DESIGN AND IMPLEMENTATION OF IOT BASED SMART HOME APPLIANCE CONTROL

by

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MASTER OF ENGINEERING

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Dedicated to my beloved parents with all my heart

List of Contents

List of Figures

List of Tables

List of Symbols and Abbreviations

IoT	Internet of Things
SDB	Sub-Distribution board
PIR	Passive Infrared
LDR	Light Dependent Resistor
CT	Current Transformer
PT	Potential Transformer
DC	Direct Current
SMPS	Switched-Mode Power Supply
LCD	Liquid Crystal Display
AC	Alternating Current
LED	Light Emitting Diode
SMPS	Switch Mode Power Supply

Acknowledgment

Firstly, I would like to express my sincere gratitude to Allah (SWT) for giving me the patience, and strength to finish the project work successfully.

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Zayed Hossain

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Abstract

Nowadays, technology has grown at high speed and the internet is available everywhere. People are very much dependent on the technology. For this reason, home appliances smart control systems have become more and more popular day by day. IoT-based home appliances smart control refers to the integration of Internet of Things (IoT) technology with household appliances to enable remote control, monitoring, automation, and enhanced functionality. This project is an implementation of IoT based complete home appliance smart control system where the user can control the SDB parameters (circuit breaker, magnetic contractor, etc.) along with other home appliances such as light, fan, fan speed, air conditioner, refrigerator, security light, etc. from a smartphone or any internet-connected smart devices from anywhere which is not found in existing projects. In addition, voice and manual control facility is also integrated in this project so that the user can feel more comfortable. Besides, the user can also monitor various real-time data such as current, voltage, power, energy, humidity, temperature, etc. using a smartphone from a remote place, and if any emergency assistance is required then it also can be obtained. Some additional features are also integrated into this project such as an energy-saving lighting system used in security and toilet lights, protection of the whole system from under voltage, sending notifications as well as switching on the alarm if the smoke crosses the acceptance level in the kitchen to prevent fire accidents initially. Overall, this project demonstrates the potential of IoT-based home appliance smart control systems in improving performance, reducing delay, more accurate real-time data monitoring, and more safety and security of homes where user experience will more better and more comfortable.

Chapter 1: Introduction

1.1. Introduction:

The IoT (Internet of Things) based home appliance control system is an innovative solution that allows users to remotely control and monitor their home appliance devices using a smartphone or other internet-connected device. This system integrates various devices, sensors, and controllers, which are connected to a central hub or gateway that communicates with the user's smartphone or other devices through the internet. The stem enables users to control various home appliances such as lights, fans, air conditioners, refrigerators, etc. using their smartphone [1] and users can check the update status of a device anytime [2]. At present, the Internet is available everywhere and this is high time we use the best technology that makes our lives easy, comfortable, and simple [3].

1.2. Background:

The need for home appliances and smart control systems in day-to-day life is rapidly growing because of their numerous advantages like comfort, convenience, centralized control of appliances, cost reduction, energy-saving, security, and safety. Home appliance's smart control system provides improved quality of life for users, especially for the elderly and differently-abled persons. Smart home technology can play a vital role in increasing energy efficiency. For example, users leave the room without switching OFF the lights, fans, air-conditioners, etc. due to laziness or due to human negligence but through a smart home appliances control system users can check the status of their home appliances from a remote place and can switch 'ON/OFF' any home appliances without human intervention from anywhere.

This project is a complete home appliance smart control system where user can also control every home appliance including SDB parameters (circuit breaker, magnetic contactor, etc.) by using voice through Google assistance by their smartphone along with virtual and manual control. With this facility, not only a normal person will be benefitted, but a physically disabled person can also control his/her home appliance devices including SDB parameters very easily. This will play an important role in our society. However, this project involves the development of a prototype IoT-based home appliance smart control system that is user-friendly, cost-effective, and scalable. The system uses popular open-source hardware and software platforms, making it easy to customize and modify based on user requirements.

1.3. Motivation:

The concept of home appliance control systems has been in existence for several years [4] and much research work on home automation and home appliance control systems has already been done and is still ongoing. However, it is observed that most of the research or project work has focused on only the common household appliances such as lights, fans, etc. controlled from a remote place using a smartphone (only virtually or only voice) with the help of the internet [3-12]. Therefore, there is a great opportunity to work on SDB parameters such as circuit breaker, magnetic contactor, etc. smart control system from the remote place along with other home appliances that we normally use in our house using all control mechanism-virtual, voice, and manual at a time without any delay.

1.4. Project Objective:

1. To develop a home appliances smart control system (Home appliances control using a smartphone, voice, and manual switch).
2. Improve user comfort and reduce energy wastage.

1.5 Project Scope:

The aim is to design an IoT-based home appliances control system from anywhere using a smartphone or web interface through an internet connection. The mobile application has been designed that provide various features like virtual switch mode control, voice command control, and a provision to view the ON/OFF status of the devices as well as various real-time data such as humidity, temperature, current, voltage, power, energy, etc. This system can be implemented in homes, small offices, and shops as well as being in charge of control of the electrical appliances.

1.6 Project Management:

Management of any project can be briefly disintegrated into several phases. This project has been decomposed into the following phases:

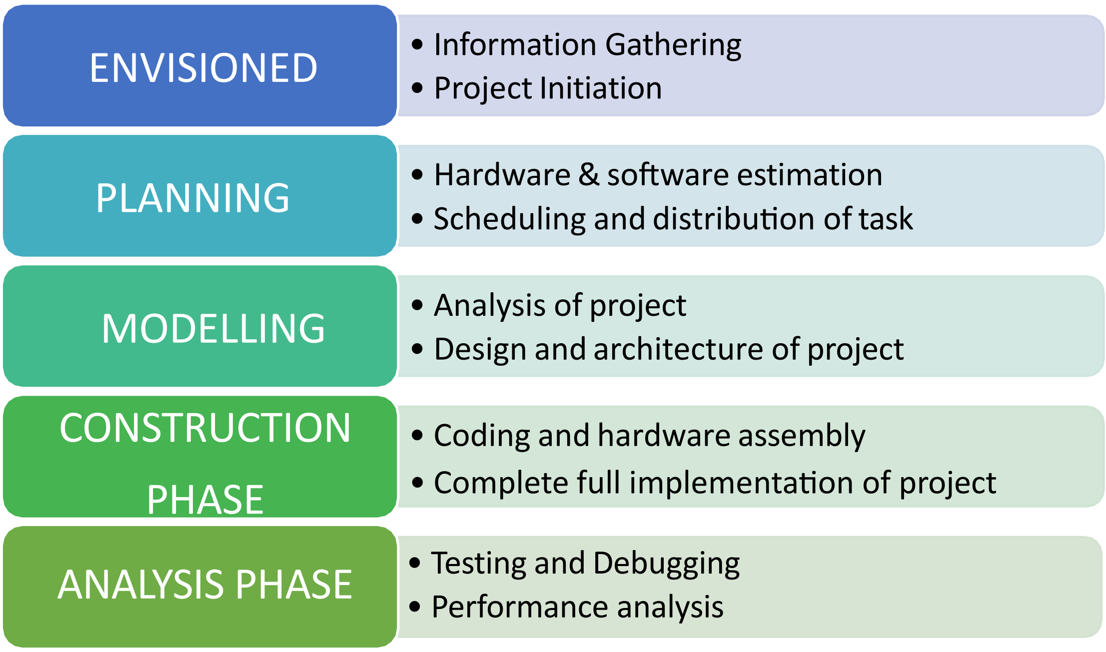


Fig-1.1: Project management steps.

Chapter 2: Project Design and Drawing

2.1 Introduction:

Design and drawing whether in the form of diagrams, sketches, or visual representations is very essential part and crucial aspect of any project. Design and drawing provide a clear and concise way to communicate ideas and concepts to others involved in the project. Visual representations can often convey information more effectively than written or verbal explanations alone. Design and drawing provide a platform for exploring different solutions, identifying potential issues, and refining ideas. By visualizing various scenarios and alternatives, designers can anticipate challenges and devise effective strategies to overcome them.

2.2 Design and Drawing Steps:

Designing and drawing an IoT-based project involves several steps, from conceptualization to implementation. Here's a simplified guide to creating a design and drawing for an IoT project [13]:

2.2.1 Define Project Requirements:

- Identify the problem that want to solve or the task you want your IoT project to accomplish.
- Determine the objectives, constraints, and target users.

2.2.2 Choose Components:

- Select appropriate hardware components based on your project requirements. This could include microcontrollers, sensors, actuators, communication modules, and power sources.
- Research and select the specific models or versions of components based on compatibility and features.

2.2.3 Design Circuit Diagram:

- Sketch a circuit diagram that shows how the selected components will be connected.
- Use symbols and labels to represent each component and their connections.
- Consider factors such as power requirements, signal flow, and communication protocols.

2.2.4 Plan Data Flow:

- Determine how data will be collected from sensors, processed, and transmitted to the internet or other devices.
- Define the communication protocols and data formats to be used.
- Plan for data storage, analysis, and visualization if required.

2.2.5 Develop Code:

- Write or adapt software code to control the microcontroller, read sensor data, and communicate with other devices or servers.
- Implement algorithms for data processing, decision-making, and automation as needed.
- Test the software components individually and integrate them into the IoT system.

2.2.6 Design User Interface:

- If the project includes a user interface (e.g., a mobile app or web dashboard), design the layout and features.
- Consider usability, accessibility, and user experience principles in project design.
- Create mockups or wireframes to visualize the user interface before implementation.

2.2.7 Finalize Documentation:

- Document the design, components, circuit diagram, software architecture, and user interface design.
- Include instructions for assembling the hardware, installing the software, and using the IoT system.

2.3 Project Drawing:

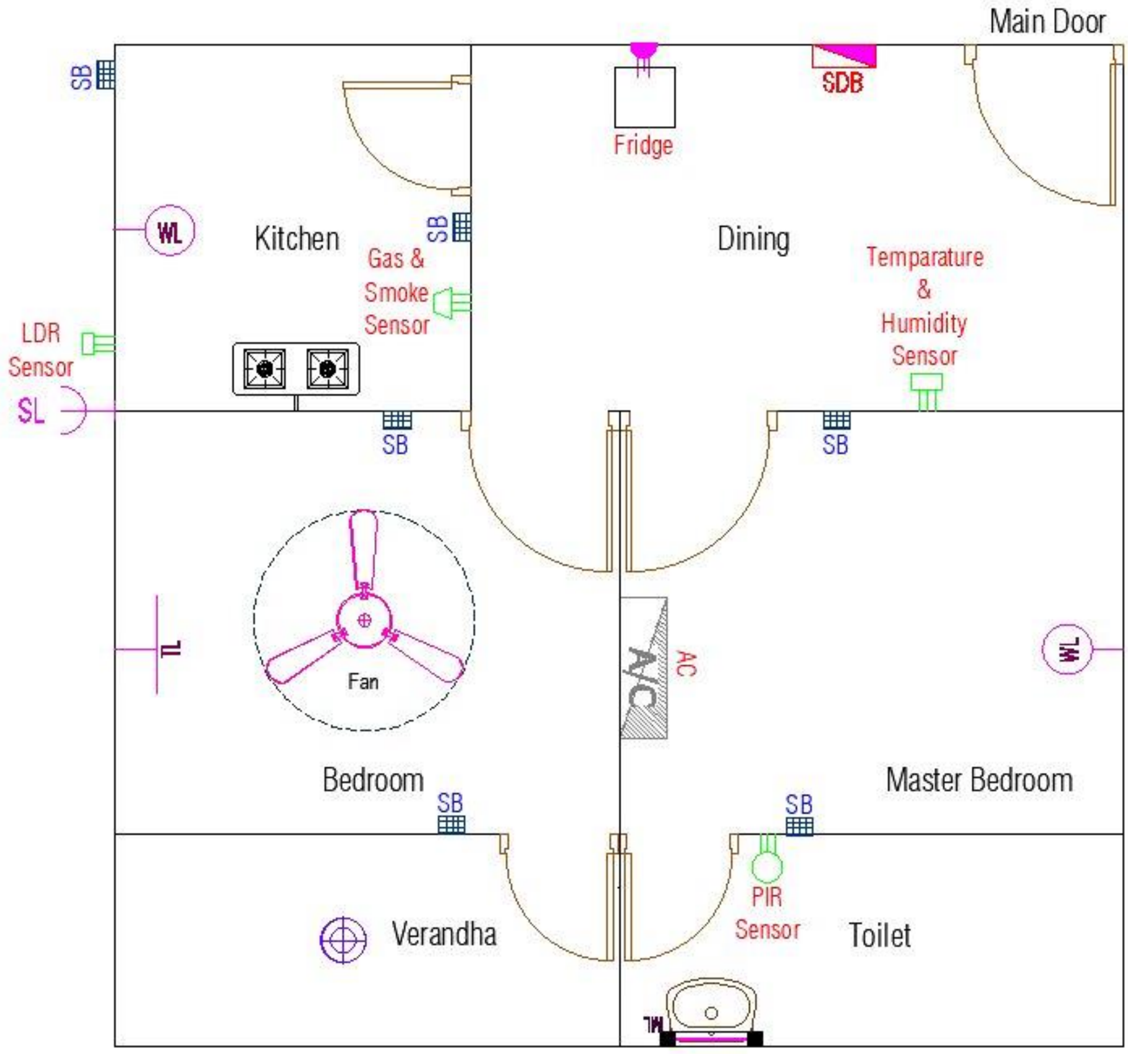


Fig-2.1: IoT-based home appliances smart control system project drawing.

This is a conceptual apartment electrical fixture layout drawing. In this conceptual design, have been considered one master bedroom, one guest bedroom, and one kitchen and dining space. There is a toilet and a verandah with the master bedroom and guest bedroom respectively. In this conceptual drawing, general common electrical home appliances such as lights, fans, refrigerators, air-conditioners, etc., and some common sensors such as temperature and humidity sensors, LDR sensors, motion sensors, gas and smoke sensors, current sensors, voltage sensors, etc. have been considered.

2.4 Project Description:

The project brief description is given below….

2.4.1 Main SDB:

3. Users will control the main circuit from a remote place using a servomotor through a smartphone. Manual control will also be possible through a push switch in the SDB.
4. Users will see the main circuit current, voltage, power, and energy in the SDB display as well as the smartphone application. Besides users can also see the last trip current and last trip time voltage in the smartphone application.
5. Will protect users' home appliances devices from over current as well as under voltage also through CT, PT, and Magnetic contractors.
6. Every room will individual circuit in the SDB so any room will be isolated when needed during maintenance through the smartphone application, computer, or web interface, and manual control will also be possible through some push switch in the SDB.

2.4.2 Dining Room:

Appliances: One refrigerator and one temperature and humidity sensor.

- The refrigerator will be controlled (ON/OFF) by virtual switch or voice using a smartphone and also by manual switch.
- It is possible to monitor room temperature and humidity using a temperature and humidity sensor that will be seen from a smartphone application from anywhere.

2.4.3 Kitchen:

Appliances: One light and one smoke and gas sensor.

- Light will be controlled (ON/OFF) from a virtual switch or voice using a smartphone and also by a manual switch.
- Smoke and gas levels will be monitored through a gas and smoke sensor when the microcontroller board finds that the gas or smoke crosses the acceptance level that is set in the microcontroller through the pre-uploaded codes then the buzzer will turn ON and microcontroller sends a notification to the user's smartphone application.

2.4.4 Bedroom and Verandah:

Appliances: Two lights and one fan with manual switch and regulator.

- All lights and fan control (ON/OFF with fan speed variation) from a virtual switch or voice using a smartphone and a manual switch. Besides, the fan speed is also controlled using a smartphone.

2.4.5 Master Bedroom:

Appliances: One light and one air-conditioner.

- All light and air-conditioner control (ON/OFF) from a virtual switch or voice using a smartphone and also by manual switch.
- The toilet light will automatically switched ON through a motion sensor which is activated by sensing the movement when the toilet door opens. This light will automatically be switched OFF and if no movements are found every 10-second interval. This sensor mode can be deactivated from the smartphone application anytime which can convert the light into the normal light.

2.4.6 Outside area:

Appliances: One security light.

- The security light will automatically control (ON/OFF) through an LDR sensor which is activated by sensing night or daylight. This sensor mode can be deactivated from the smartphone application.

2.5 Different from other similar projects [1-12]:

1. Control or trigger the main circuit breaker from anywhere using a virtual switch or voice through the smartphone application. Besides, the user can see the live status of the main circuit from anywhere and trigger off the main circuit breaker in an emergency when no one is in the house.
2. Every room will individual circuit in SDB so any room can be isolated when needed during maintenance from a smartphone or voice or manual switch.
3. Provide more safety from short circuit current due to current transformer (CT) and magnetic contractor have been used along with circuit breaker.
4. The main circuit automatically shuts down not only in over current but also under-voltage which is also harmful to our home appliance devices. In that case, the system will immediately turn off the main circuit and show the last tripping time current and voltage in the user's smartphone.
5. When the PDB line disconnects then the main circuit will be OFF and when the PDB reconnects then the main circuit will automatically be ON. So, it ensures more safety for the appliances.
6. Security and toilet light sensor modes feature an ON/OFF facility from a smartphone.
7. The user can see not only the real-time current, voltage, power, energy, etc. but also the users can see the last trip time current and trip time voltage from the smartphone application or web interface.
8. Reduce cable requirement by using a separate control board (Esp32/ESP8266) instead of using one Arduino giga development board.
9. Devices can be controlled using a smartphone application or manually at a time, in that case, no need to reset the system.
10. Best user experience since the device is also controlled through voice along with manual and virtual control.

