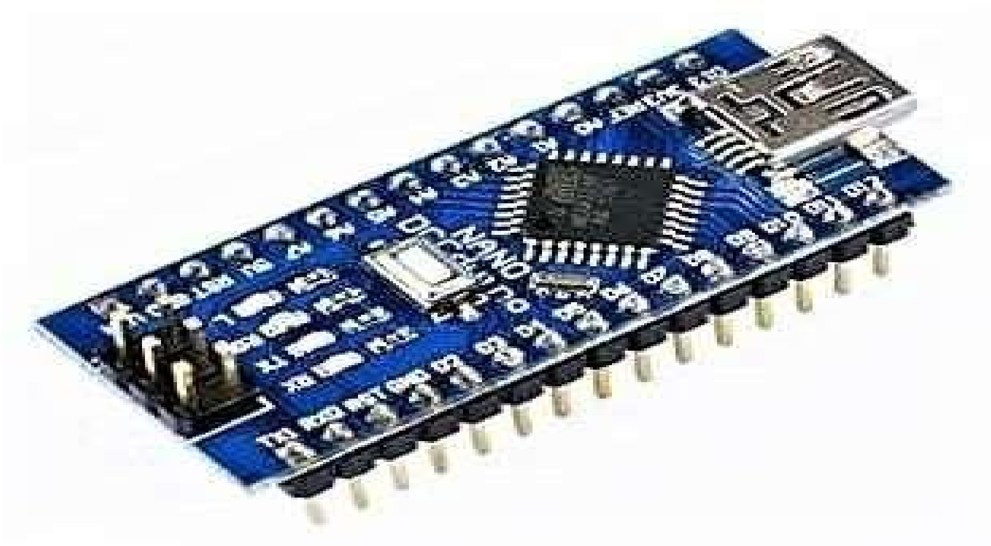

Plate 3.1.2 Arduino Nano (Abdulkarim and Anas, 2020)

Currently, there are two main versions of the Arduino IDE: IDE 1.x.x and IDE 2.x (Meenakshi et al., 2023). The IDE 2.x version represents a significant upgrade, offering faster performance, a modernized editor, an intuitive interface, and enhanced debugging tools to improve the user's programming experience.

The editor has four main areas:

1. A toolbar with buttons for common functions and a series of menus. The toolbar

Buttons let you verify and upload programs, create, open, and save sketches, and Open the serial monitor.

2. The message area provides feedback while saving and exporting; it also shows

Errors.

3. The text editor is for writing your code.

4. The text console displays output from the Arduino Software (IDE), including

Complete error messages and other information. The bottom right corner of the

Window shows the configured board and serial port. (Ismailov and Jo'Rayev, 2022)

