“Seamless Home Automation via ESP32 and Alexa Integration”

MINOR PROJECT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS & COMMUNICATION ENGINEERING

Submitted By

Deepnarayan Mahto (00913207322)
Harshit Gupta (00113207322)
Nitish Kumar Mahto (00313207322)
Prateek Sharma (00413207322)

2024-25

Guru Gobind Singh Indraprastha University, New Delhi.

Guru Tegh Bahadur Institute Of Technology G-8 Area, Rajouri Garden, New Delhi-110064.

CERTIFICATE

This is to certify that report entitled **"Seamless Home Automation via ESP32 and Alexa Integration"** which is submitted by **Deepnarayan Mahto** (00913207322), **Harshit Gupta** (00113207322), **Nitish Kumar Mahto** (00313207322), **Prateek Sharma** (00413207322) in part of fulfilment of the requirement for the award of degree B.Tech for Electronics and Communication Engineering to GTBIT, GGSIP UNIVERSITY, G-8 AREA, RAJOURI GARDEN, NEW DELHI-110064 is a record of the candidate's own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

Project Guide

Mr. Amrish Maggo

Candidate's Declaration

I hereby declare that the work which is being presented in this major project entitled, **"Seamless Home Automation via ESP32 and Alexa Integration"** submitted to **Guru Gobind Singh Indraprastha University, New Delhi** in the partial fulfillment of the requirements for the award of the degree of **Bachelor Of Technology** In **Electronics & Communication Engineering,** is an authentic record of my own work carried out from Aug, 2024 to Nov, 2024 under the supervision of Mr. Amrish Maggo**, In Ece Dept. GTBIT**

The matter embodied in this project report has not been submitted by me for the award of any other degree.

Deepnarayan Mahto (00913207322)
Harshit Gupta (00113207322)
Nitish Kumar Mahto (00313207322)
Prateek Sharma (00513207322)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Project Guide **External Examiner**
Mr. Amrish Maggo

INDEX

ACKNOWLEDGEMENT

We, the members of this group, would like to express our sincere gratitude to all the individuals who have contributed to the successful completion of this project. First and foremost, we extend our heartfelt thanks to the Director of **Guru Tegh Bahadur Institute of Technology** for providing the necessary infrastructure, resources, and a conducive environment that made this project possible. We are deeply grateful to the Head of the Department HOD, **Deepali**, for their unwavering support and for allowing us to pursue this project within the department. Their guidance, encouragement, and trust in our abilities have been invaluable throughout the course of this work.

We would also like to express our sincere appreciation to the Project Coordinator, **Amrish Maggo**, for their constant support, insightful suggestions, and for organizing regular discussions and reviews. Their expertise and feedback have significantly contributed to shaping the direction of this project.

Our deepest gratitude goes to our Mentor **Amrish Maggo**, for their mentorship, constructive criticism, and continuous support throughout this endeavour. Their valuable guidance, technical insights, and encouragement have been instrumental in overcoming challenges and refining the work. We are especially grateful for their patience and for providing us with the opportunity to explore the practical applications of our learning.

We would also like to thank all our classmates and peers for their assistance and feedback during the various stages of the project. Their collaborative spirit and constructive input have enhanced the overall quality of the work

Lastly, we would like to acknowledge all the administrative and technical staff of the department for their cooperation and assistance, which ensured smooth project development. We sincerely thank all of them for their contributions and encouragement throughout this project. Without their support, this work would not have been possible.

Abstract

Due of its many benefits, home automation is growing in popularity every day. The home automation system is currently being controlled via emails, SMS, or other applications, according to the present state of development. The scientific community and the industry, however, have made large investments in the Internet of Things (IoT) space in recent years. With the release of gadgets like the Alexa, Amazon Echo, Google Home, and Samsung Smart Things, among others, the Smart Home market has been given special attention.

An industry's expansion produces creative, cost-effective, and cutting-edge solutions. This essay focuses on creating a reliable, economical solution that may be used broadly in non-smart houses. Amazon Echo, Amazon Cloud, and Amazon Speech Services are used to power our system. The hardware utilized to provide smart features for non-smart homes is Arduino ESP32. Identify the various parts of our product and demonstrate how well our system works to turn on and turn off our appliances.

Any equipment or appliances at home will be able to be controlled using voice commands. In comparison to conventional homes, automated homes will have better communication because to this. The idea of this project lies in the increasing adoption and development of home automation systems offering homeowners the convenience of remotely controlling and monitoring their appliances through computer or smartphone interfaces. The developed system provides multiple control options to users. It enables appliance control through voice command via Alexa, allowing users to control their devices hands-free. The system offers user-friendly and efficient interaction between users and their appliances.

I. INTRODUCTION

1.1 Overview of Home Automation via ESP 32

In today's rapidly evolving technological landscape, Home automation systems have witnessed substantial growth in recent years due to the increasing popularity of smart gadgets and Internet of Things (IOT). As smart devices become increasingly affordable and accessible, homeowners are increasingly embracing home automation systems. Developed by Amazon and driven by Artificial Intelligence (AI), the Alexa device empowers users to control their devices and execute various tasks through voice commands. This functionality is achieved through the integration of hardware and software components. The project titled "Seamless Home Automation via ESP32 and Alexa Integration" aims to create a versatile, voice-controlled smart home system by leveraging the power of the ESP32 S3 microcontroller, Alexa voice commands, and Sinric Pro cloud services. By integrating various sensors, relay-controlled appliances, and Alexa's voice capabilities, this project will deliver a fully functional home automation system where users can monitor environmental factors such as temperature, humidity, and air quality, and control home devices such as lights, fans, and sockets both locally and remotely. A smart home system incorporates metering for light, moisture, and other factors in the home, together with security management and appliance control. For a home appliance to function as an intelligent smart device, it must be connected via IOT or another method. It can be used in smart home systems to provide home monitoring in addition to controlling appliances. Low-cost systems are needed in India because home automation systems there are highly expensive. Buildings and households may automate at little cost with Alexa-integrated solutions. Register the names of the connected devices as smart devices and turn on home automation using the Alexa app and server. With a focus on simplicity, efficiency, and user-friendliness, our home automation project aims to simplify and elevate your quality of life. By leveraging the robust capabilities of the ESP32 microcontroller, alongside an array of control options and interoperability with leading voice assistants, we offer a comprehensive solution that sets the standard for modern home automation. Join us in embracing the future of smart living and experience the transformative power of our integrated home automation system today. Home Automation achieving popularity day by day,

because of large usage of Smart Devices. We can achieve Home Automation simply by connecting the home gadgets to the internet.

1.2 Objectives and Scope

A home automation system will monitor and/or control home attributes such as lighting, climate, entertainment systems, and appliances. It may also include home security such as access control and alarm systems. The phrase smart home refers to home automation devices that have internet access. Home automation, a broader category, includes any device that can be monitored or controlled via wireless radio signals, not just those having internet access. When connected with the internet, home sensors and activation devices are an important constituent of the Internet of Things (IoT).

A home automation system typically connects controlled devices to a central smart home hub (sometimes called a “gateway”). The user interface for control of the system uses either wall-mounted terminals, tablet or desktop computers, a mobile phone application, or a Web interface that may also be accessible off-site through the internet.

Home automation makes it possible to automate tasks related to security, well-being, and comfort through a smart system installed in a home or building. In other words, it integrates technology into the design of a space. One of the main advantages of home automation systems is energy efficiency. Automating air conditioning, lighting, security, or communication translates to significant savings in energy consumption. There is also an improvement in the quality of life of users who now have a home adapted to all their needs.

Internet arrived to homes at the end of the 90s, taking the first step to bring home automation closer to reality. Some years later, smartphones appeared in 2007, which combined with the Internet of Things (IoT) make it possible to control functions of other devices from a cell phone. Currently, people use apps or virtual assistants based on artificial intelligence (AI) systems such as Siri, Google and Alexa.

1.3 Introduction to ESP32

ESP32 is a series of low-cost, low power system on chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. ESP32 is a feature rich microcontroller with integrated Wi-Fi and Bluetooth connectivity for a wide range of applications. ESP32 is capable of functioning reliably in industrial environments, powered by advanced calibration circuitries. ESP32 can dynamically remove external circuit imperfections and adapt to changes in external conditions.

Engineered for mobile devices, wearable electronics and IoT applications, ESP32 achieves ultra-low power consumption with a combination of several types of proprietary software. ESP32 also includes state of the art features, such as finegrained clock gating, various power modes and dynamic power scaling.

ESP32 is highly integrated with in-built antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, and power management modules. ESP32 adds priceless functionality and versatility to your applications with minimal Printed Circuit Board (PCB) requirements.

ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI/ SDIO OR I2C/ UART interfaces.

II. LITERATURE REVIEW

- An automated home can be a very simple grouping of controls, or it can be heavily automated where any appliance that is plugged into electrical power is remotely controlled. Costs mainly include equipment, components, furniture, and custom installation.
- Home automation is designed to introduce convenience and efficiency to a home. People living with physical handicaps may rely on the features of a home automation system to accomplish tasks that might otherwise be difficult or impossible.
- Most of the automation works using the online but in this project it can be used offline as well.

2.1 Home Automation

Automation is the process of automatically performing everyday functions around the home to save you time, energy, money and at the same time offering improved security.

The automation is performed by a central controller. This can be either a standalone unit or a piece of software on a PC. Both options have their advantages.

2.2 Functions of Home Automation

Home automation is anything that gives you remote or automatic control of things in & around the home. The systems that you can control include: Lighting, Appliances, Heating and cooling, Security and monitoring systems, Entertainment (home audio and video), Communications (telephones and intercoms, internet), Lawn sprinklers, Curtain movements, Pool filter pump, Spa heater, Filtration unit, Gate/garage door motor, Shade motor control, Roof sprinklers, Electric strikes, Keyless entry etc.

This central controller can be accessed and controlled through interfaces like keypad, wired or wireless touch-screens (with/without video), universal remotes, mobile devices. Home automation provides a more convenient & elegant atmosphere for the family to compliment and match the lifestyle. Everyone in the family experiences the comfort of automation with added convenience through integrated control of scheduled common lifestyle activities performed every day. An automated home can provide security, temperature, lighting, and audio control for comfort, convenience, and safety. It creates reliable and coordinated controls to operate home devices automatically for simplifying operations.

Home automation saves your time and effort by controlling you home automatically for performing routine functions such as watering your grass, or turning off all lights, setting the thermostat to economy mode, control scheduled appliances operation and arming the security system when you retire for the night.

Home automation provides you with the comfort of whole home audio/video integration so that any source could be placed anywhere in a home and still be enjoyed everywhere in a home.

Home automation provides you pro-active home security so that you can look in on your home remotely from anywhere in the world, or that your home will phone you if it finds anything suspicious, or that a fire will alert your home to wake you, shut down the gas and ventilation system, turn on a lighting path for your escape, and automatically phone the fire/police department. In other words it integrates your alarm system with other home systems for a response to intrusion that meets your needs of enhanced Safety.

The term 'home automation' is now acknowledged as covering most I.T., automation, communication and wiring aspects of our homes. Most of these functions can be installed independently of each other, but the real benefits of the automated home are realized when these different aspects communicate with each other. For example, having two PC’s networked together in the home, giving both users access to the internet may seem like the forefront of technology, but imagine if they were tied into our house wiring and could turn lights and appliances on and off automatically when we are away from home even via the internet. Imagine that the PC was networked into our security system and could display images from our home security cameras onto our computer screen at work.

2.3 Wireless Communication Protocols

Wireless communication implies no use of wires to transmit and receive information using RF signals. Wireless communication protocols are becoming popular in smart home networks, due to the ease of use and lower costs of setting up the network and installing new devices. There are several advantages of wireless over wire communication:

- Mobility: since connecting a device to a network does not require any physical linkage, the device can be moved around without loosing connectivity; moving the device to a different wireless network is also easy.
- Expandability: adding new devices to a network is easy, as long as the maximum number of supported devices is not exceeded; wireless networks are easy to scale up or down as needed, with no or minimal costs.
- Costs: setting up a wireless network is quite simple, often without any professional help.
- Flexibility: creating a wireless network in a new place, is as easy as connecting the device to power; this makes it easy to experiment with new devices, or sensor placement.

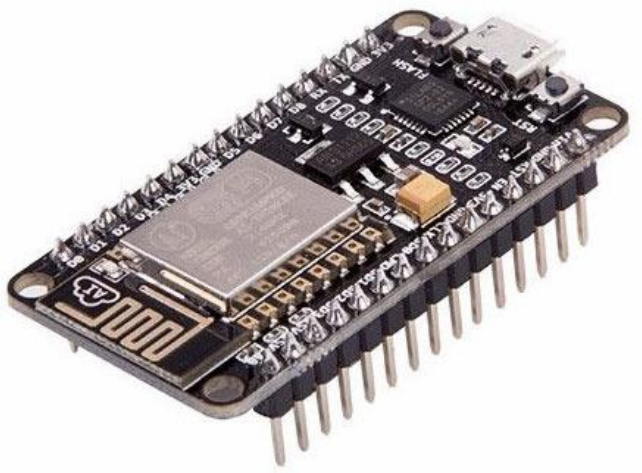
Types of Wireless Communication Protocols in IOT are :-

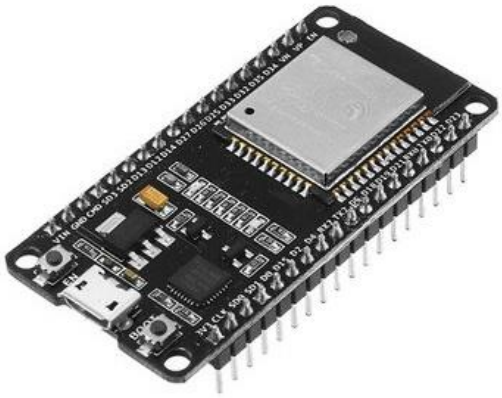
Wi-Fi

Wi-Fi (Wireless Fidelity) is the most popular IOT communication protocols for wireless local area network (WLAN) that utilizes the IEEE 802.11 standard through 2.4 GHz UHF and 5 GHz ISM frequencies.

