Mobile Phone Enabled Smart Home Automation Using GSM Call Activation with Real-Time WhatsApp and LCD Monitoring

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ABSTRACT
Advancement in technology has led to the development of more secure, convenient, and energy-efficient living environments. This paper presents a smart home system that is enabled via the use of a mobile phone. The proposed system utilizes call-based functionality of the mobile device to remotely access, control, and operate appliances, eliminating the need for traditional physical controls. At the heart of the smart home system architecture is a PIC18F4620 microcontroller. Other components employed are a GSM module, WhatsApp Application Programming Interface (API), and liquid crystal display (LCD) unit. The integration of these three functionalities: call, WhatsApp messaging, and real-time display, creates a hybrid communication and reliable control system for device automation. User interaction with the system is realized through a subscribed mobile telephone line. Upon the receipt of a call, the microcontroller processes the caller ID for identification. When the caller is an authorized user, issued commands are interpreted, and actuation of the corresponding connected devices through relays or other control mechanisms follows. If the caller ID is unauthorized, no response is received from the system. Real-time updates on the status of the controlled devices are sent via WhatsApp message to the user's registered number, providing increased user engagement and situational awareness. Evaluation results show that the device average response time is 10 seconds, while WhatsApp notification takes approximately 22 seconds. These indicate the developed system is a practical and efficient solution for modern home management.

Keywords
Smart Home, Home Automation, GSM Communication, WhatsApp API, PIC Microcontroller, Real-Time Energy Monitoring

1. INTRODUCTION
With the increasing rate of global population growth, especially among the elderly and youth, there is a need for solutions that enable individuals to live independently and safely in their homes. Sometimes it may be quite difficult for an elderly person to move about either to turn on or off their appliances at home due to their ages and health issues that come with aging. This could lead to wastage of resources, and the failure to control the status of the appliances used in these homes remotely is one of the major reasons for energy wastage. We

cannot afford to waste the limited energy that is available to use [1]. Especially in most developing countries like Nigeria, where elderly homes are not given special consideration when it comes to electricity billings. One of the ways to conserve energy in these homes is by controlling the appliances or devices used, like fans, bulbs, televisions, security lights, the temperature of the room, etc. As a result, an efficient system that can remotely access, monitor, and control appliances in these homes "called a home automation system, is required". Home automation systems (HAS) is the process of reducing the amount of human labor required in carrying out typical and common domestic chores using control systems and information technology [2]. Apart from controlling, accessing, or automating appliances, automation systems can be used to provide critical support for elderly persons through features such as fall detection, emergency response systems, and automated medication reminders. These technologies enhance the quality of life for seniors and provide peace of mind for their families [3]. The HAS can be used to control appliances like entertainment systems, lighting, surveillance camera, fans etc. [4]. In addition to controlling appliances at home, the activities around a home can be monitored or accessed remotely, and energy consumed by appliances can also be observed. Therefore, this reduces resource wastage, saves costs, and conserves the limited energy available for use, which are the major challenges faced in developing countries [5]. In this paper a robust, effective and flexible home automation system is presented, in which the appliances are controlled by dialing registered mobile telephone number configured on the GSM/GPRS module to facilitate interaction with connected devices and appliances. The status of the appliances is displayed on the WhatsApp. This is accomplished by combining a number of subsystems, including microcontroller, relay, switches, and modules to form a single control unit for home automation [6]. The proposed system is required in order to attain security, safety, convenience, and control of a house.

2. RELATED WORKS

A few existing home automation systems, developed using various techniques and technologies are reviewed below, along with their features [3], implemented an IoT-enabled smart home system using Raspberry Pi and MQTT protocol for cloud integration. The proposed system featured a real-time dashboard and strong responsiveness, the requirement for continuous internet access limits its deployment in underdeveloped areas. The simulation and analysis of an automatic room heater control system using an LM35 temperature sensor and a PIC 16F877A microcontroller were developed [7]. The temperature levels are adjusted by the proposed system by turning fans on and off when room temperature exceeds or falls below the reference, which serves as a benefit to people or individuals with disabilities but lacks any feedback loop. In [8], Bluetooth based technology system using Arduino was proposed for control of devices at home. The proposed system uses a wireless communication system that cannot be damaged like a wired system, which makes it a more effective, less expensive, and more user-friendly means of controlling devices. However, its operation is limited to a short communication range (~10 meters) and required physical proximity for it operate.