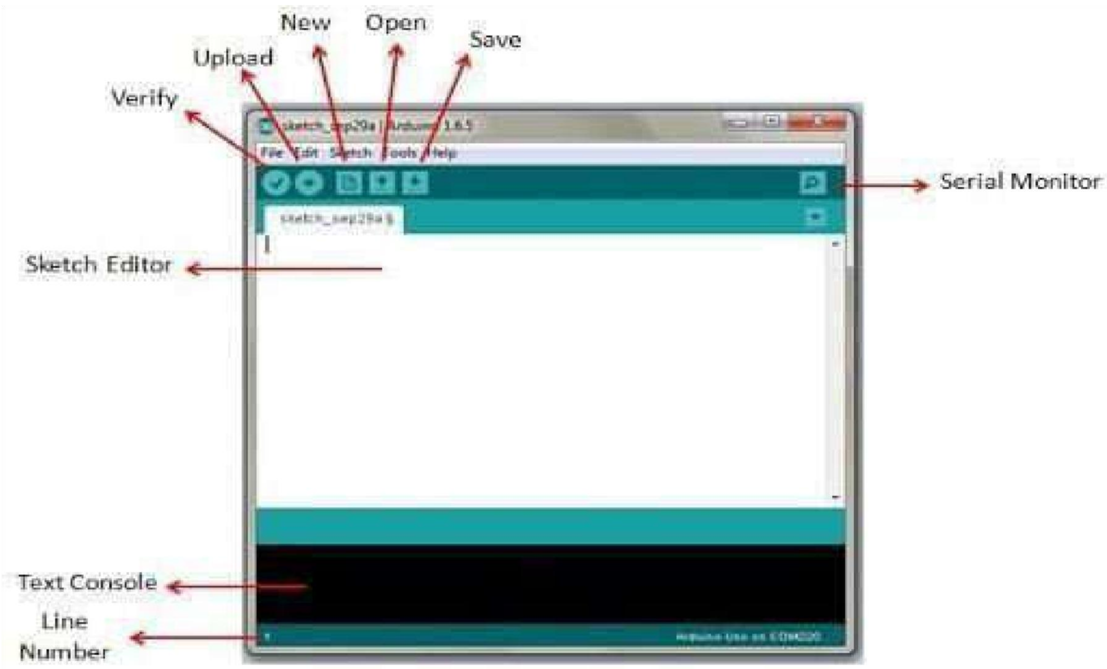

Plate 3.1.2: Arduino IDE (Bhikule *et al., 2021)*

3.1.3 Relay Modules

A relay module is an electromechanical device that controls the switching of electrical circuits through the use of an electromagnet. It acts as an interface between low-power control signals (from devices such as Arduino, Raspberry Pi, or other microcontrollers) and high-power electrical loads (like motors, lamps, or home appliances). The module ensures electrical isolation and protection by allowing a small control voltage or current to safely switch larger voltages and currents in separate circuits (Adhikari, 2022).

Plate 3.1.3 RF301 Relay Module (Stiawan and Supardi, 2024)

3.1.4 VERO BOARD: A Vero board is a prototyping board made from fiberglass or phenolic resin, commonly used for assembling and testing different electronic circuit designs. It features a grid of small holes with copper strips running along one side, which act as conductive pathways. These copper tracks enable easy interconnection of electronic components such as resistors, transistors, capacitors, and other devices mounted on the board, making it suitable for circuit experimentation and development.

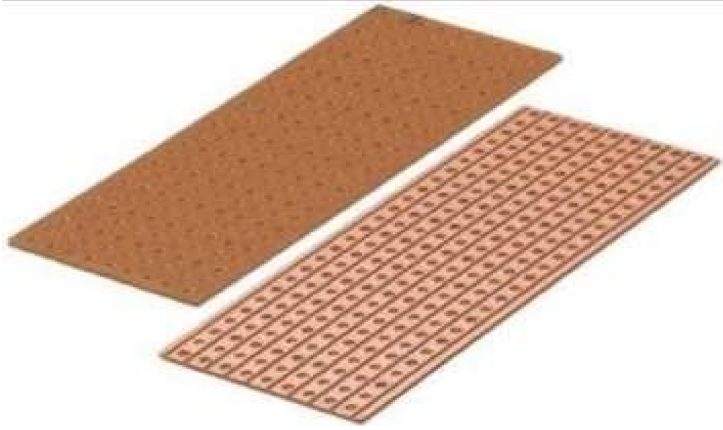

PLATE 3.1.4 VERO BOARD (Miah *et al*., 2019)

3.1.5 Capacitor: A capacitor is an electronic component that stores electrical energy through the use of dielectric materials such as air, paper, or plastic placed between two conductive plates. When a voltage is applied across these plates, a potential difference is created, leading to the accumulation of electric charge or energy within the device. Capacitors are commonly used for energy storage, current filtering, and signal smoothing in electronic circuits.

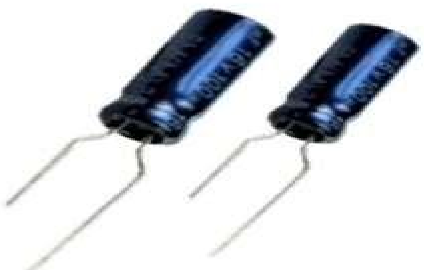

PLATE 3.1.5 CAPACITOR (Beyaz and Parlak, 2021)

3.1.6 The LED: The LED infrared (IR) remote control performs several important functions that make it more advanced and easier to use than the normal infrared remote. The remote uses an infrared LED to send light signals that carry different commands such as ON, OFF, or channel change. These signals are received and understood by the device being controlled.

PLATE 3.1.6. LED

3.1.7 RESISTOR: The main function of a resistor in an IR remote control is to limit the amount of current flowing to the infrared LED. This prevents the LED from receiving too much current, which could damage or burn it out.

PLATE 3.1.7. RESISTOR

3.1.8. POWER SUPPLY: The 12V power supply delivers the electrical energy needed for the proper functioning of all parts of the IR remote control circuit. It provides a steady voltage and current to operate the transmitter, receiver, and control units. This power source ensures that the infrared LED, sensors, and other components like transistors, resistors, and integrated circuits (ICs) perform efficiently.

PLATE 3.1.8. POWER SUPPLY

3.2. OTHER TOOLS USED

1. Soldering iron

2. Soldering lead

3. Dignity box

4. Multi-meter

5. Wire cutters

3.2.1. Soldering Iron

The soldering iron is a hand tool used in soldering. It supplies enough heat to melt

The soldering lead so that it flows into the joint between two work pieces.