Wi-Fi provides Internet access to devices that are within the range of about 20 - 40 meters from the source. It has a data rate upto 600 Mbps maximum, depending on channel frequency used and the number of antennas.

In embedded systems, ESP series controllers from Espressif are popular for building IoT based Applications. ESP32 and ESP8266 are the most commonly use wifi modules for embedded applications.





Bluetooth

Bluetooth is a technology used for exchanging data wirelessly over short distances and preffered over vaouros IOT network protocols. It uses short-wavelength UHF radio waves of frequency ranging from 2.4 to 2.485 GHz in the ISM band. The Bluetooth technology has 3 different versions based on its applications:

- **Bluetooth:** The Bluetooth that is used in devices for communication has many applications in IOT/M2M devices nowadays. It is a technology using which two devices can communicate and share data wirelessly. It operates at 2.4GHz ISM band and the data is split

in packets before sending and then is shared using any one of the designated 79 channels operating at 1 MHz of bandwidth.

- **BLE (Bluetooth 4.0, Bluetooth Low Energy):** The BLE has a single main difference from Bluetooth that it consumes low power. With that, it makes the product of low cost & more long-lasting than Bluetooth.
- **iBeacon:** It is a simplified communication technique used by Apple and is completely based on Bluetooth technology. The Bluetooth 4.0 transmits an ID called UUID for each user and makes it each to communicate between iPhone users.

Bluetooth has many applications, such as in telephones, tablets, media players, robotics systems, etc. The range of Bluetooth technology is between 50 – 150 meters and the data is being shared at a maximum data rate of 1 Mbps.

After launching the BLE protocol, there have been many new applications developed using Bluetooth in the field of IOT. They fall under the category of low-cost consumer products and Smart-Building applications. Like Wi-Fi, Bluetooth also has a module Bluetooth HC-05 that can be interfaced with development boards like Arduino or ESP to build DIY projects.

ZigBee

ZigBee is another IOT wireless protocols has features similar to the the Bluetooth technology. But it follows the IEEE 802.15.4 standard and is a high-level communication protocol. It has some advantages similar to Bluetooth i.e. low-power consumption, robustness, high security, and high scalability.

Zigbee offers a range of about 10 – 100 meters maximum and data rate to transfer data between communicated devices is around 250 Kbps. It has a large number of applications in technologies like M2M & IOT.

it provides a 128-bit AES encryption and is giving a big hand in making secure communication for Home automation & small Industrial applications. Zigbee too has its DIY module named XBee & XBee Pro which can be interfaced with Arduino or Raspberry Pi boards to make simple projects or application prototypes. The company Develco has made products using Zigbee technologies like Sensors, gateways, meter interfaces, smart plugs, smart relays, etc which all work on the Zigbee wireless Mesh network, consuming low power and free from external interferences.

2.4 Microcontrollers and Their Applications

A microcontroller is a small, low-cost, and self-contained computer-on-a-chip that can be used as an embedded system. A few microcontrollers may utilize four-bit expressions and work at clock rate frequencies, which usually include:

- An 8 or 16-bit microprocessor.
- A little measure of RAM.
- Programmable ROM and flash memory.
- Parallel and serial I/O.
- Timers and signal generators.
- Analog to Digital and Digital to Analog conversion

Microcontrollers usually must have low-power requirements since many devices they control are battery-operated. Microcontrollers are used in many consumer electronics, car engines, computer peripherals, and test or measurement equipment. And these are well suited for long-lasting battery applications. The dominant part of microcontrollers being used nowadays is implanted in other apparatus.

Microcontrollers Working

The microcontroller chip is a high-speed device, but as compared with a computer it is slow. Thus each instruction will be executed within the microcontroller at a quick speed. Once the supply is turned ON, then the quartz oscillator will be activated through the control logic register. For a few seconds, as the early preparation is in development, then parasite capacitors will be charged.

Once the voltage level achieves its highest value & oscillator's frequency turns into the stable process of writing bits over special function registers. Everything happens based on the CLK of the oscillator & overall electronics will start working. All this takes extremely few nanoseconds.

The main function of a microcontroller is, it can be considered like self-contained systems using a processor memory. Its peripherals can be utilized like an 8051 Microcontroller. When the

microcontrollers majority in use at present are embedded within other kinds of machinery like telephones appliances, automobiles & computer systems peripherals.

Basics of Microcontrollers

Any electric appliance used to store, measure & display the information otherwise measures comprise of a chip in it. The microcontroller's basic structure includes different components.

CPU: The microcontroller is called a CPU device, used to carry & decode the data & finally completes the allocated task effectively. By using a central processing unit, all the microcontroller components are connected to a particular system. Instruction fetched through the programmable memory can be decoded through the CPU.

Memory: In a microcontroller, the memory chip works like a microprocessor because it stores all the data as well as programs. Microcontrollers are designed with some amount of RAM/ROM/flash memory to store the program source code.

I/O Ports: Basically, these ports are used to interface otherwise drive different appliances like LEDs, LCDs, printers, etc.

Serial Ports: Serial ports are used to provide serial interfaces between microcontroller as well as a variety of other peripherals like parallel port.

Timers: A microcontroller includes timers otherwise counters. These are used to manage all the operations of timing and counting in a microcontroller. The main function of the counter is to count outside pulses whereas the operations which are performed through timers are clock functions, pulse generations, modulations, measuring frequency, making oscillations, etc.

ADC (Analog to Digital Converter): ADC is the acronym of analog to digital converter. The main function of ADC is to change the signals from analog to digital. For ADC, the required input signals are analog and the production of a digital signal is used in different digital applications like measurement devices

DAC (Digital to Analog Converter): The acronym of DAC is digital to analog converter, used to perform reverse functions to ADC. Generally, this device is used to manage analog devices such as DC motors, etc.

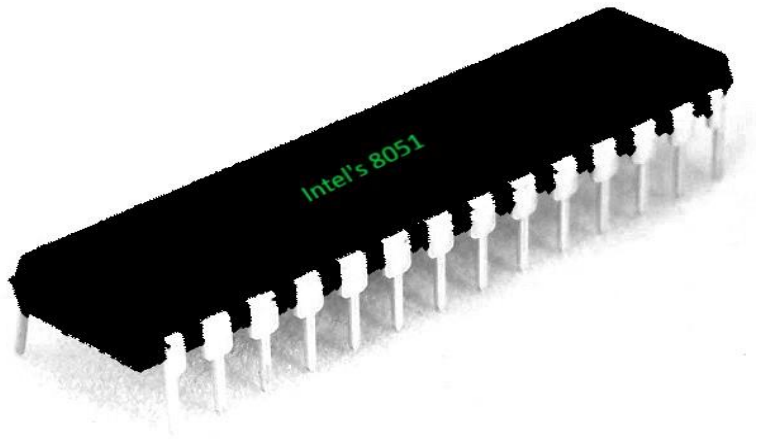
Interpret Control: This controller is employed to give delayed control to a running program & interpretation is either internal otherwise external.

Special Functioning Block: Some special microcontrollers designed for special devices like robots, space systems include a special function block. This block has extra ports to carry out some particular operations.

Types of Microcontrollers

There are different microcontroller types like 8051, PIC, ARM.

8051 Microcontroller :-



The most universally employed set of microcontrollers come from the 8051 family. 8051 Microcontrollers persist to be an ideal choice for a huge group of hobbyists and experts. In the course of 8051, the humankind became eyewitness to the most ground-breaking set of microcontrollers. The original 8051 microcontroller was initially invented by Intel. The two other members of this 8051 family are -

8052 – This microcontroller has 3 timers & 256 bytes of RAM. Additionally it has all the features of the traditional 8051 microcontroller.

8031 – This microcontroller is ROM less, other than that it has all the features of a traditional 8051 microcontroller. For execution an external ROM of size 64K bytes can be added to its chip.

PIC Microcontroller :-

Peripheral Interface Controller (PIC) provided by Micro-chip Technology to categorize its solitary chip microcontrollers. These appliances have been extremely successful in 8 bit micro-controllers. The foremost cause behind it is that Micro-chip Technology has been constantly upgrading the appliance architecture and included much required peripherals to the micro-controller to go well with clientele necessities. PIC microcontrollers are very popular amid hobbyists and industrialists; this is only cause of wide availability, low cost, large user base & serial programming capability.

AVR Microcontroller :-

AVR also known as Advanced Virtual RISC, is a customized Harvard architecture 8 bit RISC solitary chip micro-controller. It was invented in the year 1966 by Atmel. Harvard architecture signifies that program & data are amassed in different spaces and are used simultaneously. It was one of the foremost micro-controller families to employ on-chip flash memory basically for storing program, as contrasting to one time programmable EPROM, EEPROM or ROM, utilized by other micro-controllers at the same time. Flash memory is a non-volatile (constant on power down) programmable memory.

Application of Microcontroller in Day to Day Life Devices:

- Light sensing & controlling devices
- Temperature sensing and controlling devices
- Fire detection & safety devices
- Industrial instrumentation devices
- Process control devices

Application of Microcontroller in Industrial Control Devices:

- Industrial instrumentation devices
- Process control devices

Application of Microcontroller in Metering & Measurement Devices:

- Volt Meter
- Measuring revolving objects
- Current meter
- Hand-held metering systems

2.5 ESP32: Applications and Advantages

The ESP32 is a versatile and widely-used microcontroller and Wi-Fi/Bluetooth system-on-chip (SoC) produced by Espressif Systems. A SoC, is essentially an integrated circuit that takes a single platform and integrates an entire electronic system onto it, for an specific application. Contrary to a simple microcontroller (like Atmega324p Arduino Uno), that offers several general usage peripherals instead of a specific set of tools for one application.

The applications of ESP32 are :-

1. IoT devices: The ESP32 is often used to build IoT devices due to its built-in Wi-Fi and Bluetooth capabilities. It can be used to create smart home devices, environmental sensors, and more.

2. Home automation: ESP32-based devices can control lights, thermostats, and other home appliances through Wi-Fi or Bluetooth connections, making it a popular choice for DIY home automation projects.

3. Wireless communication: It can be used for wireless communication in various applications, such as creating mesh networks, remote control systems, and data transmission between devices (see IoT protocols).

4. Robotics: ESP32 can be used as the control unit in robotics projects, providing wireless control and communication capabilities to robots.

5. Wearable devices: Due to its compact size and low power consumption, the ESP32 is suitable for wearable IoT devices, including smartwatches, fitness trackers, and health monitoring products.This technology can be used to collect and log data from various sensors, such as temperature sensors, humidity sensors, and accelerometers. This data can be stored locally or transmitted to the cloud for analysis.

6. Industrial automation: ESP32 microcontroller can be integrated into industrial systems for remote monitoring and control, as well as for predictive maintenance. This is a great ally for industrial IoT applications, since companies can improve their operations with the help of this technology.

7. Environmental monitoring: It can be used to build environmental monitoring systems for measuring air quality, pollution levels, and weather conditions.

8. Education and prototyping: The ESP32 is popular in educational settings for teaching electronics and programming due to its affordability and versatility; in fact, we built something cool with an ESP32 board – How to build a mechanical 7 segment display clock.

9. Security Systems: It can be used in DIY security systems, including cameras, alarms, and access control systems.

10. Healthcare: ESP32 can be used in several healthcare solutions, such as patient monitoring, medication reminders, and telemedicine devices.

The adavantages of ESP32 are :-

- **Robust Processing Power:** With its dual-core architecture and efficient processing units, the ESP32-S3 exhibits remarkable computational capabilities. This prowess enables swift data processing, facilitating real-time responsiveness in HMI applications, and ensuring a smooth user experience.

- **Versatile Wireless Connectivity:** The ESP32-S3's support for Wi-Fi and Bluetooth technologies proves instrumental in establishing wireless connections between the HMI system and external devices. This feature enables remote control, data exchange, and seamless integration into IoT ecosystems, enhancing the system's flexibility and usability.

- **Abundance of GPIO Pins:** Equipped with a generous number of General-Purpose Input/Output (GPIO) pins, the ESP32-S3 allows for seamless interfacing with various peripherals, including displays, sensors, and actuators. This flexibility simplifies hardware integration and expands the range of functionalities achievable within the HMI setup.