An Android mobile application using Arduino UNO was proposed for control of home appliances in [9], the system provides an intuitive, user-friendly home automation system that allows tracking, monitoring, and control of appliances. It includes two cellphones and an embedded system with Arduino, Bluetooth, and relay modules, ensuring user comfort and happiness. [10], explored Bluetooth and Android integration with a PIC microcontroller, demonstrating smart home control via a mobile application. Although efficient, the system did not incorporate cloud-based or feedback mechanisms. Additionally, most earlier systems lacked basic authentication or multi-user control functions. A study by [11] proposes a low-cost real-time energy monitoring system using the ESP32 microcontroller. The system captures and transmits energy consumption data, including voltage, current, and power measurements, on hourly, daily, and monthly bases. The system uses WhatsApp messaging for real-time usage alerts and integrates with the Blynk IoT platform for graphical visualization. Blynk's user-friendly interface, however, faced limitations in scalability, data storage, and advanced analytics due to its reliance on free services.

In [12], a home-automated system using Bluetooth technology and an Android application with voice prompts was proposed. The Arduino, programmed in C++, was used to control all connected components. Relays and triacs are used for switching. The user controls electrical appliances via voice prompts with a Google assistant, with a preset 12-hour shutdown time, which makes the system easy to use via smartphone. A home automation system using IoT and SMS was proposed in [13]. The developed system composes of five sections: Power Supply Unit, Controller Unit, Connectivity Unit, Relay Unit and Sensing Unit. The system uses a Nano technology for the control of components like relay, sensors and connectivity. Passive infrared (PIR) sensor is used to monitor motion while information on average temperature and humidity of the home are sent via Internet and SMS to the home owner. A smart home management was proposed in [14] using ~~a~~ support vector machine mechanism (SVM), a machine learning algorithm for making decisions and ~~a~~ blockchain technology for device intelligent identification and authentication using internet of things (IoT). The SVM is used to note the status (ON or OFF) of the devices at the home at any particular time while the blockchain technology facilitates decentralization of the IoT device of the proposed system. A Raspberry Pi was used as the wireless communication link for the user to view the status of the appliance at home via a developed an Android platform. The data can easily be hacked by hacker since it involves internet.

[15] implemented a WhatsApp-based smart appliance control system using the ESP32 microcontroller. Their system delivered rapid switching (~5–8 seconds) and used cloud APIs for feedback via WhatsApp. However, full dependence on internet connectivity makes it unsuitable for low-connectivity regions. A client-server-based system for smart home automation was developed and reported [16]. Interaction between the developed system and the user was established using natural language processing (NLP) and machine learning techniques. The instructions are sent by the user to allow the system to perform tasks like control of appliances, doors, and monitoring voice bed movement. An intelligence module was also included in the developed system for people with physical disabilities. An SMS-based home monitoring system reported in [17] built around some entities like sensing units, processing units, and communication units. The sensing unit senses the home appliances to be monitored; the processing unit consists of the microcontroller used for analyzing the signal that is sent from the sensing unit and processing it for further use; while the communication unit has the GPRS modem, which is used to establish wireless communication between the developed system and smart phone. In [18] proposed android-based application for modelling of home automation system using Zig-bee for establishment of communication link between the

smart phone and the modeled home automated system. Due to the need to connect an external ZigBee transceiver to the Android phone, this is an ineffective communication method that results in power waste, and more components are needed than Bluetooth, which is already present in an Android phone.

A speech recognition-based home automation system via the internet of things was designed by [19] where microprocessors were used to monitor and analyze the signals from the radio frequency (RF) antenna, which was later utilized to control the applications. [20] utilized PIC16F877A microcontroller to develop a home automation system for ON and OFF control of connected appliances via SMS command from registered mobile phone lines. However, the system had an average switching time of 19 seconds and lacked feedback capability, providing no indication of device status. While effective for remote control, its usability is limited by the absence of acknowledgement messages and user authentication.