Chapter 3: Project Component

3.1 Introduction:

To enable smart control of home appliances using a mobile device typically needs a combination of hardware components and software solutions. Once the hardware components are in place, then it needs to develop or configure the software to enable communication between the mobile app and the smart control system, as well as to implement any desired automation or scheduling features. This typically involves programming the microcontroller, developing a mobile app, and setting up a cloud service for remote access.

3.2 Hardware Component:

Designing an IoT-based home appliance smart control system involves several hardware components to enable communication, sensing, and control of home appliances and devices. These hardware components involve a microcontroller, power supply, relay, sensors, input-output devices, etc **[components details in Appendix-1]** Here's a list of the hardware components that are involved in this project is given below table.

SI	COMPONENTS NAME		QUANTITY	SL	COMPONENTS NAME		QUANTITY
1	Node MCU Development Board (ESP 32 or ESP 8266)		04 Pcs	13	Smoke and Gas Sensor,MQ2		01 Pcs
2	DP Circuit Breaker		01 Pcs	14	PIR motion Sensor, HC-SR 501		01 Pcs
3	Servo Motor,MG995		01 Pcs	15	Tube light ,5W,Ac		01 Pcs
4	Magnetic Contractor		01 Pcs	16	Led Light, 5w, Ac		01 Pcs
5	SDB Box		01 Pcs	17	Led bulb Holder		05 Pcs
6	Relay Module DC,5V (8 CH, 4CH, 2 CH & 1 CH)		06 Pcs	18	Fan, AC 250V		01 Pcs
7	Voltage Sensor ZMPT101B		01 Pcs	19	Multi Socket with switch, 15A		02 pcs
8	Current Sensor HW670		01 Pcs	20	2 pin push switch		08 Pcs
9	LCD Display		01 Pcs	21	Board		01 Pcs
10	Power Supply, 5V DC SMPS		01 Pcs	22	Switch and regulator, Piano type		09Pcs
11	LDR Module, 5V		01 Pcs	23	Others (Wires, buzzer, Screw, Glue etc)		01 Lot
12	Temperature and Humidity sensor DHT11						

Table 3.1: Project components list.

3.3 Software Item:

There are several software platforms and tools available for IoT projects, each with its strengths and suitability for different kinds of projects. In this project, two popular and user-friendly online software platforms have been chosen for virtual and voice control from remote places BLYNK and another is IFTTT. Besides, the coding part for the ESP 32 and ESP 8266 development board is completed using Arduino IDE software.

3.3.1 BLYNK Platform:

BLYNK is a popular platform for building IoT applications, especially for those who want to create mobile apps to control and monitor their connected devices without writing a lot of code [14]. Here's an overview of BLYNK [15]:

Features:

1. **Drag-and-Drop Interface:** BLYNK offers a user-friendly drag-and-drop interface for designing mobile apps. Users can easily add buttons, sliders, graphs, and other widgets to create a custom user interface for their IoT projects.
2. **Support for Multiple Platforms:** BLYNK supports a wide range of hardware platforms, including Arduino, Raspberry Pi, ESP8266, ESP32, and others. This makes it versatile and suitable for various IoT projects.
3. **Cloud Connectivity:** BLYNK provides cloud connectivity for remote monitoring and control of devices. Users can access their IoT projects from anywhere with an internet connection.
4. **Widgets and Libraries:** BLYNK offers a library of widgets that can be easily added to the mobile app interface. These widgets allow users to interact with their devices, visualize sensor data, and control connected devices.
5. **Customizable:** Users can customize their BLYNK apps by adding custom widgets, themes, and backgrounds. This allows for a personalized user experience tailored to the specific IoT project.

6. **Integration with Third-Party Services:** BLYNK can be integrated with third-party services such as IFTTT (If This Then That) and Zapier for automation and interoperability with other smart home devices and platforms.

7. **Security:** BLYNK provides security features such as encrypted communication between the mobile app and the cloud server, ensuring the privacy and integrity of data transmitted between devices.

Overall, BLYNK simplifies the process of creating IoT applications with its intuitive interface, extensive hardware support, and cloud connectivity features. It's a great choice for hobbyists, makers, and IoT enthusiasts looking to build connected projects without a steep learning curve.

3.3.2 IFTTT Platform:

IFTTT (If This Then That) is a web-based service that allows users to create chains of simple conditional statements, called applets, which are triggered based on changes in various online services and devices [16]. Here's an overview of the IFTTT platform:

Features:

1. **Applets:** An applet is a simple conditional statement that consists of a trigger (the "if this" part) and an action (the "then that" part). Users can create custom applets or choose from a library of pre-made ones to automate tasks.

2. **Triggers and Actions:** IFTTT supports a wide range of triggers and actions, allowing users to connect to different online services and devices. Triggers can include events like receiving an email, a new post on social media, or a change in the weather forecast, while actions can include tasks like sending a notification, turning on a smart light, or updating a spreadsheet.

3. **Channels:** IFTTT integrates with various online services and devices through channels. Channels represent the different platforms and services that IFTTT supports, such as Gmail, Twitter, Facebook, Philips Hue, Nest, and many others. Users can connect their accounts to these channels to access their data and trigger actions.

4. **Customization:** Users can customize applets to suit their specific needs by choosing the trigger and action, as well as setting additional parameters or filters. This allows for highly tailored automation workflows.
5. **Cross-Platform Integration:** IFTTT enables cross-platform integration, allowing users to connect services and devices that might not natively work together. For example, users can create applets to automatically save email attachments to cloud storage, or to control smart home devices based on the weather forecast.
6. **Mobile App:** IFTTT offers a mobile app for iOS and Android devices, allowing users to create and manage applets on the go. The app provides a convenient way to stay connected and control automation tasks from anywhere.
7. **Discoverability:** IFTTT provides a curated library of applets created by both the IFTTT team and the user community. Users can explore and discover new applets based on different themes and categories.

Overall, IFTTT simplifies the process of automating tasks and connecting different online services and devices through its intuitive interface and extensive library of applets. It's a versatile platform that can be used for a wide range of automation purposes, from personal productivity to smart home control.

3.3.3 Arduino IDE:

The Arduino IDE (Integrated Development Environment) is the official software used to write, compile, and upload code to the development board. Here's an overview of the Arduino IDE [17]:

Features:

1. **Code Editor:** The Arduino IDE provides a simple yet powerful code editor with syntax highlighting, auto-completion, and other features to facilitate writing sketches (programs).
2. **Built-in Examples:** The IDE comes with a variety of built-in examples covering different functionalities and components, such as blinking LEDs, reading sensors, and communicating with other devices.
3. **Library Manager:** Arduino IDE includes a Library Manager that allows you to easily search for and install additional libraries, expanding the capabilities of your projects. Libraries provide pre-written code for interfacing with specific sensors, displays, communication protocols, and more.
4. **Board Manager:** Arduino IDE supports a wide range of boards. The Board Manager feature installs and manages board definitions, enabling users to program different boards.
5. **Upload Manager:** Once the code is written then use the Upload Manager to compile and upload it to the board. The IDE handles the compilation process, converting the sketch into machine code that the board can execute. Here is the procedure...
6. **Integrated Help:** The Arduino IDE provides integrated documentation and help resources, including reference guides, tutorials, and links to the Arduino website and community forums.

The Arduino IDE's simplicity, ease of use, and extensive documentation make it a great tool for beginners and experienced users alike who want to create interactive electronic projects with Arduino boards.

Chapter 4: Circuit Diagram

4.1 Introduction:

A circuit diagram or wiring diagram is a graphical representation of an electrical circuit [18]. The circuit diagram makes it easier to understand a circuit. Circuit diagrams are essential for IoT (Internet of Things) projects for several reasons:

1. **Component Connection**: They illustrate how different components are connected within the system. This includes microcontrollers (like Arduino or Raspberry Pi), sensors, actuators, and communication modules (like Wi-Fi, Bluetooth, or GSM modules).

2. **Understanding the System**: Circuit diagrams provide a clear visual representation of how the hardware components are structured and connected. This is particularly useful for understanding the flow of data and electricity within the system.

3. **Troubleshooting**: When issues arise during the development or deployment of an IoT project, a circuit diagram can serve as a reference for troubleshooting. It helps in identifying potential points of failure or incorrect connections.

4. **Documentation**: Circuit diagrams serve as important documentation for the project. They provide a detailed overview of the hardware setup, which can be helpful for future reference, replication of the project, or collaboration with others.

5. **Design and Planning**: Before building the physical prototype of an IoT project, having a circuit diagram allows designers and engineers to plan and design the system effectively. It helps in determining the layout of components on a breadboard or PCB, as well as estimating power requirements and potential interferences.

6. **Safety**: Understanding the circuit layout is crucial for ensuring safety, especially when dealing with high voltages or sensitive components. A clear diagram helps in identifying potential safety hazards and taking necessary precautions.

Overall, circuit diagrams are indispensable tools for designing, implementing, and maintaining IoT projects, providing clarity, understanding, and a roadmap for successful development and operation.

4.2 Circuit Diagram of Master Bedroom:

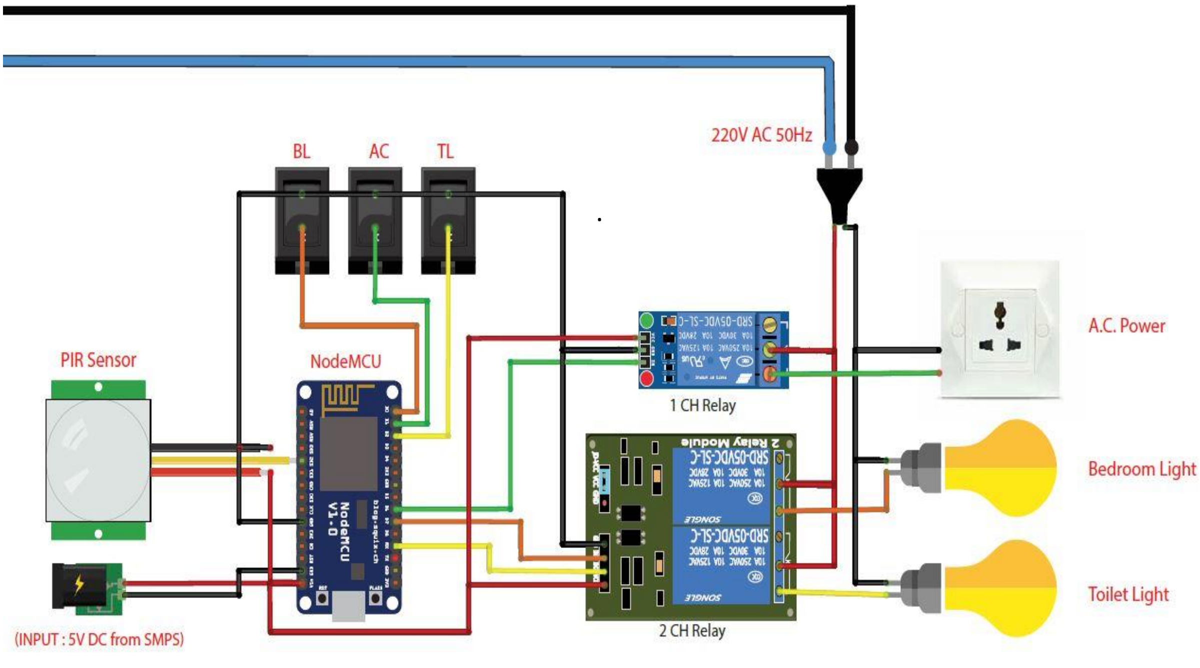


Fig-4.1: Circuit diagram of the master bedroom.

In the master bedroom nodemcu, ESP 8266 development board is used for controlling the master bedroom for all electrical appliances. In the master bedroom, two lights are connected with the ESP 8266 board through a double-channel relay and one 3-pin socket for air-conditioner power purposes is connected through a single-channel relay. Besides, a motion sensor is directly connected to the ESP 8266 board. Here, three electrical switches are also connected to the board for manual control of the electrical appliances (two lights and one air-conditioner). When the relay gets a signal from ESP 8266 then it will connect the appliances with the AC source and the appliances will activated.

4.3 Circuit Diagram of Bedroom:

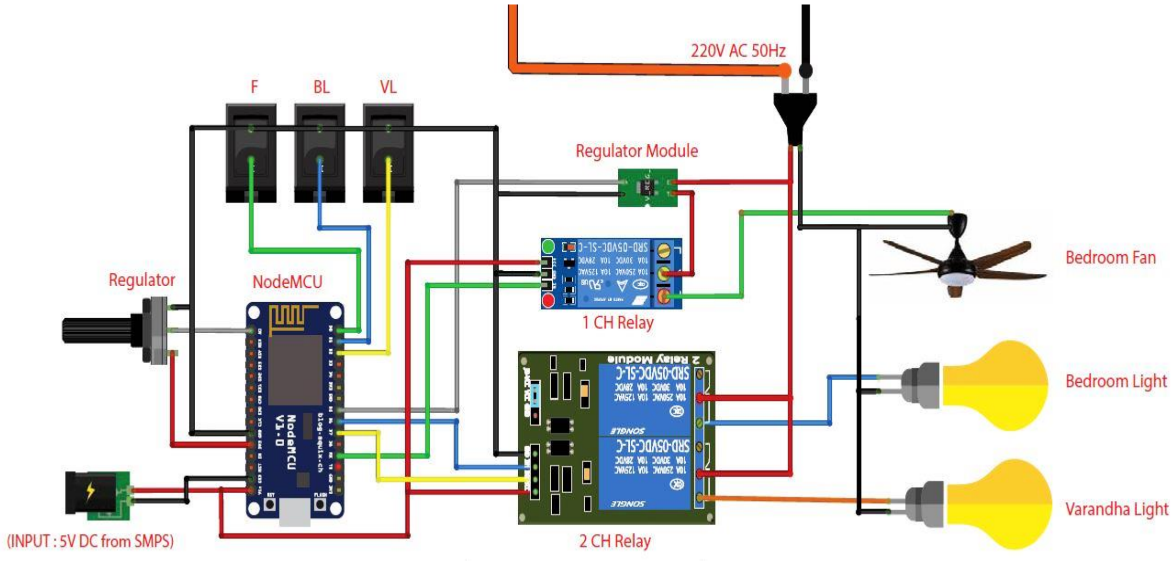


Fig-4.2: Circuit diagram of the bedroom.

In the bedroom nodemcu, ESP 8266 development board is used for controlling the bedroom for all electrical appliances. In the bedroom, two lights are connected with the ESP 8266 board through a double channel relay and one 3 fan is connected through a single channel relay. Besides, a fan dimmer is directly connected to the ESP 8266 board. The ESP 8266 board is connected to a 5V DC source as the power supplier of the board. Here, three electrical switches are also connected to the board for manual control of the electrical appliances (two lights and one fan). When the relay gets a signal from ESP 8266 then it will connect the appliances with the AC source and the appliances will activated. An electronic device named Triac is used for controlling the fan speed virtually from the smartphone application.

4.4 Circuit Diagram of Kitchen and Dining:

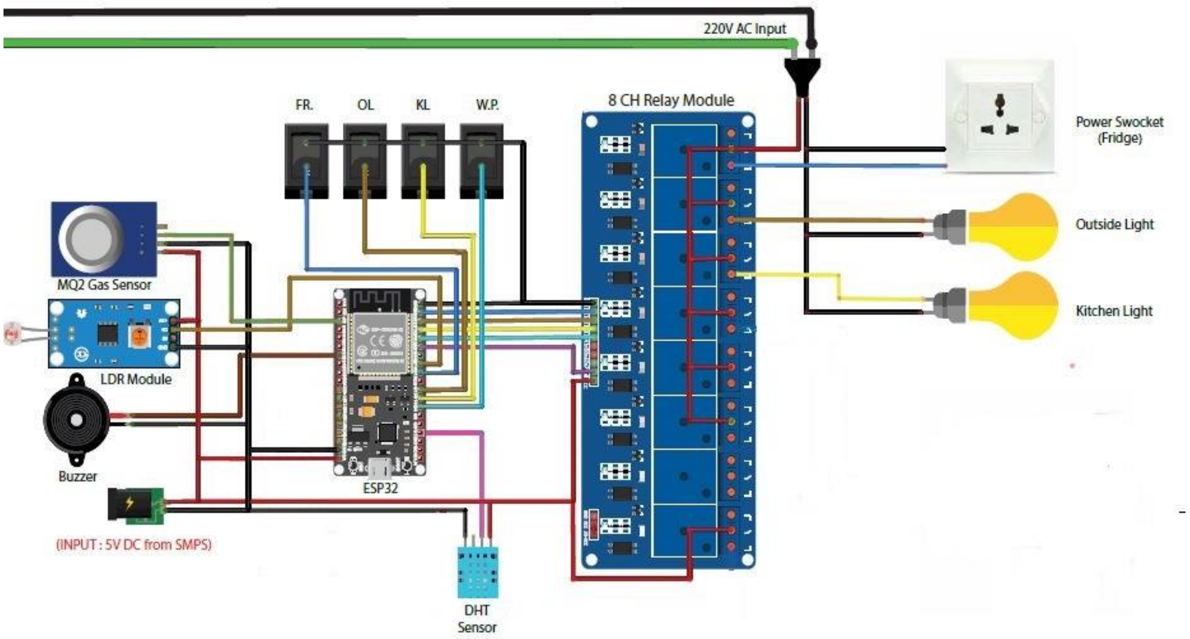


Fig-4.3: Circuit diagram of the kitchen and dining.