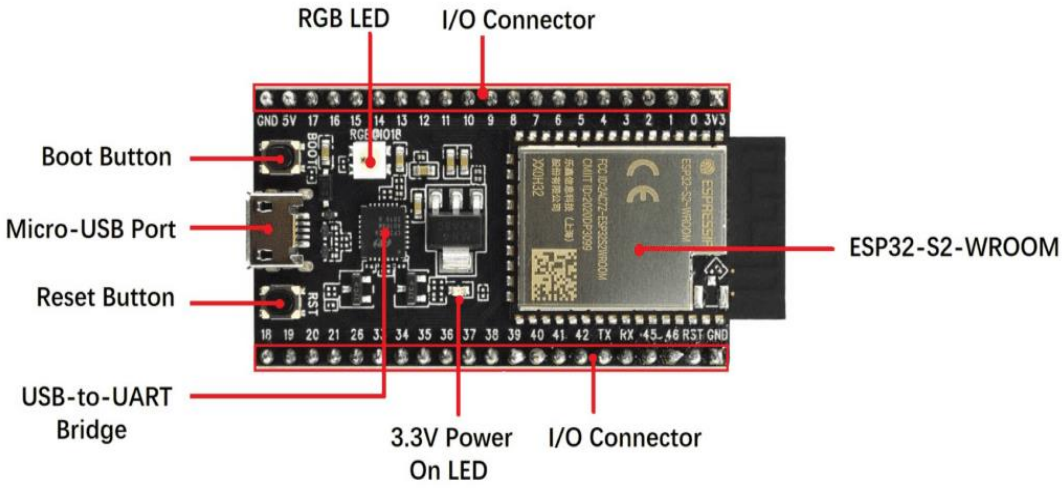
- **Rich Set of Peripherals:** The ESP32-S3 incorporates a diverse array of peripherals, including SPI, I2C, UART interfaces, ADCs, DACs, and more. These peripherals facilitate interfacing with a wide range of sensors, displays, and input devices, enabling the creation of comprehensive and feature-rich HMIs.

- **Low Power Consumption:** Efficient power management features in the ESP32-S3 contribute to reduced power consumption, which is crucial for battery-operated devices or applications where energy efficiency is paramount. This ensures prolonged operation without frequent recharging or power interruptions.

- **Integrated Security Features:** The microcontroller integrates robust security mechanisms, including secure boot, flash encryption, and cryptographic hardware acceleration. These features bolster the overall security of the HMI system, safeguarding against potential cyber threats and unauthorized access.

- **Rich Development Ecosystem:** Supported by robust development environments like ESP-IDF and Arduino IDE, the ESP32-S3 offers an extensive library of resources, documentation, and community support.

2.6 ESP32 WROOM



The ESP32 WROOM is a generic WiFi + Bluetooth and Bluetooth LE MCU module for various applications like MP3 decoding, voice encoding, and music streaming. Also, ESP32 WROOM is ideal for applications that range from low-power sensor networks to high-power tasks. It is an SMD module that can be integrated in your own PCB layout and design. The ESP32 WROOM module is a family that comprises other modules.

The use of Wi-Fi, Bluetooth LE, and Bluetooth in ESP32 WROOM helps to ensure various applications is easily targeted. Integrating Wi-Fi enables a direct connection to the internet via a Wi-Fi router. The Bluetooth enables users to broadcast low energy beacons.

ESP32 WROOM 32 comprises 38 pins. Furthermore, ESP32 WROOM modules are suitable for WiFi and Bluetooth applications. This ESP32 offers a solid dual-core performance. Also, the sleep current for this chip is below 5 µA which makes it ideal for wearable electronics applications.ESP32 WROOM 32 module offers support to a data rate of about 150 Mbps. Therefore, this module provides the best specifications and industry-leading performance for power consumption and electronic integration. ESP32 WROOM is ideal for custom PCB layout.

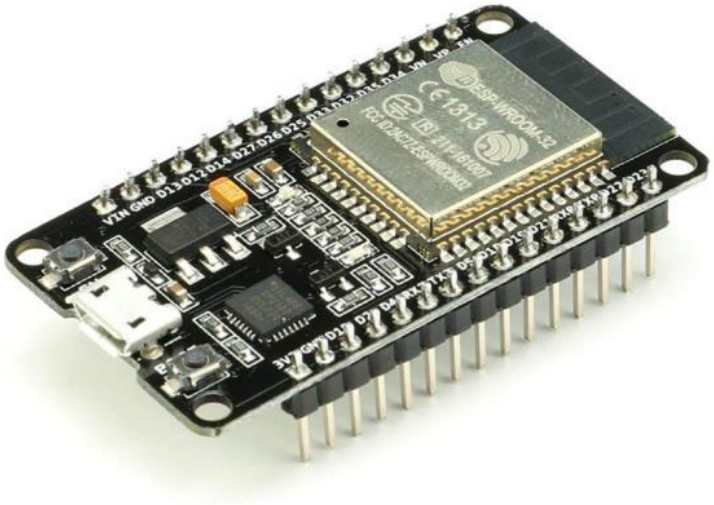
Also, the ESP32 WROOM 32 is a commonly used ESP32 module. It was officially the first module of WROOM family released. The ESP32 WROOM is a module that comprises gerber and BOM files, OrCAD schematic, and PCB layout.

III. REQUIREMENTS

3.1 Hardware Requirements

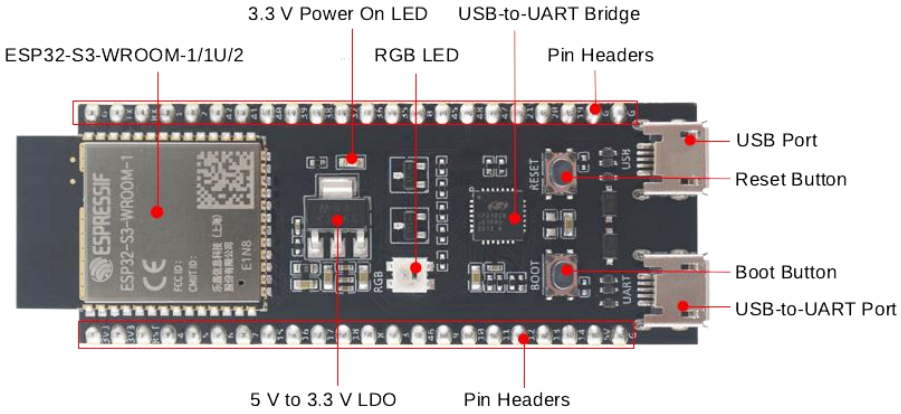
The Hardware Requirements of the project are :-

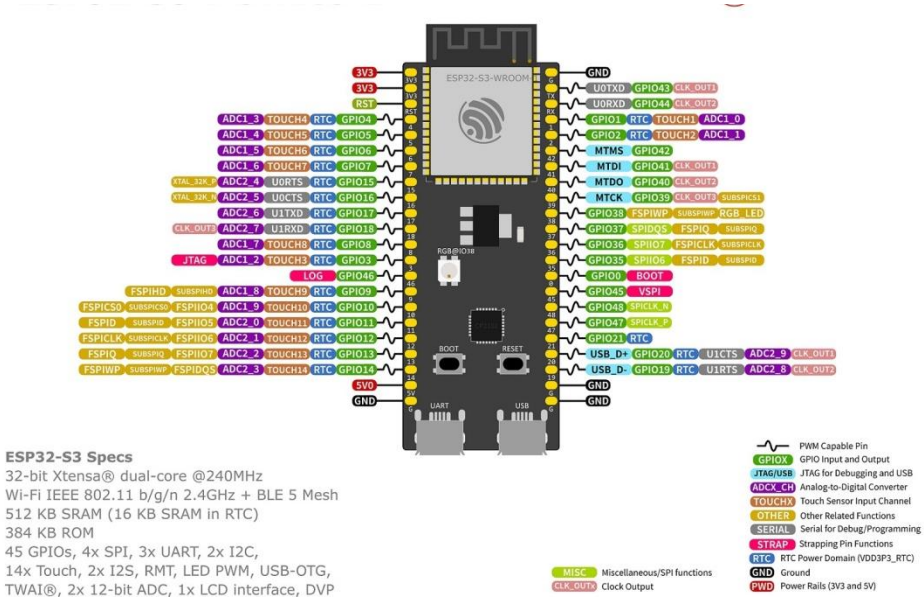
1. ESP32 S3 –



The ESP32-S3 is a low-power, dual-core microcontroller designed for IoT and wearable applications. It's part of the ESP32 series from Espressif Systems. The ESP32-S3 uses a RISC (Reduced Instruction Set Computing) architecture, with a dual-core CPU that provides high performance and low power consumption. The microcontroller's Wi-Fi and Bluetooth capabilities are based on the IEEE 802.11b/g/n and Bluetooth 5.0 standards, respectively.The ESP32-S3's Wi-Fi module uses a combination of hardware and software to provide Wi-Fi connectivity.

The ESP32-S3's Bluetooth module uses a combination of hardware and software to provide Bluetooth connectivity.





Key Features

1. Dual-core CPU: 2x Xtensa LX7 cores, up to 240 MHz

2. Wi-Fi and Bluetooth: Integrated 802.11b/g/n Wi-Fi and Bluetooth 5.0 (BLE and Mesh)

3. Low Power: Ultra-low power consumption, with a deep sleep current of 5 Ma

4. Memory and Storage: 512 KB RAM, 1.5 MB flash, and external SPI flash support

5. GPIO and Peripherals: 44 GPIOs, 5 SPI, 2 I2S, 2 I2C, 1 UART, and more

2. SSD1306 OLED Display –

OLED is Organic Light Emitting Diode that emits light in response to an electric current. OLED display works with no backlight so it can display deep black levels. It is small in size and light in weight than Liquid Crystal Displays. 128x64 OLED display is simple dot matrix graphic display. It has 128 columns and 64 rows which make it display of total 128x64 = 8192 pixels. By just turning on/off these pixel's led we can display a graphical image of any shape on it.

OLED displays driven by SSD1306 driver IC. SSD1306 is a CMOS OLED driver with controller for OLED dot-matrix graphic display system. Due to use of SSD1306 driver, number of external components required and power consumption has reduced.

OLED display is used for displaying text, images and various patterns. It is also suitable for mobile phone sub-display, MP3 player, calculators etc. OLED display has 256 steps for brightness control. OLED display also available with different resolution like 128x32, 128x64.

OLED display module can be interfaced with microcontrollers using three interfaces given below:

6800/8000 series compatible Parallel Interface :

In this interface 8-bit data send/receive could be done through parallel lines i.e. D0-D7.

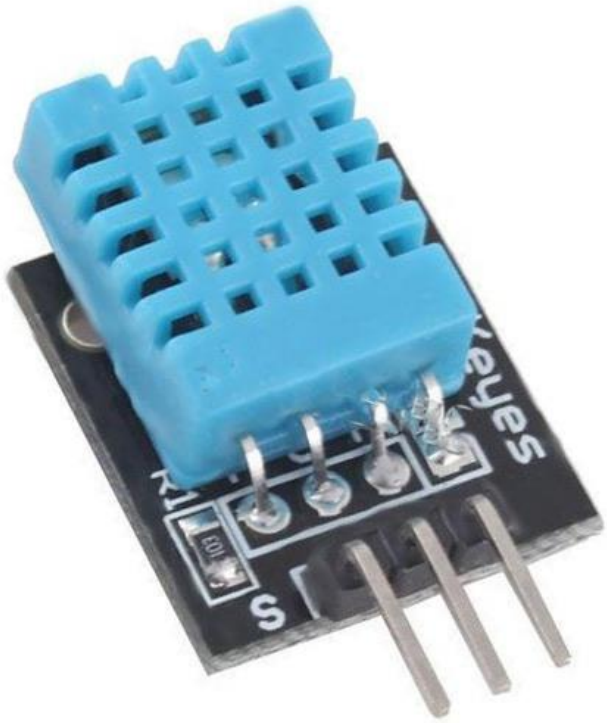
I2C interface :

In this interface, data send/receive could be done serially through SDA line.

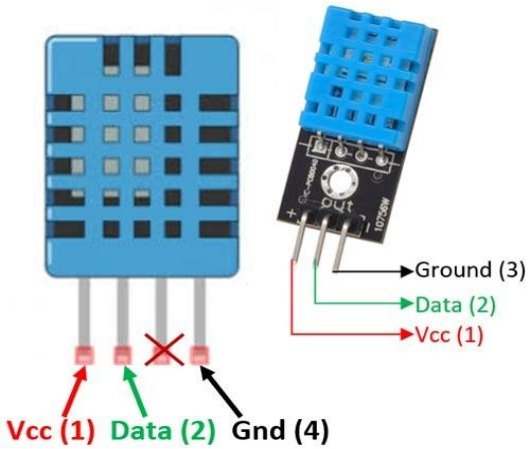
Serial Peripheral Interface :

In this interface, data send/receive could be done serially through SDI and SDO lines.

3. DHT11 Temperature and Humidity Sensor –



The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%.



A humidity sensor (or hygrometer) senses, measures, and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity.

Relative humidity becomes an important factor when looking for comfort.A humidity sensor is an electronic device that measures the humidity in its environment and converts its findings into a corresponding electrical signal. Humidity sensors vary widely in size and functionality; some humidity sensors can be found in handheld devices (such as smartphones), while others are integrated into larger embedded systems (such as air quality monitoring systems).

4. MQ2 Smoke Sensor –

The MQ2 sensor is one of the most widely used in the MQ sensor series. It is a MOS (Metal Oxide Semiconductor) sensor. Metal oxide sensors are also known as Chemiresistors because sensing is based on the change in resistance of the sensing material when exposed to gasses.

