VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELAGAVI-590018

A Mini-Project
Report on

"Smart Junction Box based on IOT"

Submitted In partial fulfilment for the award of degree of

BACHELOR OF ENGINEERING

In

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

Nagarjuna	**3BR21EC405**
Raghavendra L C	**3BR21EC409**
Sai Abhishek B	**3BR21EC411**
Yallappa N Hallur	**3BR21EC415**

Under the guidance of
Mrs. Shilpa K R
(Asst. Professor)

BALLARI INSTITUTE OF TECHNOLOGY & MANAGEMENT
NAAC A+ Accredited Institution
(Recognized by Govt. of Karnataka, approved by AICTE, New Delhi & Affiliated to Visvesvaraya Technological University, Belagavi)
"Jnana Gangotri" Campus, No.873/2, Bellary-Hospet Road, Allipur, Ballari-583 104 (Karnataka) (India)
Ph: 08392 – 237100 / 237190, Fax: 08392 – 23719

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Belagavi, Karnataka
2023-2024

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the Mini-Project work entitled **"Smart Junction Box based IOT"**, is a bonafide work carried out by Nagarjuna(3BR21EC405), Raghavendra LC (3BR21EC409), Sai Abhishek B(3BR21EC411), Yallappa N Hallur (3BR21EC415) the bonafide students of Ballari Institute of Technology and Management in partial fulfilment for the award of degree of **Bachelor of Engineering** in **ELECTRONICS AND COMMUNICATION ENGINEERING** of the **Visvesvaraya Technological University, Belagavi** during the academic year 2023-2024. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The report has been approved as it satisfies the academic requirements in respect of Mini-Project work prescribed for the said Degree.

Mrs. SHILPA K R
Project guide and Mentor

Dr. SADYOJATHA K M
HOD, Dept. Of ECE

Dr. V C PATIL, Dr. MALLIKARJUNA, Dr. RENUKA SAGAR
Mini-Project Coordinator

External Viva

Name of the Examiner **Signature with date**

1.

2.

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Nagarjuna	3BR21EC405
Raghavendra L C	3BR21EC409
Sai Abhishek B	3BR21EC411
Yallappa N Hallur	3BR21EC415

ABSTRACT

People want smart technology in every place possible when they are into their homes or away from their homes. A Smart Junction Box based on IOT is a device or method used to control the switches using mobile by connecting Wi-Fi. The implemented system was developed in combination of hardware and software. It's a unique device are used Wi-Fi module is used to connect mobile to control the switches. The system empowered the user to connect the internet and by connecting the Wi-Fi module i.e., ESP8266 connecting devices and relays in an IOT network.

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CHAPTER: -01
INTRODUCTION

1.1 INTRODUCTION

[1] Home Automation has always been inspiring projects for most of us. Toggling an AC load from the comfort of our chairs or bed of any room without reaching for the switch in another room sounds cool doesn't it!!, Thanks to the ESP8266 modules this idea can be easily implemented with subtle knowledge on electronics. A smart junction box, also known as an intelligent junction box or smart distribution box, is a device that is used in electrical systems to control and monitor the distribution of power and manage various electrical components. It acts as a central hub that connects and communicates with different devices and systems within a building or industrial facility.

One of the key features of a smart junction box is its ability to collect and analyse data from various sensors and devices, providing real-time information about the status and performance of the electrical system. This data can include information about power consumption, voltage levels, temperature, and other relevant parameters. By having this data readily available, facility managers and operators can make informed decisions regarding energy management, maintenance scheduling, and troubleshooting. They can identify potential issues or inefficiencies in the system and take proactive measures to address them, leading to improved energy efficiency, reduced downtime, and cost savings.

In addition to data monitoring and analysis, smart junction boxes often have built-in communication capabilities, allowing them to connect to other smart devices and systems, such as building automation systems or energy management systems. This integration enables centralized control and automation of various electrical components, such as lighting, HVAC systems, and security systems, enhancing overall system performance and efficiency.