In the kitchen and dining ESP 32 development board is used for controlling the kitchen and dining for all electrical appliances. The kitchen light, dining refrigerator socket, outside light, one water lifting pump, and a solenoid door lock are connected with the ESP 32 board through an 8-channel relay. Besides, one gas and smoke sensor, one LDR module, one buzzer, and one humidity and temperature sensor are directly connected to the ESP 32 board. Here, four electrical switches are also connected to the board for manual control of the electrical appliances (light, refrigerator, water pump, and solenoid door lock). When the relay gets a signal from ESP 32 then it will connect the appliances with the AC source and the appliances will activated. An electronic device named Triac is used for controlling the fan speed virtually from a smartphone application.

4.5 Circuit Diagram of SDB:

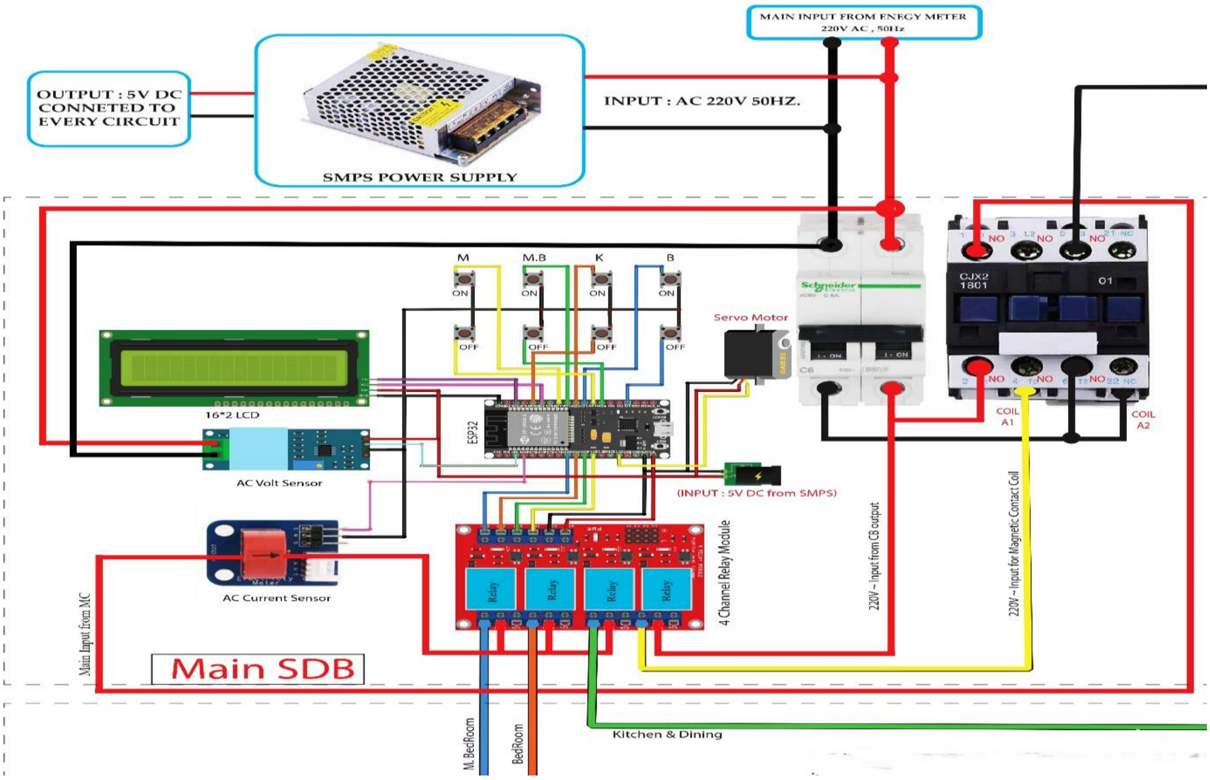


Fig-4.4: Circuit diagram of main SDB.

In the SDB ESP 32 development board is used for controlling the master bedroom, bedroom kitchen, and dining main AC power through three relays. Here, a total of eight push-button switches are also directly connected with the Esp 32 board so that the individual room main power is also controlled through the manual switch. In the SDB there is a voltage sensor and a current sensor is used with an ESP 32 board that continuously monitors the system's incoming voltage and current. When ESP 32 founds the system current or voltage crosses the acceptance value that is given in the program then it immediately shuts down the magnetic contactor through a relay and by following this circuit breaker is also tripped immediately with the help of a servo motor. Thus the system remains safe from abnormal current and voltage. There is an LCD in front of the SDB board for real-time various data monitoring purposes such as current, voltage, power, etc. A DC power supply is also used in SDB to give power supply (SMPS) to the development board and other components.

4.6 Circuit Diagram of Full Project:

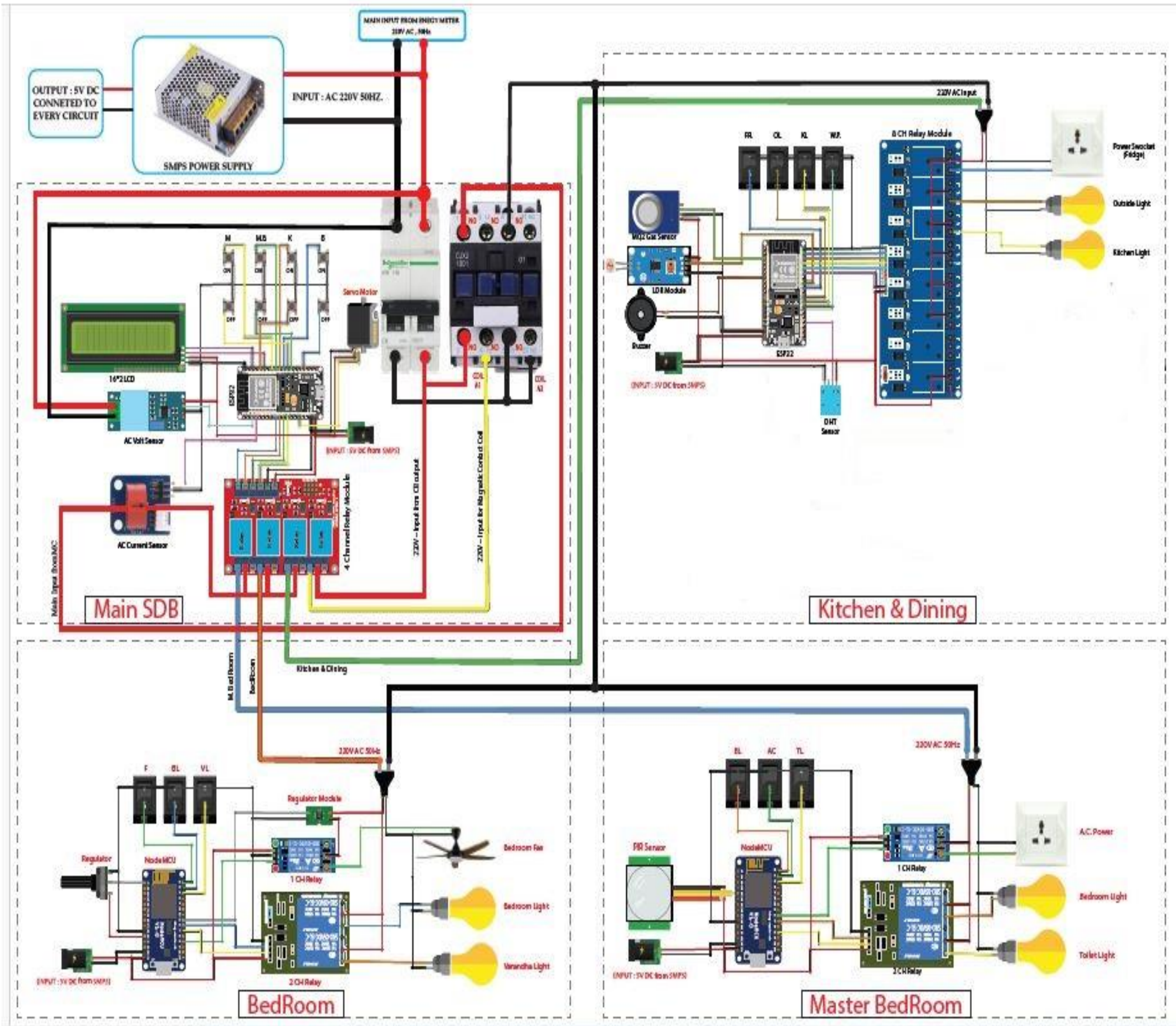


Fig-4.5: Circuit diagram of the full project.

This is the full circuit diagram of this project. This full circuit diagram shows every component along with all appliances (sensors, development boards, light, fan, switch, circuit breaker, etc.) and electrical connection at a glance.

Chapter 5: Project Implementation

5.1 Introduction:

Project implementation refers to the process of putting plans, strategies, and ideas into action to achieve the objectives of a specific project. It involves the practical execution of tasks, outlined in the project plan, allocation of resources, and coordination of activities to ensure that the project is completed successfully and delivers the desired outcomes. Effective project implementation is essential for achieving project success. It requires strong focus, positive thinking, and a hardworking mentality throughout the implementation process until the target outcome is achieved

5.2 Hardware components assembling:

As per the design and drawing hardware components need to be fixed at the plywood board. For this reason, first need to sketch the room layout plan on the board. After the room layout drawing, fixed the hardware material such as light, fan, sensor, switch socket, circuit breaker, magnetic contactor, etc. on the ply board by following the drawing using screws and glue. The IoT devices such as the development board, relay, and SMPS power supply fixed on the backside of the board for simplicity. After completing the all hardware components and IoT devices implementation, then complete the electrical cable wiring between them. I have followed wiring diagrams or pinout references provided by the component manufacturers or project guides to ensure correct connections. After assembling and wiring all hardware components, test the connections to ensure that all sensors and communication modules are properly interfaced with the microcontroller board. If any issues arise during testing, debug and troubleshoot the hardware connections to identify and resolve the problem. Check for loose connections, incorrect wiring, or faulty components that may be causing issues. Once all hardware components are properly assembled and tested, finalize the assembly by securing any loose connections, tidying up the wiring, and ensuring that the enclosure is properly closed and sealed.

Here is a real picture of the hardware components implementation.

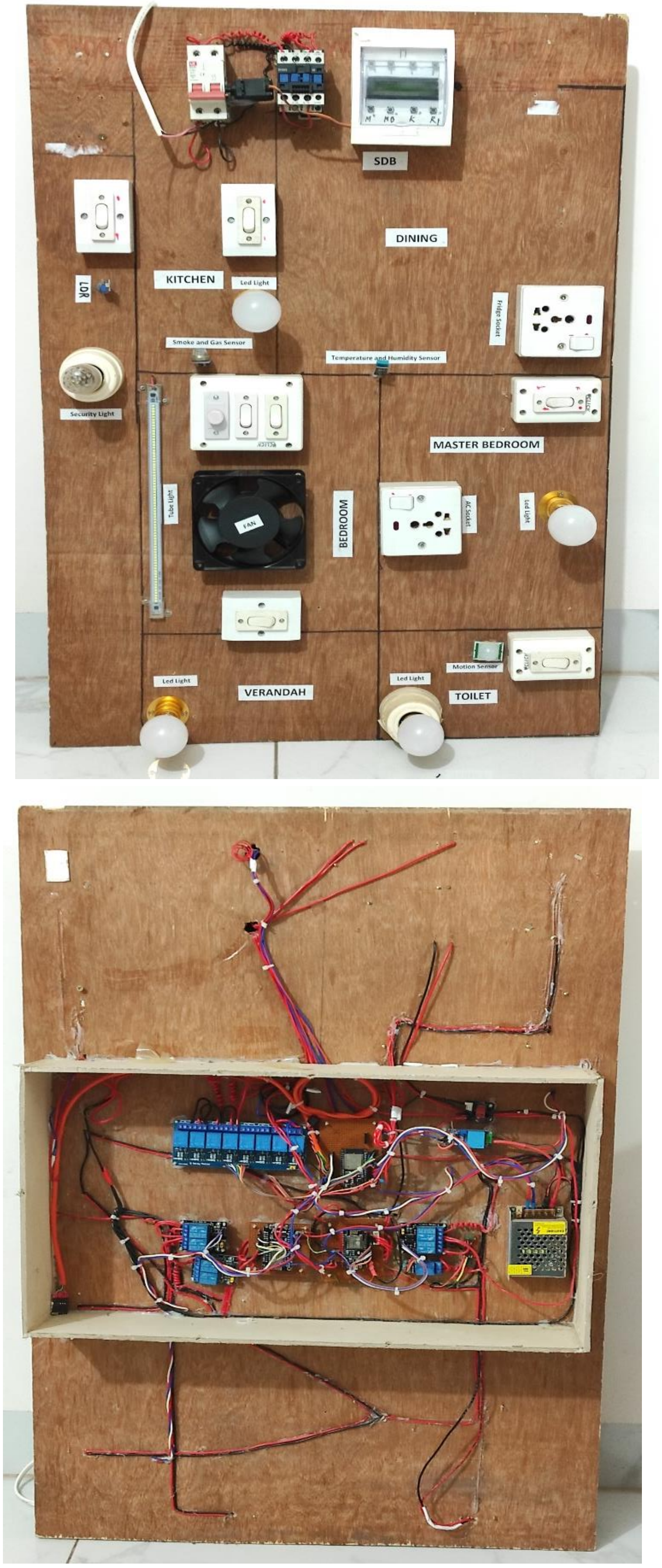


Fig-5.1: Hardware components implemented in the project.

5.3 Code Uploading:

Coding for an IoT (Internet of Things) project involves writing software that enables devices to communicate, collect data, and perform tasks within an IoT ecosystem. Coding for the ESP32 or ESP 8266 development board with Arduino IDE is a popular choice for developing IoT projects due to its simplicity and ease of use. For this reason, in this project, coding write and uploading work completed using Arduino IDE software. Here's a basic guide [19] to get started:

1. Install Arduino IDE:

- Download and install the Arduino IDE from the official website (https://www.arduino. cc/en/software) and then open Arduino IDE.

2. Select Board:

- Go to Arduino IDE > Tools > Board and select your ESP32 or ESP 8266 board from the list of available options. Choose the appropriate board variant and settings based on your specific ESP32 or ESP 8266 development board.

3. Write Sketch:

- Select a new sketch.
- Write the code in the Arduino IDE editor. Users can use familiar Arduino functions and libraries to interact with GPIO pins, serial communication, analog inputs, etc.
- Make sure to include the necessary libraries for the project by going to Arduino IDE > Sketch > Include Library > Manage Libraries.

4. Upload Sketch:

- Connect the ESP32 or ESP 8266 development board to the computer via USB.
- Go to Arduino IDE > Tools and configure the following settings:
- Board: Select ESP32 or ESP8266 board.
- Port: Select the port to which your ESP32 is connected (e.g., COM3)
- Click the Verify button (checkmark icon) to compile the code.
- Once compiled without errors, click the Upload button (right arrow icon) to compile the sketch and upload it to the ESP32 or ESP 8266 board.

5.4 Application Configuration:

Application configuration refers to the process of setting up and customizing software applications to meet specific requirements or preferences. It involves adjusting various parameters and settings within the application to optimize its functionality, behavior, and performance according to the needs of the user.

5.4.1 BLYNK Set Up:

To get started with BLYNK, need to follow these steps [20]:

1. **Sign Up:** Create an account on the BLYNK platform.
2. **Create a New Project:** Start a new project in the BLYNK app or web dashboard.
3. **Select Hardware:** Choose the hardware platform (Arduino, Raspberry Pi, etc.) and connectivity option (Wi-Fi, Bluetooth, etc.) for your project.
4. **Design User Interface:** Use the drag-and-drop interface to design the user interface for your mobile app, adding widgets to control and monitor your devices.
5. **Write Code:** Write code for the hardware device using the BLYNK library. This code establishes communication between the device and the BLYNK cloud server. Here, are the four simple steps to configure the code [21].
   - i. Open Arduino IDE and install the BLYNK library
   - ii. Define Template ID and Device Name on top of your firmware, before any includes
   - iii. Define your physical button and LED if needed
   - iv. Upload this sketch to your test board.
6. **Connect Devices:** Connect your hardware device to the BLYNK cloud server using the authentication token provided in your project settings.
7. **Test and Deploy:** Test the BLYNK app to ensure that it's working correctly, then deploy it to the devices for real-world use.

5.4.2 IFTTT Set Up:

To get started with IFTTT, users typically follow these steps [22]:

1. **Sign Up:** Create an account on the IFTTT platform through the website or mobile app.
2. **Connect Channels:** Connect the online services and devices that you want to integrate with IFTTT by linking your accounts to the corresponding channels.
3. **Create Applets:** Create custom applets by selecting a trigger channel and event, then choosing an action channel and task to perform when the trigger occurs.
4. **Customize Applets:** Customize applets by adding additional parameters or filters to refine their behavior, if necessary.
5. **Activate Applets:** Activate applets to start automating tasks based on the specified conditions.
6. **Explore and Discover:** Explore the library of pre-made applets or create new ones based on your needs and preferences.