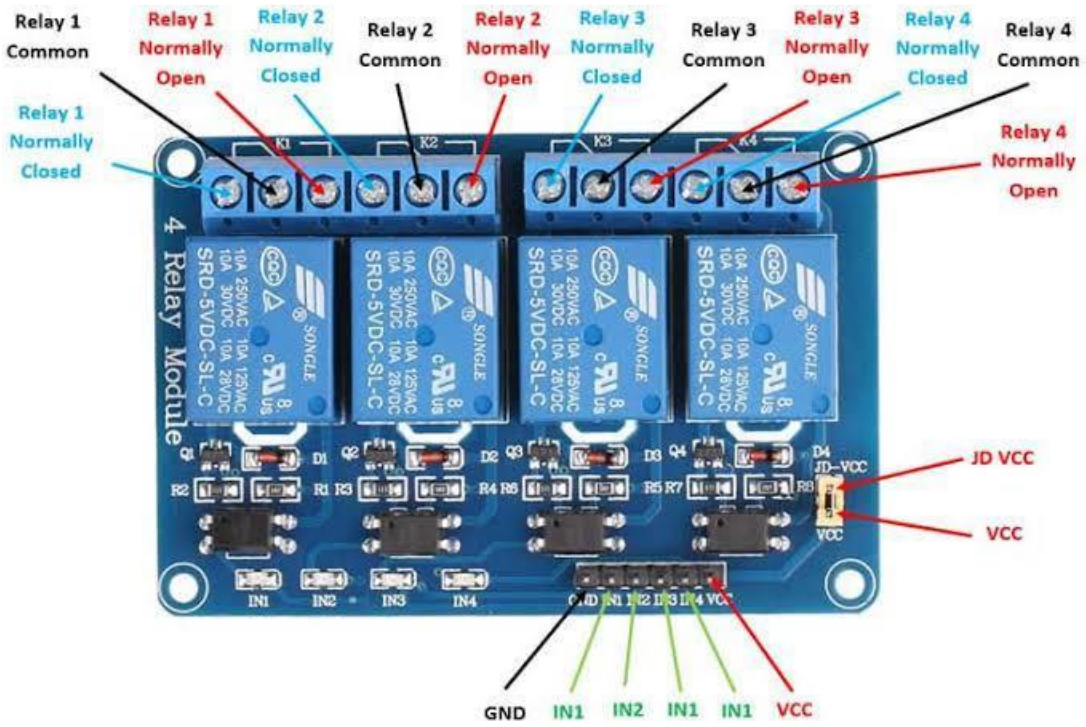
The MQ2 gas sensor operates on 5V DC and consumes approximately 800mW. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and CarbonMonoxide concentrations ranging from 200 to 10000 ppm. the MQ2 gas sensor detects multiple gases, but cannot identify them! That is normal; most gas sensors operate in this manner. Therefore, it is best suited for measuring changes in a known gas density rather than detecting which one is changing.

A smoke sensor is a device that senses smoke, typically as an indicator of fire. Smoke sensors are usually housed in plastic enclosures, typically shaped like a disk about 125 millimetres (5 in) in diameter and 25 millimetres (1 in) thick, but shape and size vary. Smoke can be detected either optically (photoelectric) or by physical process (ionization). Sensors may use one or both sensing methods. Sensitive alarms can be used to detect and deter smoking in banned areas. Smoke sensors in large commercial and industrial buildings are usually connected to a central fire alarm system.

5. 4-Channel 5V Relay Module –

The four-channel relay module contains four 5V relays and the associated switching and isolating components, which makes interfacing with a microcontroller or sensor easy with minimum components and connections. There are two terminal blocks with six terminals each, and each block is shared by two relays. The terminals are screw type, which makes connections to mains wiring easy and changeable.

The four relays on the module are rated for 5V, which means the relay is activated when there is approximately 5V across the coil. The contacts on each relay are specified for 250VAC and 30VDC and 10A in each case, as marked on the body of the relays.



The switching transistors act as a buffer between the relay coils that require high currents, and the inputs which don't draw much current. They amplify the input signal so that they can drive the coils to activate the relays. The freewheeling diodes prevent voltage spikes across the transistors when the relay is turned off since the coils are an inductive load. The indicator LEDs glow when the coil of the respective relay is energized, indicating that the relay is active. The optocouplers form an additional layer of isolation between the load being switched and the inputs.

6. Female DC Power Jack –

Compared to domestic AC power plugs and sockets, DC connectors have many more standard types that are not interchangeable. The dimensions and arrangement of DC connectors can be chosen to prevent accidental interconnection of incompatible sources and loads. Types vary from small coaxial connectors used to power portable electronic devices from AC adapters to connectors used for automotive accessories and for battery packs in portable equipment.

DC female power jack are commonly used in electronic industry to connect adapters to your circuit board. Most commonly used DC female jack is 2.1mm x 5.5 mm DC jack. Where 5.5mm is the outer diameter and 2.1mm is the intrenal pin size.

The DC plug (male) should match this dimension for proper matching. Most of the non proprietary co-axial power plugs match the 2.1 x 5.5 dimensions. In most of the DC plug the outer body is the negative supply and the internal is the positive.

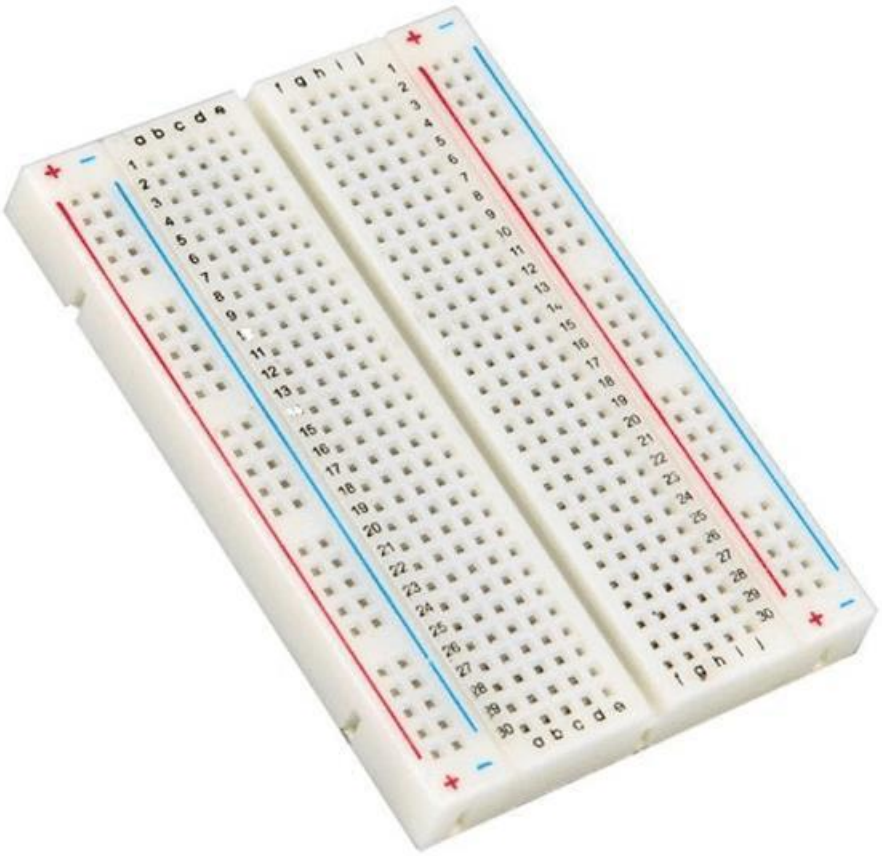
7. Socket Switch Board –

An electric switchboard is a piece of equipment that distributes electric power from one or more sources of supply to several smaller load circuits. It is an assembly of one or more panels, each of which contains switching devices for the protection and control of circuits fed from the switchboard.

Several manufacturers make switchboards used in industry, commercial buildings, telecommunication facilities, oil and gas plants, data centers, health care, and other buildings, and onboard large ships.

A switchboard is divided into different interconnected sections, generally consisting of a main section and a distribution section. These two sections are sometimes replaced by a combination section, which is a section that can fulfill the roles of both of the aforementioned sections. Switchboards can also sometimes come with an auxiliary section that is used to house devices that cannot be housed in the same section as other devices.

8. Standard Breadboard –



400 point printed circuit board (PCB) is electrically equivalent to the above solderless breadboard.

A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

Compared to more permanent circuit connection methods, modern breadboards have high parasitic capacitance, relatively high resistance, and less reliable connections, which are subject to jostle and physical degradation.

Signaling is limited to about 10 MHz, and not everything works properly even well below that frequency.

9. 5V 2Amp Power Adapter –

The power adapter supplies the necessary power to the ESP32 and other 5V components, ensuring stable operation and consistent performance.

"Power brick" in-line configuration, with detachable AC cord and NEMA 1-15 plug.When used with battery-powered equipment, adapters typically charge the battery as well as powering the equipment.

Aside from obviating the need for internal power supplies, adapters offer flexibility: a device can draw power from 120 VAC or 230 VAC mains, vehicle battery, or aircraft battery, just by using different adapters. Safety can be another advantage, as hazardous 120 or 240 volt mains power is transformed to a lower, safer voltage at the wall outlet before going into the appliance handled by the user.

10. AC Fan (220V) –

A 220V AC fan motor is designed to operate at a voltage of 220V AC and a frequency of 50Hz. The motor consists of a stator and a rotor, which are designed to produce a rotating magnetic field.

The stator winding is connected to the 220V AC power source, and the rotor winding is connected to a capacitor, which helps to improve the motor's efficiency and power factor. When the motor is turned on, the stator winding generates a magnetic field, which induces a voltage in the rotor winding. The rotor winding then produces a rotating magnetic field, which causes the rotor to rotate.

The motor's speed is controlled by the frequency of the AC power source. The motor's torque is controlled by the voltage applied to the stator winding.

3.2 Software Requirements

The Software Requirements of the project are :-

1. **Sinric Pro –**

Sinric Pro is a platform designed to simplify the integration of IoT devices with voice assistants such as Amazon Alexa and Google Assistant. It provides an easy-to-use framework for building smart home applications and controlling appliances remotely via the internet.

Advantages of Sinric Pro

- Ease of Use: Predefined templates and APIs simplify development.
- Scalability: Supports multiple devices and is ideal for both hobbyists and professionals.
- Low Latency: WebSocket communication ensures fast and real-time control.
- Cross-Platform: Works with both Alexa and Google Assistant, making it versatile.

2. **Blynk IoT –**

Blynk IoT is a platform that enables the development of Internet of Things (IoT) applications. It allows users to build connected devices and control them remotely through customizable dashboards.

Advantages of Blynk IoT

- Ease of Use: Simplifies IoT development with a user-friendly interface.
- Cross-Platform Support: Works on Android, iOS, and web browsers.
- Scalability: Suitable for individual projects and enterprise-level applications.
- Community and Documentation: A large community and extensive resources for learning.

3. **Arduino IDE –**

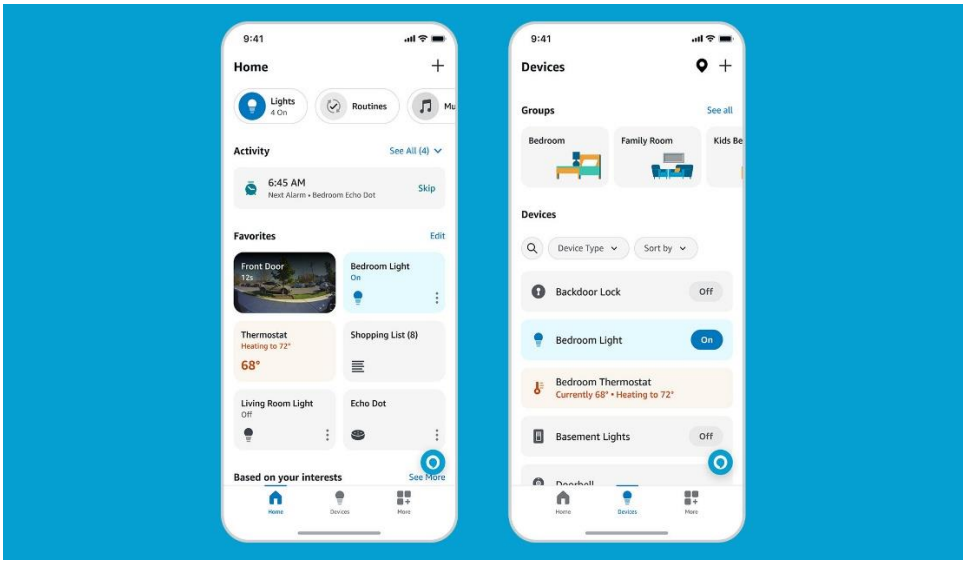
The Arduino IDE (Integrated Development Environment) is a software application used to write, compile, and upload code to Arduino boards and other compatible microcontrollers. It provides a beginner-friendly platform for programming and controlling hardware.

Advantages of Arduino IDE

- User-Friendly: Designed for beginners with a straightforward interface.

- Open Source: Free to use, with a large community contributing libraries and tutorials.
- Extensible: Supports additional board definitions and libraries through a board manager and library manager.
- Wide Hardware Support: Compatible with official Arduino boards and many third-party microcontrollers (ESP8266, ESP32, etc.).

4. Alexa App –



The Alexa App is the official companion application for Amazon's voice assistant, Alexa. It provides users with a platform to configure, manage, and interact with Alexa-enabled devices, such as Amazon Echo smart speakers, Echo Show, Fire TV, and other compatible devices.

Advantages of Alexa App

- User-Friendly Interface: Simplifies device setup and smart home control.
- Cross-Device Integration: Supports a wide range of Alexa-compatible devices and services.
- Automation: Empowers users to automate daily tasks with custom routines.
- Continuous Updates: Regularly adds new features, improving functionality over time.

5. **Google Home –**

The Google Home App is the central platform for managing Google Nest devices, Google Assistant, and other smart home devices. It allows users to configure, control, and monitor their smart home ecosystem directly from a smartphone.

