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IoT-Based Smart Home Switch System Using the ESP32 Microcontroller

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Abstract: Nowadays, people tended to forget to turn off their appliances, particularly those that used a lot of electricity at home, resulting in a significant increase in their monthly electricity bill. Some people could not walk to turn on and off the appliances because of their health conditions, which forces them to either leave the appliances on or ask others to assist, and they were not always by their side when they needed it most. In this current period of technological advancement, most people were addicted to automatic devices, believing that these could simplify their daily life, particularly at work. This project was accomplished through the internet of things (IoT), which provides consumers with a higher level of living comfort. A smart home switch system based on IoT using an ESP32 microcontroller was developed in this project to make people's lives easier, particularly for those who were disabled. Even if they were away from home, they could save time by turning on and off electrical appliances and assisting people who were in need to complete their daily tasks more conveniently. The switches for this smart technology were operated by an online server accessible via a mobile device or a personal computer. The Blynk Application and an ESP32 microcontroller controlled lights and other electrical appliances. Users could control the appliance manually or online, depending on the user preference, and it provided updates to the Blynk controlled panel regarding their state

Keywords: IoT, ESP32, Blynk

1. Introduction

The current state of technology demonstrates that most people of all ages depend on automatic devices, also known as smart devices. IoT has the potential and influence to significantly improve the quality of life and work with the advent of modern technology. The convergence of multiple technologies, including pervasive wireless connectivity, real-time analytics, machine learning, commodity sensors, and embedded systems, has facilitated the evolution of the IoT [1].

The earliest machines for home automation were labor-saving devices. With the advent of electricity in the 1900s, self-contained electric and gas-powered home appliances became feasible,

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leading to the invention of washing machines (1904), water heaters (1889), freezers, sewing machines, dishwashers, and clothing dryers [2].

In 1975, Pico Electronics of Glenrothes, Scotland [3] introduced the X10 interface protocol for electronic devices. X10 utilised signals to transmit commands to specific devices, allowing them to control when and how the action began. A home automation transmitter sends a signal through the home's electrical wiring, instructing a device to turn on at a predetermined time [4].

Early in the twenty-first century, home automation, also known as smart homes, gained popularity. As a result, new technologies began to emerge, and smart homes became a viable consumer technology almost immediately after becoming an affordable option [5]. Because of this, home technology, networking, and other products appeared on store shelves. Most of the more than one billion personal computers in use worldwide are connected to the internet. Eighty percent of homes worldwide use wireless Wi-Fi networking, and the number of commercial hotspots is growing [6].

The objectives aim to create a home monitoring and device control system utilising ESP32 for long-distance. Evaluate ESP32 with Blynk in an IoT-based home switch system. Smart home switch system based on IoT using ESP32 Microcontroller controls lighting and sockets over the internet. This device monitors and controls home appliances. Individuals can also control it manually, and it shows the device's state.

2. Materials and Methods

This part will explain the concept of using ESP32 and Blynk in the home automation controller and a list of materials that were used in the completion of this project.

2.1 Properties Materials

Table 1: Materials and their function

Materials	Description
Switch Socket	• Use to power up external appliances • 240V 13A
1 gang 1-way Switches	• To switch ON lighting system • 240V 10A
Wire Cables	• 1.5mm is for a lighting system • 2.5mm is for switch socket
Relay Module	• Use to trigger high voltage load • 5V DC Trigger Voltage • 240V 10A
Protection Device (Main Switch, RCCB, MCB)	• Giving protection to the electrical circuit from any disturbances • 63A Main Switch • 40A RCCB • 16A and 6A MCB
ESP32	• Acts as brain of the system to control the behavior of the system • Operating Voltage 3.3V • 30 I/O Pins
Rectifier (Hi-Link)	• Convert AC to DC to supply ESP32 and Relay • 240 AC Input Voltage • 5V DC Output Voltage

2.2 Graphical Interface and Platform

As shown in Figure 1 the Blynk control panel is an online control application that allows users to operate appliances using the Blynk server. In this project, four variables were constructed, each of which represents a switch that controls four different loads. Aside from switching, the variables will also provide feedback when there is a change in the state of the appliances in question.