Chapter 6: Results and Discussion

6.1 Results:

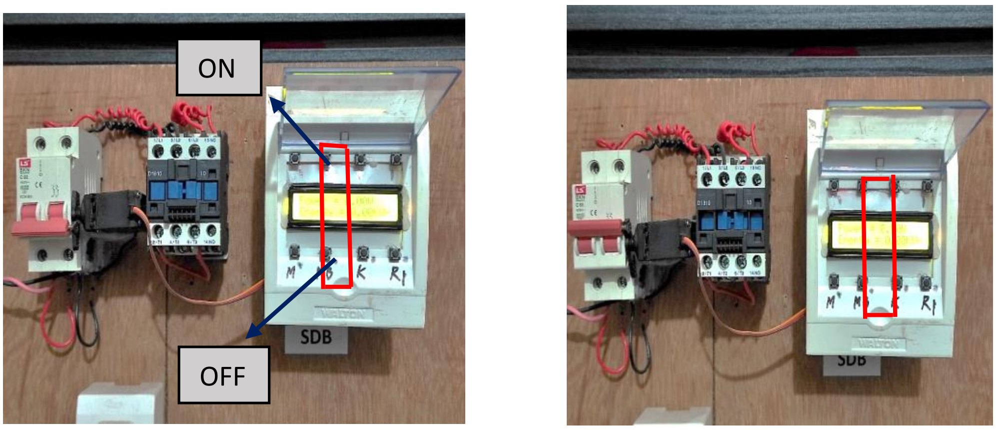
After successfully projecting hardware item implementation and software platform setup, I checked the overall system. The findings are given below…

1. Light and fan control:

All lights and fans including fan speed have been easily controlled without any delay through a smartphone virtual switch or voice and also manual switches. Besides, the real-time live status of the home appliances has been observed from anywhere with the help of the internet.

2. SDB devices control:

The main circuit breaker including the magnetic contactor has been smoothly controlled through a smartphone virtual switch or voice. Besides, individual room main circuit power also has been controlled by pressing the virtual switch through the smartphone BLYNK application or manual push switch.



OFF State ON State

Fig-5.2: Main circuit ON and OFF state.

3. Data monitoring:

It has been easy to monitor and observe real-time data such as current, voltage, power, temperature, humidity, etc. from a smartphone.

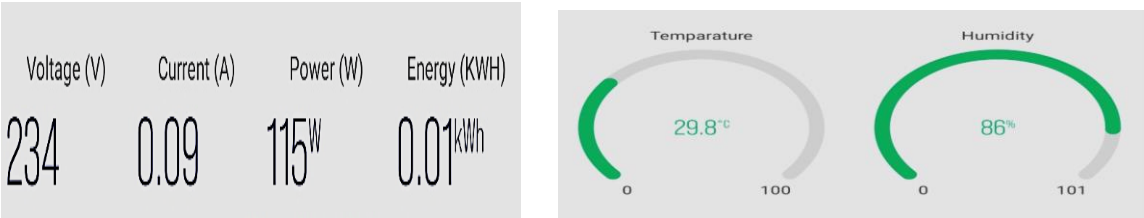


Fig-5.3: Real-time live data monitoring.

4. Sensor Features:

1. The toilet light is automatically turning ON and OFF depending on movements. After switching ON, if the light does not find any movements within 10 sec then it will automatically switch OFF and save electricity.
2. The outside Security light has been turning OFF when it finds daylight in the morning and it turns ON automatically when the LDR sensor finds dark in the evening.
3. When gas and smoke in the kitchen cross the acceptance level then the gas and smoke sensor sends a notification to the smartphone along with switching a buzzer and the buzzer does not stop until the gas or smoke level is below the set value in the microcontroller.

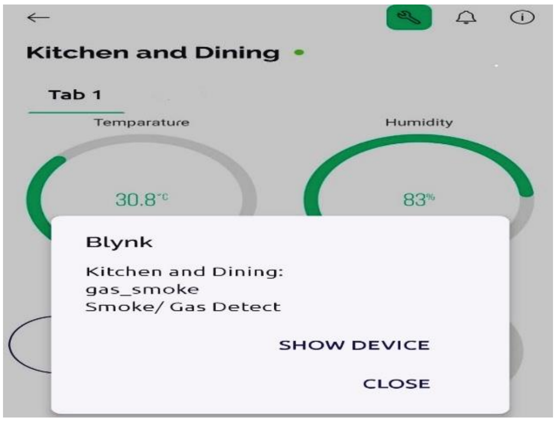


Fig-5.4: Gas and smoke alarm notification.

4. All sensor mode facilities are easily turned OFF by the smartphone BLYNK application and in that case, appliances are working in a normal way.

6.2 Performance Analysis:

Overall, the system is working very smoothly. All lights and fan remotely ON/OFF are very quick and fast without any delay. Besides, the circuit breaker is remotely ON/OFF with the help of the servo motor smoothly. Moreover, all the sensors have a quick response through the microcontroller as programmed and give various real-time actual data for monitoring. So, the overall performance of this IoT-based home appliances smart control system project has been satisfactory till now.

6.3 Project BLYNK Application Interface:

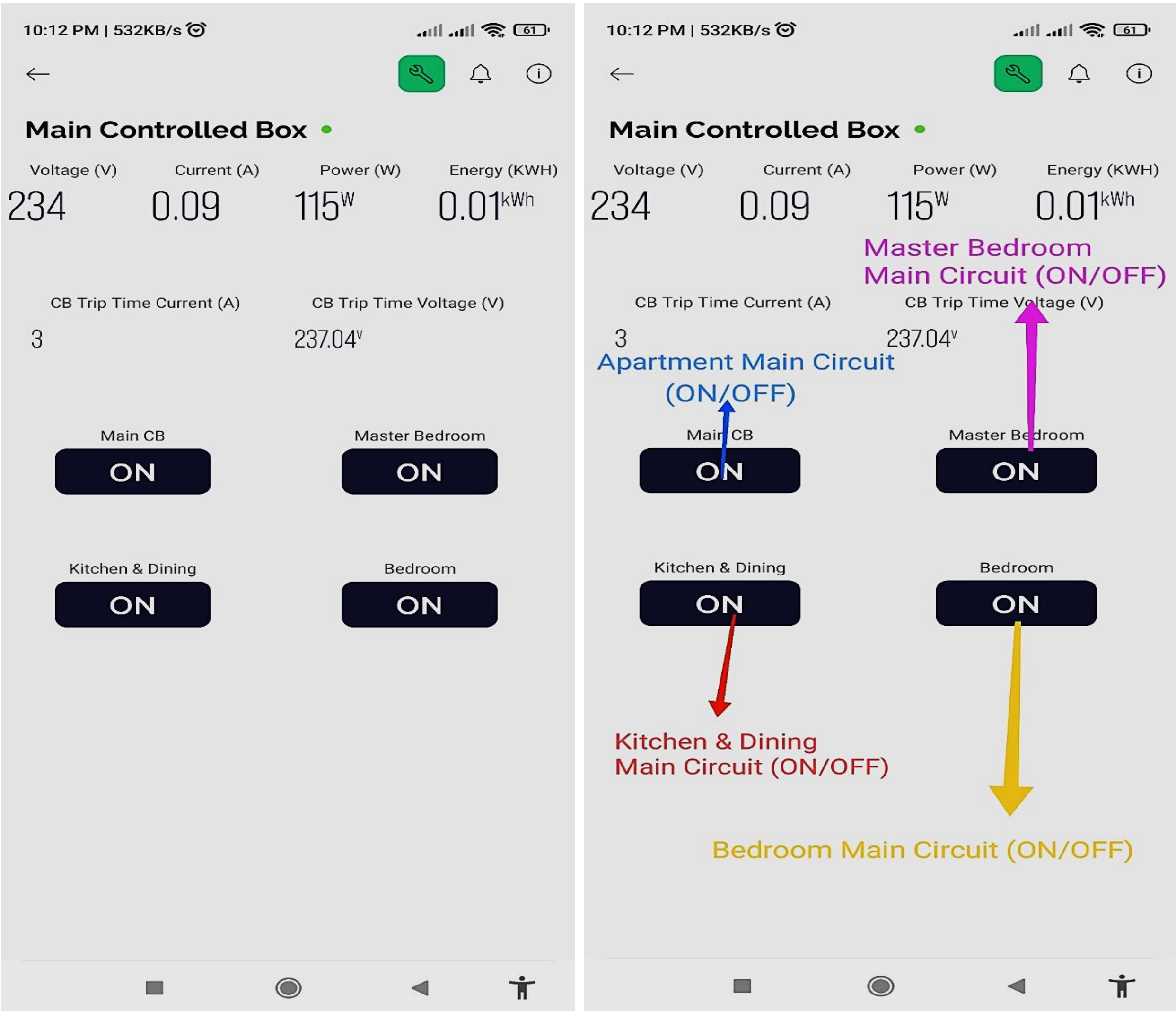


Fig 6.1: Main SDB interface of BLYNK application.

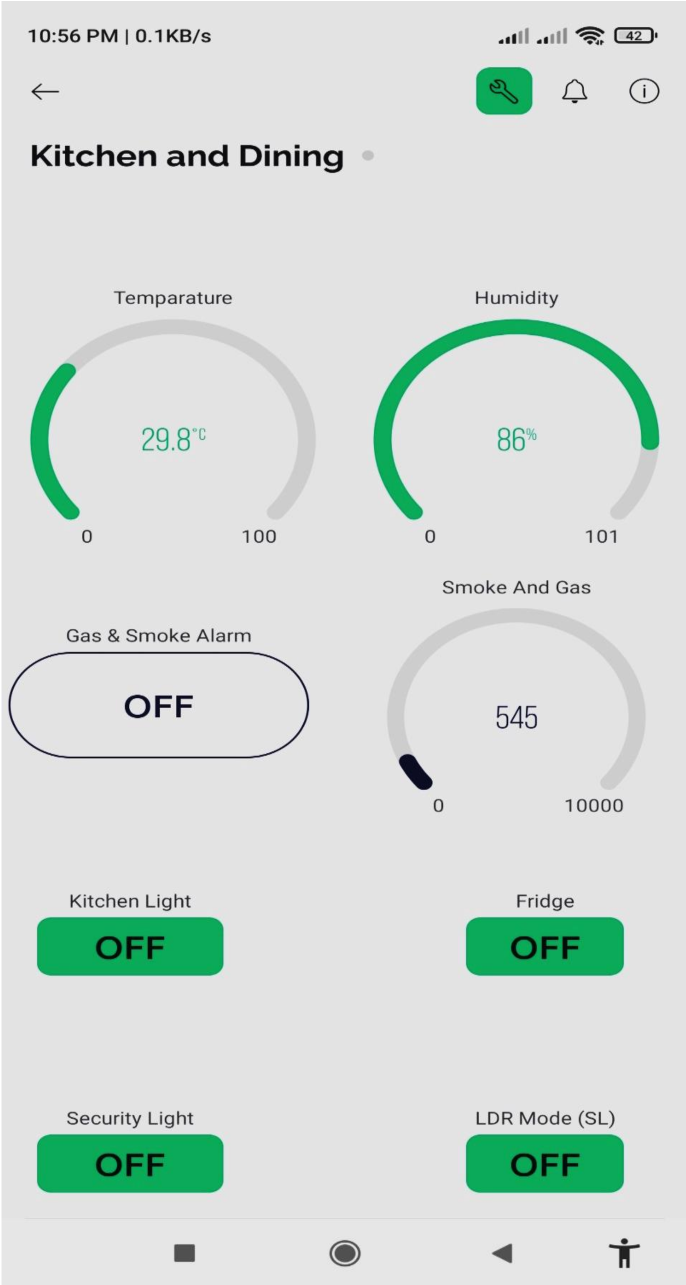


Fig 6.2: Kitchen and dining interface of BLYNK application.

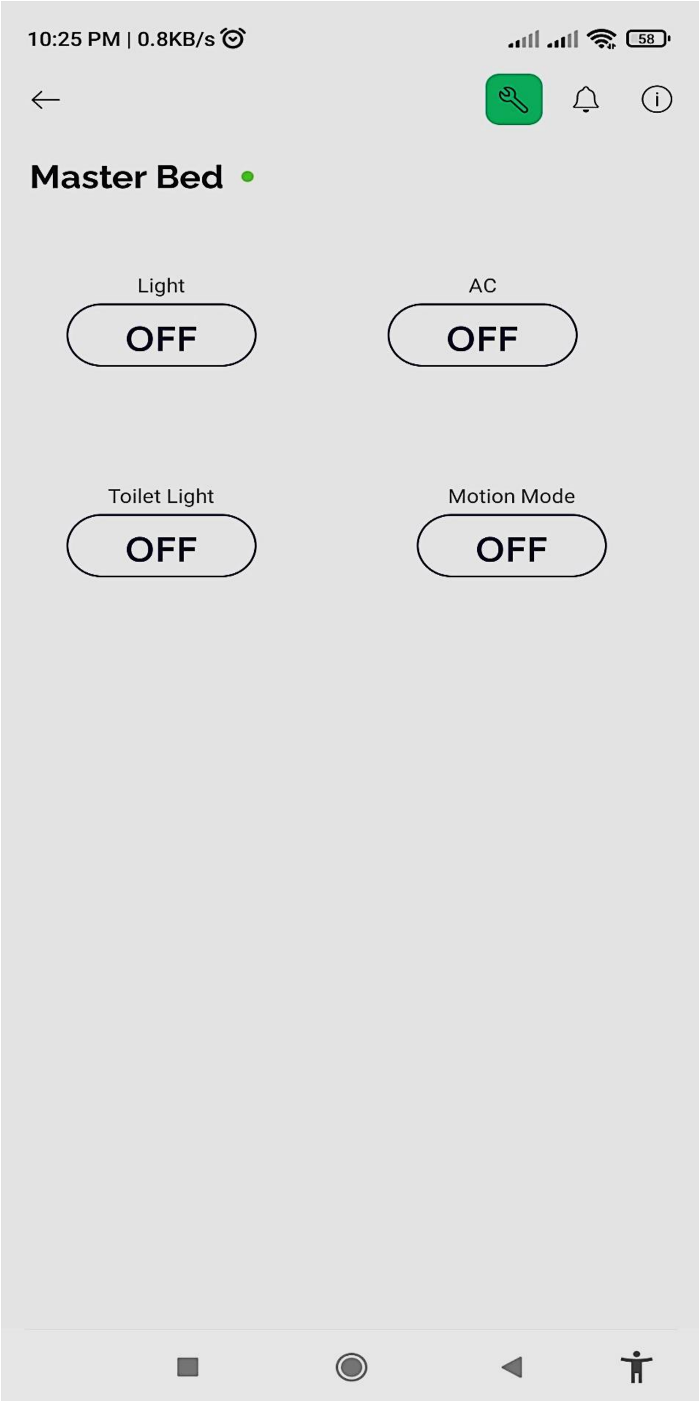


Fig 6.3: Master bedroom and bedroom interface of BLYNK application.

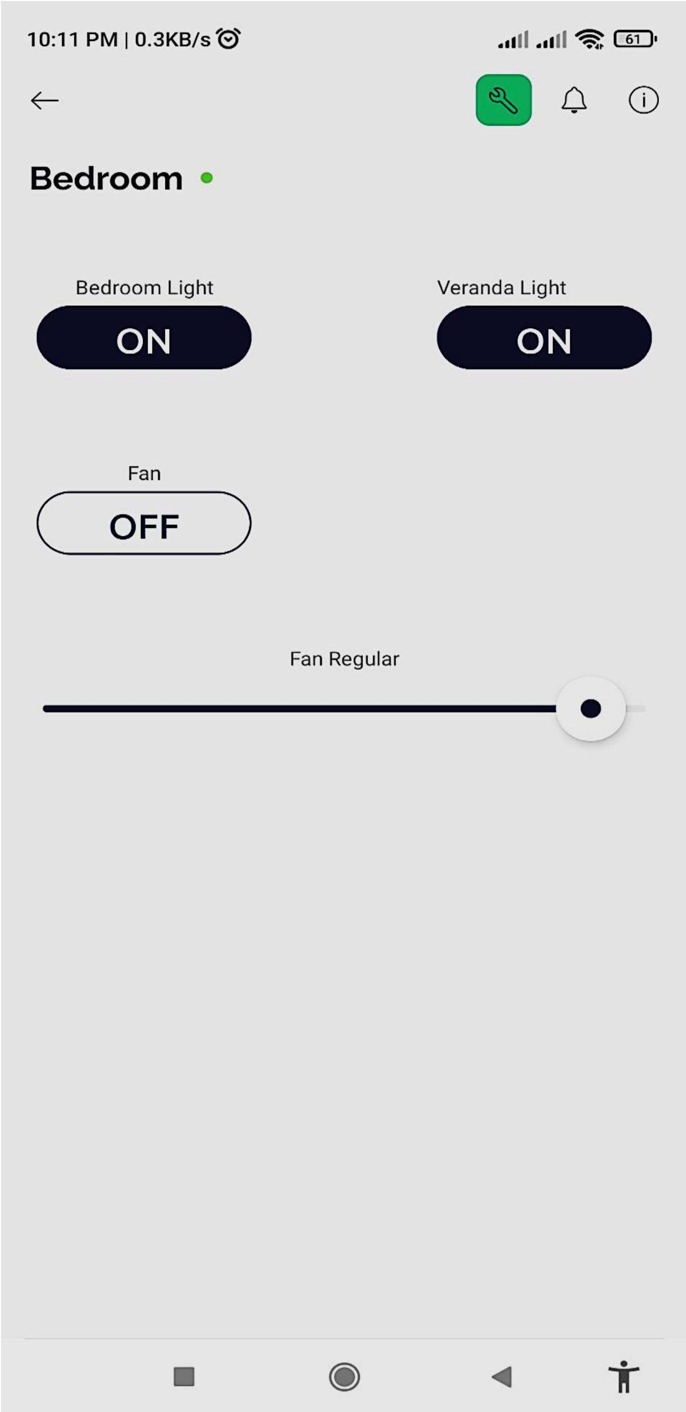


Fig 6.4: Bedroom interface of BLYNK application.