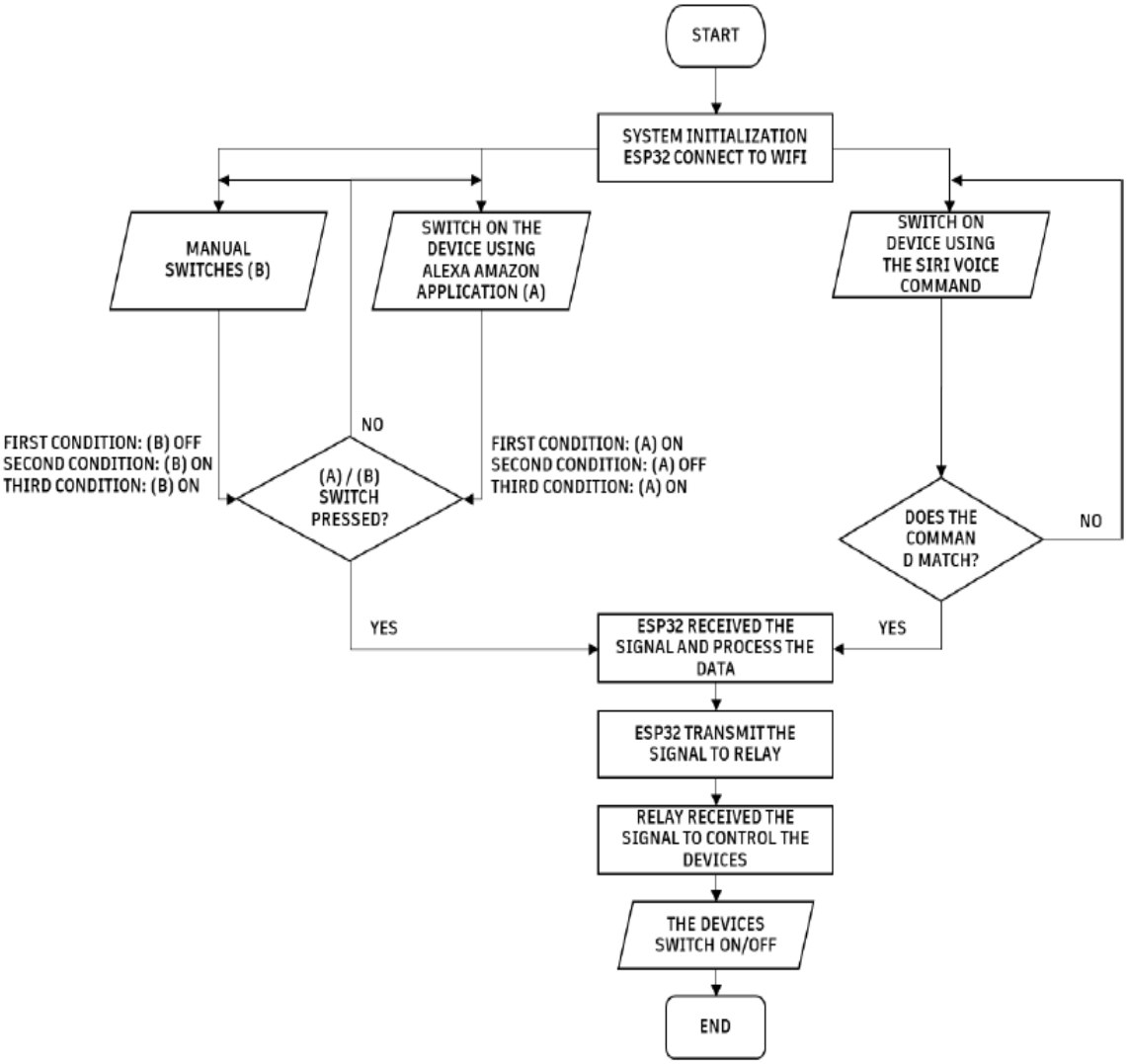
Advantages of Google Home

- Intuitive Interface: Simplifies smart home setup and management with a user-friendly design.
- Comprehensive Ecosystem: Works seamlessly with Google Assistant and a wide range of third-party devices.
- Personalized Experience: Offers individual user recognition and tailored responses.
- Automation Capabilities: Enables complex routines for a smarter home experience.

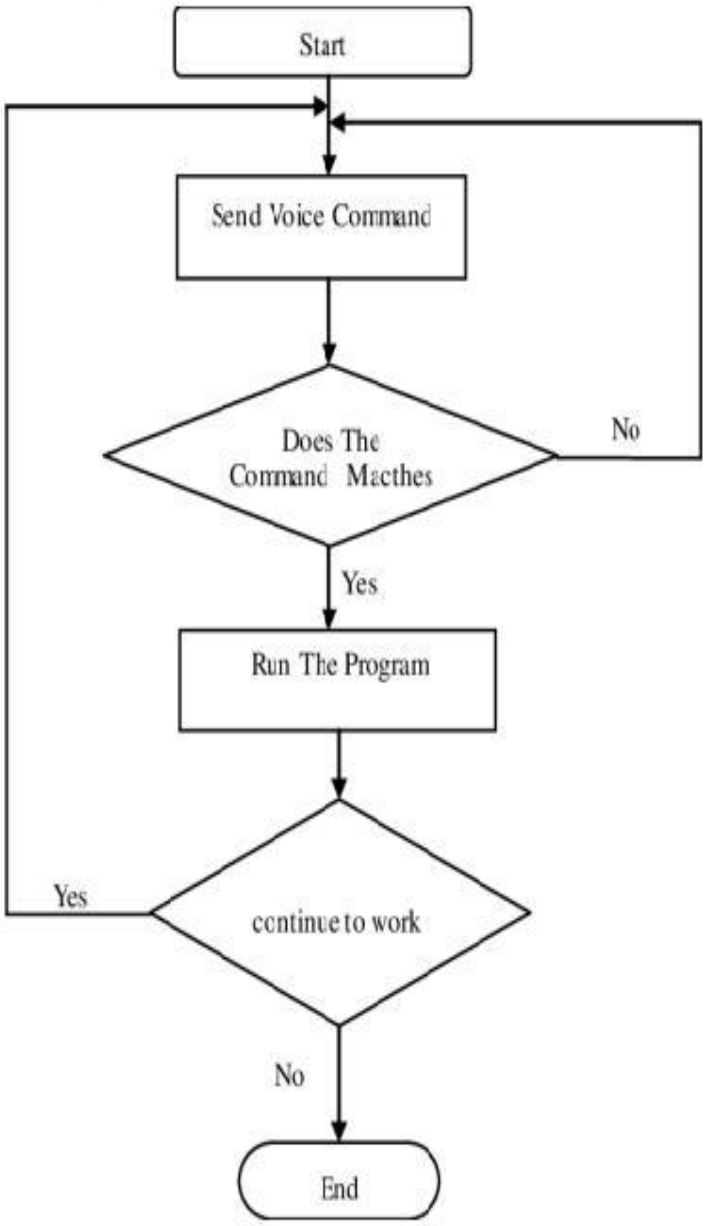
IV. PROJECT WORK

4.1 Flowchart's

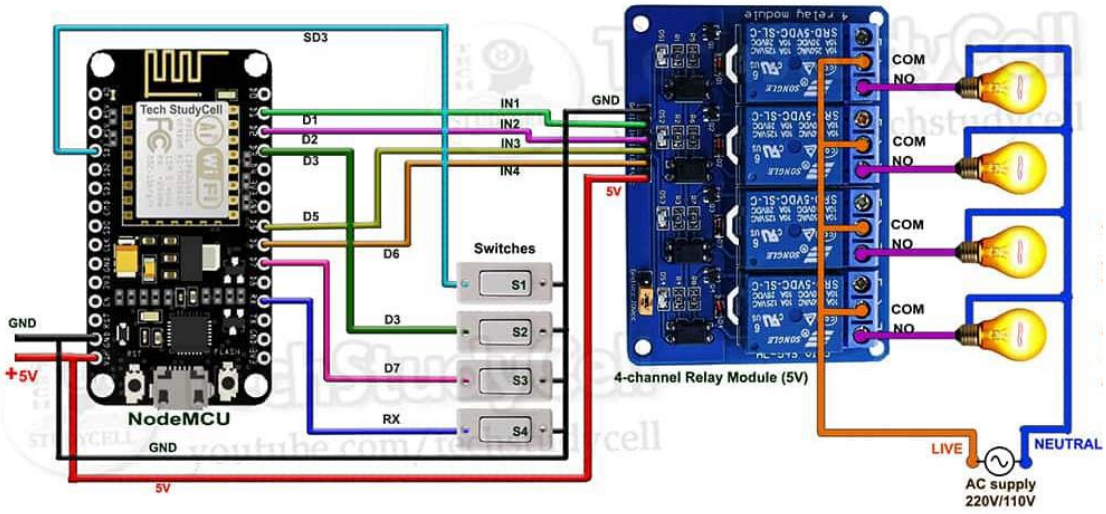
Flowchart of the control system:

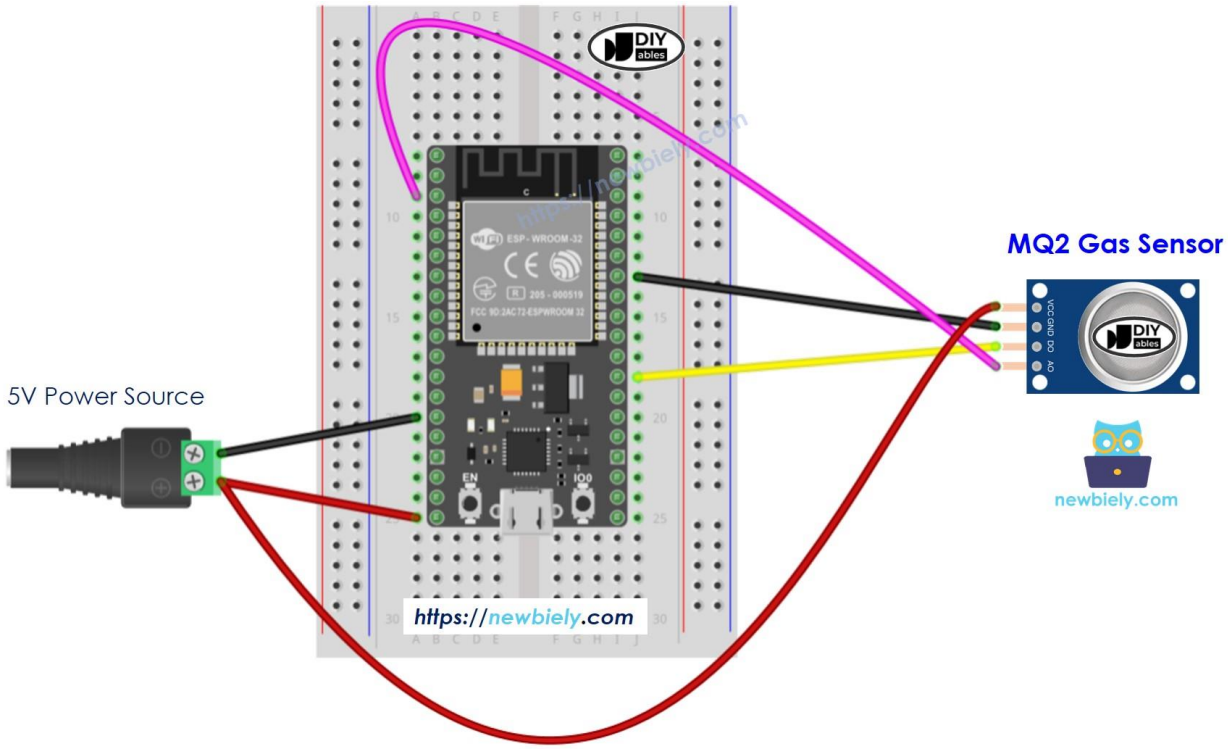


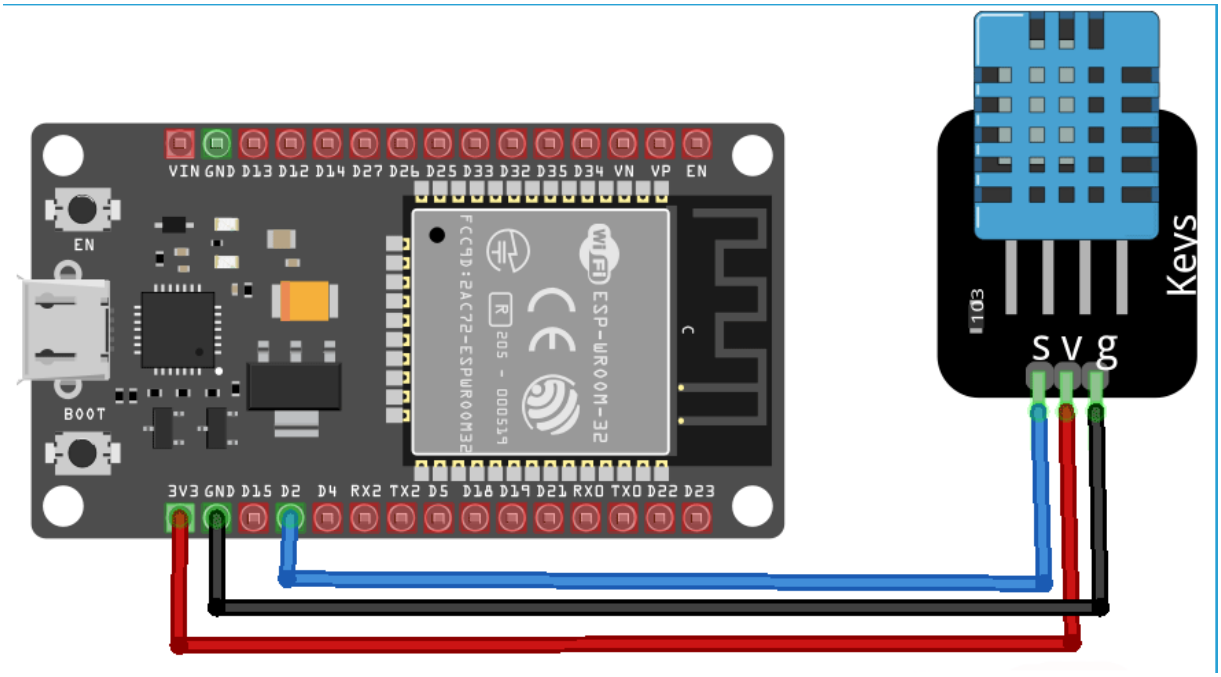
Flowchart of Home Automation using Alexa:

