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DEVELOPMENT OF A SMART HOME AUTOMATION SYSTEM (HAS) FOR REMOTE APPLIANCE CONTROL AND ENHANCED SECURITY AGAINST FIRE HAZARDS AND INTRUSIONS

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ABSTRACT
Home automation has come a long way thanks to the development of smart technologies, which have increased efficiency, security, and convenience. The creation of a Smart Home Automation System (HAS) that allows for the remote control of appliances and strong protection against intruders and fire threats is detailed in this article. In this study, we build a home automation system that can be controlled remotely through a web browser. The system uses an internet connection and SMS alerts. The GUI is a web page. Regardless of the user's location, our proposed model for a monitoring and controlling device that warns them via Internet and SMS notification for security purposes tries to solve the difficulty. Various sites were examined to determine the prototype's efficiency, and the results revealed that the prototype was most effective at sites with the strongest signals. This research paper explores HAS in detail, including its technical foundations and the ways it can revolutionize human-home interaction for the better, leading to a future that is smarter, safer, and more environmentally friendly.

Keywords: Internet of Things (IoT), Remote Appliance Control, Fire Hazard, Intrusion Security, Energy Efficiency, Home Automation.

I. INTRODUCTION
The way we use our homes has undergone radical transformations as a result of the fast development of technology. The Smart Home Automation System (HAS) is one of the most innovative and ground-breaking solutions that brings efficiency, safety, and convenience into people's daily lives. With the help of automation technology, smart sensors, and the Internet of Things (IoT), HAS gives homeowners complete command over their home appliances and makes it very resistant to intruders and fires.

Efficient, secure, and uniquely one's own lifestyle are hallmarks of contemporary living. For these reasons, and particularly with regard to ease of use and prompt action in the event of an emergency, conventional approaches to home management frequently fall short. HAS fills these voids with its automated reactions, real-time monitoring, and remote control features. Whether it's controlling the temperature from afar or getting a notification about a security breach, HAS gives homeowners complete control over their homes, even when they're not there.

Advantages of Automation in Modern Living
Thanks to automation, contemporary life is more convenient, efficient, and safe than ever before. An example of how automation is changing home life is the rise of smart home automation systems (HAS), which allow for remote control of appliances and increase protection against intruders and fires. With the use of intelligent sensors, automated response mechanisms, and the Internet of Things

(IoT), HAS creates a networked environment for homes that improves their quality of life and solves important problems with efficiency and safety.

Streamlining Daily Life with Remote Appliance Control

Simplifying ordinary tasks through remote appliance control is a crucial function of home automation in current times. Through the use of smartphones, voice commands, or programmed schedules, users may control various home gadgets including lights, air conditioners, and kitchen appliances with HAS. Users may do things like set the oven to warm on the way home or turn off the heat when no one is in the room to save electricity. Not only does this degree of automation make modern life more efficient and eco-friendly, but it also offers convenience like never before.

Enhancing Security Against Intrusions

One essential part of contemporary life is home security, and automation has greatly improved it. Home automation systems (HAS) protect residences from intruders by integrating security cameras, smart locks, motion detectors, and intrusion detection systems. By way of illustration, a smart lock has the capability to alert householders in the event that someone tries to manipulate the door, and surveillance systems offer video feeds in real-time. The detection of suspicious activities might cause automated systems to activate lights, alarms, or even inform local authorities. These features demonstrate the revolutionary effect of automation on home security, making families feel secured regardless of their whereabouts.

Proactive Fire Hazard Mitigation

Proactively addressing fire dangers is one of the most notable advantages of HAS. Integrated smoke, heat, and gas detectors in state-of-the-art fire alarm systems keep a constant eye on the house. When these systems identify danger, they can sound alarms, notify homeowners, and even automate safety procedures like turning off gas or turning on sprinklers. The importance of automation in making sure that modern homes are safe havens is highlighted by the rapid response capabilities, which not only avoids property damage but also saves lives.

Creating a Connected and Intelligent Ecosystem

HAS promotes a networked home where gadgets talk to each other without a hitch, improving the quality of life for everyone. For instance, motion detectors can be programmed into an automatic lighting system so that routes are illuminated at night, which enhances convenience and safety. Likewise, integrated systems can improve energy use, cut electricity bills, and promote sustainability by turning off unused equipment. No matter where they are, homeowners can stay connected to their living environments thanks to the ability to operate and monitor all systems remotely.