6.4 Project IFTTT Platform Interface:

Fig 6.5: Home appliances voice control IFTTT Platform interface.

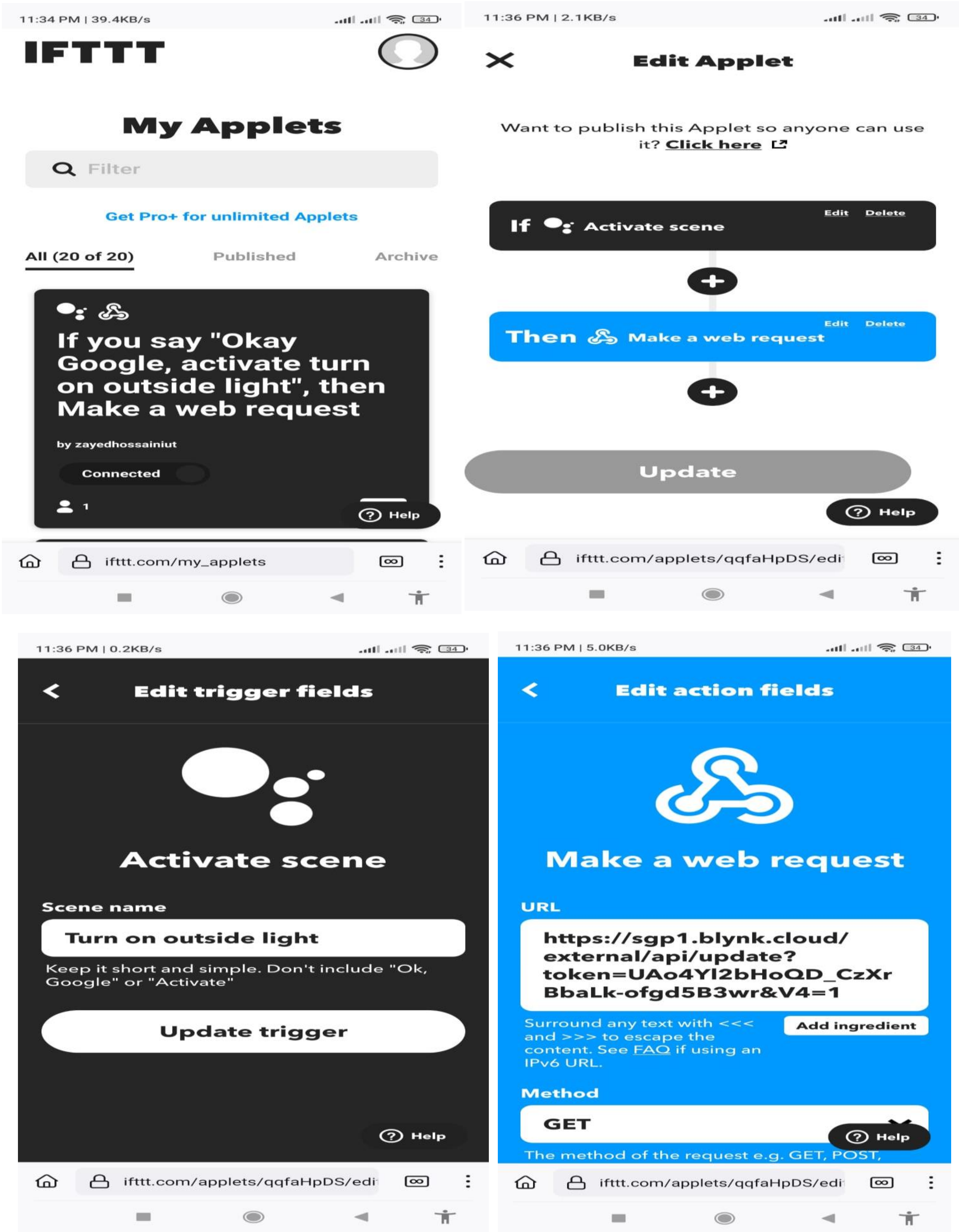


Fig 6.6: IFTTT activated sense.

Chapter 7: Conclusion, Limitations, and Future Prospect

7.1 Conclusion:

In conclusion, IoT-based home appliance smart control systems offer significant benefits in terms of convenience and energy efficiency. By integrating various hardware components and leveraging internet connectivity, these systems enable users to remotely monitor and manage their home appliances and devices from anywhere in the world using smartphones, tablets, or computers. This project involves the development of a prototype IoT-based home appliances smart control system that is a more user-friendly, cost-effective, and more secure system for home appliances. The system uses popular open-source hardware and popular user-friendly software platforms that make it easy to customize and modify based on the user's requirements. This proposed project is very flexible and can be easily expanded and applied to larger buildings by increasing the number of sensors, measured parameters, and control devices. More functionality and smartness could be also added to the existing system to make the home appliance smart control system grow, adapt, and evolve by itself using advanced artificial intelligence. However, it's essential to consider potential challenges such as cyber security risks, interoperability issues between different devices and platforms, and privacy concerns associated with collecting and storing sensitive data.

Overall, IoT-based home appliance smart control systems have the potential to revolutionize modern living by offering greater convenience, energy efficiency, security, and customization options for homeowners. In the future, with advanced AI systems and research, this IoT-based home appliance smart control system may permit automatic judgment and avoid human intervention. Thus, it will reduce waste electricity, provide an efficient controlling system, and also help to decrease the maintenance cost.

7.2 Limitation:

In this project, there are some limitations which are described below….

- Without internet access, a smartphone or web interface cannot control the devices.
- Sometimes a little delay is observed depending on network conditions.
- BLYNK and IFTTT are paid platforms so users have to pay monthly to renew their subscription.
- During voice commands, external noises may affect the result. The speech instruction we command in the voice mode sometimes may not give the exact result as expected.

7.3 Future Prospect:

There is a lot of future work scope, including:

- Can be developed own application system. By which the monthly subscription fee of BYLINK and IFTTT is fully omitted and thus project cost will be reduced.
- Can be used keypad/fingerprint /face verification/voice verification lock system in the main door.
- Advanced home security systems such as the automatic alert system or auto door lock system detect unauthorized activity.
- Can be added energy efficient lighting system by adjusting brightness automatically depending on the user's work activity.
- Can be added Home air quality and water quality monitoring systems because both are vital parts of a healthy life.
- Can be added smart curtain-controlling system by which users can control the amount of light entering the home.
- Smart garage door openers by which users open and close garage doors.

Appendix-1

1. Microcontroller:

This is the brain of the smart home appliances control system. It processes commands received from the mobile device and controls the operation of the appliances accordingly. Popular choices include microcontrollers like Arduino, and Raspberry Pi, or specialized IoT development boards such as ESP 32, ESP 8266, etc. [23]. In this project, separate ESP 32 and ESP 8266 development boards are used as the main hardware platform.

1.1 ESP 32 Development Board:

The ESP32 is a powerful microcontroller and system-on-chip (SoC) that's widely used in IoT (Internet of Things) projects, including smart home automation. It integrates a dual-core processor, Wi-Fi and Bluetooth connectivity, GPIO pins, analog-to-digital converters (ADC), and other peripherals into a single chip. ESP32 was created and developed by Espressif Systems, a Chinese company based in Shanghai, and is manufactured by TSMC using its 40 nm process [24].

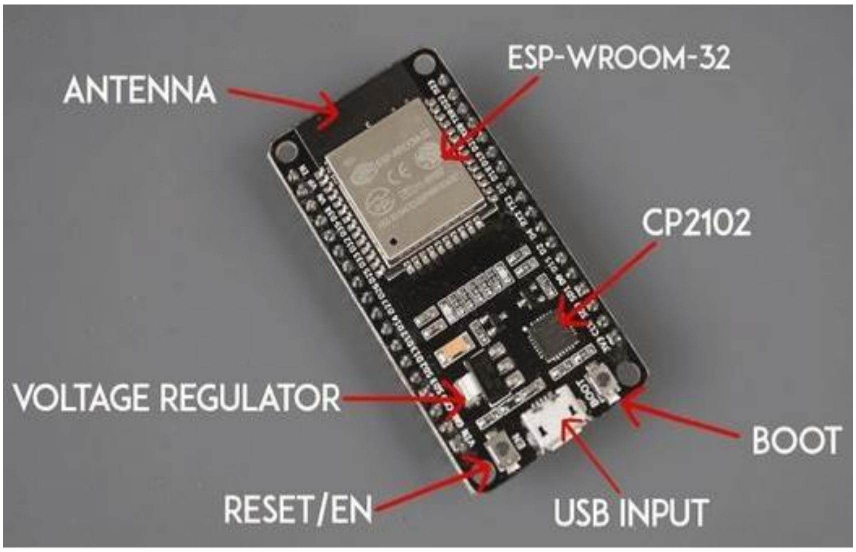


Fig-1: ESP 32 development board specification [25].

1.2 ESP 8266 Development Board:

The ESP8266 is a low-cost, low-power microcontroller with built-in Wi-Fi capabilities. It is commonly used in Internet of Things (IoT) devices because of its ability to connect to Wi-Fi networks and make HTTP requests [26]. The ESP8266 Wi-Fi microchip is produced by Espressif Systems [27]. The Wi-Fi module is compatible with the 802.11 b/g/n standard at 2.4 GHz, has an integrated TCP/IP stack, 19.5 dBm output power, data interface (UART / HSPI / I2C/I2S/Ir Remote Control GPIO/PWM) and PCB antenna.
It also has a micro USB connector and a reset button. Programmable with Arduino IDE, it includes interpreters for processing commands for languages such as LUA.

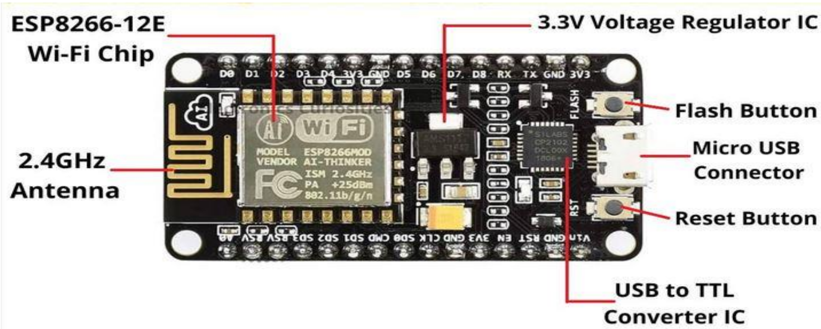


Fig-2: ESP 8266 development board specification [28].

With its low cost, small size, and adaptability with embedded devices, the ESP8266 is now used extensively across IoT devices. Although it's now been succeeded by the newer generation ESP32 microcontroller chip, the ESP8266 is still a popular choice for IoT developers and manufacturers.

2. Relay Module:

A relay module is an essential component in IoT (Internet of Things) projects, especially when needed to control high-voltage devices or appliances remotely. A relay is an electrically operated switch. It allows you to control high-power devices (such as lights, fans, heaters, etc.) using a low-power signal (usually from a microcontroller or a sensor) [29].

Fig-3: Relay module [30].

That means, it physically controls the power supply of the appliances. They're typically connected to the microcontroller and can be toggled on or off based on the commands received from the mobile application.

3. Sensors:

Depending on the functionality desired, it might be integrated various sensors into the system. For example, temperature and humidity sensors, gas and smoke sensors, motion sensors, LDR sensors, current sensors, and voltage sensors are used in this project for various real-time data monitoring purposes.

3.1 Temperature and Humidity Sensor:

Temperature and humidity sensors are devices that can convert temperature and humidity into electrical signals that can easily measure temperature and humidity. In this project, DHT11 sensor is used to measure the amount of temperature and relative humidity in the air inside the room.

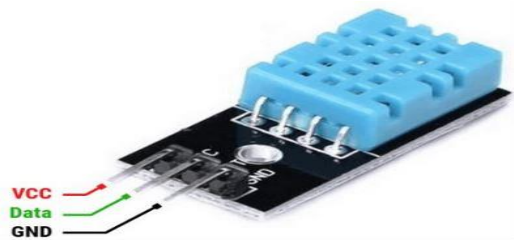


Fig-4: DHT 11 temperature and humidity control sensor [31].

The DHT11 is a digital sensor that measures both temperature and humidity. It consists of a capacitive humidity sensor and a thermistor for temperature measurement. The sensor provides a digital output that can be read by a microcontroller or other digital devices. Its temperature Range: is 0°C to 50°C and its humidity Range: is 20% to 90% RH (Relative Humidity). The DHT11 provides temperature readings with an accuracy of ±2°C and humidity readings with an accuracy of ±5% RH [32]. The DHT11 communicates using a simple protocol making it easy to interface with popular microcontrollers like Arduino, Raspberry Pi, ESP8266, ESP32, etc. The DHT11 is a commonly used temperature and humidity sensor in many IoT projects due to its simplicity, low cost, and ease of use.

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3.2 Smoke and Gas Sensor:

Smoke and gas sensors are critical components in IoT systems aimed at enhancing safety and security in various environments. These sensors detect the presence of harmful gases or smoke in the air and trigger appropriate actions, such as sounding alarms, sending notifications, or activating ventilation systems. In this project, the MQ2 gas and smoke sensor is used to sense the gas and smoke levels in the kitchen area.

Fig-5: MQ2 Gas and Smoke sensor [33].

MQ2 Gas sensor is a Metal Oxide Semiconductor (MOS) type Gas Sensor mainly used to detect gases like Methane, Butane, LPG, Smoke, etc. It is also known as Chemiresistors as gas detection is based on the change of resistance of the sensing material when the Gas comes into contact. If you want to measure a different type of Gas you can check these Gas Sensors. The MQ2 sensor typically operates at a voltage of around 5V DC and consumes a low amount of power. The sensor provides an analog output voltage proportional to the concentration of the detected gas. This analog signal can be read by an analog-to-digital converter (ADC) of a microcontroller for further processing and analysis. The MQ2 sensor can be easily integrated into IoT systems using microcontrollers such as Arduino, Raspberry Pi, or ESP32/ESP8266. The sensor's analog output can be interfaced with the microcontroller's ADC pin for gas concentration measurement. The measured data can then be processed, transmitted to the cloud, and visualized using IoT platforms or applications [34].

3.3 Motion Sensor:

Motion sensors are essential components of IoT (Internet of Things) systems, enabling the detection of movement within a designated area. These sensors can be integrated into various smart devices and applications for security, automation, and energy efficiency purposes. The HC-SR501 is a popular passive infrared (PIR) motion sensor module commonly used in IoT projects. In this project, the PIR HC-SR501 motion sensor is used to detect the motion in the toilet, and depending on the motion the toilet light is automatically switched ON/OFF.

Fig-6: HC-SR501 motion sensor [35].

The HC-SR501 operates based on passive infrared technology. It detects changes in the infrared radiation emitted by objects within its detection range. When a warm body moves across its field of view, the sensor detects the change in infrared energy and triggers an output signal. The detection range of the HC-SR501 can be adjusted using its onboard potentiometers. Typically, it can detect motion within a range of a few meters [36].

3.4 LDR Sensor:

LDR (Light Dependent Resistor) sensors, also known as photoresistors, are widely used in IoT applications for detecting ambient light levels. A light-dependent resistor is a type of passive electronic sensor used to detect light. It’s made up of two conductors separated by an insulator which becomes more conducting when exposed to light levels of light intensity, forming a variable resistor in the circuit.

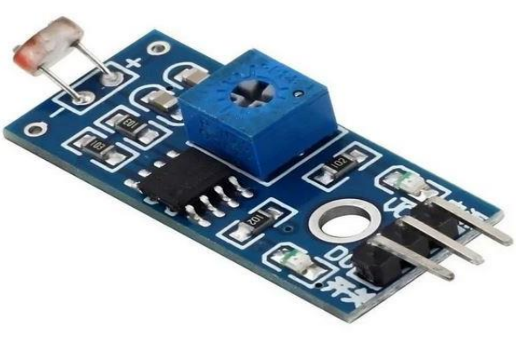


Fig-7: LDR sensor [37].

This allows it to measure the amount of brightness or darkness within its environment and provide information accordingly. These sensors are typically used as a part of automated lighting control systems for energy conservation purposes such as dimming lights based on natural daylight that can be detected outside without human intervention [38]. In this project, an LDR sensor is used for the outside security light auto-controlling and saved electricity.

