SMART HOME AUTOMATION IOT BASED USING NODEMCU ESP8266

Asst. Prof. Pratibha Sakhare
Kamla Nehru Mahavidyalaya, Nagpur
Email : pratibhasakhare@gmail.com
M: 8208349219

Miss Payal Titare
Kamla Nehru Mahavidyalaya, Nagpur

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Abstract :

Internet of Things (IoT) has paved the way for smarter living environments by connecting everyday devices to the internet. This project presents a smart home automation system developed using the NodeMCU ESP8266 microcontroller, which enables users to monitor and control home appliances remotely via a smartphone and web application. The node MCU ESP8266 Wi-Fi module acts as the communication backbone, allowing real-time data exchange between the user and home devices through cloud-based services (such as Blynk). The proposed prototype uses Node MCU board with internet being remotely controlled by Android/iOS OS smart phone. Node MCU is the heart of this system and it can perform as a micro web server and it acts as an interface for the wide range of hardware modules. To control lights, fans and other home appliances which are connected to the relay system, the system offers switching functionalities. Users can easily turn devices on or off and set schedules from anywhere with internet access. This approach enhances energy efficiency, comfort, and security, allowing for features like automatic lighting control and smart energy management. The system's design prioritizes low cost, scalability, and ease of implementation, making it suitable for both residential and small commercial environments. In conclusion, the IoT-based smart home automation system utilizing NodeMCU ESP8266 demonstrates how affordable microcontrollers and cloud connectivity can transform traditional homes into intelligent, responsive living spaces. Future scope implementation of AI for learning user behaviour and automating appliances accordingly, predictive control of lighting & fans, automatic load control to reduce electricity bills, solar power system integration for green energy solutions.

Keywords : Internet of Things (IoT), NodeMCU ESP8266, smart home automation, Artificial learning (AI)

Introduction :

Smart homes concept increasingly connected world prominence, driven by the need for convenience, energy efficiency, and enhanced quality of life. With urban populations growing and energy demands rising, there is a strong need to manage household environments in a way that optimizes comfort while minimizing energy use. In the past few years, advancement of Automation Technology home automation segment has seen a rapid

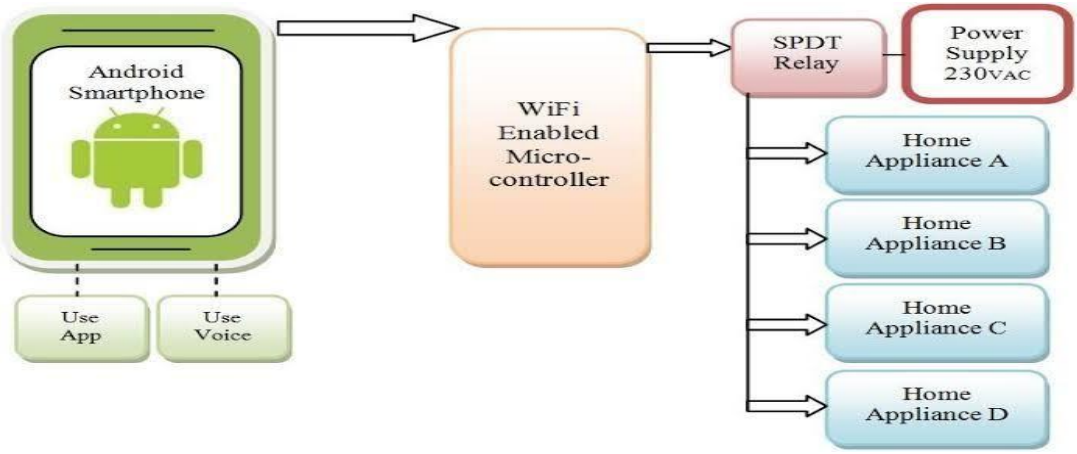
advancement and with that advancement, the evolution and development of new and improved technologies. With, life is getting simpler and easier in all aspects. In today's world, Automatic systems are being preferred over manual systems. Internet of Things is the latest emerging internet technology and has got its origin from home automation. The pivotal difference between standard home automation devices and IoT devices is that the IoT devices can transfer and share data over the existing network framework. Also, IoT devices are capable of being controlled remotely over the internet. Present technologies have to rely on different protocols for communication. Also some proprietary and some standard like Wi-MAX, Ethernet, Bluetooth, Z-Wave, and Fiber Optics. The major problem with all these protocols is that they are not suited with each other. This paper uses basic and most extensively used standard like IEEE 802.11 (Wi-Fi).the need for convenience, energy efficiency, and enhanced quality of life. With urban populations growing and energy demands rising, there is a strong need to manage household environments in a way that optimizes comfort while minimizing energy use. This is where the integration of Internet of Things (IoT) technology has emerged as a transformative solution. By connecting household appliances to the internet, IoT enables real-time monitoring, data logging, and remote control, providing homeowners with greater control over their home environment while enhancing energy efficiency and convenience.