3.2.2. Soldering Lead

The soldering lead is the key element in the soldering process. The soldering lead,

Commonly known as ‘solder’, is a metal alloy (made of tin and lead) used to join two

Or more metal surfaces together. It provides mechanical and electrical joint that is

Essential to keep components in place once a circuit has been assembled.

3.2.3. Dignity Box:

Dignity box also known as an electronic project box is an enclosed casing that is

House or protect electronic components and circuit construction from

Environmental factors such as dust, moisture and physical damage. It is made from

Plastic or wood, screw or bolts.

It can also prevent electric shock and short circuit, give a finished project work a

Professional look and also serves as a mounting structure for components such as

Indicators, switches, connectors.

3.2.4. Multi-meter:

The multi-meter is a devise used to measure electric current, voltage and resistance,

Over several ranges of value.

3.2.5. Wire Cutter:

The wire cutter is a small hand-held tool used for cutting of wire, not for grabbing

Or turning things over.

PLATE 3.2 TOOLS

3.2.6. BLOCK DIAGRAM

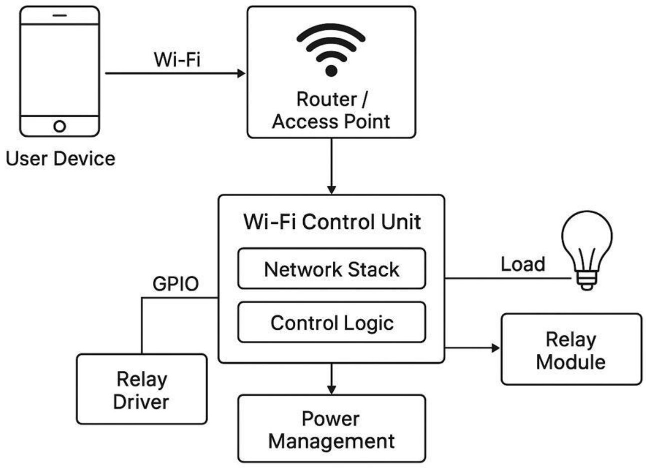

Figure 3.2.6.

1) User Interface

- Purpose: send commands (on/off, dim, schedule).
- Examples: smartphone app (Blynk, custom web UI), web browser, MQTT client.
- Notes: UI ↔ router ↔ Wi-Fi module (HTTP requests, WebSocket or MQTT).

2) Network / Router

- Purpose: provides local Wi-Fi network and internet if remote access required.
- Notes: Can be local hotspot or your home router. For remote control from outside home, you’ll need port forwarding, dynamic DNS, or use a cloud service (Blynk, MQTT broker).

3) Wi-Fi Control Unit (Core)

- Purpose: receive network commands, run control logic, interact with peripherals.
- Typical modules: ESP8266 (NodeMCU) or ESP32 (preferred if more IO/CPU/BLE).
- Network stack: handles Wi-Fi, TCP/IP, MQTT, HTTP server.
- Control logic: maps incoming commands to GPIO/relays, timers, schedules.
- ADC / sensors interface: read sensors (light, temp) if present.
- Power: 3.3 V logic (ensure stable supply).

4) Power Management

- Purpose: convert mains/adapter to stable voltages for MCU and peripheral (5 V / 3.3 V).
- Components:
- Wall adapter (5 V DC) or DC-DC converter.
- 5 V → 3.3 V regulator (AMS1117-3.3 or equivalent) if using 5V adapter.
- Filtering caps (100 µF, 0.1 µF), decoupling.
- Optional UPS / battery backup.

5) Enclosure and Mechanical

- Project box, mounting hardware, terminal blocks for safe wire connections.
- Cable glands for mains wiring, insulating materials and warning labels.

The whole block diagram of the infrared remote control can be divided into 4 parts:

1. Control unit (ESP32 Microcontroller section)

2. Relay Module section

3. Load section

4. Power Supply section (5V and GND lines)

Control unit: The ESP32 functions as the main control unit of the Wi-Fi-based circuit. It connects to a wireless network to receive instructions from a smartphone or web app, processes these instructions, and transmits control signals to the relay module through its GPIO pins. This enables the ESP32 to handle both communication and logic operations, allowing users to remotely operate electrical devices such as lights or fans.