Addressing Evolving Lifestyles

Automation fits well with the requirement for everyday adaptation and flexibility in today's fast-paced environment. HAS adapts to people's changing ways of living by giving them the freedom to design their homes the way they want. Depending on the time of day or the event, you can adjust the temperature, lighting, and security settings, among other things. This tailored approach showcases the seamless integration of automation with various needs, making modern living more natural and enjoyable.

Building Sustainable and Efficient Homes

By decreasing energy usage and waste, HAS also helps with sustainability. Appliances run more efficiently with the help of automated systems, which reduces energy waste and environmental impacts. For instance, energy monitoring systems give insights to promote responsible usage, and smart irrigation systems save water by altering schedules according to weather conditions. Smart and

sustainable houses are made possible through automation, which combines eco-consciousness with ease.

As shown by Smart Home Automation Systems, the function of automation in contemporary life goes well beyond mere convenience. Housing automation systems (HAS) are revolutionizing home living by making it possible to control appliances from a distance and making homes more secure against intruders and fires. A prime example of the far-reaching effects of automation on modern ways of living, it enables householders to lead more efficient, secure, and environmentally friendly lives. The potential for HAS to further enhance modern living is boundless, especially given the rate of technological evolution.

II. IOT BASED SMART HOME AUTOMATION SYSTEM

The IoT is a network that enables interconnection and remote monitoring of physical objects through the web. The Internet of Things (IoT) has come a long way in recent years, and it's already finding applications in many different fields, including smart homes, telemedicine, industrial settings, and more. A worldwide network of interconnected smart devices with sophisticated capabilities is made possible by the Internet of Things (IoT) and wireless sensor network technologies. The core technology for creating smart homes is a wireless network of interconnected sensors and actuators that may share resources. A "smart home" is an Internet of Things (IoT) concept that seeks to automate many aspects of a household. By enabling Internet connectivity in a home, users can remotely monitor and manage various objects and gadgets. Smart home devices include light switches that can be controlled by voice commands or smartphone apps, thermostats that can regulate indoor temperatures and provide reports on energy consumption, and irrigation systems that can be programmed to begin watering at a certain time each day or month to reduce water waste. This past year has seen a meteoric rise in the popularity of smart home solutions. Various Internet of Things (IoT) utilities are illustrated in Figure 1 as an example of a smart home.

Figure 1: An example of IOT based Home Automation system

The ability to manage and operate home automation systems from a variety of devices—smartwatches, computers, tablets, laptops, desktops, and even voice assistants—is one of their biggest advantages. A home automation system can help you in many ways: it can make your life easier by allowing you to control the temperature in your house, it can add security by locking doors automatically, it can save you time and energy by adjusting the lights and appliances, and it can save you money.

Academic researchers have proposed multiple IoT-based home automation systems in the literature during the past decade. Numerous technologies, each with its own set of advantages and disadvantages, have been included into wireless-based home automation systems. If we take Bluetooth-based automation as an example, it's cheap, quick, and easy to install—but it can only cover short distances. Another popular wireless technology is ZigBee, however GSM is also rather popular. With GSM, users can communicate across great distances for the price of their local mobile plan. Zigbee is a power-efficient and inexpensive wireless mesh network technology aimed at battery-operated devices used for remote monitoring and control. Having said that, it's expensive to maintain, has poor data speed and transmission, and has unstable networks.

Research Scope and Objectives

The creation of HAS is an attempt to meet the ever-changing needs of contemporary life, rather than just a technical undertaking. This study's overarching goal is to learn more about what goes into creating a smart home system that allows for easy remote management of appliances and strong security measures. The study's secondary objective is to assess the system's performance in reducing energy waste and protecting users from dangers. With these goals in mind, this study adds to the growing body of literature on smart technology and the revolutionary changes they bring to homes.