Furthermore, smart junction boxes are designed with advanced safety features, such as overload protection, short-circuit detection, and ground fault monitoring. These features help prevent electrical accidents and minimize the risk of damage to equipment and infrastructure. In summary, a smart junction box is a sophisticated device that plays a crucial role in modern electrical systems. It combines data monitoring, analysis, communication, and control capabilities to optimize energy efficiency, improve system performance, and enhance safety.

In this project let us learn how to make a Junction Box whose switches can be toggled remotely using your Phone or Computer with active internet connection. This project is capable of toggling any two AC loads whose current rating is not more than 5A or ~800Watts. Once you understand the concept you can extend the number or AC loads by using advanced ESP modules and also increase the power rating of the loads by using high rating relays.

CHAPTER: - 02
LITERATURE SURVEY

The Internet of Things (IoT) has revolutionized various sectors, including home automation and industrial applications. A smart junction box is an essential component in building automation systems that enables the connectivity and control of electrical devices. This literature review aims to explore the existing research and developments related to smart junction boxes based on IoT using the ESP8266 microcontroller.

IoT-Based Smart Junction Box for Home Automation, the system allowed users to remotely monitor and control various electrical devices using a mobile application. The study demonstrated the feasibility and effectiveness of IoT-based smart junction boxes in enhancing home automation systems [1].

It focuses on an IoT-based smart junction box for energy management in buildings. It explores the use of ESP8266 for real-time energy monitoring, control, and optimization. The paper also discusses the integration of the smart junction box with cloud platforms for remote monitoring and analysis [2].

This research paper presents a smart junction box for electrical power monitoring and control. It highlights the use of ESP8266 for real-time data acquisition, transmission, and control. The paper also discusses the integration of the smart junction box with a mobile application for user interaction and control [3].

Design and Implementation of a Smart Junction Box for Industrial Applications system used various sensors to monitor environmental conditions, energy consumption, and connectivity status. The study highlighted the importance of real-time data collection and analysis in improving industrial processes [4].

Secure Communication in IoT-Based Smart Junction Boxes A research paper by Agarwal et al. (2019) focused on the security aspects of IoT-based smart junction boxes. The study proposed a secure communication framework using the ESP8266 module to ensure the confidentiality and integrity of data transmission. The research emphasized the need for robust security measures in IoT devices to protect against cyber threats.

CHAPTER: -03

OBJECTIVES

The objectives of a smart junction box based on IoT (Internet of Things) can include:

Remote monitoring and control: The smart junction box aim to enable remote monitoring and control of electrical connections and devices. This objective involves developing a system that allows users to access and manage the junction box's functionality from anywhere, using a web or mobile interface.

Real-time data collection: The smart junction box should be equipped with sensors and data collection capabilities to gather real-time information about power consumption, voltage levels, current flow, and other relevant electrical parameters. This data can be used for analysis, optimization, and proactive maintenance.

Energy efficiency and optimization: The smart junction box should provide insights into energy usage patterns and enable energy optimization strategies. This objective involves developing algorithms and analytics to identify energy-saving opportunities, such as detecting idle devices or optimizing power distribution.

Fault detection and predictive maintenance: The smart junction box aims to detect faults or anomalies in the electrical system. By analysing data from sensors, it can identify potential issues, such as overheating, abnormal voltage fluctuations, or circuit failures. This objective involves developing algorithms to enable predictive maintenance and minimize downtime.

Integration with existing infrastructure: The smart junction box should be designed to seamlessly integrate with existing electrical infrastructure, such as power distribution panels or building management systems. This objective involves ensuring compatibility and interoperability with different protocols and systems.

Enhanced safety and security: The smart junction box should prioritize safety and security. This objective includes implementing features such as surge protection, fire detection, and secure communication protocols to prevent unauthorized access or tampering.

Scalability and flexibility: The smart junction box should be scalable to accommodate varying numbers of electrical connections and devices. It should also be flexible in terms of configuration and customization to meet the specific needs of different applications or environments.

Cost-effectiveness: The smart junction box should provide a cost-effective solution, considering factors such as initial setup costs, maintenance requirements, and potential energy savings. This objective may involve optimizing the design, choosing appropriate components, and considering long-term operational costs.