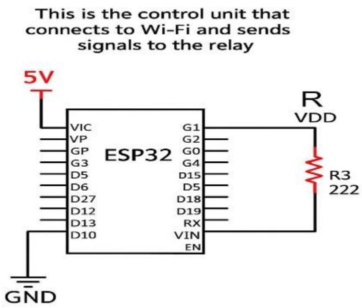

Figure 3.2.7

Relay module section: The relay module functions as an electronically controlled switch that enables the low-voltage output from the ESP32 to manage high-voltage electrical appliances. When the ESP32 transmits a control signal, current flows through the relay coil, creating a magnetic field that pulls the internal contacts to either connect or disconnect the load circuit—turning the connected device, such as a fan or light bulb, ON or OFF. In addition to switching, the relay module offers electrical isolation, protecting the microcontroller from voltage spikes or surges from the high-voltage side. It is an essential component for safe and efficient interface between low-power control electronics and high-power electrical systems, making it ideal for automation and remote-control applications.

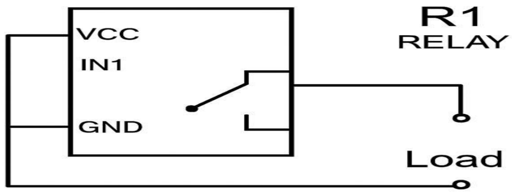

Figure 3.2.8

Load section: The load section includes the electrical appliance such as a light, fan, or motor managed by the relay. When the relay is triggered by the ESP32, the load receives power from the main source and operates accordingly. It serves as the system's output stage, where the real switching and control actions occur in response to user commands.

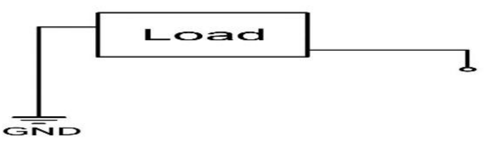

Figure 3.2.9

Power Supply Section: The power supply section provides the necessary voltage and current required for the operation of all circuit components. It generally comprises a step-down transformer, bridge rectifier, filter capacitors, and a voltage regulator that work together to convert high-voltage AC from the mains into a smooth and regulated

DC output, commonly 5V. This stable DC supply ensures the ESP32, relay module, and associated components operate safely and efficiently. Additionally, the power unit plays a crucial role in protecting sensitive electronic parts from sudden voltage spikes, noise, and power surges. By maintaining consistent output and minimizing ripple, it enhances the performance, durability, and stability of the entire Wi-Fi-controlled circuit, ensuring reliable operation even under varying power conditions.