III. REVIEW OF RELATED STUDIES

V, Dr et al., (2024). The overarching structure of a cost-effective wireless HAS is presented in this study. In particular, it aims to facilitate the installation of an IoT-based home automation system that can automatically configure itself according to external factors and allow for the remote management of numerous devices through the internet. The goal is to create firmware that can intelligently operate all of the home's electrical equipment, guaranteeing their safety through automatic functioning with little to no human input. The automation method has made use of Node MCU, an open-source IoT platform that is widely acknowledged. To transfer user commands from the Node MCU to the real device, different system components use different communication modalities. Using a smartphone, you can access the central control system remotely thanks to its wireless technology. Adding a communication system that is based on a cloud server makes the project more practical because it allows users to use appliances freely, no matter how far away they are. We have set up a data transfer network to strengthen automation. It is the perfect choice for controlling electrical appliances and devices in the home due to its user-friendly interface, inexpensive build, and easy installation. Through an Android platform, you can keep tabs on the status of both the control and the appliances. Through providing essential support and assistance, the system aims to improve the living conditions of those with disabilities and the elderly, ultimately elevating the whole home living experience through the concept of a smart home.

Bello, Oluwaseyi & Obasanya, Tayo. (2023). The proliferation of IoT-based automation in settings outside of manufacturing has been fueled by the lightning-fast evolution of a wide range of communication and data-gathering technologies. It has become an integral part of our daily lives, guiding us toward using smart home technologies. A smart home system is an intelligent network that allows users to manage their house's lighting, climate, and security systems from a central location. Few intelligent systems exist that can manage various parts of home automation at once, like controlling appliances, detecting security bridges, and cutting costs and energy usage. Therefore, an intelligent home automation system was created as a result of this research to address these issues. Methods: The system's foundation was a gas detector (MQ2), a motion detector (passive infrared, or IR), and a flame detector (to detect fire outbreaks) built into the Arduino ATMEGA328P microcontroller. To achieve a smart home automation system, an Arduino ATMEGA328P served as the central controller unit, regulating the flow of system operations. The system's output is a buzzer

that immediately alerts the user to something. Moreover, it notifies the user via their cell phone via the worldwide system for mobile communication module.

Subbaraj, Rajarajeswari et al., (2021). In order to save time and make better use of resources, the smart home automation system is built to make managing and monitoring household appliances and lighting fixtures convenient and easy. Access to home automation devices can be controlled by this system. A few examples of the automated equipment are lighting, fans, cameras, and doors. Furthermore, it improves the project's core functionality, which allows users to remotely control their home appliances from any location. A home can be kept safe and under constant watch with the help of the camera module. Optimal energy use leads to a considerable decrease in utility expenses. This effort is physically, financially, and operationally practical since it can be implemented using low-cost electronic and interactive instruments. The main idea is to use a mobile app and graphical user interface to remotely control everything. To ensure the safety of device-based data sent and received across the network, the automation system makes use of the MQTT protocol. One of the primary goals of our automated system is to protect against Man in the Middle attacks (MITM). At the intermediate hub, we scan all of the routed communications for Man-in-the-Middle (MITM) based Denial of Service (DoS) attacks that use manual reset points.

Stolojescu-Crisan, Cristina et al., (2021). As technology has advanced at a rapid pace, making daily tasks easier, home automation has become increasingly popular. Digitalization and automation have permeated nearly every aspect of life. The goal of this work is to present a system that can connect various home automations by means of sensors, actuators, and other data sources. The q Toggle system is based on an Application Programming Interface (API), which is both powerful and adaptable; it is the backbone of a common and straightforward communication strategy. The q Toggle API is often implemented by sensors or actuators that have an upstream network connection. The majority of q Toggle's hardware is built on Raspberry Pi boards and/or ESP8266/ESP8285 processors. A user-friendly app has been created for smartphone users to manage a range of household appliances and sensors. The q Toggle system is adaptable, simple to use, and has room to grow with the help of various devices and accessories.