Literature survey :

The expeditiously growing internet has opened new horizons for development in various fields. The home automation industry has seen a rapid growth in the previous years.[1,11] It has become a topic of interest for many people around the world. Vishwateja Mudiam Reddy & Naresh Vinay in their paper "Internet of Things Enabled Smart Switch" designed a system which integrates the cloud and web app.With the assistance of flip-flops, logic gates and a processor, the switches might be controlled. The proposed model was intended for reducing the value of those systems which was the most barrier within the wide adaptation of this technology. Khusvinder Gill & Shuang-Hua Yang created a common home gateway for ZigBee and Wi-Fi. [4]This enables a remote control using a simple graphical user interface. The system was cost effective and had a good security inside the house. [5,6]Salma and Dr. Radcliffe with a goal of increasing the popularity and reach of home automation designed a system that used the Novel Network Protocol. It gave the choice of controlling the commercial devices through a mobile phone or laptop.[3,10] An additional network device had been used for remote access in place of a microcontroller.A reliable and simple system with a power to integrate with very lesser efforts for off the shelf products was created by Carelin and I. Jacob Raglend. The system uses ZigBee for home automation and GSM for remote access. It didn't provide any GUI and also it had been susceptible to security threats as anyone could access the system. Rozita Teymourzadeh, Salah Addin Ahmed designed a GSM based system for home automation. Using the GSM protocol, it became possible to access the system by using the Short Message System (SMS). The system also gave feedback to the user about the present state of any desired object.[2,12]

System block diagram :

Fig .1:



Ref

Working Principle :

Introduction :

Home automation refers to the automatic and electronic control of household features, activity, and appliances. In this system, the NodeMCU (based on the ESP8266 chip) serves as the main controller that enables IoT (Internet of Things) functionality. It connects physical appliances to the internet, allowing users to monitor and control them remotely via a smartphone app or web interface.

Core Components and Their Roles :

a. NodeMCU (ESP8266 Wi-Fi Module)

- Microcontroller Unit (MCU) with built-in Wi-Fi capability.
- Acts as the central processing and communication hub.
- Receives user commands from a cloud/app and controls physical devices.
- Also reads data from connected sensors.

b. Relay Module :

- An electrical switch operated by a low voltage (from NodeMCU) to control high-voltage appliances.
- Allows safe interfacing between low-power microcontroller logic and high-voltage AC devices like fans and lights.

c. Sensors (Optional) :

- Motion sensors (PIR), temperature sensors (DHT11/22), LDRs, etc.
- Provide data inputs to the NodeMCU to automate based on environmental changes.

d. Smart phone App or Web Interface :

- Used to control the appliances and monitor sensor data.
- Apps like Blynk or custom-built apps are commonly used.
- Communicates with NodeMCU via the cloud.

e. Cloud/Server :

- Platforms like Blynk, Firebase, MQTT broker, or ThingSpeak.
- Acts as a bridge between user interface and NodeMCU.
- Stores and forwards commands and data.

Working Principle (Step-by-Step) :

Step 1: Initialization and Network Connection :

- When powered, the NodeMCU initializes and connects to the pre-configured Wi-Fi network.
- It establishes a connection with the cloud server (e.g., Blynk).

Step 2: User Input or Sensor Trigger :

- The user uses a mobile app to send a command (e.g., turn ON light).
- Alternatively, a sensor detects an event (e.g., motion detected or high temperature).

Step 3: Cloud Communication :

- The user command is sent via the internet to the cloud server (like Blynk).
- The cloud forwards this command to the NodeMCU connected to the internet via Wi-Fi.