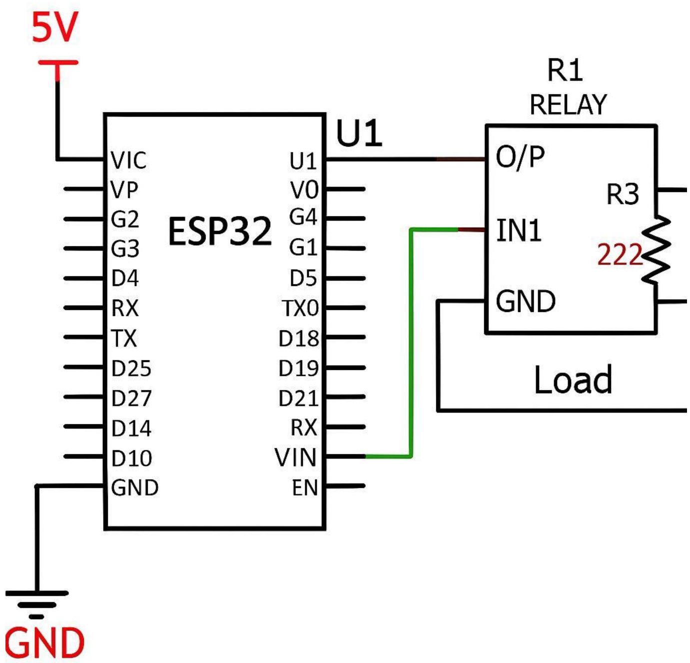

Figure 3.2.10

COMPLETE CIRCUIT DIAGRAM

3.3. WORKING PRINCIPLE

The infrared (IR) ray remote control enhanced with Wi-Fi technology functions by merging the principles of traditional infrared communication with modern wireless networking to achieve greater operational range, versatility, and user convenience. In the basic IR configuration, the transmitter (remote control) produces modulated infrared light using an IR LED that is driven by a microcontroller. This modulated light beam carries encoded data representing specific control actions such as switching a device ON or OFF. On the other side, the receiver circuit, which uses an IR sensor like the TSOP1738 or VS1838B, captures these infrared signals, filters out noise, and demodulates the signal to retrieve the command pulses. These pulses are then interpreted and used to drive transistors or relays, which in turn activate the connected electrical load or appliance. The Wi-Fi enhancement introduces a Wi-Fi-enabled microcontroller, such as the ESP8266 or ESP32, into the system. This microcontroller connects to a local Wi-Fi network and allows the user to control the system either manually via the IR remote or remotely through a smartphone or web-based interface. The microcontroller communicates with cloud platforms or mobile applications (such as Blynk, ThingSpeak, or Arduino IoT Cloud) to receive and execute commands sent over the internet. When a control signal is sent via Wi-Fi, the ESP microcontroller processes the command and activates the same relay or output stage that the infrared signal would normally control. This dual-control feature ensures that the system remains functional even without an internet connection, providing both local (IR) and remote (Wi-Fi) operation options. Furthermore, the integration of Wi-Fi brings real-time monitoring, status feedback, and multi-device control, making it possible to manage several appliances from one interface. This enhances the system's reliability and usability, especially in home automation, industrial automation, and energy management applications. Overall, this hybrid system combines the simplicity of infrared communication with the versatility of wireless networking, offering improved control range, enhanced safety, energy efficiency, and seamless integration with modern smart home technologies.

PICTURES OF THE WORK

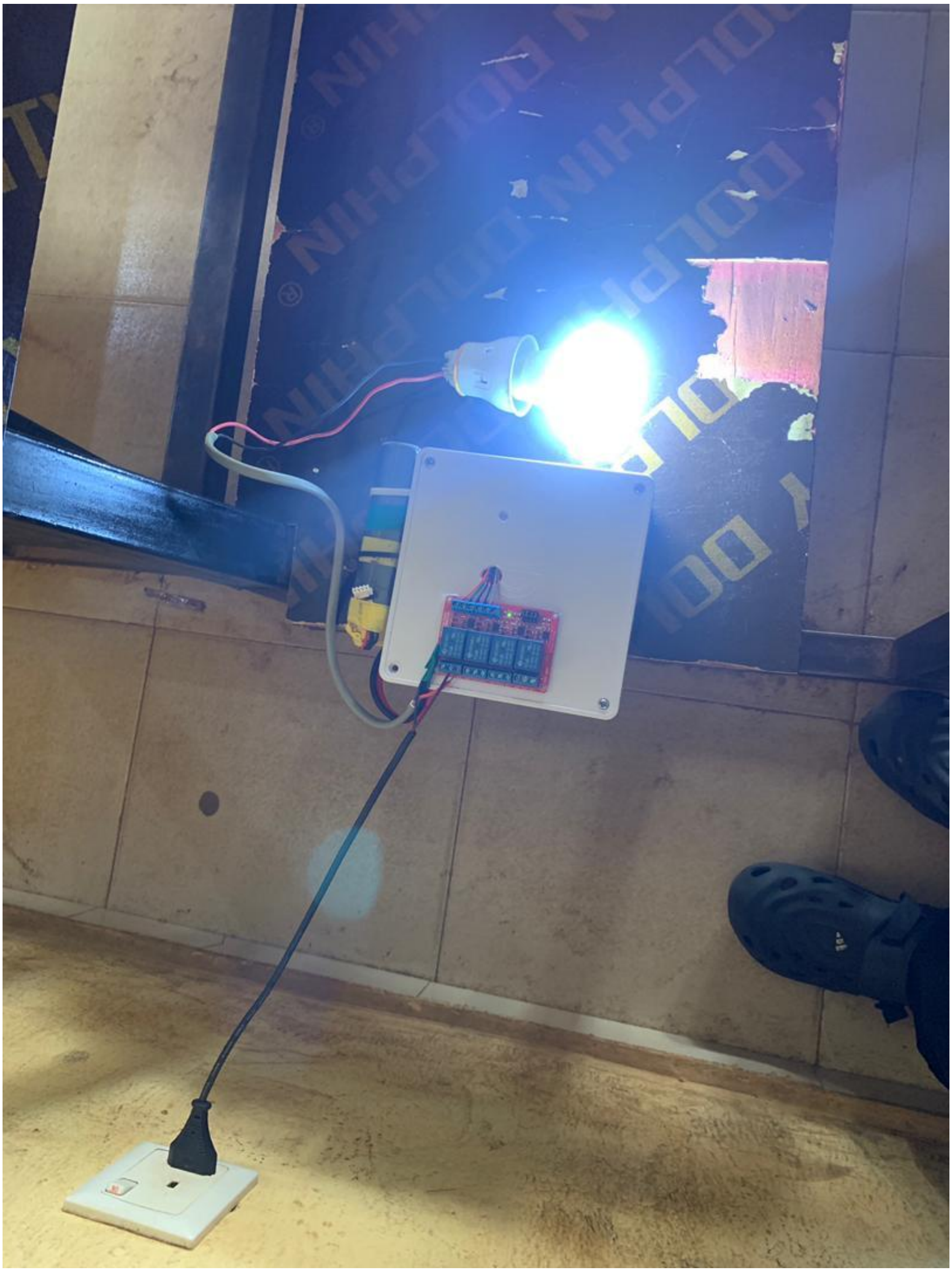

PLATE3.3: shows the full setup of the work when connected to a power source.