3.5 Current Sensor:

Current sensors for IoT applications are used to measure the flow of electric current in a circuit. They are crucial for monitoring power consumption, detecting faults, and ensuring efficient operation of electrical systems. In this project, the HW670 current sensor is used for measuring the main circuit current for calculating the total power in the system as well as the overload current.

Fig-8: HW670 current sensor [39].

The HW670 utilizes the Hall Effect principle to measure the flow of electric current in a conductor. When current passes through the primary conductor (typically a busbar or cable), it generates a magnetic field perpendicular to the direction of current flow. The Hall sensor inside the HW670 detects this magnetic field and produces an output voltage proportional to the current being measured. The HW670 offers high accuracy and linearity over its specified measurement range [40]. This ensures precise measurement of current, making it suitable for applications where accurate current monitoring is essential. When the microcontroller board finds an abnormal current than the set current then the microcontroller board immediately shuts down the system for the home appliances safety purpose.

3.6 Voltage Sensor:

A voltage sensor is a device that measures the voltage of an electrical circuit. The ZMPT101B is a voltage sensor module commonly used for measuring AC voltage in IoT applications and electronic projects. In this project, the ZMPT101B voltage sensor is used for measuring the main input voltage of the system.

Fig-9: ZMPT101B voltage sensor [41].

The ZMPT101B utilizes a transformer-based design to measure AC voltage. It consists of a transformer with a primary winding connected to the AC voltage source to be measured and a secondary winding connected to the sensor circuitry. The sensor circuitry includes a rectifier and conditioning circuitry to convert the AC voltage into a proportional DC voltage suitable for measurement. The ZMPT101B voltage sensor module is typically designed to measure low to moderate AC voltage levels, commonly in the range of 0 to 250 volts AC [42]. The measurement range may vary depending on the specific model and configuration. The output signal of the ZMPT101B is a DC voltage proportional to the measured AC voltage. This voltage signal can be interfaced with a microcontroller, analog-to-digital converter (ADC), or other electronic devices for further processing and analysis. The output voltage typically scales linearly with the input AC voltage. The ZMPT101B offers high accuracy and linearity over its specified measurement range, making it suitable for various voltage measurement applications.

4. Servo Motor:

Servo motors are widely used in IoT applications for controlling the position, speed, and movement of mechanical components. These motors offer precise control over angular rotation and are commonly used in robotics, automation, and various electronic projects. In this project, the MG995 servo motor is used to control the main circuit breaker from a remote place using the IoT platform BLYNK with the help of the internet.

Fig-10: MG995 servo motor [43].

The MG995 typically operates with a pulse width modulation (PWM) signal. For MG995 servo motor needs to connect the signal wire of the servo to a PWM-capable pin on the microcontroller, such as an Arduino Raspberry Pi, or ESP development board. The MG995 usually operates at around 5V-7V [44].

5. **Magnetic Contactor**:

A magnetic contactor is an electromechanical switch used in applications that require a circuit "ON and OFF" process, such as starting motors, heaters, and lighting applications. Through the switch contacts, the magnetic energy from one place to another. In this project, one magnetic contactor is used in the main circuit so that in an abnormal situation when CT finds abnormal currents than the permissible current then it immediately shuts down the circuit through a magnetic contractor which will ensure more safety for the electrical appliances in the system.

Fig-11: Magnetic contactor [45].

The working principle of the magnetic contactor is that the main contact is closed due to the coil being energized, and the main contact is disconnected due to the de-energization of the coil. The control circuit is composed of an electromagnetic and spring system. The current through the coil activates the magnetism, and the two magnetisms approach each other. This movement shuts off two magnetic forces. Therefore, the contact is closed and the spring provides power to the contact. When the control current is disconnected, the contact is disconnected [45].

6. **Circuit Breaker**:

A circuit breaker is a crucial component in electrical systems that helps protect against overcurrent and short circuits. It acts as a safety device that automatically interrupts the flow of electricity when it detects a fault or an abnormal condition in the electrical circuit. In this project, one double pole circuit breaker is used for the entire system's protection from overcurrent

Fig-12: DP circuit breaker [46].

During normal operation, electricity flows through the circuit breaker without any interruption. The contacts within the breaker remain closed, allowing the current to pass through. If the current exceeds the rated capacity of the circuit or if a short circuit occurs, the circuit breaker quickly detects the abnormal condition. After the fault has been cleared or the overload condition has been resolved, the circuit breaker can be manually on again [46].

7. **LCD Display**:

LCD and the Internet of Things (IoT) are related in that LCDs are often used as display devices for IoT devices and systems. For example, LCD screens can be used to display real-time data from IoT sensors and it's possible to create powerful and interactive systems that can monitor and control physical devices and environments [47]. In this project, an LCD is used to display the real-time current, voltage, and power of the system.

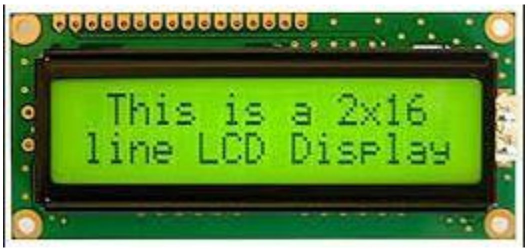


Fig-13: LCD display [47].

8. Buzzer:

The buzzer is a component that is used for generating sound. It is a digital component that can be connected to digital outputs and emits a tone when the output is HIGH. Alternatively, it can be connected to an analog pulse-width modulation output to generate various tones and effects. The Buzzer operates at both 3.3V and 5V with a sound output of 85 decibels [48]. In this project, a buzzer is used to give an alarm when the gas and smoke sensor found the gas or smoke level is higher than the acceptance level.

Fig-14: Buzzer [48].

9. **Power Supply**:

A stable power source is crucial to ensure the reliable operation of IoT-based projects. Using a Switched-Mode Power Supply (SMPS) for an IoT project is a great choice because of its efficiency, compact size, and stability. For this reason, in this project, one 5V SMPS DC power supply is used for supplying the DC in the devices in the whole system.

Fig-15: SMPS DC power supply [49].

The working principle of a 5V DC SMPS power supply involves converting an input DC or AC voltage into a regulated output DC voltage. It's first rectified AC into DC using diodes or a bridge rectifier. The rectified DC voltage may have ripples or fluctuations. Capacitors are used to smooth out these fluctuations, resulting in a relatively stable DC voltage. The heart of an SMPS is the switching circuit, typically composed of a high-frequency oscillator and a switching element such as a transistor (often a MOSFET) or a semiconductor switch. The switching element rapidly switches on and off, controlling the flow of current through an inductor or transformer. This process allows energy to be transferred from the input side to the output side of the circuit. By rapidly switching the input voltage on and off, SMPS achieves high efficiency compared to linear power supplies, which regulate the output voltage by dissipating excess power as heat. SMPS is commonly used in various electronic devices due to their compact size, high efficiency, and ability to operate over a wide range of input voltages [49].

10. Fan:

Integrating a mini 250V AC fan into IoT projects can be beneficial for applications such as temperature regulation, air circulation, or ventilation control. In this project, a 6" 250 V AC fan is used as a prototype version of a ceiling fan. By using a smartphone this fan can be controlled with speed from a remote place [50].

Fig-16: 250V " AC fan [51].

11. Led Light:

Integrating an LED light into IoT projects offers various possibilities, such as smart lighting control, ambient lighting, notification indicators, or visual feedback [52]. In this project, some LED light is used for the room, toilet, kitchen, and outside areas. These lights are connected through a relay module and the relay module is connected to the microcontroller. When the relay gets a signal to operate from the microcontroller then the lights glow. The wattage of LED lights is very low and that’s why LED lights are getting popular day by day.

Fig-17: LED light [52].

12. Switch-Socket:

The switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another [53]. Whereas, Electrical sockets allow electrical equipment to connect to the electrical grid. The electrical grid provides alternating current to the outlet [54]. In this project, Piano type switch is used for manually controlling the home appliances, and the socket is used for refrigerator and air-conditioner power purposes.

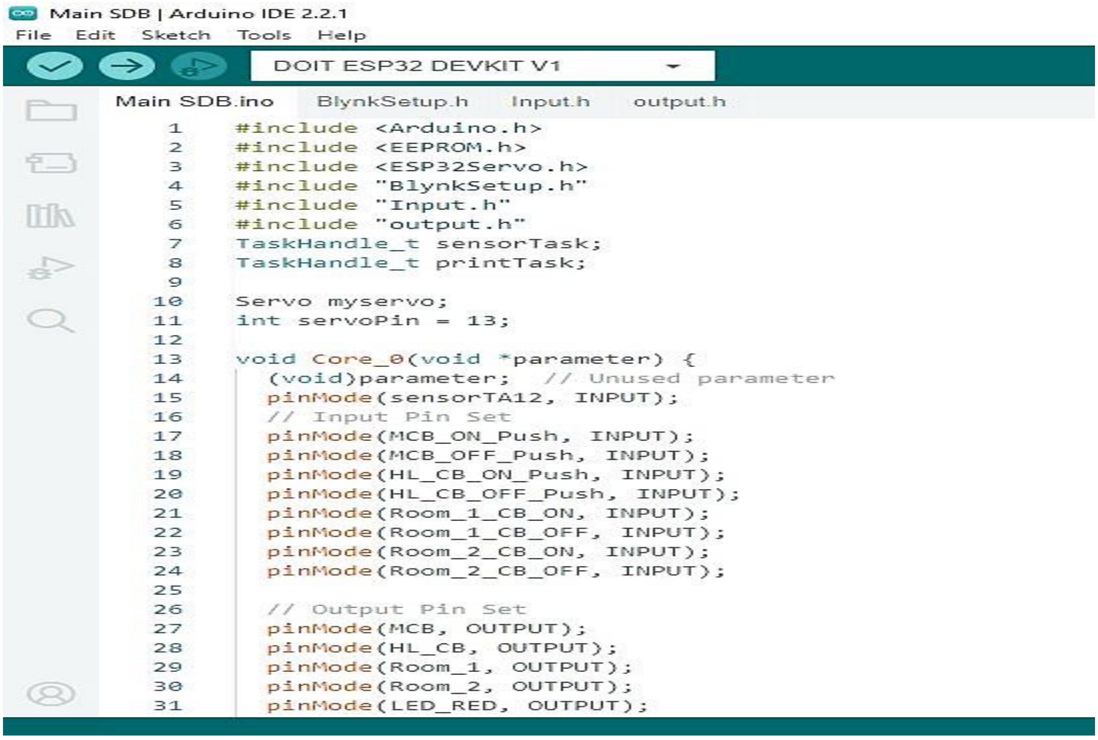
Fig-18: Switch [53] and socket [54].

13. SDB Box:

A sub-distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits while providing a protective circuit breaker for each circuit in a common enclosure [55]. In this project, an SDB is used where the main circuit breaker room individual control switch, and main microcontroller have been used.

Fig-19: Sub Distribution Board [55].

Appendix-2



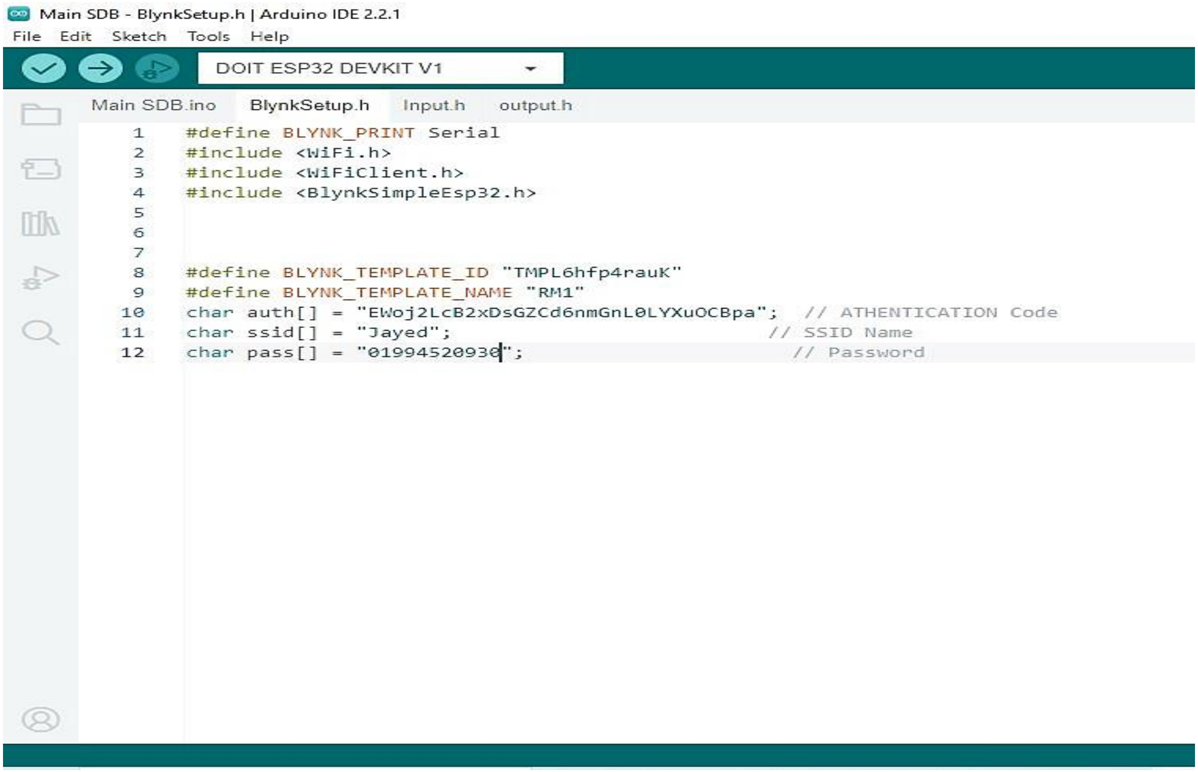


Fig-1: SDB and BLYNK integration coding sample.

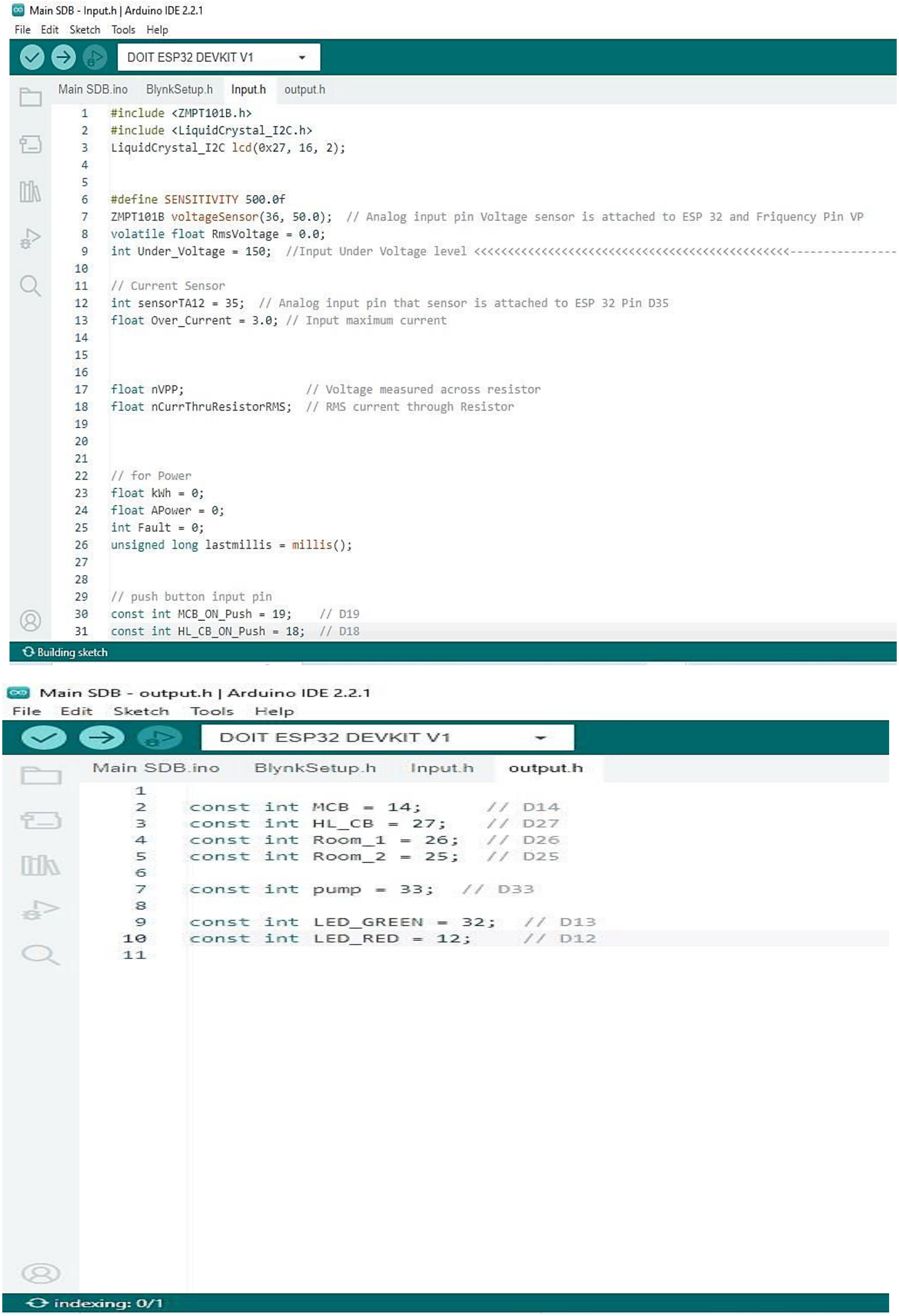
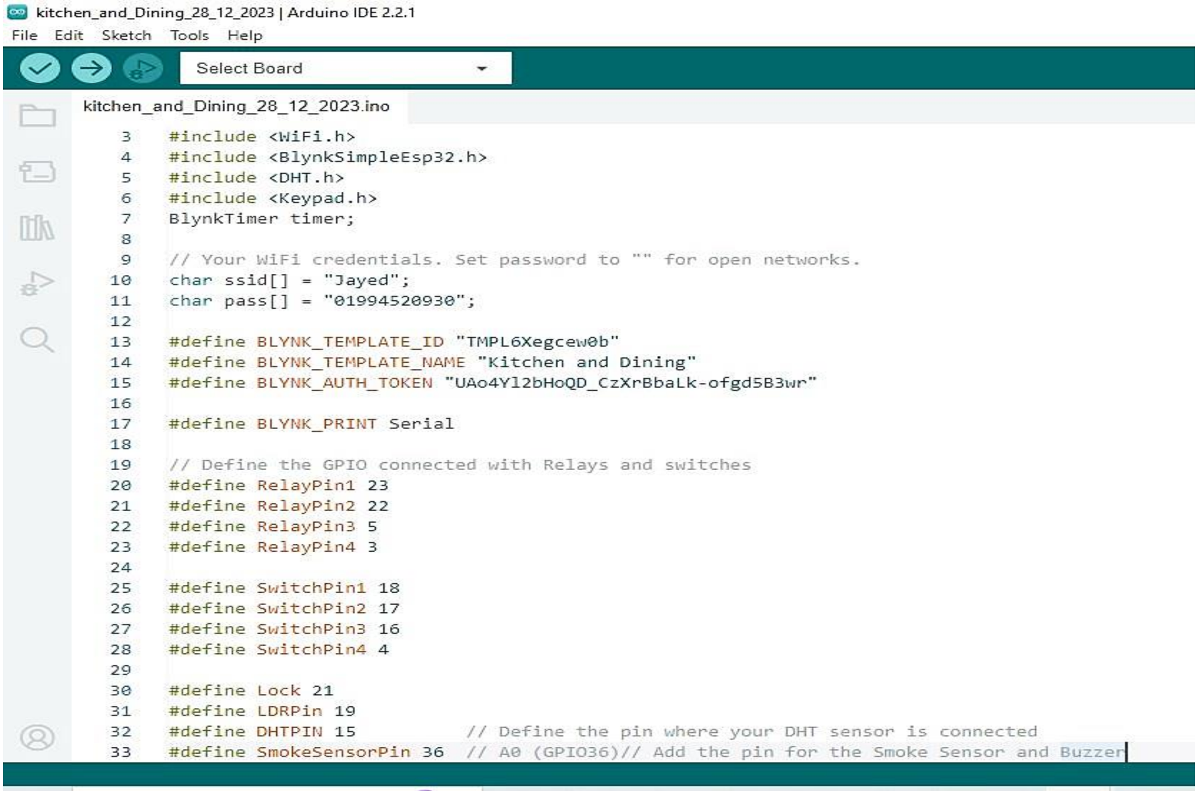