Step 4: NodeMCU Processes Command :

- NodeMCU receives the command (like "turn ON relay 1").
- Based on this, it sends a digital HIGH/LOW signal to the corresponding relay pin.

Step 5: Appliance Control via Relay :

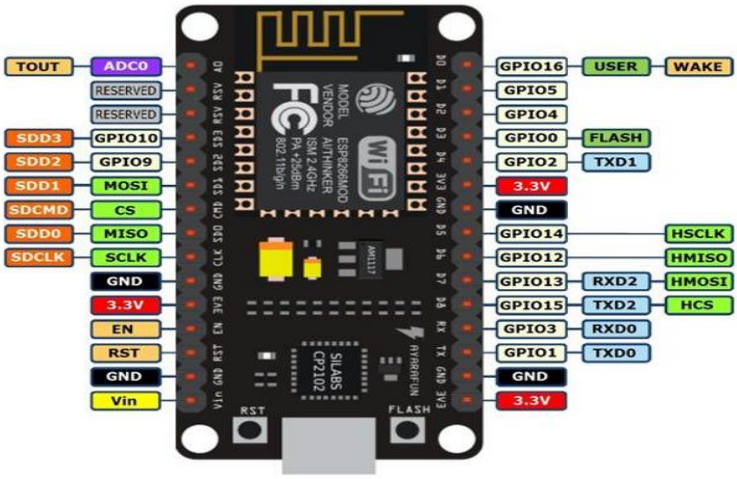
- The relay module receives the signal and switches the connected appliance ON/OFF.
- For example, if relay is connected to a light bulb, it will turn ON the light.

Step 6: Feedback (Optional) :

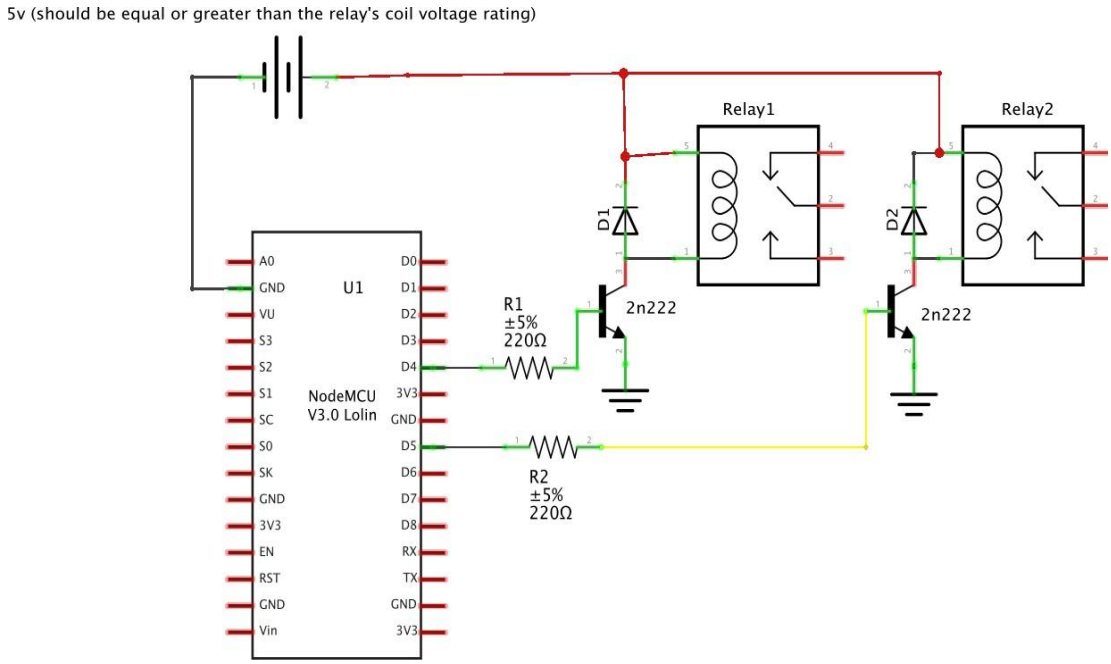
- NodeMCU can send back the current status (like "Light is ON") to the cloud.
- The app updates the UI to reflect this change in real-time.