Plate 3.4: shows the top view of the work.

CHAPTER FOUR
RESULTS

4.1 SYSTEM TESTING AND PERFORMANCE EVALUATION

After construction, the system was tested under various conditions to evaluate its functionality. The main aspects of testing included:

1. Infrared Transmission and Reception Range

2. Load Switching Response Time

3. Wi-Fi Signal Response and Control Speed

4. Power Usage and System Stability

The infrared section of the project worked effectively within a range of 8–10 meters under indoor lighting conditions. The receiver responded quickly to commands with little to no interference.

The Wi-Fi section, which was added to extend the system's range, allowed users to operate the appliances using a mobile phone or any Wi-Fi-enabled device. The Wi-Fi control responded within about one second, providing reliable performance even when operated from another room.

4.2. RESULT PRESENTATION

Parameter	IR Mode	Wi-Fi Mode
Communication Range	8–10 m	Unlimited(within network)
Response Time	0.3 s	0.8 s
Error Rate	2%	1.5%
Power Consumption	0.5 W	0.8 W
Line-of-Sight Required	Yes	No

The table shows that both control methods performed effectively. The infrared mode provided faster response and lower power consumption, while the Wi-Fi mode offered wider range and more flexibility.

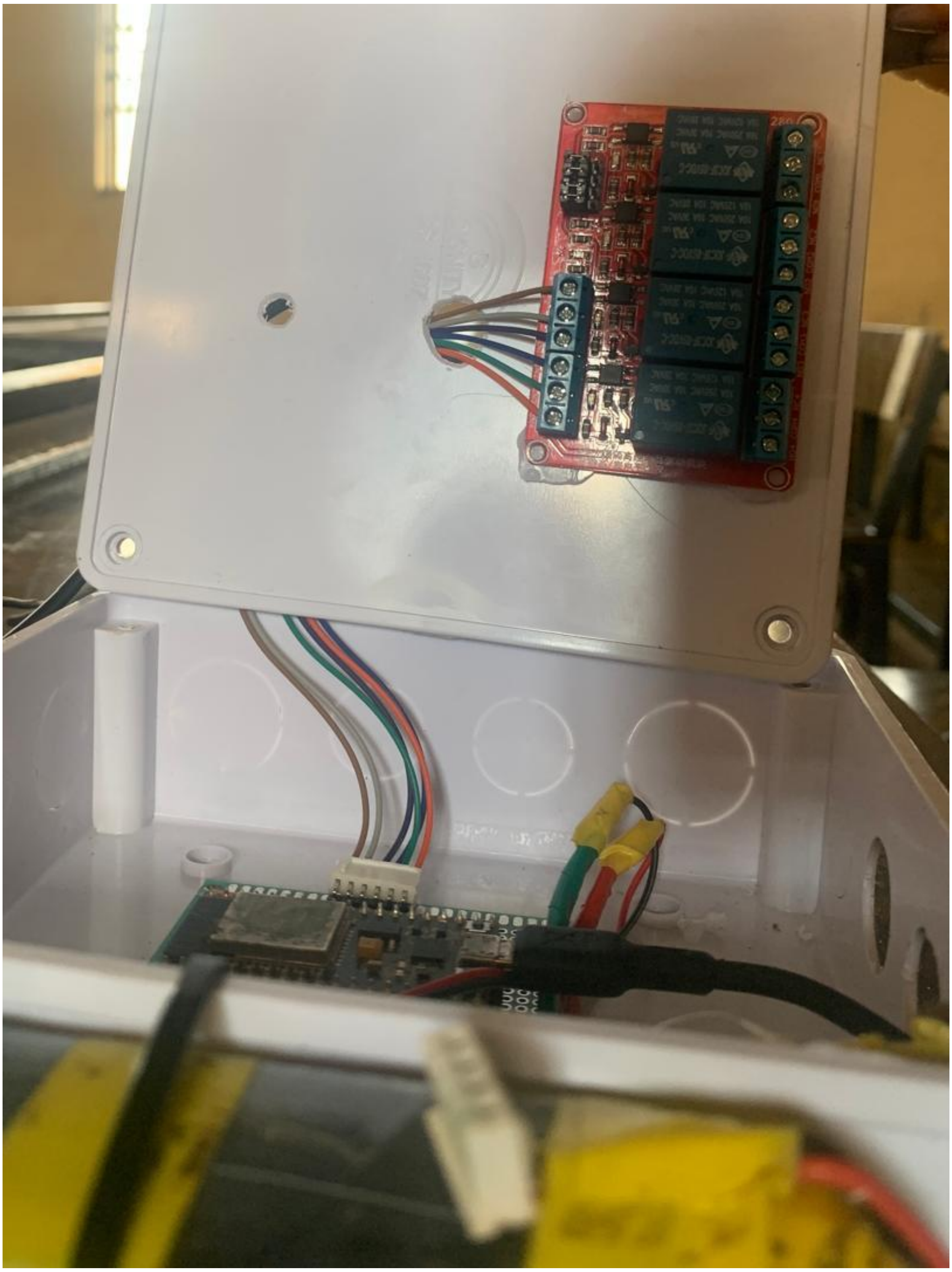

Plate 3.5: shows the relays

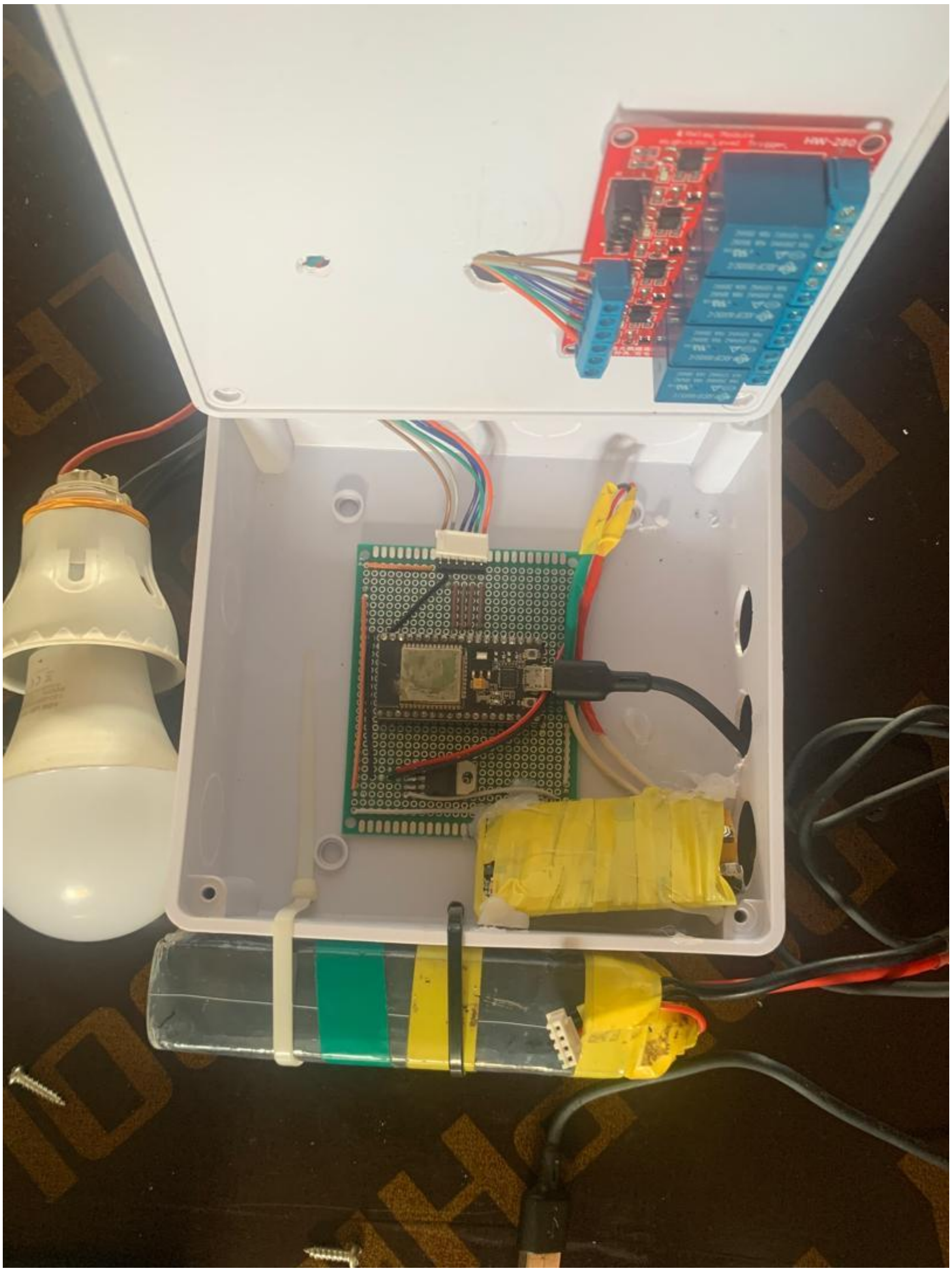

PLATE 3.6: Shows the voltage regulator the batteries and the ESP32.

4.3. SYSTEM RELIABILITY AND LIMITATIONS

Both infrared and Wi-Fi controls operated reliably during testing. The infrared control was limited by obstacles that blocked the signal, while Wi-Fi control worked smoothly as long as there was network connectivity. The circuit remained stable during operation and consumed little power. The overall design proved suitable for long-term use with minimal maintenance. To further improve the system, additional features like Bluetooth or voice control could be added in future designs. The test results and analysis confirmed that the system successfully performed its intended function. The combination of infrared and Wi-Fi control provided both short-range and long-range operation options. Infrared control offered quick, low-power operation for nearby devices, while Wi-Fi control provided remote accessibility and flexibility. The system is therefore practical for modern home and office automation where both convenience and reliability are important.