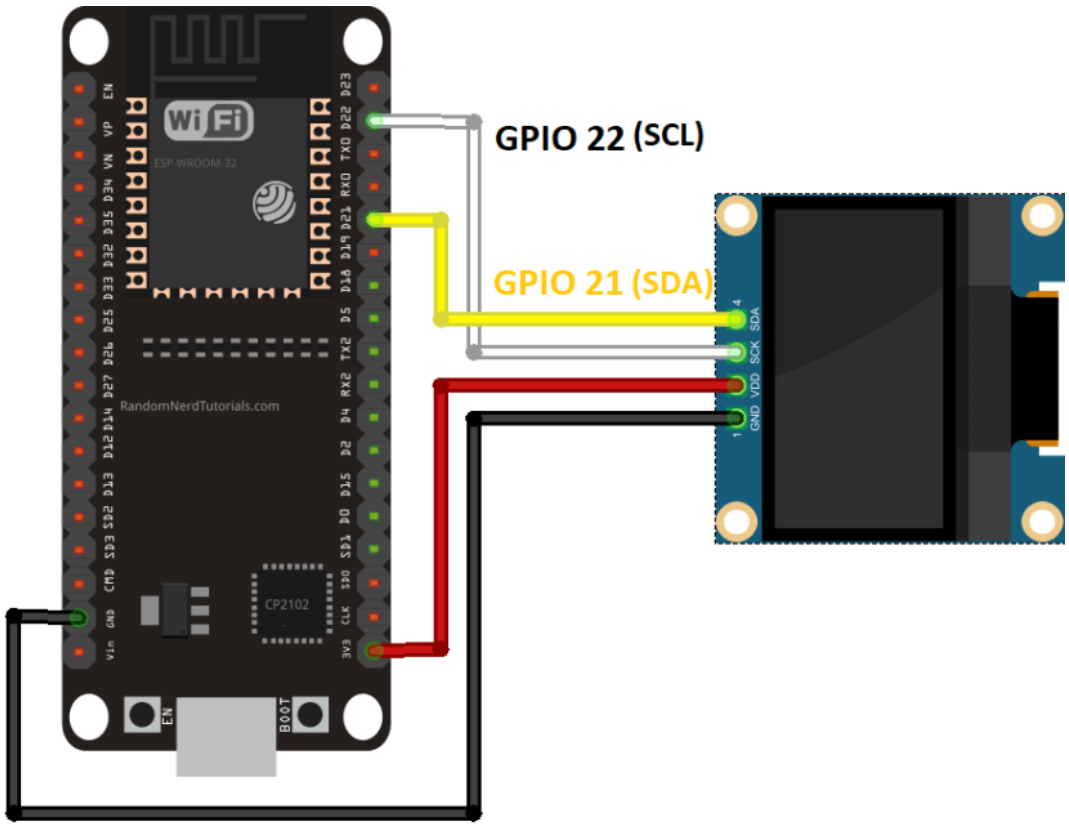


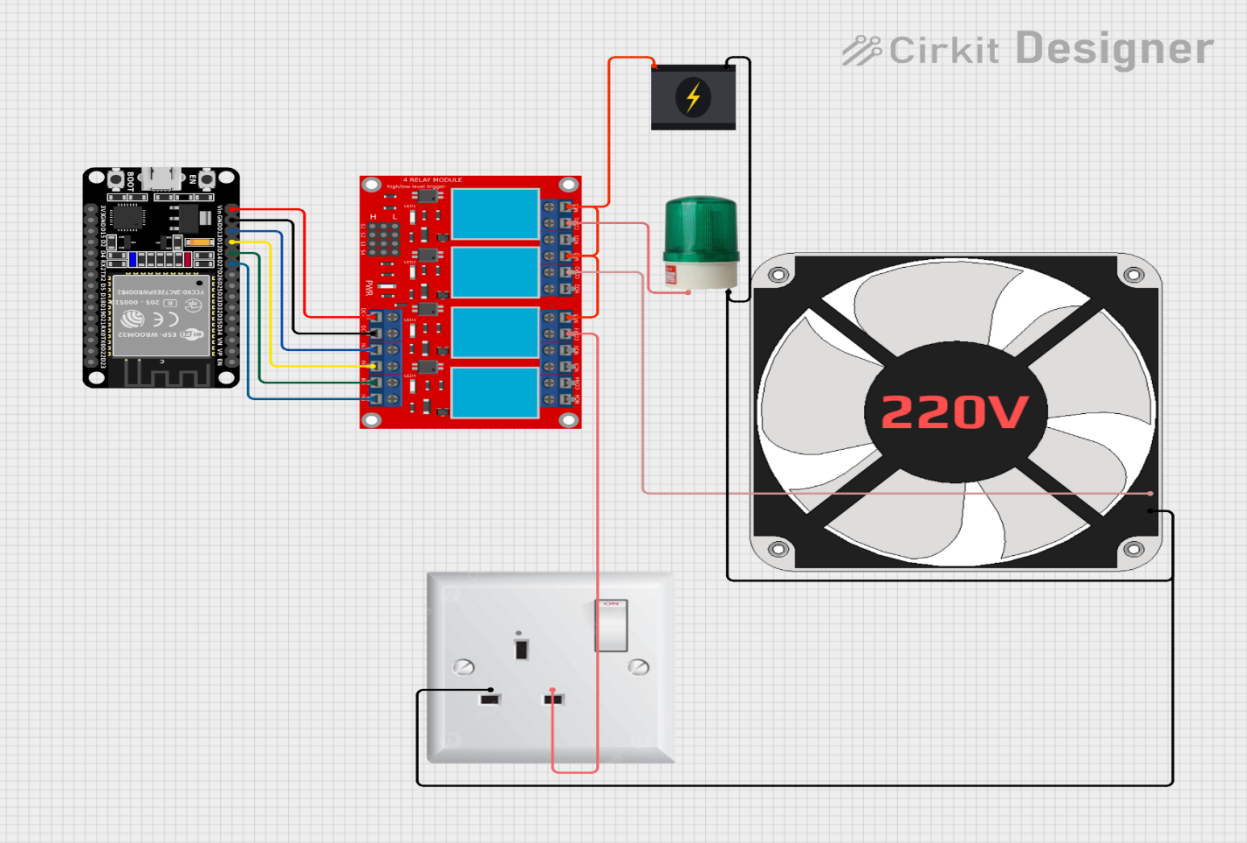
4.2 Schematic Diagram's

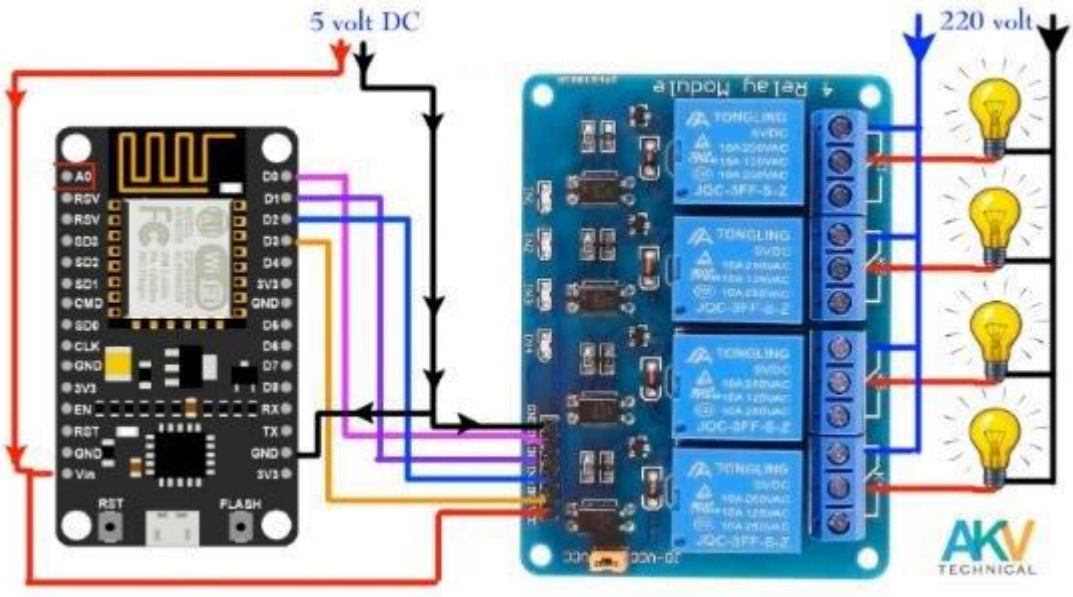





VIN GND D13 D12 D14 D27 D26 D25 D33 D32 D35 D34 VN VP EN
EN
BOOT
3V3 GND D15 D2 D4 RX2 TX2 D5 D18 D19 D21 RX0 TX0 D22 D23
ESP-WROOM-32
Kevs
S V g


GPIO 22 (SCL)
GPIO 21 (SDA)
RandomNerdTutorials.com
CP2102
EN
BOOT
GND VDD SCK SDA


Cirkit Designer
220V


5 volt DC
220 volt
4 Relay Module
AKV
TECHNICAL

xl

4.3 Project Code

```
#define BLYNK_TEMPLATE_ID "TMPL3nua0ELL-"

#define BLYNK_TEMPLATE_NAME "Seamless Home Automation via ESP32 and Alexa"

#define BLYNK_AUTH_TOKEN "uhKHXojln4xlNFu_JN1gJ81DB1t7R6b1"


#include <WiFi.h>

#include <BlynkSimpleEsp32.h>

#include <DHT.h>

#include <Wire.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>

#include <SinricPro.h>

#include <SinricProSwitch.h>


// Wi-Fi credentials

char ssid[] = "Ansh enterprise";

char pass[] = "8802694511";


// SinricPro credentials

#define APP_KEY "e29fda54-83bf-4d65-8a76-29873e353a07"

#define APP_SECRET "476a392f-b7bd-4b3d-97a1-6eb656848822-469fbc02-0d3a-42cf-9279-c237b1eb5ffd"
```

```
// Device IDs from SinricPro
#define device_ID_1 "67386981ca1dbba89b642d69" // Bulb 1
#define device_ID_2 "673869a0de70d3c324bd1460" // Bulb 2
#define device_ID_3 "673869d9de70d3c324bd14cc" // Fan

// Pin definitions
#define RelayPin1 26   // GPIO5 for Bulb 1 (Alexa controlled)
#define RelayPin2 25    // GPIO4 for Bulb 2 (Alexa controlled)
#define RelayPin3 33   // GPIO14 for Bulb 3 (Blynk controlled)
#define RelayPin4 32   // GPIO12 for Fan (Alexa controlled)
#define DHTPIN 14      // GPIO33 for DHT sensor data pin
#define DHTTYPE DHT11  // DHT11 or DHT22
#define SMOKE_SENSOR_PIN 34  // GPIO34 for MQ-2 smoke sensor

// Blynk virtual pins
#define BLYNK_VPIN_TEMP V5     // Temperature virtual pin
#define BLYNK_VPIN_HUMIDITY V6 // Humidity virtual pin
#define BLYNK_VPIN_SMOKE V7    // Smoke level virtual pin
#define BLYNK_PIN_BULB3 V3
#define BLYNK_PIN_FAN   V4

// OLED display settings
#define SCREEN_WIDTH 128  // OLED display width in pixels
```

```
#define SCREEN_HEIGHT 64  // OLED display height in pixels
#define OLED_RESET -1     // Reset pin, set to -1 if sharing Arduino reset pin
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

DHT dht(DHTPIN, DHTTYPE);

// Blynk timer
BlynkTimer timer;

// SinricPro callback for Alexa-controlled devices
bool onPowerState(const String &deviceId, bool &state) {
  if (deviceId == device_ID_1) {
    digitalWrite(RelayPin1, !state);
  } else if (deviceId == device_ID_2) {
    digitalWrite(RelayPin2, !state);
  } else if (deviceId == device_ID_3) {
    digitalWrite(RelayPin4, !state);
  }
  return true;
}

// Setup SinricPro for Alexa
```

```
void setupSinricPro() {
  SinricProSwitch &mySwitch1 = SinricPro[device_ID_1];
  SinricProSwitch &mySwitch2 = SinricPro[device_ID_2];
  SinricProSwitch &mySwitch3 = SinricPro[device_ID_3];

  mySwitch1.onPowerState(onPowerState);
  mySwitch2.onPowerState(onPowerState);
  mySwitch3.onPowerState(onPowerState);

  SinricPro.begin(APP_KEY, APP_SECRET);
  SinricPro.restoreDeviceStates(true);
}

// Blynk write handlers
BLYNK_WRITE(BLYNK_PIN_BULB3) {
  int state = param.asInt();
  digitalWrite(RelayPin3, state);
}

BLYNK_WRITE(BLYNK_PIN_FAN) {
  int state = param.asInt();
  digitalWrite(RelayPin4, state);
}
```

```
// Sensor update function
void updateSensors() {
  // Read temperature and humidity
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();

  // Read smoke level
  int smokeLevel = analogRead(SMOKE_SENSOR_PIN);  // Declare smokeLevel here

  // Check if readings are valid
  if (!isnan(temperature) && !isnan(humidity)) {
    Blynk.virtualWrite(BLYNK_VPIN_TEMP, temperature);
    Blynk.virtualWrite(BLYNK_VPIN_HUMIDITY, humidity);

    // Display on OLED
    display.clearDisplay();

    // Set normal text size for labels
    display.setTextSize(1);
    display.setTextColor(SSD1306_WHITE);
```