Overall, the objectives of a smart junction box based on IoT aim to improve monitoring, control, efficiency, safety, and maintenance of electrical infrastructure through the integration of sensor technologies, data analytics, and remote connectivity.

CHAPTER: -04
IMPLEMETATION AND METHODOLOGY

4.1 HARDWARE AND SOFTWARE REQUIRED

4.1.1 SOFTWARE

Arduino IDE

Fig.2.1.1

[7] The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuine and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.' and user community that designs and manufactures single board microcontrollers and microcontroller kits for building digital devices. It is hardware products are licensed under a CC BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.

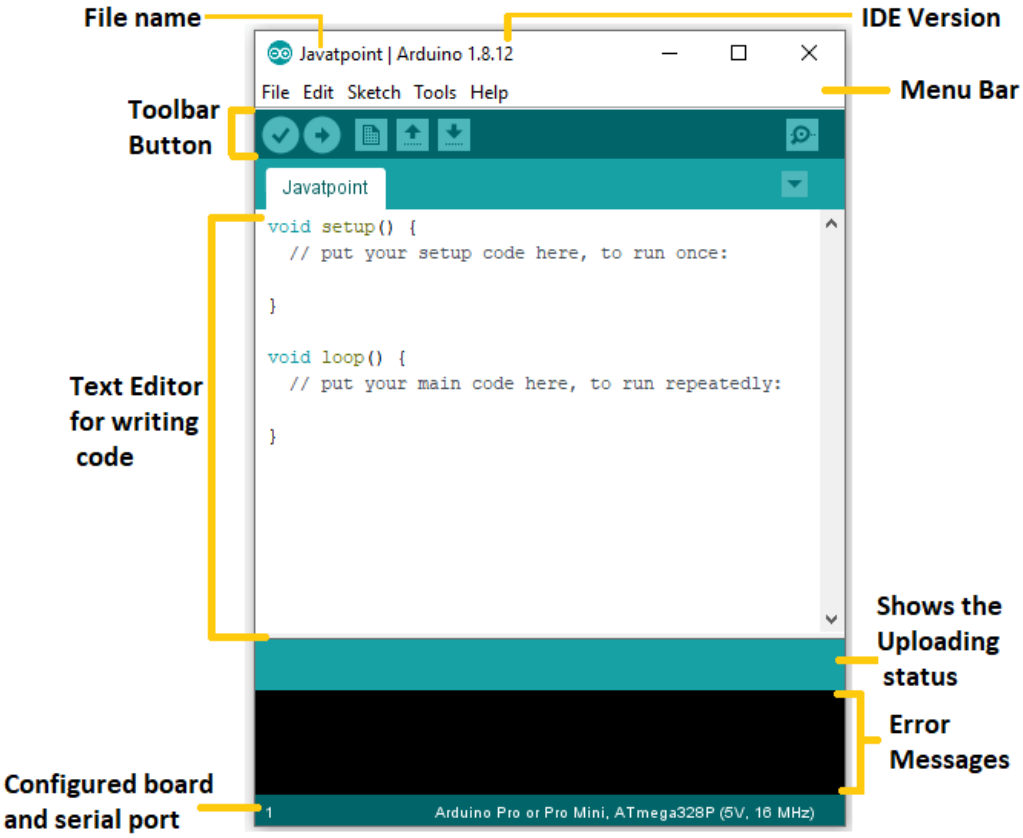

Fig.4.1.2

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boars ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino language, inspired by the Processing language and used with a modified version of the Processing IDE. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) and a command line tool developed in Go.