NodeMCU ESP8266 :

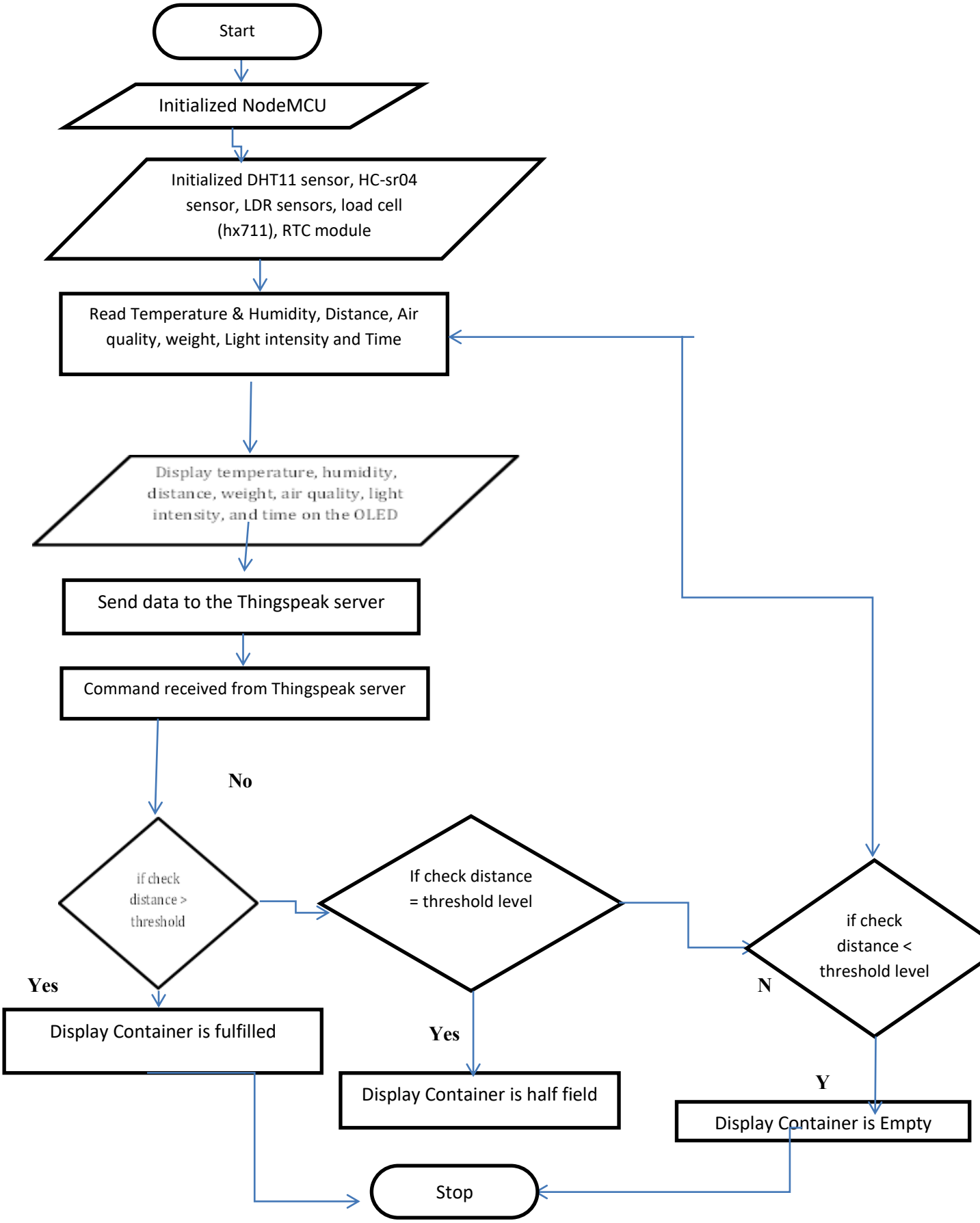
The NODEMCU ESP8266 development board comes with the ESP-12E module containing the ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This micro-processor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for Iot projects. NodeMCU can be powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.[6,7]



Circuit Diagram :



Flowchart :