Adedoyin, Mary et al., (2020). Modern technological developments, such as the internet of things (IoT) and its many uses, have necessitated the installation of smart home systems. The convenience of being able to remotely monitor and operate household equipment raises living standards since automatic procedures can take the place of human work to do some of the most fundamental tasks around the house. The urgent requirement for smart homes has been heightened by people's hectic lifestyles. Even when they aren't physically there, homeowners often end up paying extra for electricity because they forgot to turn off their devices or left them on by accident. Manually turning on and off household equipment, such as lights, fans, and televisions, can be a burden for the elderly and others with physical disabilities. Here, we present the idea of a "smart home," which would allow residents to control their appliances from afar and make intelligent decisions with little to no human input. This paper also introduces a smart home system that uses an android device's graphical user interface to let the user control and monitor their home from anywhere or set it to automatically control itself using sensors connected to a PIC microcontroller in their home. On one end, the PIC microcontroller receives data from sensors like temperature and light, as well as passive infrared (PIR) and Wi-Fi modules that allow the microcontroller to communicate with the Android app through the internet. On the other end, the graphical user interface app on the Android device issues commands to the microcontroller, which in turn controls the loads and sensors. Energy conservation is a top priority for the proposed system, which also makes it easy for healthy and physically impaired people to control their household appliances from a distance.

Kang, Won et al., (2017). A boon to people's lives, smartphones have proliferated since the turn of the millennium. Smartphones paved the way for the introduction of other "smart" products, including as tablet PCs, smart TVs, smart refrigerators, and smart air conditioners, which quickly spread beyond the realm of individuals and into the realms of businesses and homes. As a service focused on people, smart home services have recently gained a lot of popularity. Connected smart home appliances and other gadgets provide better service and experience for users. The present state of smart home services relies solely on wireless home networks to carry out linked home functions. Because the service lacks smart home security, consumers run the risk of losing money due to data leaks or hacked home appliances. So, considering the safety of smart devices is essential when implementing smart home services into the environment. In this article, we present a more robust security architecture for smart home gadgets. To protect against security risks including data leakage, code fabrication, and alteration, the security framework includes an integrity system that employs self-signing and access control approaches.

IV. EXPERIMENTAL SET-UP

Power Supply Unit, Connectivity/Network Unit, Controller Unit, Sensing and Buzzing Unit, and Relay Unit are the five (5) sub-units that make up a HAS. This division helps to simplify and streamline the design process. Figure 2 is a block diagram of the system that shows how the aforementioned subunits are connected and how they work.

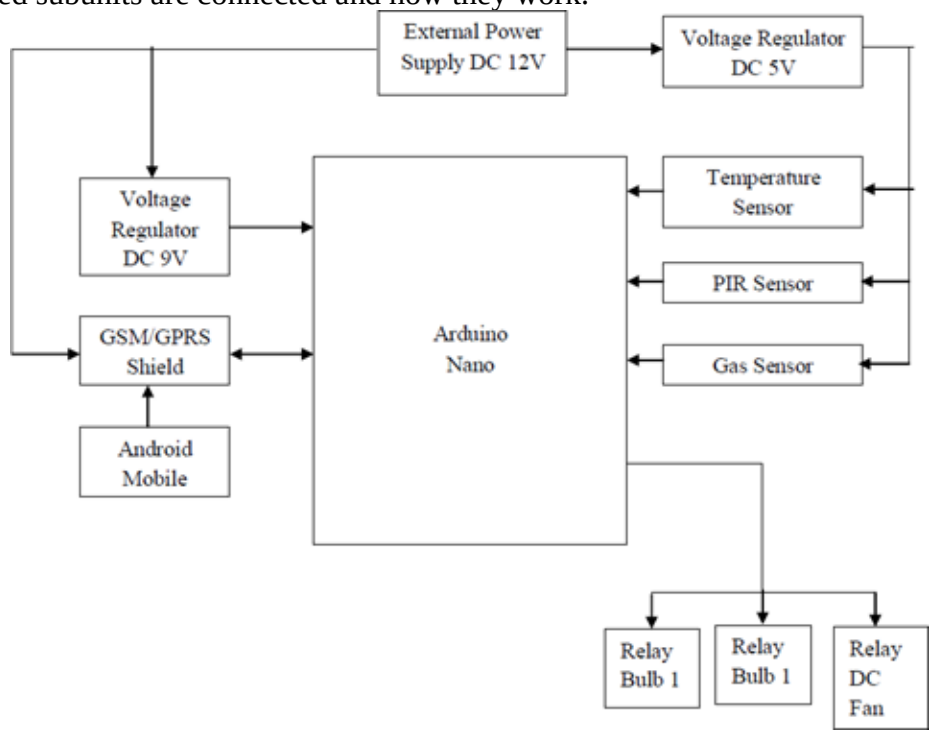

Figure 2: Functional arrangement and interconnectivity of the proposed Home Automation System