4.2 HARDWARE

4.2.1 ESP8266WIFI MODULE

Fig.4.2.1

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

Technical Specifications

- Processor: L106 32-bit RISC microprocessor core based on the Ten silica Xtensa Diamond Standard 106Micro running at 80 MHz
- Memory:
    - 32 KiB instruction RAM
    - 32 KiB instruction cache RAM
    - 80 KiB user-data RAM
    - 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
    - Integrated TR switch, balun, LNA, power amplifier and matching network
    - WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI
- I^2C (software implementation)
- I^2S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC)

4.2.2 RELAY MODULE

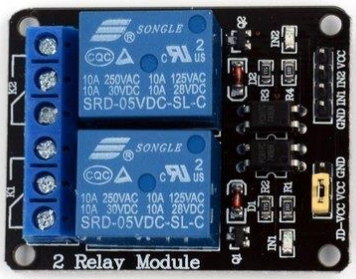

Fig.4.2.2

2-Channel 5V Relay Module is a relay interface board, it can be controlled directly by a wide range of microcontrollers such as Arduino, AVR, PIC, ARM and so on. It uses a low level triggered control signal (3.3-5VDC) to control the relay. Triggering the relay operates the normally open or normally closed contacts. It is frequently used in an automatic control circuit. To put it simply, it is an automatic switch to control a high-current circuit with a low-current signal.5V relay signal input voltage range, 0-5V. VCC power to the system. JD-VCC relay in the power supply. JD-VCC and VCC can be a shorted.

The features of 2-Channel Relay module:

- 2-channel high voltage system output, meeting the needs of dual channel control.
- Brand new and high quality.
- Standard interface that can be controlled directly by microcontroller (Arduino , 8051, AVR, PIC, DSP, ARM)]
- Wide range of controllable voltages.
- Being able to control high load current, which can reach 250V, 10A or 125V, 15A
- With a normally-open (NO) contact and a normally-closed (NC) contact.
- Around the board with 4 mounting holes, easy installation and fixing
- It has a common end, a beginning, a closed-end

Specification of 2-Channel Relay module:

- Relay Module; Model : JQC-3FF-S-Z, 2 Channel
- Voltage to operate: 5V D
- Color : Blue Relays on a black PCB
- Load : 10A, AC 250V/ 15A, 125V

4.2.3 AC-to-DC Converter

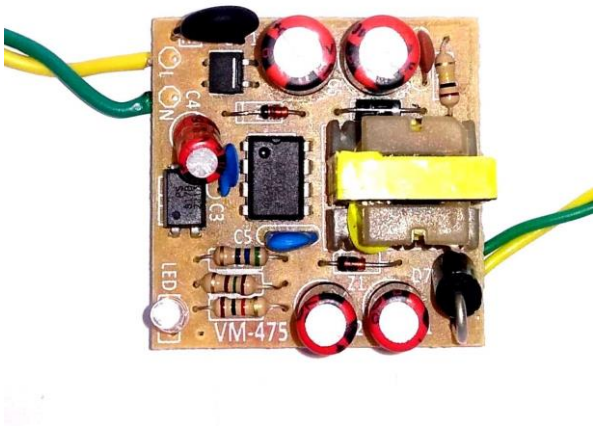

Fig.4.2.3

The AC-DC converter used in this project outputs 5V with 700mA continuous and 800mA peak current. You can easily buy one similar online since they are easily available. Designing our own converter or using a battery will be less efficient for our Project. Once you buy this module simply solder a wire to the input terminal and you should be ready to go with the rest of the circuit.AC/DC converters are electrical circuits that transform alternating current (AC) input into direct current (DC) output. AC/DC Converters are also called “rectifiers”; they convert the input AC voltage to variable DC voltage, then optimize it through a filter to obtain an unregulated DC voltage.

Specifications

- Input Rating: 110-240V AC 50Hz, Output rating 5V DC 2Amp 10Watt
- Product Dimensions LWH: 40X40X22mm
- Resoldered Wires, wire length 3Inch, output marked with voltage.
- High class component and PCB, IC based accurate voltage regulation
- 3 Months brand warranty excluding physical and liquid damage

4.2.4 Junction box

Fig.4.2.4

junction box has three terminals (plug points). Out of which one (the right most) is used to power our AC-Dc converter module the other two is used to connect the AC loads. As you can see the Neutral wire (black wire) is connected to all three plug points. But the Phase wire is (yellow wire) is left free. The phase ends of the two plug points (two red wires) are also left free. All these three free wires should be connected to the Relay terminals that we added to our Perf board.

4.2.5 POWER SUPPLY

A power supply is an electrical device that converts the electric current that comes in from a power source, such as the power mains, to the voltage and current values necessary for powering a load, such as a motor or electronic device.