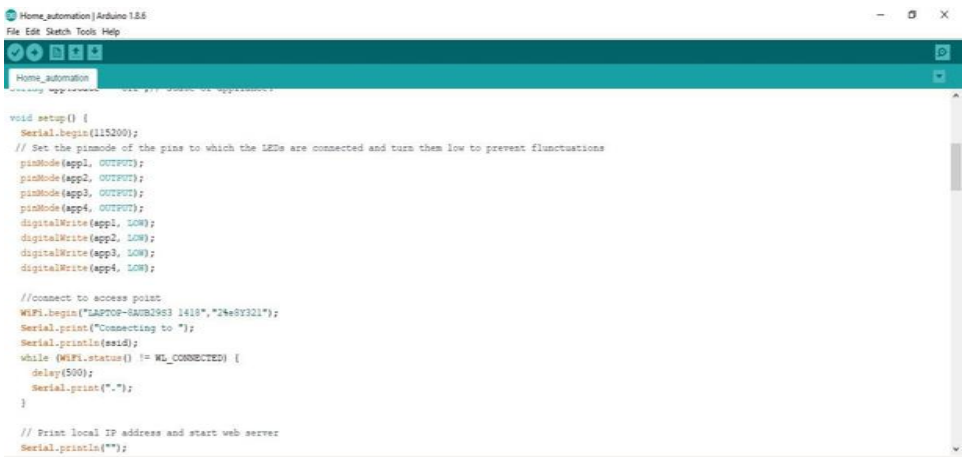

Start
Initialized NodeMCU
Initialized DHT11 sensor, HC-sr04 sensor, LDR sensors, load cell (hx711), RTC module
Read Temperature & Humidity, Distance, Air quality, weight, Light intensity and Time
Display temperature, humidity, distance, weight, air quality, light intensity, and time on the OLED
Send data to the Thingspeak server
Command received from Thingspeak server
No
if check distance > threshold
If check distance = threshold level
if check distance < threshold level
Yes
N
Yes
Y
Display Container is fulfilled
Display Container is half field
Display Container is Empty
Stop

Experiential Work :

The heart of this project is the WiFi enabled board that needs no introduction; the ESP8266 based Node MCU development board. It is an open source platform for developing WiFi based embedded systems and it is based on the popular ESP8266 WiFi Module, running the Lua based Node MCU firmware. Node MCU was born out of the desire to overcome the limitations associated with the first versions of the ESP8266 module which was not compatible with breadboards, it was difficult to power and even more difficult to program. The Node MCU board is easy to use, low cost and that quickly endeared it to the heart of makers and it is one of the most popular boards today.For this project, we will add a 4-channel relay module to the ESP8266 board. The project flow involves the control of Node MCU's GPIOs from a webpage on any device connected on the same network as the board. The status of the GPIOs control the coils of the relays and that causes the relay to alternate between normally open (NO) and normally closed (NC) condition depending on the state of the GPIO, thus, effectively turning the connected appliance "ON" or "OFF".

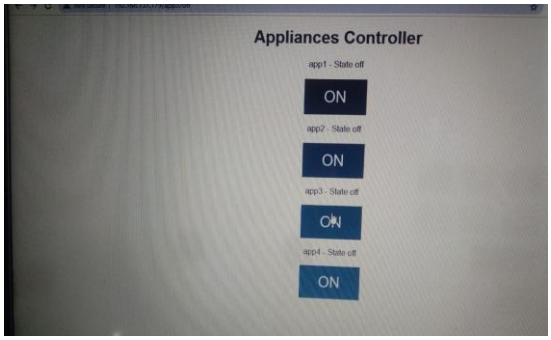
Working CODE :

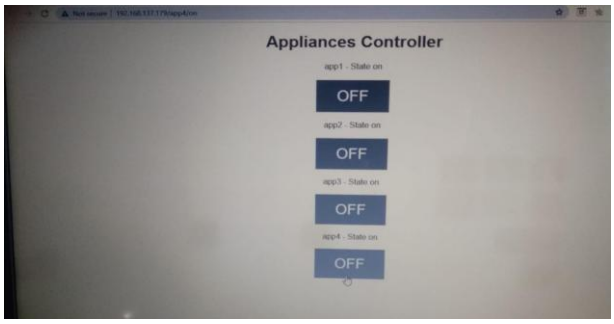
The code will enable us to control appliances connected to the GPIOs (via relays) of the Node MCU board remotely. To start with, we include the library that we will use for experiment which in this case, is ESP8266WiFi.h library.