Figure 1: Blynk Control Panel

2.3 Methods

Figure 2 shows the project flowchart.

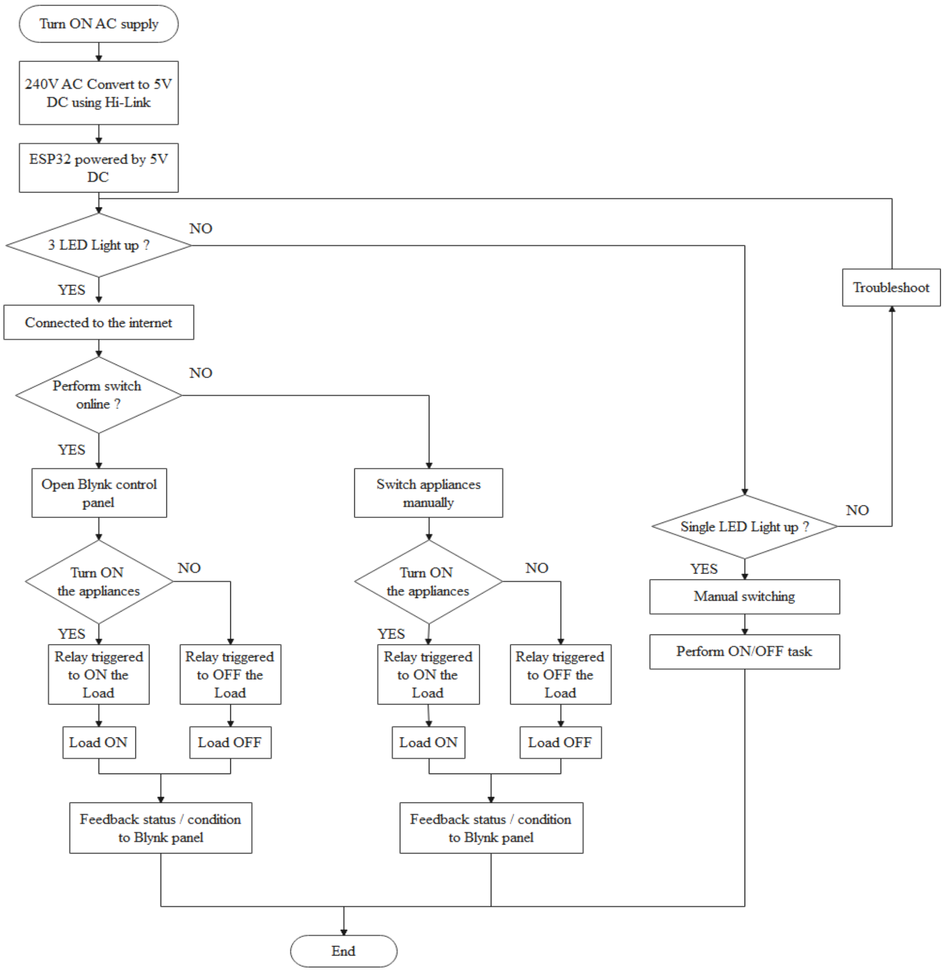

Figure 2: Project's Flowchart

As illustrated in Figure 2, after the primary source is which is a 240V AC supply turned on, the power source came from a 13A household socket, it will be converted to 5V DC by using Hi-Link to give supply for the ESP32 microcontroller. Hi-Link is an AC to DC converter that can generate 5V from either 120V or 240V [7]. Because the ESP32 has an onboard regulator that converts the voltage from 5V to 3.3V, this converter is used to power up the ESP32 via the VIN pin, which provides 5V output. Aside from that, it's also used to power a relay that requires 5V to activate on command from the microcontroller. The ESP32 is equipped with Wi-Fi and Bluetooth capabilities, making it a well-rounded chip for creating IoT applications and embedded systems in general [8]. This microcontroller will send a signal to the relay, which will then switch the condition of the appliances ON or OFF.