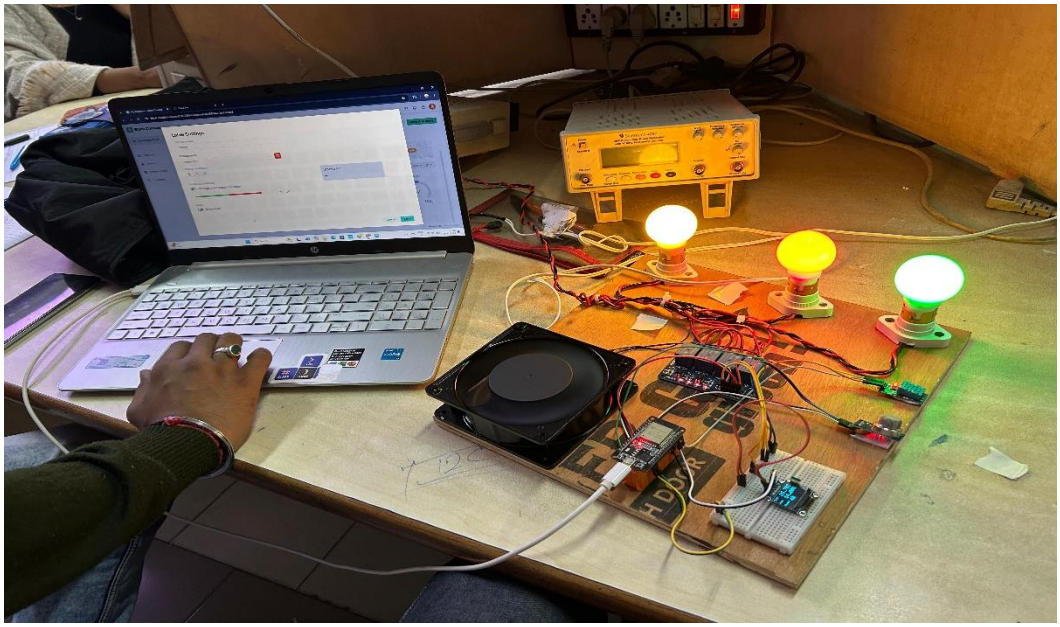
```
    // Temperature label
    display.setCursor(0, 0);
    display.print("Temp: ");

    // Humidity label
    display.setCursor(0, 20);
    display.print("Hum: ");

    // Smoke label
    display.setCursor(0, 40);
    display.print("Smoke: ");

    // Set larger text size for sensor readings
    display.setTextSize(2);

    // Reduce the gap between label and value
    display.setCursor(40, 0); // Reduced horizontal position to bring closer to the label
    display.print(temperature);
    display.print("C");  // Adding space between value and unit

    display.setCursor(40, 20); // Reduced horizontal position
    display.print(humidity);
```

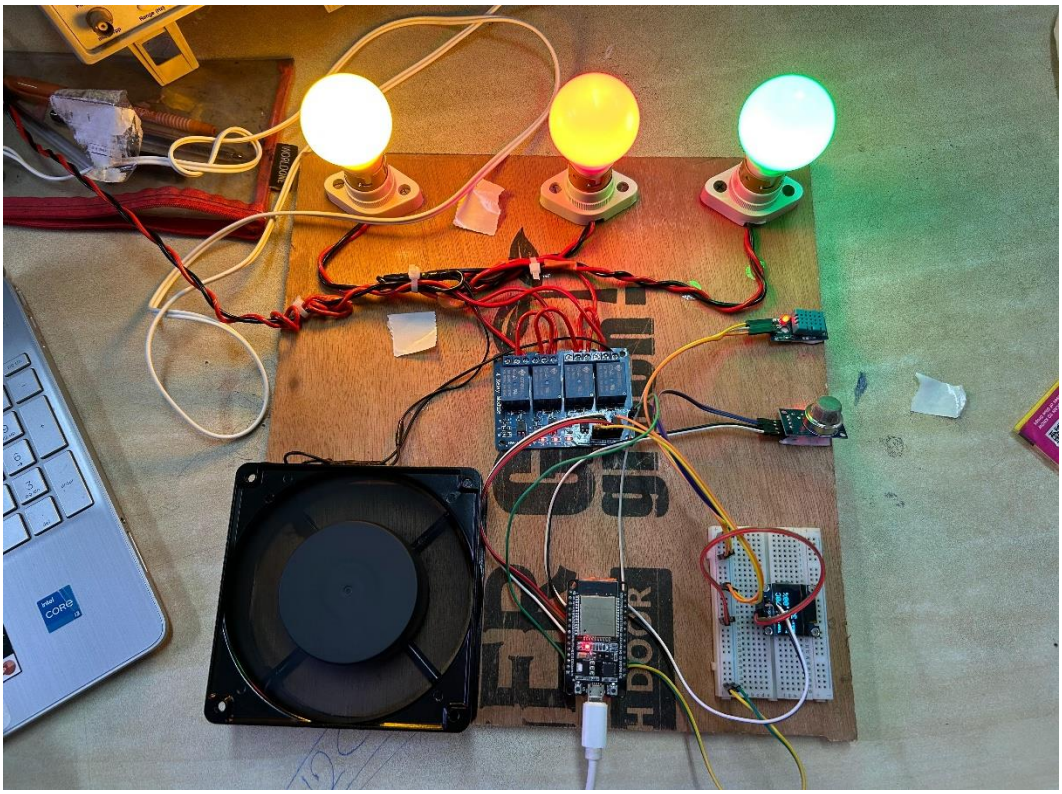
```
    display.print("%");  // Adding space between value and unit

    display.setCursor(40, 40); // Reduced horizontal position
    display.print(smokeLevel);

    display.display();
  } else {
    Serial.println("Failed to read from DHT sensor!");
  }

  // Debugging
  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.print(" C, Humidity: ");
  Serial.print(humidity);
  Serial.print(" %, Smoke Level: ");
  Serial.println(smokeLevel);  // Print smokeLevel here
}

void setup() {
  Serial.begin(115200);

  // Initialize relays
```

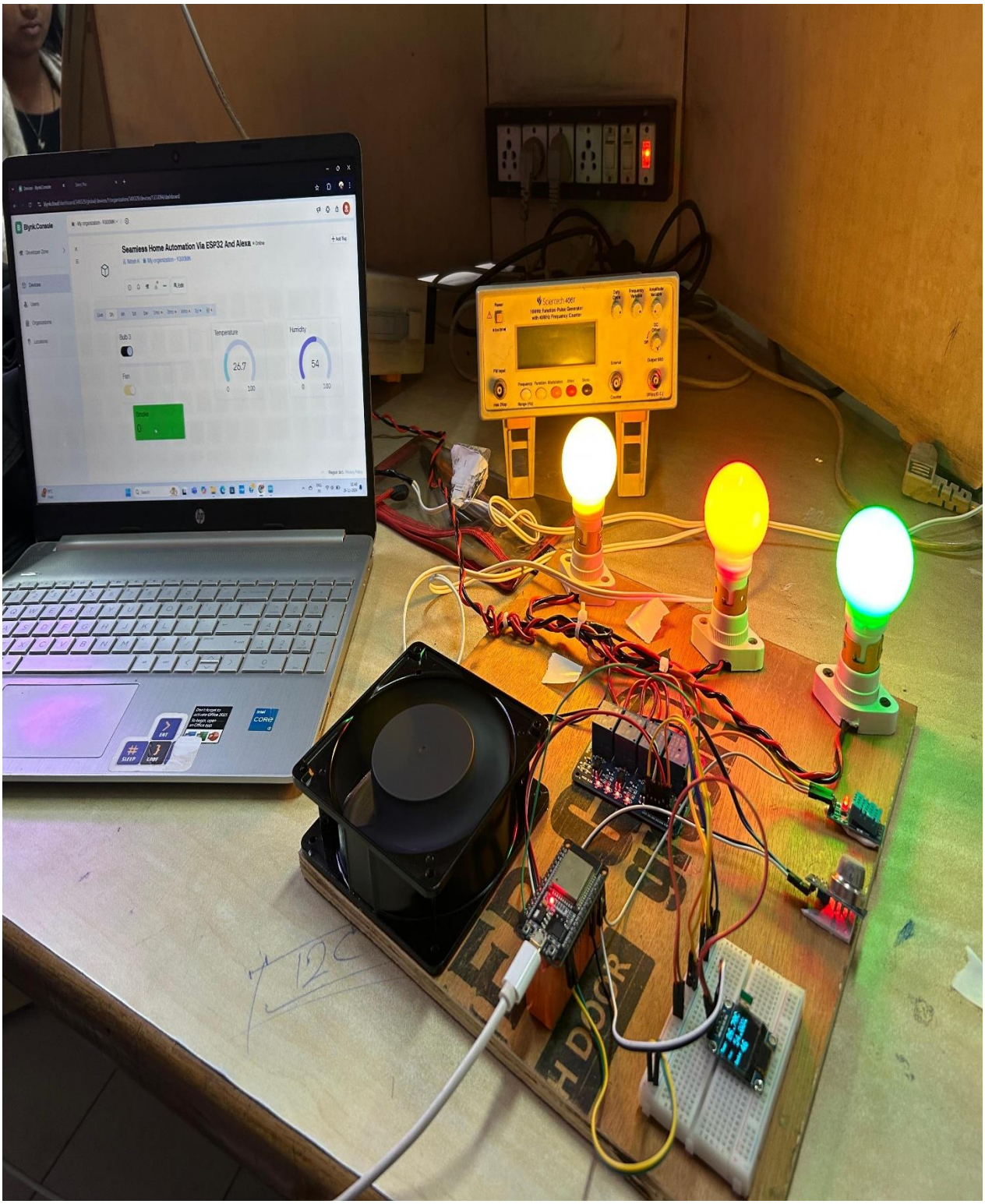
```
pinMode(RelayPin1, OUTPUT);
pinMode(RelayPin2, OUTPUT);
pinMode(RelayPin3, OUTPUT);
pinMode(RelayPin4, OUTPUT);
digitalWrite(RelayPin1, HIGH);
digitalWrite(RelayPin2, HIGH);
digitalWrite(RelayPin3, HIGH);
digitalWrite(RelayPin4, HIGH);

// Initialize smoke sensor
pinMode(SMOKE_SENSOR_PIN, INPUT);

// Initialize DHT sensor
dht.begin();

// Initialize OLED
if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
  Serial.println(F("SSD1306 allocation failed"));
  for(;;); // Don't proceed, loop forever
}
display.display();
delay(2000);  // Pause for 2 seconds
display.clearDisplay();
```

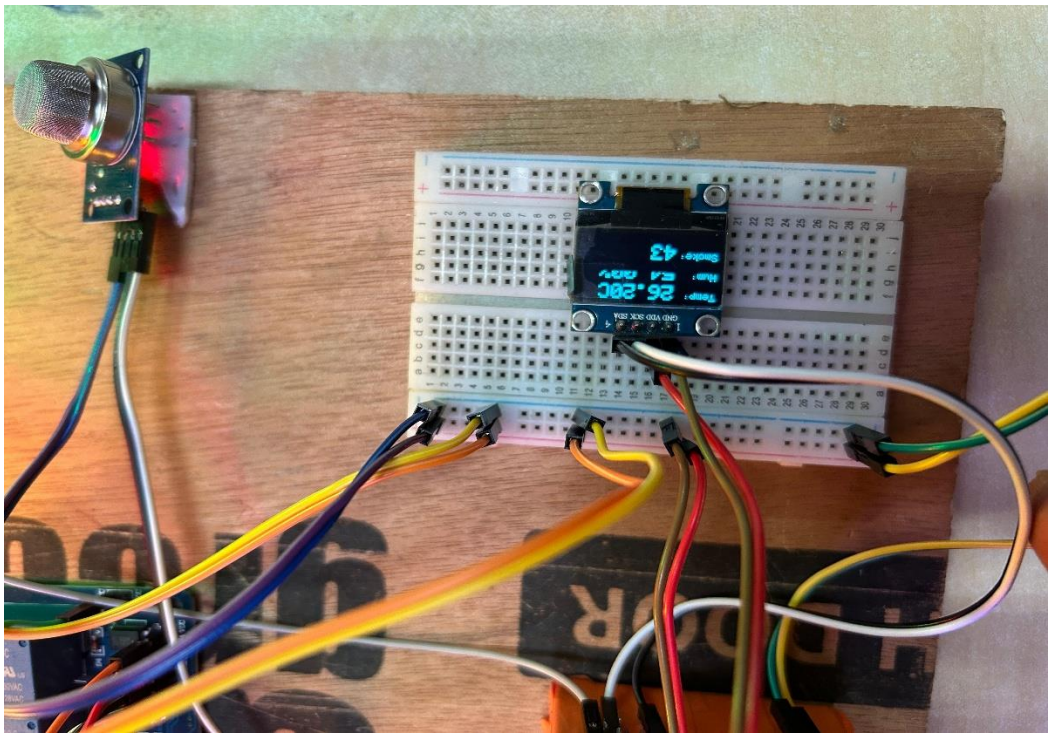
```
  // Setup Wi-Fi and Blynk
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);

  // Setup SinricPro
  setupSinricPro();

  // Set timer to update sensors every 2 seconds
  timer.setInterval(2000L, updateSensors);

  display.setCursor(0, 0);
  display.setTextSize(1);  // Default font size for initial message
  display.print("System Ready");
  display.display();
}

void loop() {
  Blynk.run();
  SinricPro.handle();
  timer.run();
}
```