- **Power Supply Unit (Unit – I)**

The Power Supply Unit is made up of a 240/12V step-down transformer, a full bridge rectifier circuit that changes the 12V AC current into 12V DC, and a 2200µF input capacitor that prevents ripple in the voltage regulators. The LM 7812 and LM7805 voltage regulators were used to get a 12V and 5V steady voltage output, respectively. Output capacitors, typically 10µF in value, are used to minimize glitches and spikes in the output voltage caused by transient changes in the ac input. To prevent back electromagnetic fields (EMFs), diodes are employed in reverse polarity prevention. Figure 3 below shows the circuit diagram:

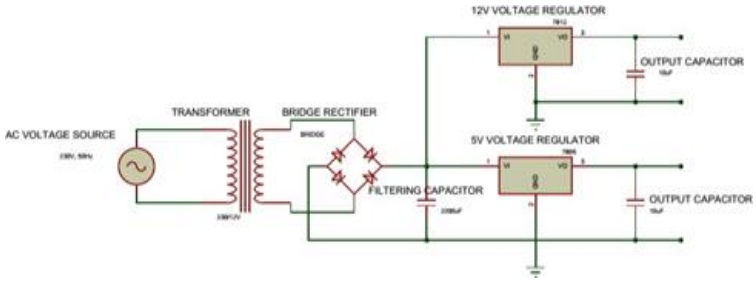

Figure 3: Circuit diagram of Unit – I

Connectivity/Networking Unit (Unit – II)

The main components of this setup are an Android device (such as a phone or tablet), an Arduino Nano, and a GSM/GPRS Module. The latter is linked to the former via a series of connections, first linking the Arduino's transmission pin to the GSM/GPRS module's reception pin, and then the reverse. The GSM/GPRS Module requires a 5V power source from an external source. The HAS webpage can be accessed through an Android device; it acts as an internet of things (IoT) interface connecting the internet capabilities of the GSM/GPRS module to the android device; it displays important data like humidity, temperature, and levels of harmful gases; and it can be controlled remotely through the internet. Figure 4 below shows the connectivity unit's circuit diagram.

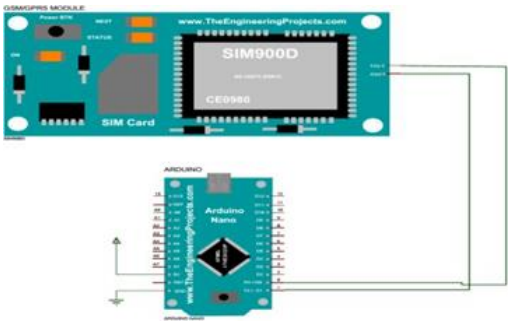

Figure 4 Circuit diagram of Unit – II

Controller Unit (Unit – III)

The Arduino Na is the controller unit; unlike the Arduino Uno, it runs on 5V and has a voltage range of 6- 20V, with the recommended limit being 7-12V. The Arduino Nano is a simple, compact, and all-inclusive board that uses the ATmega 328 and ATmega168 microcontrollers. It differs from the Arduino Uno in that it doesn't have a DC power jack, but it does have a clock speed of 16MHz, 16KB of flash memory (for the ATmega168) or 32KB (for the AT mega 328), and 14 digital I/O pins and 6 analogue pins. You can control the circuit operation by turning the corresponding pins on and off, and it can be connected to a webpage. You can see an example of an Arduino Nano in Figure 5 below.

Figure 5 Circuit diagram of Unit – III

Sensing Unit (Unit – IV)

The two main components of a sensing unit are a PIR (Passive Infrared) sensor for motion detection and a humidity and temperature sensor for high temperature detection. The sensing unit serves as the eye and ear of the user even when absent from the home alerting the user via SMS in case of an emergency. You can see the Sensing Unit in Figure 6.