After receiving the power supply, the router will display the LED to indicate whether three lights are ON or only single. The LED is made up of two terminals, which are known as the anode and the cathode. When these two terminals are properly linked to a voltage source with the correct polarity, the red light which is used in this project will be produced. Three LEDs will be connected to the ESP32 in this project, and they will be used to determine whether the device is connected to the internet. It is, without a doubt, utilised to inform the administrator if the application is in manual automation or online.

If yes, it suggests that the application is connected to the internet. There would be no internet connection if no LED lights up or only a single LED light up. As an outcome, if only a single LED is displayed in the case of an internet connection, the ON/OFF switch will be accomplished by manual switching. If no, then it will begin to detect the internet connection once more. After the first three LEDs light up, the user will have two options which are to complete the switch online or manually. If the transition is made online, it will be done through the Blynk control panel, which may be accessed by a mobile phone, laptop, or another device. Blynk has the ability to control hardware remotely, show data from sensors, store data, and visualise it, in addition to performing a variety of other useful functions [9].

A 5VDC relay is used to power high-voltage loads like lamps, fans, and other household appliances. The ESP32 is programmed to activate the relay, allowing it to be controlled remotely. ON or OFF conditions are selected on the ESP32, and the signal is sent to the relay, which turns on and off the appliances through the webpage control panel generated in Blynk when the button is touched. The relay includes three high-voltage terminals (NC, C, and NO), which will be used to connect the relay to various appliances [9]. There are three low voltage pins on the other side of the board (Ground, VCC, and Signal), and these three pins are often connected to the microcontroller (ESP32).

A transistor is used to increase the strength of electronic signals and electrical power or to switch between them. It is necessary to employ a BC547 transistor to regulate and operate the relay. It is possible to drive a transistor into saturation (turn it ON) when LOGIC 1 is written to the port pin, resulting in the relay being turned on, but the relay will be turned off when LOGIC 0 (or no logic) is written to the port pin [10]. It goes without saying that a transistor is needed to boost the current so that the entire current may travel through a coil to fully energise it, as the ESP32 is incapable of driving the relay directly. The terminals listed below must be taken into consideration while making the connection to the transistor.

After the load is turned ON or OFF, it will provide feedback to the Blynk control panel. When using a manual switch, after the light is turned on or off manually, it will give feedback to the Blynk control panel.

3. Results and Discussion

3.1 Hardware Testing Using Blynk

Blynk Application was used to regulate and monitor the load (socket and lights) via an internet application. Figure 3 shows widgets that represent switches for each load in the application. To determine whether the load is ON or OFF, simply glance at the switch while it is on, the switch will light green, while when it is off, it will glow black. As illustrated in Figure 3, the values 1 and 0, also known as HIGH and LOW, can be used to signify ON and OFF the load, with 1 representing ON and 0 representing OFF.