3. METHOD

The proposed mobile phone-enabled smart home automation control system is built around both hardware and software subsystems. The software used MikroBasic Pro for PIC to write the firmware, which was compiled and uploaded using PICkit2 to control the appliance's operation through a computer system, tablet, or smartphone, and the firmware written on the PIC also interacts with the WhatsApp API for the status of the appliance to be displayed. The hardware part consists of microcontroller unit, which is the heart of the project, GSM/GPRS module, relays and few other circuit components.

The block diagram which depicts the development of a WhatsApp-based home management system for appliance is shown in Figure 1.

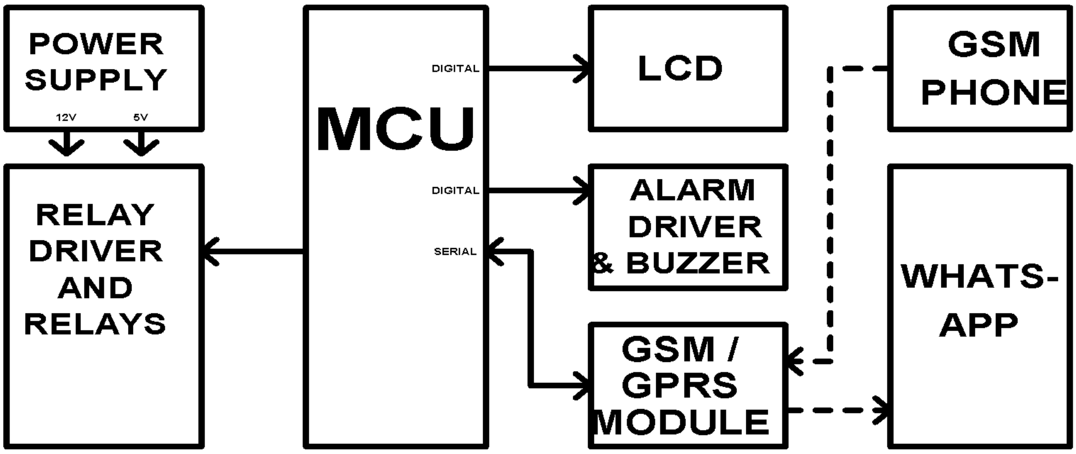

Figure 1: Block Diagram of Mobile Phone enabled Smart Home Automation System

3.1 Hardware System Design

3.1.1 Power supply

The unit supplies the entire developed system with a 220 V/50 Hz A.C. power supply, converted to 12 V DC using a switching mode power supply (SMPS), and 5 V DC for the MCU, liquid crystal display, and GSM/GPRS modules which was depicted in Figure 2. To achieve 5 V at 2 A, two positive voltage regulators (U_1 and U_2) are connected in parallel, with capacitors C_1 and C_4 filtering the output voltage while C_2 and C_3 decoupling likely spike to ground.

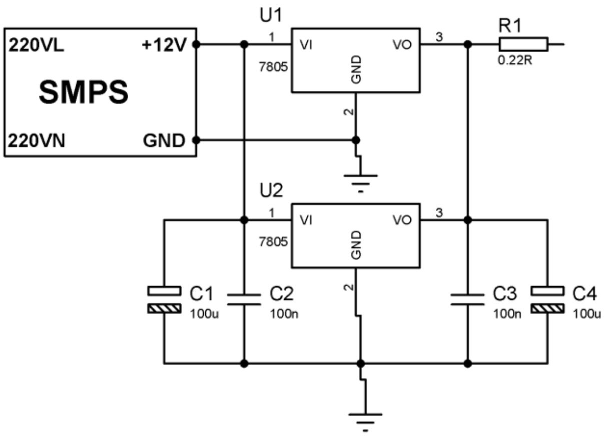

Figure 2: Power Supply Unit

To prevent over-voltage and under-voltage, the mains supply voltage is measured using an analog-to-digital converter (ADC) of the MCU. The voltage to the ADC should be reduced by scale-down resistors to prevent the module from being damaged which is depicted by figure 3. Scale-down resistors R8 and R9 form a potential divider network, dividing the 220 V mains voltage to a safe value of 5V or lower, calculated using Ohm's law.