The objective of a power supply is to power the load with the proper voltage and current. The current must be supplied in a controlled manner — and with an accurate voltage — to a wide range of loads, sometimes simultaneously, all without letting changes in the input voltage or in other connected devices affect the output.

A power supply can be external, often seen in devices such as laptops and phone chargers, or internal, such as in larger devices such as desktop computers. A power supply can either be regulated or unregulated. In a regulated power supply, the changes in the input voltage do not affect the output. On the other hand, in an unregulated power supply, the output depends on any changes in the input.

4.3 CIRCUIT DIAGRAM

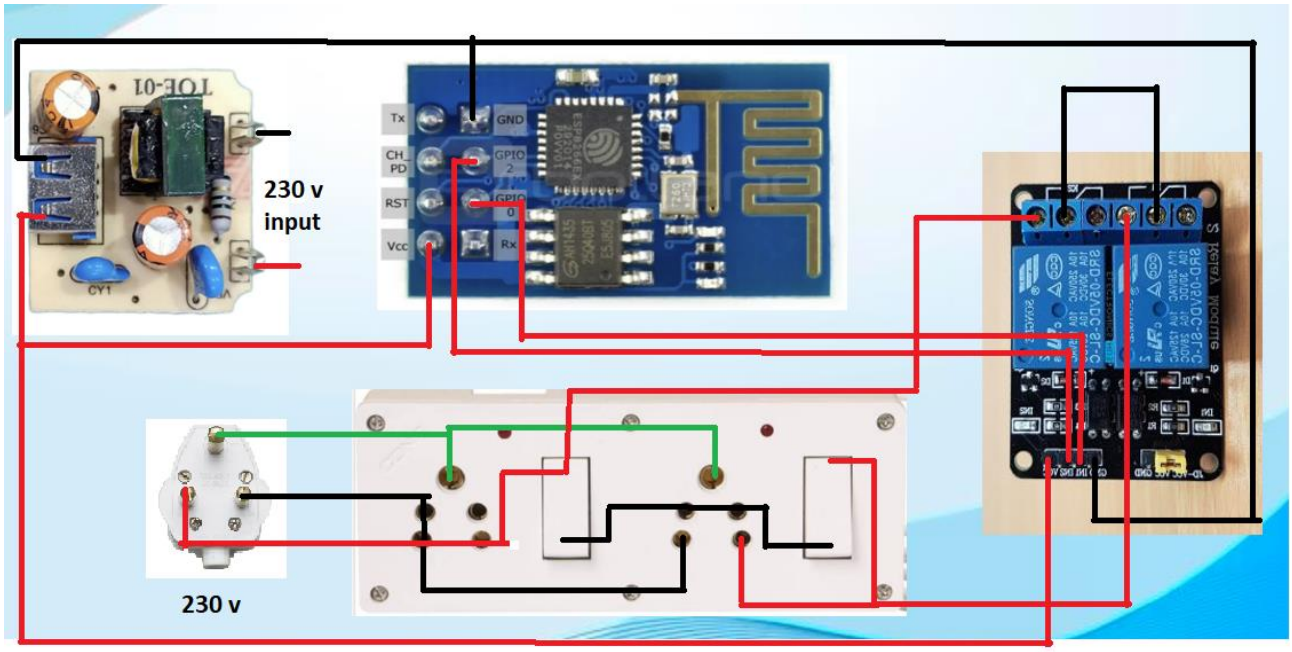

Fig.4.3

4.4 IMPLEMANTATION

Hardware setup: Gather the necessary components, including an ESP8266 development board, sensors (such as current and voltage sensors), relays or switches for control, and any additional components required for your specific application.

Install development environment: Set up the Arduino Integrated Development Environment (IDE) and install the ESP8266 board package. This allows you to program the ESP8266 microcontroller using Arduino code.

Connect sensors and peripherals: Connect the sensors, relays, and any other peripherals to the appropriate pins on the ESP8266 development board. Ensure proper wiring and connections, following the datasheets and guidelines provided for each component.