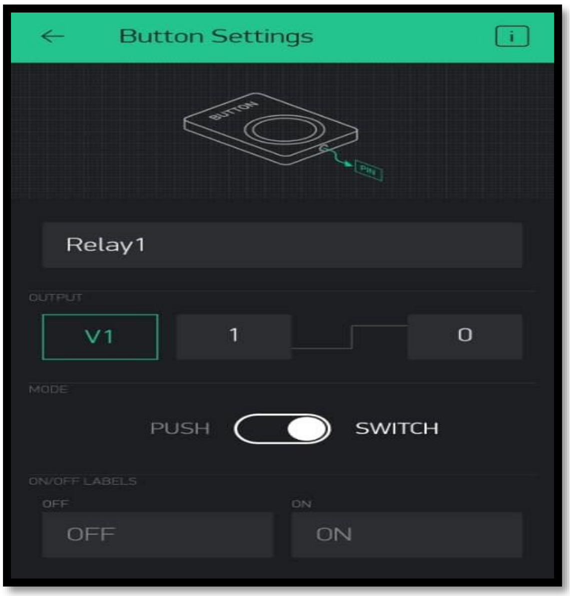

Figure 3: High and Low for the switch in the Blynk control panel

When the relay button in Blynk Dashboard is pressed, as shown in Table 2, the lightbulb of the load will light up in line with the relay in Blynk Dashboard. Based on the relay in the Blynk Dashboard, the lightbulb of the load will be illuminated when the relay button in the Blynk Dashboard is turned OFF. The fact that this event occurred suggests that the project was successful and that its goal was accomplished.

Table 2: Comparison of Relay Between Blynk Dashboard and Loads

Switch (S)				Relay (R) (Blynk Dashboard)			
S1	S2	S3	S4	R1	R2	R3	R4
ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
ON	ON	ON	ON	ON	ON	ON	ON

According to Table 3, when the manual switches are switched ON, the Blynk control panel will also be turned ON simultaneously, depending on which relay is being used. Unless the switches are turned on, the operation of any other relay will not be affected. However, when the relay is controlled through the Blynk control panel, the switches will have no effect on the behavior of the relay. The switches have to be manually turned on or off in order to get them into their initial condition.

Table 3: Comparison Between Manual Switch and Blynk Dashboard

Switch				Relay(Blynk Dashboard)			
S1	S2	S3	S4	R1	R2	R3	R4
ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
ON	ON	ON	ON	ON	ON	ON	ON

3.2 ESP32 Internet Connection

According to Table 4, the maximum distance an ESP32 can be from a mobile hotspot before it is unable to connect to the internet is 15 m. Meanwhile, the maximum range that can be achieved by connecting to a Wi-Fi network is 40 m. This leads us to the conclusion that the use of wireless internet for the ESP32 can reach a greater range than the use of a mobile hotspot.

Table 4: Range of ESP32 Internet Connection

Range (m)	Mobile Hotspot	Wi-Fi
5	Connected	Connected
10	Connected	Connected
15	Connected	Connected
20	Disconnected	Connected
25	Disconnected	Connected
30	Disconnected	Connected
35	Disconnected	Connected
40	Disconnected	Connected
45	Disconnected	Disconnected

3.3 Hardware Control Through Blynk Range

The hardware was placed at Taman Universiti, Parit Raja. According to Table 5, the test had been done at four separate locations with different ranges. The range data for this project is obtained from the Google Maps application. This result shows that the ESP32 can be controlled anywhere. As a result, the results demonstrated that the first objective, which was to be able to develop a home monitoring and device control system using an ESP32 microcontroller in a wide range, has been accomplished as such long as there is an internet connection for the ESP32 microcontroller.

Table 5: Hardware test at four separate locations with different ranges

Testing Location	Range from hardware (km)	Connection
Johor Bahru, Johor	103	Connected
Banting, Selangor	252	Connected
Putatan, Sabah	3138	Connected
Sandakan, Sabah	3455	Connected

4. Conclusion

The ESP32 microcontroller, which is based on the IoT, was used in this project to create a system that can monitor and control switches on several devices at home. This system is constructed with an embedded microcontroller in conjunction with an ESP32 Wi-Fi module. The system that has been designed is minimal in cost, simple to operate, and can be quickly integrated with household appliances. It is anticipated that the performance of various gadgets in the home would be improved because of this suggested system's autonomous and remote control. Additionally, the use of an internet connection that can be controlled from a distance can make it easier for people to control appliances when they are away from home, as well as for persons who are disabled. Also available via smartphone and laptop, as long as there is an internet connection to be connected to the Blynk Application control panel, this system may be accessed from anywhere. Furthermore, it has the capability of being controlled through two different methods which is online and manual. Even though the aims of this system were achieved, there is still more work to be done to improve it. For example, the system can only manage the ON and OFF appliances, but it cannot modify the speed or dim of a specific appliance such as a fan or light using ESP32

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