Fig-2: SDB input and output coding sample.

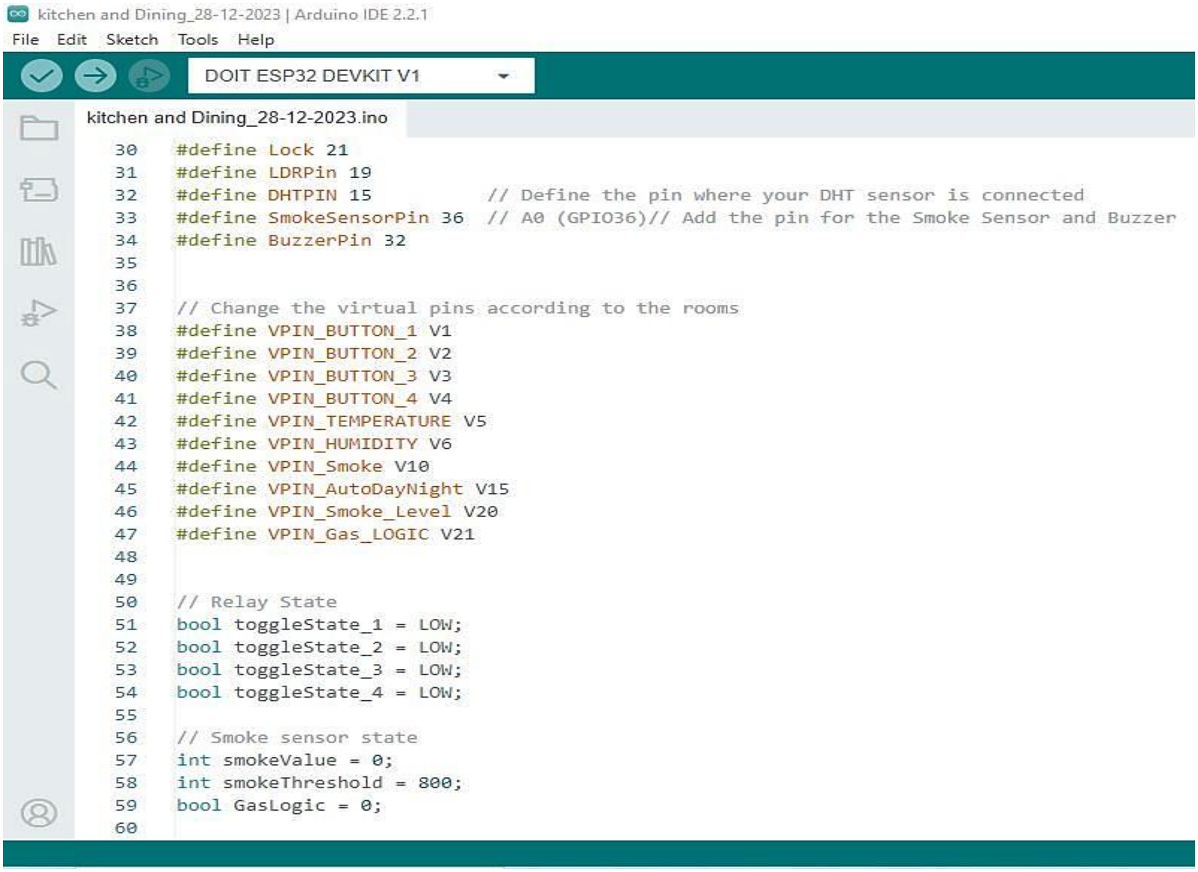

kitchen_and_Dining_28_12_2023 | Arduino IDE 2.2.1

File Edit Sketch Tools Help

Select Board

kitchen_and_Dining_28_12_2023.ino

```
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#include <DHT.h>
#include <Keypad.h>
BlynkTimer timer;

// Your WiFi credentials. Set password to "" for open networks.
char ssid[] = "Jayed";
char pass[] = "01994520930";

#define BLYNK_TEMPLATE_ID "TMPL6Xegcew0b"
#define BLYNK_TEMPLATE_NAME "Kitchen and Dining"
#define BLYNK_AUTH_TOKEN "UAo4Yl2bHoQD_CzXrBbaLk-ofgd5B3wr"

#define BLYNK_PRINT Serial

// Define the GPIO connected with Relays and switches
#define RelayPin1 23
#define RelayPin2 22
#define RelayPin3 5
#define RelayPin4 3

#define SwitchPin1 18
#define SwitchPin2 17
#define SwitchPin3 16
#define SwitchPin4 4

#define Lock 21
#define LDRPin 19
#define DHTPIN 15             // Define the pin where your DHT sensor is connected
#define SmokeSensorPin 36   // A0 (GPIO36)// Add the pin for the Smoke Sensor and Buzzer
```


kitchen and Dining_28-12-2023 | Arduino IDE 2.2.1

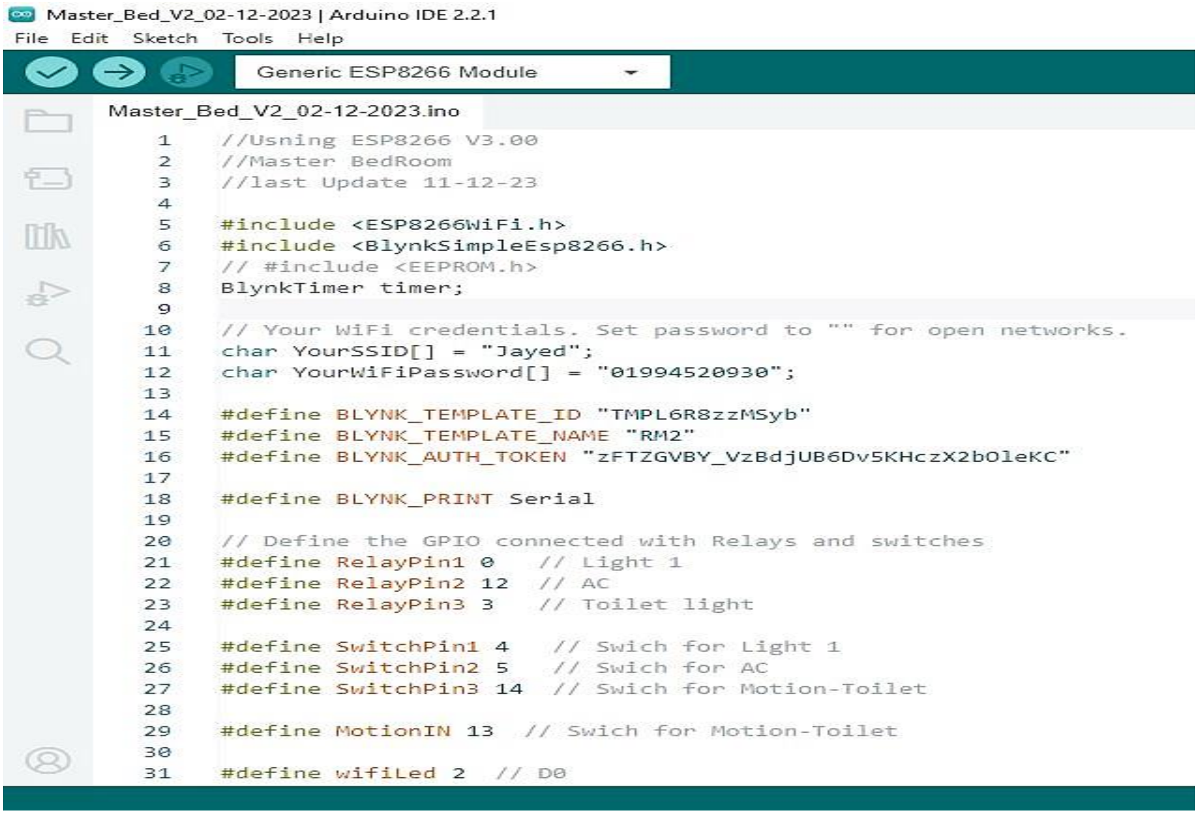
File Edit Sketch Tools Help

DOIT ESP32 DEVKIT V1

kitchen and Dining_28-12-2023.ino

```
#define Lock 21
#define LDRPin 19
#define DHTPIN 15             // Define the pin where your DHT sensor is connected
#define SmokeSensorPin 36   // A0 (GPIO36)// Add the pin for the Smoke Sensor and Buzzer
#define BuzzerPin 32


// Change the virtual pins according to the rooms
#define VPIN_BUTTON_1 V1
#define VPIN_BUTTON_2 V2
#define VPIN_BUTTON_3 V3
#define VPIN_BUTTON_4 V4
#define VPIN_TEMPERATURE V5
#define VPIN_HUMIDITY V6
#define VPIN_Smoke V10
#define VPIN_AutoDayNight V15
#define VPIN_Smoke_Level V20
#define VPIN_Gas_LOGIC V21


// Relay State
bool toggleState_1 = LOW;
bool toggleState_2 = LOW;
bool toggleState_3 = LOW;
bool toggleState_4 = LOW;

// Smoke sensor state
int smokeValue = 0;
int smokeThreshold = 800;
bool GasLogic = 0;
```

Fig-3: Kitchen and dining coding sample.



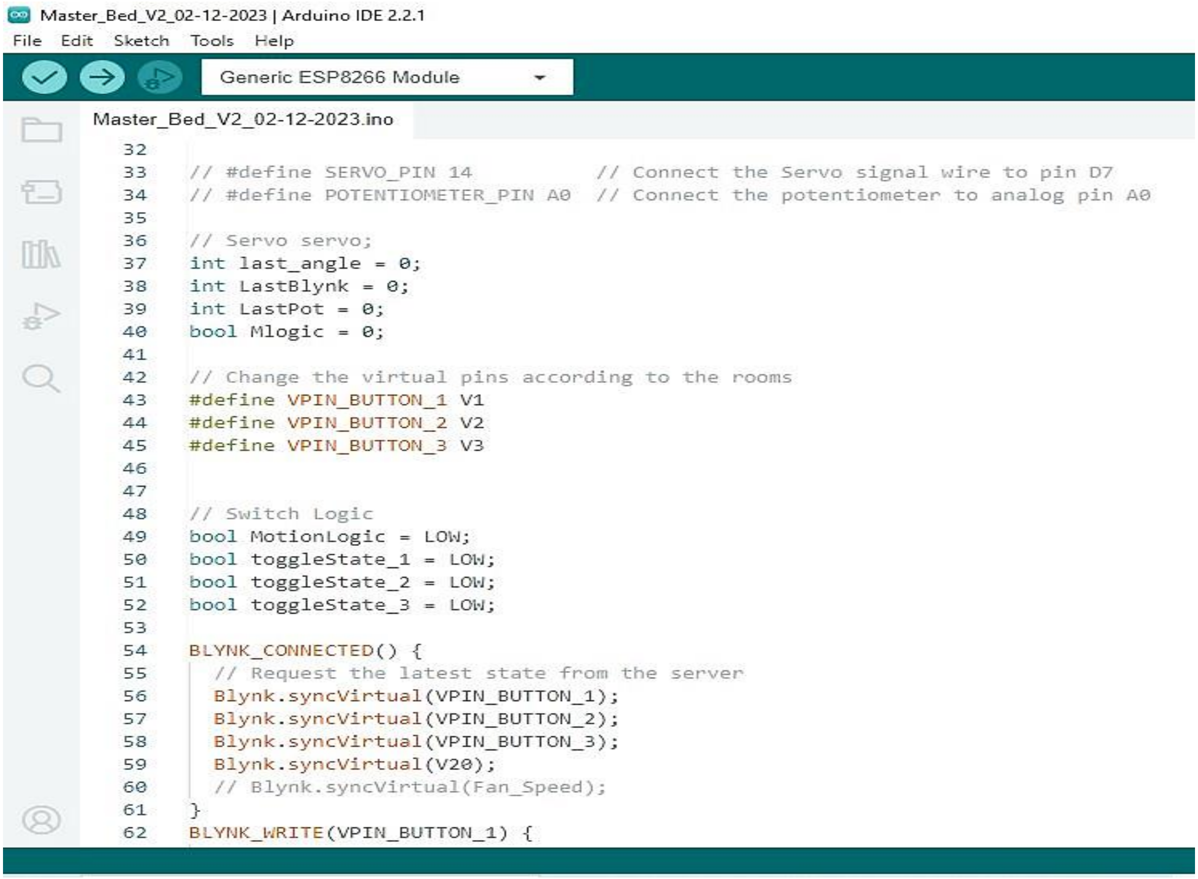
Master_Bed_V2_02-12-2023 | Arduino IDE 2.2.1

File Edit Sketch Tools Help

Generic ESP8266 Module

Master_Bed_V2_02-12-2023.ino

```
//Usning ESP8266 V3.00
//Master BedRoom
//last Update 11-12-23

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
// #include <EEPROM.h>
BlynkTimer timer;

// Your WiFi credentials. Set password to "" for open networks.
char YourSSID[] = "Jayed";
char YourWiFiPassword[] = "01994520930";

#define BLYNK_TEMPLATE_ID "TMPL6R8zzMSyb"
#define BLYNK_TEMPLATE_NAME "RM2"
#define BLYNK_AUTH_TOKEN "zFTZGVBY_VzBdjUB6Dv5KHczX2bOleKC"

#define BLYNK_PRINT Serial

// Define the GPIO connected with Relays and switches
#define RelayPin1 0    // Light 1
#define RelayPin2 12   // AC
#define RelayPin3 3    // Toilet light

#define SwitchPin1 4    // Swich for Light 1
#define SwitchPin2 5    // Swich for AC
#define SwitchPin3 14   // Swich for Motion-Toilet

#define MotionIN 13  // Swich for Motion-Toilet

#define wifiLed 2  // D0
```