Develop firmware: Write the firmware code in the Arduino IDE to control the sensors, read data, and communicate with external devices or platforms. Use the ESP8266 library and available sensor libraries to simplify programming tasks.

Set up Wi-Fi connection: Configure the ESP8266 to connect to your local Wi-Fi network. Provide the necessary credentials (SSID and password) in the firmware code to establish a connection. This enables the smart junction box to communicate with other devices and platforms over the internet.

Implement data collection and analysis: Use the firmware code to read data from the connected sensors, such as current and voltage values. Process and analyze the data as required, applying any necessary algorithms or calculations to derive meaningful insights.

Enable control and automation: Implement control mechanisms using relays or switches connected to the ESP8266. Use the firmware code to control the electrical components of the smart junction box based on certain conditions or user commands.

Deployment and ongoing maintenance: Deploy the smart junction box in the intended environment and continuously monitor its performance. Regularly update the firmware, implement security measures, and perform maintenance tasks as needed.

4.5 METHODOLOGY

4.5.1 CODE:-

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266mDNS.h>
MDNSResponder mdns;
const char* ssid = "SJB";  //Enter you Wifi SSID here
const char* password = "jaishreeram"; //Enter your password here
ESP8266WebServer server(80);
String mainPage = ""; //The default page
String feedback = ""; //Gives staus of the switch
String currentPage = ""; //Combines main and feedback page
int GPIO_0 = 0; //Pin defanition
int GPIO_2 = 2; //Pin defanition
void setup(void){
  mainPage += "<h1 align=\"center\">Smart Junction Box</h1><h2
align=\"center\">by ECE DIP-BOYS</h2><h1 align=\"center\"><p>Switch 1 <a
href=\"switch1On\"><button>ON</button></a> <
href=\"switch1Off\"><button>OFF</button>  </a></p>";
mainPage+="<p>Switch2<ahref=\"switch2On\"><button>ON</button></a> 
<a href=\"switch2Off\"><button>OFF</button>  </a></p>";feedback = "<h3
align=\"center\">Both Switch 1 and switch 2 are OFF</h3>";  currentPage =
mainPage+feedback;  // preparing GPIOs
```

```
 pinMode(GPIO_0, OUTPUT);
 digitalWrite(GPIO_0, LOW);
 pinMode(GPIO_2, OUTPUT);
 digitalWrite(GPIO_2, LOW);
 delay(1000);
 Serial.begin(115200);
 WiFi.begin(ssid, password);
 Serial.println("");
 // Wait for connection
 while (WiFi.status() != WL_CONNECTED) {
 delay(500);
 Serial.print(".");
 }
 Serial.println("");
 Serial.print("Connected to ");
 Serial.println(ssid);
 Serial.print("IP address: ");
 Serial.println(WiFi.localIP());
 if (mdns.begin("esp8266", WiFi.localIP())) {
Serial.println("MDNS responder started");
 }
 server.on("/", []){
   currentPage = mainPage+feedback;
   server.send(200, "text/html", currentPage);
   currentPage = "";
 });
 server.on("/switch1On", []){
   feedback = "<h3 align=\"center\">Switch 1 turned ON</h3>";
   currentPage=mainPage+feedback;
   server.send(200, "text/html", currentPage);
   currentPage="";
   digitalWrite(GPIO_0, HIGH);
   delay(1000);
 });
 server.on("/switch1Off", []){
   feedback = "<h3 align=\"center\">Switch 1 turned OFF</h3>";
```