Results and discussion :

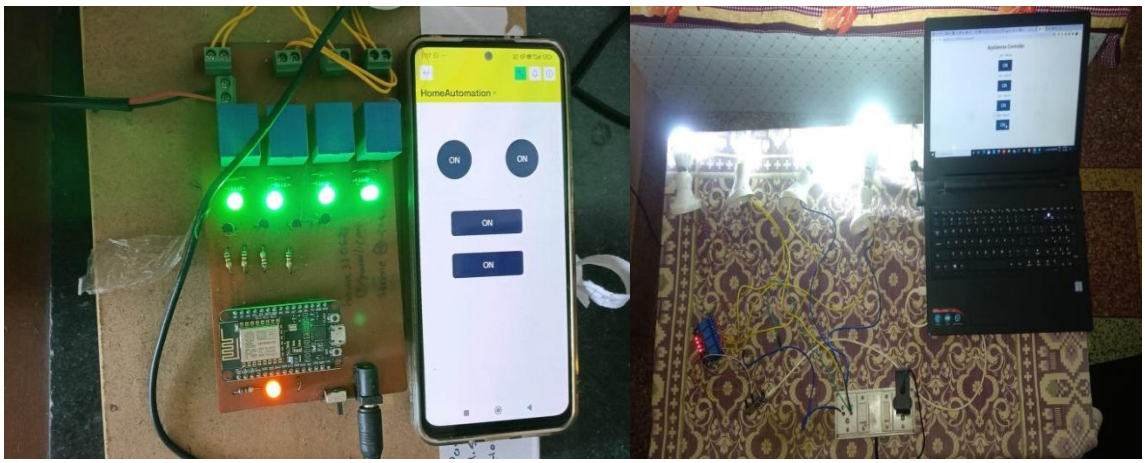
Light Control Test Results :





The Light Control Test is done by pressing the ON / OFF button widget on the Web application on the respective Android smart phone/Pc for lights and fans. This is done after the system is turned on and connected to a Wi-Fi internet connection. If at any time the internet connection is lost or bad signal, then it also affects system performance. .

Hardware Output :



Conclusion :

In the field of home automation and IoT-enabled the Smart Home Automation System represents a valuable advancement by leveraging the capabilities of the NodeMCUESP8266 microcontroller, and the Blynk IoT platform this project effectively demonstrates the potential for real-time control and appliance management. The system allows for both remote manual control and automatic adjustments based on environmental conditions, showcasing the feasibility and efficiency of IoT in creating a responsive home environment.

This Project highlights the improving energy efficiency, and promoting sustainable living practices. As more individuals seek to reduce energy consumption and optimize their living spaces. The main barrier towards the acceptance of home automation presently is its high cost. Due to use of NodeMCU and the IoT platform, these devices can be made cost-effective.[13,14,16]

Future Scope :

Implementation of AI for learning user behaviour and automating appliances accordingly, predictive control of lights fans, and AC based on user habits. Recent advancement examples are as Real-time power consumption monitoring, solar power system integration for green energy solutions, energy Monitoring and management Integration of smart energy meters, Automatic load control to reduce electricity bills.

[8, 9,10]

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- John Smith et al. (2018) developed an IoT-based home automation system using ESP8266 NodeMCU and concluded that this platform offers a low-cost, efficient method for wireless home appliance control. Their study demonstrated that users could remotely monitor and control devices using a smartphone app, increasing convenience and energy savings.

- Maria Garcia and Thomas Lee (2019) researched smart home automation systems and found that NodeMCU's integrated WiFi module significantly reduces hardware complexity compared to other microcontrollers. Their work emphasized the scalability of NodeMCU-based solutions for smart living environments.
- Ahmed Khan and Sophie Müller (2020) designed a home automation system integrating NodeMCU and Blynk, highlighting the system's reliability and responsiveness. They reported that users benefited from real-time control and energy management features.
- James Brown and Elena Ivanova (2017) studied security concerns in IoT home automation systems and recommended advanced encryption techniques to safeguard communication between NodeMCU devices and cloud services, improving system security against cyber threats.
- Lucas Martinez and Hannah O'Connor (2021) compared various wireless protocols for smart homes and concluded that WiFi-enabled NodeMCU systems provide superior connectivity and seamless integration with mobile applications, making them preferable for residential automation.
- Yuki Tanaka and David Wilson (2019) focused on user experience with home automation apps and found that applications like Blynk offer intuitive controls and easy customization, which greatly enhances user satisfaction and device management efficiency.