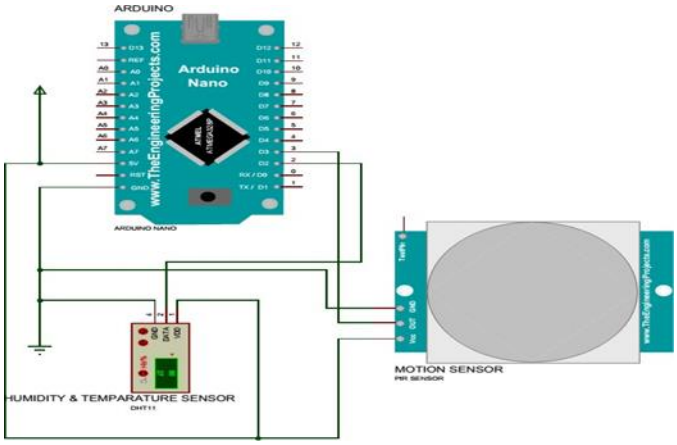

Figure 6 Circuit diagram of Unit – IV

Relay Unit (Unit – V)

The NPN transistor used in the relay unit is connected to the Arduino Nano by a 1K resistor (since the transistor is operated in the saturation region), as are diodes and other components of the unit. In this setup, diodes shield the transistors from reverse electromagnetic fields (EMFs), and relays control the lighting and DC fans. The 12V relays have a resistance value of 400Ω, and the 2N2222 transistor is often used for switching and has ratings of Low Power, Medium Current, and Medium Voltage. In Figure 7, you can see the relaying configuration.

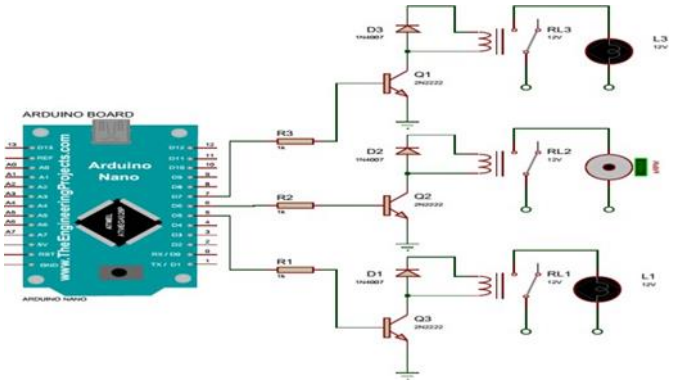

Figure 7 Circuit diagram of Unit – V

V. RESULT AND DISCUSSION

The design was put into action and tested system-wide and on individual units. Here you can find the breakdown of all the test results. Also included is a discussion of the results.

Performance Results of Unit – I

We checked the input voltage from the ac mains supply to make sure it wasn't too high or too low. We noticed and recorded the output ac voltage after connecting the input wires of the step-down transformer to the mains supply. We measured the voltages across the bridge rectifier and voltage regulators, made sure to turn the multimeter knob to the correct position for DC value measurement, and recorded the results in Table 1.

Table 1: Voltage Input and Output of Various Electronic Components (Power Supply Unit)

Component	Input (V)	Output Obtained(V)	Expected Value (V)
Transformer	225	12.71	11.95
Bridge Rectifier	12.71	16.20	15.60
LM7805	16.20	12.40	11.95
LM7812	16.20	6.00	6.00

Performance Results of Unit – II

One of this unit's main functions is to link the home automation system (HAS) to the website that allows users to manage their appliances from anywhere in the house. The data sheets for the Arduino and SIM 800L were utilized to verify the ratings, and every connection was double-checked to ensure everything was correct. From the external power source, the voltage input to the GSM/GPRS module was measured and recorded in Table 2. We attempted to connect to the webpage 10 times and then calculated the ratio of the total number of trials to the number of successful connections.

Table 2. Current and Voltage Values for GSM/GPRS Component

Component	Expected Current Value (A)	Expected Voltage Value (V)	Voltage Obtained (V)	Current Obtained (A)
GSM/GPRS	2.00	3.5-4.5	3.5	2.25

Performance Results of Unit – III

When needed, the user can toggle home appliances on and off using the virtual switches provided by the web page shown in Figure 8.