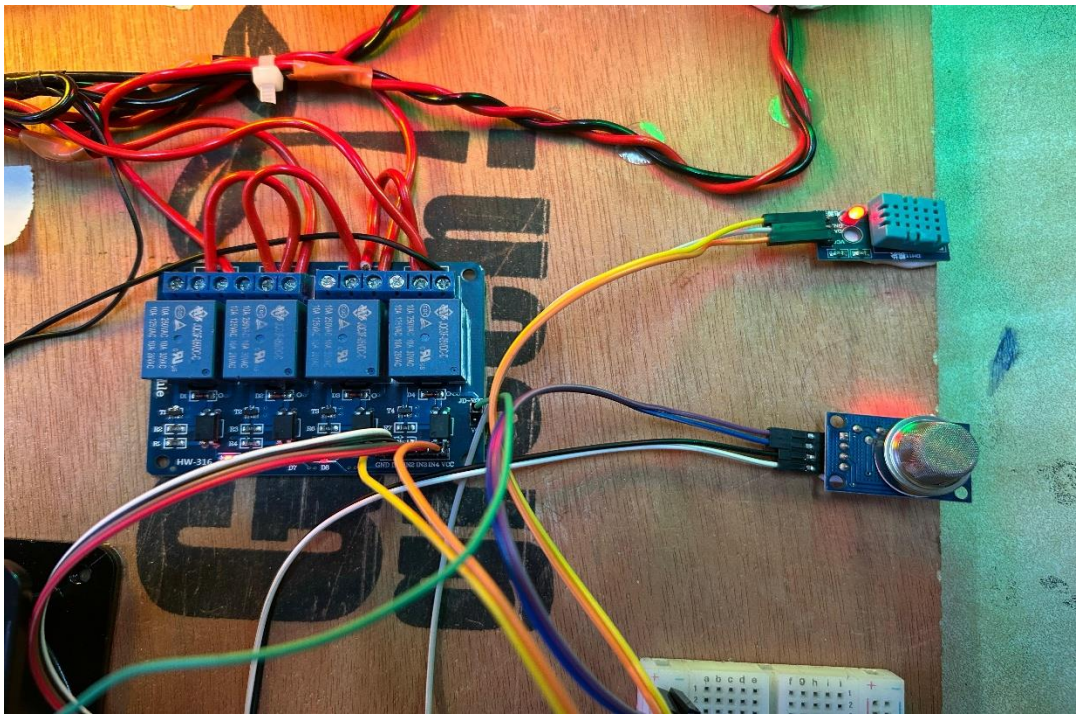
4.4 Result

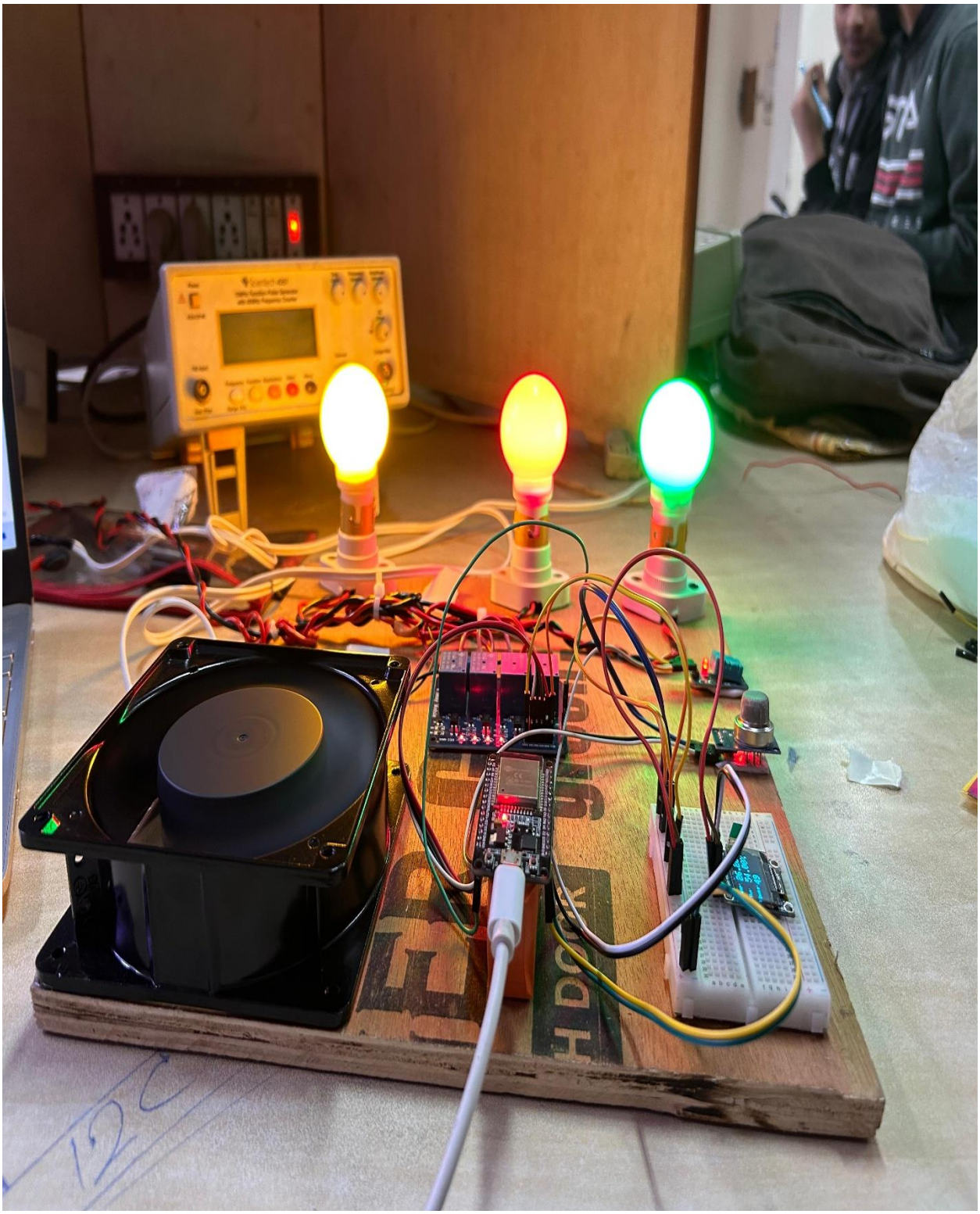


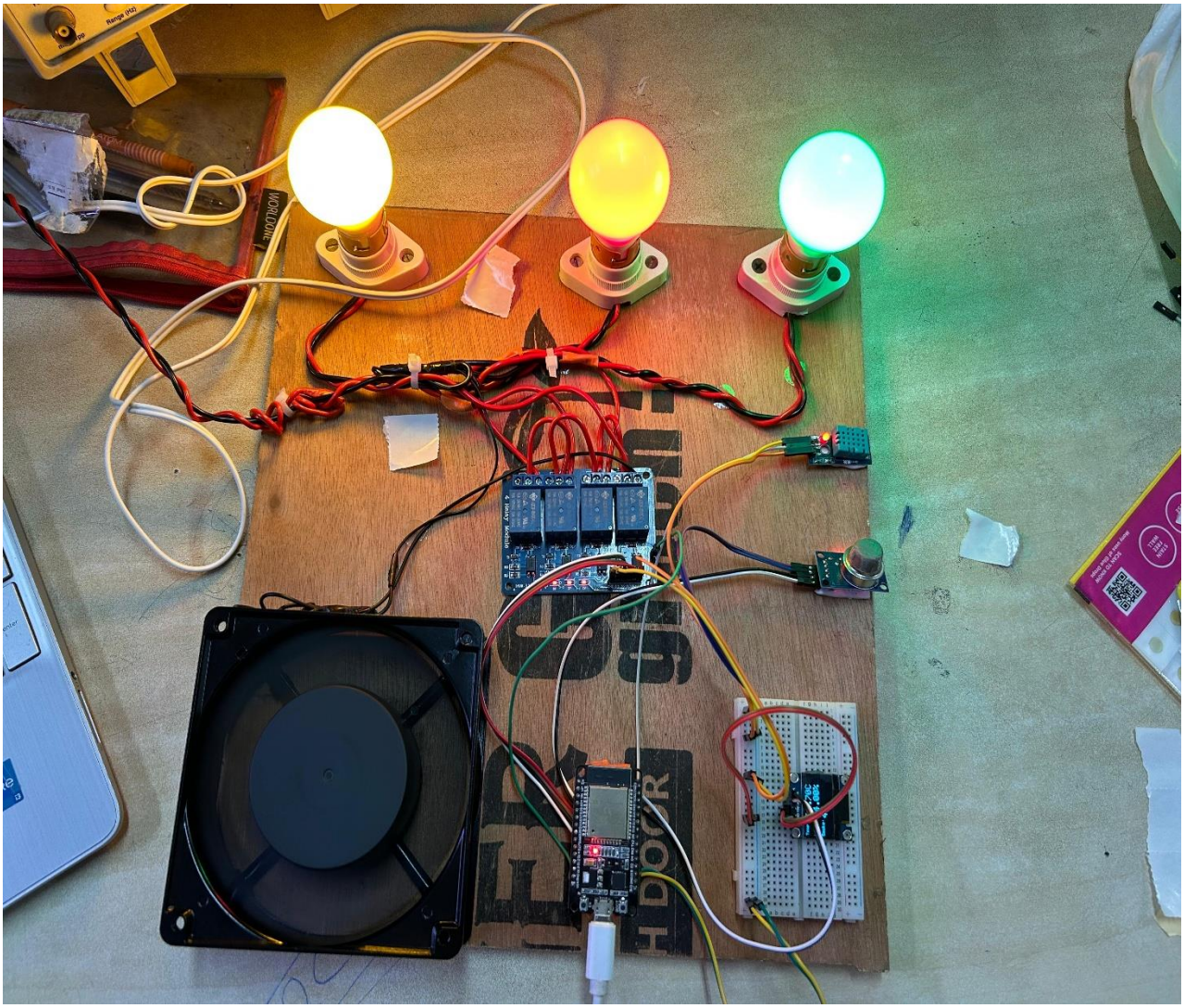



Blynk.Console
Seamless Home Automation Via ESP32 And Alexa
Bulb 0
Temperature
26.7
Humidity
54
Fan
Smoke
0


Temp: 26.20C
Humi: 54 rain
Smoke: 43







V. CONCLUSION

The integration of ESP32 with Alexa marks a significant advancement in the field of home automation, offering a harmonious blend of cutting-edge technology and user-friendly functionality. This setup leverages the ESP32's versatile hardware capabilities, such as WiFi and Bluetooth connectivity, GPIO support, and processing power, to seamlessly connect physical devices to a digital control ecosystem.

On the other hand, Alexa provides a natural and intuitive interface for managing these devices, enabling users to control appliances, monitor systems, and execute tasks through simple voice commands or remote access.

This combination provides a cost-effective and scalable solution for creating smart homes that cater to the unique needs of users. By automating repetitive tasks, optimizing energy usage, and enhancing convenience, it not only simplifies everyday life but also contributes to energy efficiency and sustainability.

Moreover, the system's flexibility allows for future expansions and customizations, ensuring that it remains adaptable to evolving technological advancements and user requirements.

Despite challenges such as network dependency and data security concerns, these can be mitigated with robust design practices, including reliable internet backups, encrypted communication protocols, and optimized system performance.

Overall, integrating ESP32 and Alexa transforms traditional homes into intelligent environments that are responsive, efficient, and future-ready, making it an indispensable approach to modern living.

VI. FUTURE SCOPE

The future of home automation with ESP32 and Alexa integration is promising, with potential for significant advancements:

1. **AI-Driven Personalization:** Enhanced AI algorithms can enable Alexa to learn user habits, automating tasks more intuitively.
2. **Energy Optimization:** Integration with smart grids and advanced sensors can further reduce energy consumption.
3. **Increased Device Compatibility:** Expanding support for more IoT devices and protocols (e.g., Zigbee, Matter) will improve interoperability.
4. **Offline Functionality:** Development of local processing capabilities in ESP32 can reduce reliance on cloud services, ensuring continuity during internet outages.
5. **Enhanced Security:** Implementing advanced encryption and biometric authentication will address privacy and security concerns.
6. **Edge Computing:** Leveraging ESP32's processing power for real-time decision-making can reduce latency and improve system responsiveness.
7. **Scalability:** Future advancements will allow seamless integration of larger networks of smart devices, making automation systems adaptable to diverse environments.

VII. REFERENCES

[1] Shopan Dey, Ayon Roy, “Home Automation Using Internet of Thing”, International Research Journal of Engineering and Technology, 2015.

[2] Clark, R., & Johnson, E., "Voice-Controlled Home Automation System using ESP32 and Alexa." International Journal of Electrical Engineering, 2021.

[3] Garcia, R., & Adams, M., "Integration of ESP32 with Alexa for Smart Home Applications." Journal of Intelligent Systems, 2019.

[4] Martinez, D., & Clark, R., "ESP32-based Home Automation System with Alexa Integration and Manual Switching." Institute of Electrical and Electronics Engineers, 2023.