```
    currentPage=mainPage+feedback;
    server.send(200, "text/html", currentPage);
    currentPage="";
    digitalWrite(GPIO_0, LOW);
    delay(1000);
  });
  server.on("/switch2On", [](){
    feedback = "<h3 align=\"center\">Switch 2 turned ON</h3>";
    currentPage=mainPage+feedback;
    server.send(200, "text/html", currentPage);
    currentPage="";
    digitalWrite(GPIO_2, HIGH);
    delay(1000);
  });
  server.on("/switch2Off", [](){
    feedback = "<h3 align=\"center\">Switch 2 turned OFF</h3>";
    currentPage=mainPage+feedback;
    server.send(200, "text/html", currentPage);
    currentPage="";
    digitalWrite(GPIO_2, LOW);
    delay(1000);
  });
  server.begin();
  Serial.println("Smart Junction Box is up and running");
}
void loop(void){
  server.handleClient();
}
```

4.5.2 RESULT:

Once ready with the Hardware and the Program, upload the program to our ESP8266 module. Then click on serial monitor of the Arduino IDE you should see something like this if the SSID and password match.

Make a note of the IP address that is displayed in the Serial monitor. In my case the IP address is "http://192.168.43.130" We have to use this IP in our browser to access the ESP webpage.

Now, place the ESP module in our Relay board close the junction box and power it ON, then short the GPIO pins to the load. If everything has worked properly when you enter the IP address in your Browser you should see the following screen

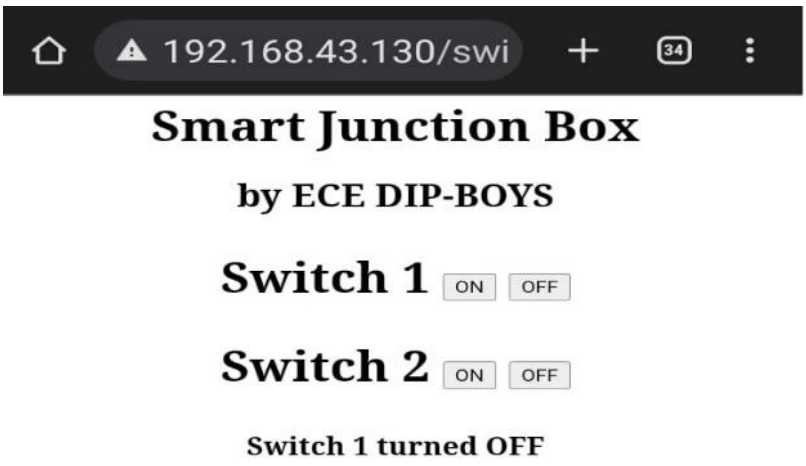

Fig.4.5.2

Now simply turn ON/OFF the switch you like to and it should be reflected on the actual Hardware. That is it guys not you can Toggle your favourite AC load by simply connecting them to the plug point. Hope you liked the project and got it working, if not use the comment section I will be happy to help you.

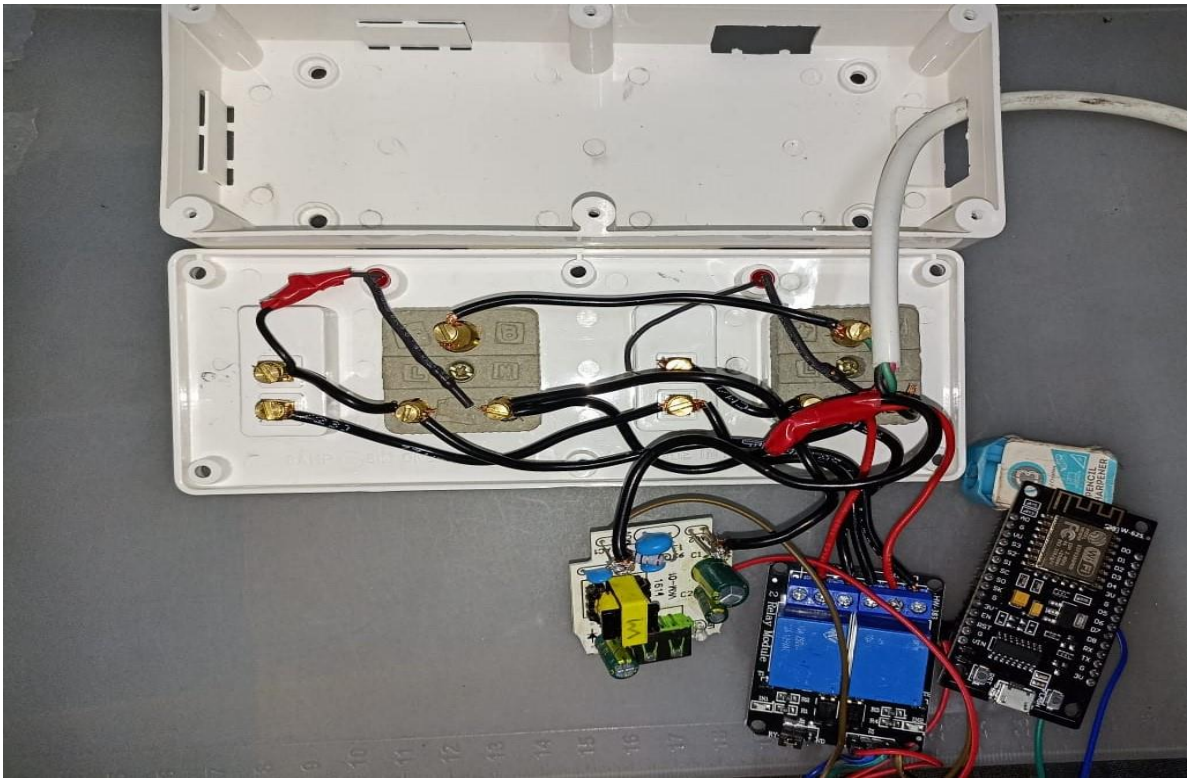

Fig. 4.5.3

CHAPTER: -05

APPLICATIONS, ADVANTAGES AND LIMITATIONS

5.1 APPLICATIONS

- Smart Homes
- Energy Management
- Industrial Automation
- Smart Grids
- Building Management Systems
- Renewable Energy Systems

5.2 ADVANTAGES

- Increased Efficiency
- Remote Monitoring and Control
- Enhanced Safety
- Improved Troubleshooting
- Flexibility and Adaptability
- Data Collection and Analysis
- Integration with Smart Grids
- Cost Savings

5.3 LIMITATIONS

- Higher cost compared to traditional junction boxes.
- Increased complexity in installation and maintenance.
- Dependency on technology, susceptible to failures or network disruptions.
- Potential compatibility issues with existing systems or devices.
- Power dependency, susceptible to power outages.
- Security risks, vulnerable to hacking or unauthorized access.