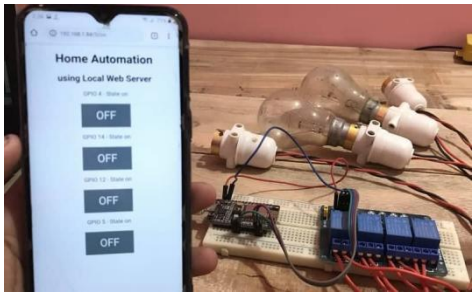

Figure 8: Virtual Switches to control home appliances webpage

Performance Results of Unit – IV

The HAS monitoring requires this equipment, which consists of a PIR motion sensor and a DHT11 sensor. After verifying the necessary ratings using the data sheets of the PIR Motion Sensor and DHT11 sensor, we proceeded to confirm the circuit connections. You may check the PIR Motion and DHT11 sensor's input and output voltages with a multi-meter. By varying the distance and temperature, we were able to test the sensitivity of the PIR Motion and DHT11 sensors, respectively. We recorded the resulting delay times in Tables 3 and 4.

Table 3. Input and Output Voltages, Sensitivity, and Delay for Measured Quantities

Data	Input Voltage (V)	Output Voltage (V)	Maximum Sensitivity (m)	Delay (s)
Manufacturer's Data	3-6	5 or 0	9	4-30
Measured Quantities	5	4.89 or 0	7	5-32

Table 4. DHT Sensor Result Data

Data	Input Voltage (V)	Output Quantities	Delay (s)
Manufacturer's Data	3-5.5	20-90%RH, 0- 50^{o}C	6-30
Measured Quantities	5	20-90%RH, 0- 50^{o}C	7-32

Figure 10 Result of an SMS notification from a PIR sensor in a smart home automation system

Performance Results of Unit – V

In this part, we will examine the tests done on the relay units, which include the relay, transistors, and diodes. Measurements were taken of the input and output voltages to the relay, as well as the currents and voltages across the diodes and transistors. The results can be seen in Tables 5 and 6.

Table 5. Component Voltage Comparison of Relay Unit

Component	Expected Input Voltage (V)	Measured Input Voltage (V)	Expected Output Voltage (V)	Measured Output Voltage (V)
Transistor	14	15	24	28
Diode	5	8	4	6
Relay	9	10	13	9

Table 6. Relay Unit Current Test Result

Component	Expected Input Current (A)	Measured Input Current (A)	Expected Output Current (A)	Measured Output Current (A)
Transistor	34	23	45	18
Diode	56	45	44	65
Relay	12	45	44	33

Results of HAS

Checking the functionality of the overall pieces of the HAS is how it is tested as a unit to ensure that its purposes have been fulfilled.

When the household appliances were connected to the webpage, they were turned on and off. The time it took to go from turning them on or off on the webpage to actually turning them on or off is

noted in Table 7. Table 7 contains the results of the measurement and recording of the time delay before each mobile device got an SMS after activating the PIR Motion and DHT11 sensors.

Table7. HAS Delay Time Test Result

Component	Delay Time (s)
Lamp 1	11
Lamp 2	14
DC Fan	10
PIR Motion Sensor	13
DHT11 Sensor	9

VI. CONCLUSION

A major step forward in home automation technology is the creation of the Smart Home Automation System (HAS), which allows for the remote control of appliances and improved protection against fire threats and intruders. With this system's combination of web-based control and text message notifications, customers can easily manage their appliances and stay safe no matter where they are. A web-based graphical user interface (GUI) allows users to view and operate different home operations remotely, making them more responsive and convenient.

The system's efficiency was shown during prototype testing across various sites, with the best performance recorded in places with robust signal coverage. This emphasizes how important strong connections are for smart home systems to be responsive and reliable. A huge step forward in home security, the system has the ability to lessen the likelihood of fire dangers and intrusions via the provision of real-time notifications and remote control.

Finally, the HAS is a game-changer in the smart home industry because it provides a workable and expandable answer to the problems of home security, comfort, and energy consumption. Users will enjoy smarter, safer, and more environmentally friendly homes as a result of the incorporation of advanced automation systems like HAS, which will be possible as technology advances.

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