Master_Bed_V2_02-12-2023 | Arduino IDE 2.2.1

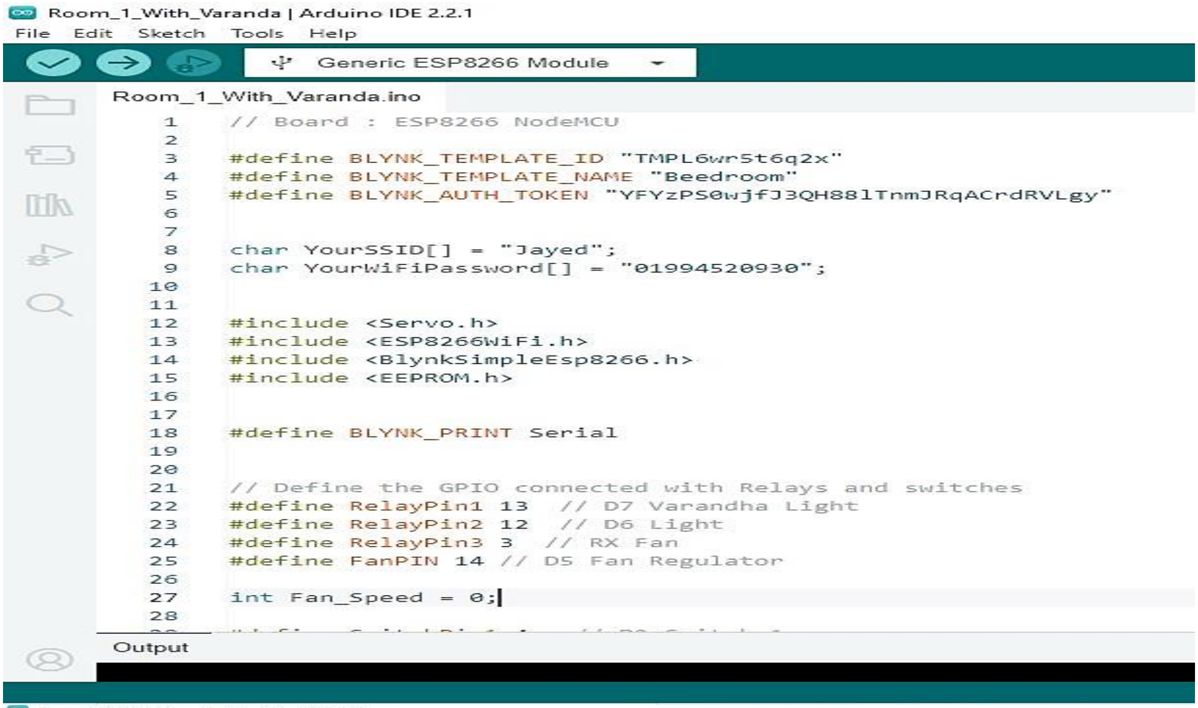
File Edit Sketch Tools Help

Generic ESP8266 Module

Master_Bed_V2_02-12-2023.ino

```

// #define SERVO_PIN 14           // Connect the Servo signal wire to pin D7
// #define POTENTIOMETER_PIN A0   // Connect the potentiometer to analog pin A0

// Servo servo;
int last_angle = 0;
int LastBlynk = 0;
int LastPot = 0;
bool Mlogic = 0;

// Change the virtual pins according to the rooms
#define VPIN_BUTTON_1 V1
#define VPIN_BUTTON_2 V2
#define VPIN_BUTTON_3 V3


// Switch Logic
bool MotionLogic = LOW;
bool toggleState_1 = LOW;
bool toggleState_2 = LOW;
bool toggleState_3 = LOW;

BLYNK_CONNECTED() {
  // Request the latest state from the server
  Blynk.syncVirtual(VPIN_BUTTON_1);
  Blynk.syncVirtual(VPIN_BUTTON_2);
  Blynk.syncVirtual(VPIN_BUTTON_3);
  Blynk.syncVirtual(V20);
  // Blynk.syncVirtual(Fan_Speed);
}
BLYNK_WRITE(VPIN_BUTTON_1) {
```

Fig-4: Master bedroom coding sample.



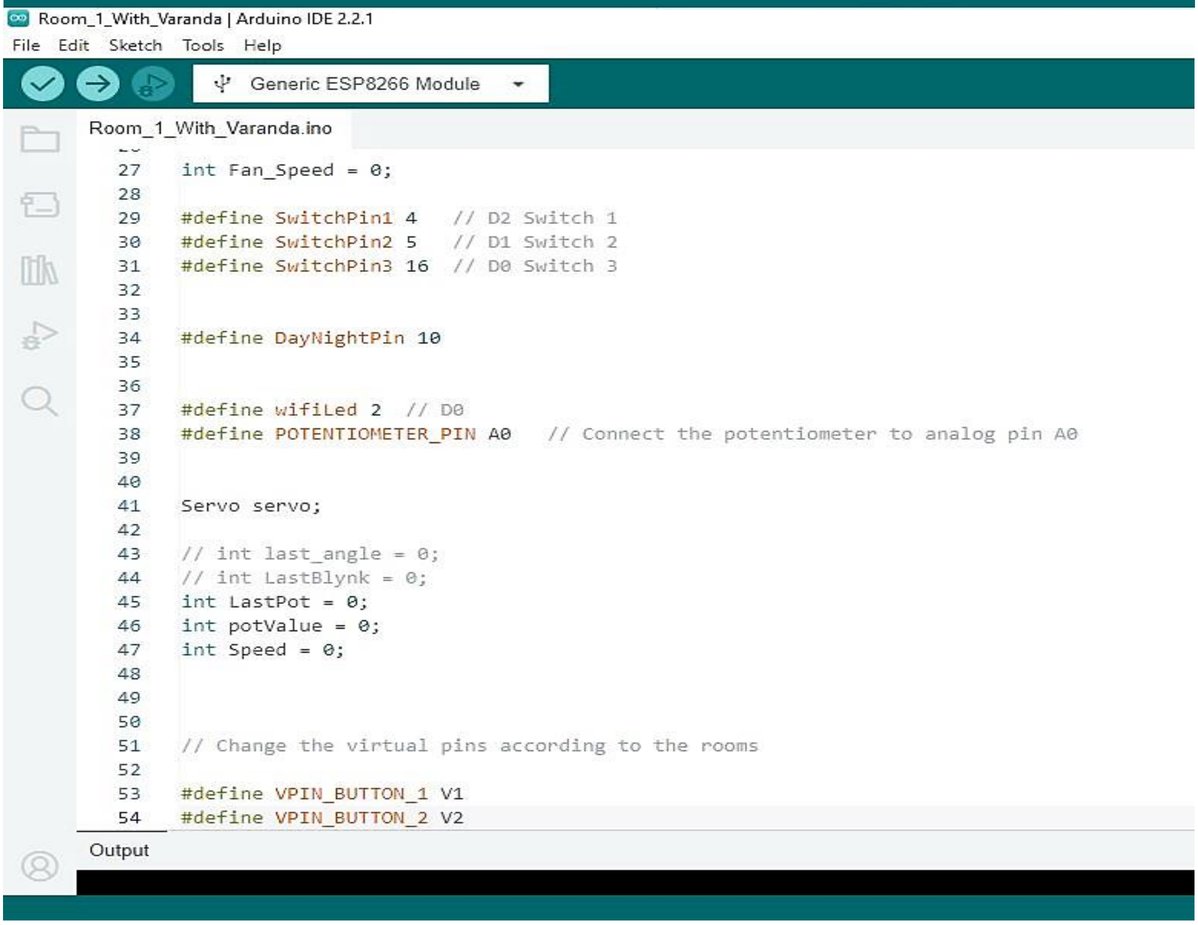


Fig 5: Bedroom coding sample.

References

[1] Z. Hasan, S. Hossain, A. N. Rimon, and R. Haque "IoT-based home automation system", Thesis, European University of Bangladesh, Jan. 2023.

[2] S. Saha, H. Ishraque, M. T. Islam and M. A. Rahman, "IoT-based smart home automation and energy management", Thesis, Brac University, 2019.

[3] M. T. Taj and A. R. Das "An IoT-based smart home system", Thesis, Daffodil International University, 2022.

[4] M. Das, P. Das, S. Das, and E. Biswas, "IoT-based home automation system", Thesis, RCC Institute of Information Technology, 2020.

[5] M. I. Joha, M. S. Islam and S. Ahmed "IoT Based Smart Control and Protection System for Home Appliances", 2022 25th International Conference on Computer and Information systems under uncertainty," *Renewable and Sustainable Energy Reviews*, vol. 168, p. Technology (ICCIT), Dec 2022, Doi:10.1109/ICCIT57492.2022.10054941.

[6] A. Doshi, D. Vakharia and Y. Rai, "Iot based home automation", International Journal for Research in Applied Science and Engineering Technology (IJRASET), Vol. 9, Issue. VIII, ISSN 2321-9653, Aug. 2021, Doi:10.22214/ijraset.2021.37287.

[7] S. Saha, M. Z. Abedin, M. M. Hemal, and M. A. H. Khan, " Iot based smart home automation and monitoring system", Article, Khulna University Studies Special Issue ICSTEM4IR:133-143, 2022, June 2022, Doi:10.53808/KUS.2022.ICSTEM4IR.0245-se.

[8] M. R. Ahsan, S. Z. Ahmed, M. S. Arefin and M. A. Bari, "Implementation of IoT-based smart security and home automation system" International Journal Engineering Research & Technology (IJERT), Vol. 8, Issue. 6, ISSN: 2278-0181, June 2019.

[9] A. Kiran, G. R. Shakthidharan, K. P. Kumar and K. Paban "Voice controlled home automation system using Google assistant", Computer Communication and Informatics (ICCCI), IEEE, 2023.

[10] A.P. Singh, A. Biswas and B. Sing, "IoT-based smart home automation enabled with manual mode Switch control", 2nd International Conference on Intelligent Communication and Computational Techniques (ICCT), Sep. 2019, Doi: 10.1109/ICCT46177. 2019.8969062.

[11] W. A Jabbar, M. H. Alsibai, N. Syaira, S. A. Samiah, and S. K. Mahayadin, "Design and implementation of IoT-based Automation System for smart home

International”, 2018 IEEE Conference on International Symposium on Networks, computers and communications (ISNCC), IEEE, 2018.

[12] Ribil Mary Roy, Blessy Sabu, Nisha A and Aneesh R P “Voice controlled home automation system”, 2021 Seventh International Conference on Bio Signals, Images, and Instrumentation (ICBSII), IEEE, Mar. 2021.

[13] Design and drawing steps for IoT projects, Accessed on: April 18, 2024 [Online]. Available: https:// iviewlabs. medium.com/ steps - to - build - your- IoT- prototype 4531333eae3b

[14] BLYNK Platform, Accessed on: May 13, 2024, [Online], Available: https://BLYNK.io/blog/new-BLYNK-iot-platform-beta.

[15] BLYNK overview and features, Accessed on: May 13, 2024, [Online], Available: https://docs.BLYNK.io/en/BLYNK.apps/overview.

[16] IFTTT platform, Accessed on: May 13, 2024, [Online], Available: https:// help.ifttt.com/ hc/ en-us/ articles/ 115010325748- What-is-IFTTT.

[17] Arduino IDE, Accessed on: May 14, 2024, [Online], Available: https:// docs. Arduino.cc/ software/ ide-v1 / tutorials / arduino-ide-v1-basics/.

[18] Circuit diagram, Accessed on: May 14, 2024. , [Online], Available: https://en.wikipedia.org/wiki/Circuit_diagram.

[19] Code upload procedures, Accessed on: May 14, 2024, [Online], Available: https:// support.arduino.cc/ hc/ en-us / articles/ 4733418441116 - Upload - a -sketch-in-Arduino-IDE.

[20] BLYNK set up procedures, Accessed on: May 15, 2024, [Online], Available: https://BLYNK.io/getting-started.

[21] BLYNK code write procedures, Accessed on: May 16, 2024, [Online], Available: https://docs.BLYNK.io/en/getting- started / template- quick- setup/prepare-code.

[22] IFTTT set up procedures, Accessed on: May 17, 2024, [Online], Available: https://ifttt.com/explore, [Online],

[23] Microcontroller, Accessed on: April. 20, 2024 [Online], Available: https://www.techtarget.com/iotagenda/definition/microcontroller.

[24] ESP 32 development board: Accessed on: April. 22, 2024, [Online], Available: https://en.wikipedia.org/ wiki/ ESP32.

[25] ESP 32 development board image, Accessed on: April. 22, 2024, [Online] Available: https://randomnerdtutorials.com/ getting - started - with - esp32/.

[26] ESP 8266 development board, Accessed on: April. 22, 2024, [Online], Available: https://www.campuscomponent.com/blogs/ post/know -about-esp8266-wifi-module-pin-configuration.

[27] ESP 8266 development board, Accessed on: Apr. 25, 2024 [Online], Available:https://www.nabto.com/esp8266-for-iot-complete-guide/.

[28] ESP 8266 development board image, Accessed on: Apr. 25, 2024, [Online], Available:https://www.electronicscuriosities.com/ 2021 / 08 / esp8266 - node - mcu-board-specifications. HTML,[Online],

[29] Relay module, Accessed on: April. 25, 2024 [Online], Available:https://installtekz.com/why-relay-is-used-in-home-automation-iot beginners/.

[30] Relay image, Accessed on: April. 25, 2024, [Online], Available:https://microcontrollerslab.com/5v- single - channel - relay - module - pinout-working-interfacing-applications-datasheet/.

[31] Temperature and humidity sensor image, Accessed on: Apr. 26, 2024, [Online], Available:https://store.roboticsbd.com/ sensors / 667 - dht11 -temperature - and-relative-humidity-sensor- module-f or- Arduino-robotics- bangladesh.html.

[32] Temperature and humidity sensor, Accessed on: Apr. 26, 2024, [Online], Available: https://www.renkeer.com/temperature- humidity - sensors - select/.

[33] Gas and smoke sensor image, Accessed on: April. 26, 2024, [Online], Available:https://saptaji.com/ 2022/02/14/ how - to - get - mq - 2- gas- sensor- data-using - nodemcu/.

[34] Gas and smoke sensor, Accessed on: April. 26, 2024, [Online], Available: https://quartzcomponents.com/products/mq-2-gas-sensor-module.

[35] Motion sensor image, Accessed on: April. 27, 2024, [Online], Available: https://www.addicore.com/ products/ pir - infrared - motion - sensor - hc - sr501.

[36] Motion sensor, Accessed on: April. 27, 2024, [Online], Available: https://www.bayalarm.com/blog/ how- do- motion- sensors- work-a- guide/.

[37] LDR sensor image, Accessed on: April. 27, 2024, [Online], Available: https://www.amazon.in/ Abhith- india - LDR - Sensor - Module /dp / B07568WMLY.

[38] LDR sensor, Accessed on: April. 27, 2024, [Online], Available: https://robocraze.com/blogs/post/what-is-the-ldr-sensor.

[39] Current sensor image, Accessed on: April. 28, 2024, [Online], Available: https://www.circuits-diy.com/current-sensor-module-acs712/.

[40] Current sensor, Accessed on: April. 28, 2024, [Online], Available: https://www.seeedstudio.com/blog/2020/02/15/acs712-current-sensor-features-how-it-works-arduino-guide/

[41] Voltage sensor image, Accessed on: April. 30, 2024 [Online]. Available: https://justdoelectronics.com/zmpt101b-voltage-sensor/.

[42] Voltage sensor, Accessed on: April. 30, 2024 [Online]. Available: https://justdoelectronics.com/zmpt101b-voltage-sensor/.

[43] Servo motor image, Accessed on: April. 30, 2024, [Online], Available: https://electrosome.com/servo-motor/#google_vignette.

[44] Servo motor, Accessed on: April. 30, 2024, [Online], Available: https://circuitdigest.com/ article/servo-motor-working-and-basics, [Online], Accessed: April. 30, 2024.

[45] Magnetic contactor, Accessed on: April 30, 2024, [Online], Available: https://www.aliontimer.com/what-is-magnetic-contactor/.

[46] Circuit Breaker, Accessed on: April 30, 2024, [Online]. Available: https://www.geeksforgeeks.org/circuit-breakers/.

[47] LCD display, Accessed on: May 01, 2024, [Online]. Available: https://www.elprocus.com/lcd-16x2-pin-configuration-and-its-working/.

[48] Buzzer, Accessed on: May 03, 2024, [Online], Available: https://sensorkit.arduino.cc/sensorkit /module/ lessons/lesson/04-the-buzzer.

[49] SMPS power supply, Accessed on: May 07, 2024 [Online]. Available: https://www.arrow.com/en/research-and-events/articles/switch-mode-power- supply.

[50] AC fan, Available: https://forumnextpcb.medium.com/ temperature - controlled - fan - using -arduino-267c8247408a, [Online], Accessed: May 10, 2024.

[51] AC fan image, Accessed on: May 10, 2024, [Online], Available: https://www.coolingfanmanufacturers.com/ Product/ 220/ Exhaust- Fan-4-Inch.

[52] LED light, Accessed on: May 10, 2024, [Online], Available: https://euristiq.com/the-future-of-led-iot-lighting/.

[53] Switch, Accessed on: May 10, 2024, [Online]. Available: https://en. wikipedia. org/ wiki / Switch.

[54] Socket, Accessed on: May 13, 2024, [Online]. Available: https:// energyeducation.ca / encyclopedia / Electrical_ outlet.

[55] Sub distribution box, Accessed on: May 13, 2024, [Online]. Available: https://pgtbd.com/ distribution- board/.