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 DISCUSSION OF RESULTS

The construction and testing of an infrared (IR) remote control system with WiFi enhancement were successfully achieved, demonstrating how traditional infrared communication can be integrated with modern wireless technology. The system consisted of two main parts the transmitter (remote) and the receiver with an additional Wi-Fi module for extended control. The transmitter generated infrared pulses through an IR LED, which was driven by a modulated signal from a transistor circuit controlled by a microcontroller. When any control button was pressed, the transmitter sent coded IR pulses to the receiver. The receiver unit, equipped with a photodiode and signal decoder, converted the incoming IR light into corresponding electrical signals for further processing. By adding Wi-Fi functionality, the system could also be controlled via a wireless network using a smartphone or computer. This enhancement overcame the line-of-sight limitation of infrared communication, allowing remote operation over long distances. The integration of the ESP32 module ensured reliable connectivity with minimal power consumption. Performance testing showed that the IR system worked efficiently within a range of about 5–8 meters, while the Wi-Fi connection provided unlimited range within the network coverage. Both control modes complemented each other, offering flexibility between short-range (IR) and long-range (Wi-Fi) operations. The resistors, capacitors, and transistors used in the circuit maintained signal stability and voltage regulation. The IR LED emitted light at around 940 nm, which was effectively detected by the photodiode in the receiver. The power unit provided a constant 5V DC supply to all active components, ensuring consistent performance.

5.2 CONCLUSION