- Learning curve for users to adapt to new technologies.
- Limited compatibility with existing systems or devices.
- Specialized maintenance and technical support may be required.

CHAPTER: -06

CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

Smart junction boxes have revolutionized the way electrical systems are managed and controlled. With their ability to collect and analyse data, communicate with other devices and systems, and provide real-time information, they offer numerous benefits. By utilizing a smart junction box, facility managers and operators can make informed decisions regarding energy management, maintenance scheduling, and troubleshooting. This leads to improved energy efficiency, reduced downtime, and cost savings.

The integration of smart junction boxes with other smart devices and systems allows for centralized control and automation, enhancing overall system performance and efficiency. This not only improves the functionality of the electrical system but also provides a more comfortable and convenient environment for occupants. Furthermore, the advanced safety features of smart junction boxes help prevent electrical accidents and minimize the risk of damage to equipment and infrastructure. This ensures the safety of both the electrical system and the people using it. Overall, smart junction boxes are an essential component of modern electrical systems. Their ability to monitor, analyse, communicate, and control makes them a valuable tool for optimizing energy efficiency, improving system performance, and enhancing safety.

6.2 FUTURESCOPE

Integration with Advanced Communication Protocols: ESP8266-based smart junction boxes can be further enhanced by integrating with advanced communication protocols like MQTT (Message Queuing Telemetry Transport) or CoAP (Constrained Application Protocol). This would enable seamless interoperability with other IoT devices and platforms, facilitating more efficient data exchange and control.

Artificial Intelligence and Machine Learning Integration: The integration of artificial intelligence (AI) and machine learning (ML) technologies can revolutionize smart junction boxes. By leveraging AI and ML algorithms, these devices can learn from historical data, predict patterns, and optimize energy consumption. This can lead to more intelligent and automated control of electrical systems.

REFERENCE

1. Home Automation has always been an inspiring project for most of us. Toggling an AC load from the comfort of our chairs or bed in any room without reaching for the switch in another room sounds cool doesn’t it!!,
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