This project successfully demonstrated the design and development of an infrared remote control system enhanced with Wi-Fi capability. The combination of IR and wireless control technologies represents a significant improvement in remote control applications, offering wider range, reliability. All project objectives were met:

1. The design and construction of a functioning IR transmitter and receiver system.
2. The successful integration of Wi-Fi connectivity for remote operation.
3. Verification of the system’s performance and reliability through testing.

The system proved to be both dependable and efficient for controlling appliances locally via infrared or remotely via Wi-Fi, making it suitable for home automation, industrial applications, and educational demonstrations.

5.3 RECOMMENDATION

Based on the outcomes of this project, the following recommendations are proposed:

1. Use of Advanced Microcontrollers: Future designs should employ higher-capacity microcontrollers such as the ESP32 or Raspberry Pi Pico W for improved performance and Iot compatibility.

2. Development of a Mobile App: A dedicated application could be created to provide a user friendly interface for Wi-Fi control.

3. Power Management: Rechargeable batteries and sleep-mode features should be added to reduce power control and enhance portability.

4. Enhanced Security: Incorporating password protection or encryption will help prevent unauthorized access via the Wi-Fi network.

5. Signal Range Extension: Wi-Fi repeaters or mesh networks can be introduced. For greater coverage in large spaces.

6. Smart Sensor Integration: Sensors like motion, light, or temperature detectors can be integrated to allow automatic and intelligent appliance control.

5.4 Contribution to Knowledge

This project illustrates how conventional infrared communication systems can be upgraded using Wi-Fi technology to form a dual-mode remote control system. It provides insight into the use of affordable electronic components in designing efficient and modern remote systems, contributing to the development of smart home and IoT technologies.

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