Let $R_9 = 10$ kΩ and $V_{R9} = 5$ V

$$I_{R9} = \frac{V_{R9}}{R_9} \quad (1)$$

$$I_{R9} = \frac{5}{10 \times 10^3} = 0.5\ mA$$

To determine the value of the scale down resistorR_8;

$$R_8 = \frac{V_{R8}}{I_8} \quad (2)$$

$$R_8 = \frac{(280 - V_{R8})}{I_{R8}} = \frac{(280 - 5)}{5 \times 10^{-3}} = 550\ k\Omega$$

Nearest preferred values for R_8 is 560 kΩ available in the market is chosen.

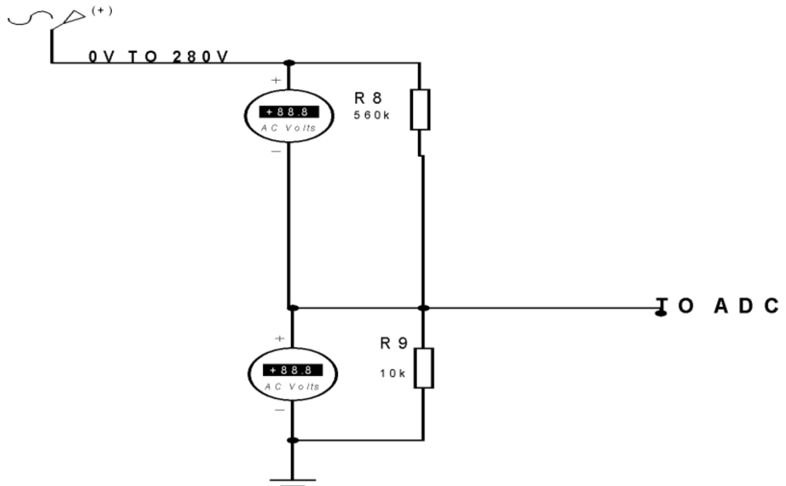

Figure 3: Scale down resistors for mains supply measurement

3.1.2 Microcontroller

The microcontroller used is PIC18F4620 with 40 pins, 64 kB of code memory, and 39.68 kB of data memory. The pin configurations are depicted in Figure 4, with pin 1 being the reset pin and pins 13 and 14 for clocking. The values of R_3 and R_{34} are shown based on the datasheet, which interfaces with the + 5 V supply. The crystal oscillator X_1 oscillates at 20 MHz, enabling the program counter to read instruction codes line by line. The smoothening capacitances C_9 and C_{10} are chosen to decouple noise generated by X_1 from ground.

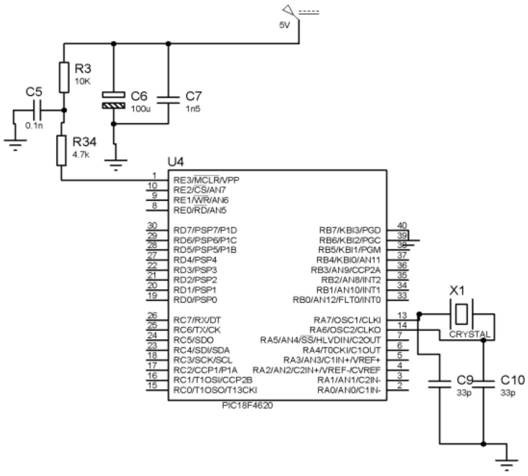

Figure 4: PIC18F4620 Microcontroller Unit

3.1.3 GSM/GPRS Module

The GSM/GPRS module was used to establish a wireless communication link, and a SIM card from a mobile telecom operator was used to gain network access. The module interfaces with the microcontroller and SIM card, requiring serial communication via the Universal Synchronous Asynchronous Receiver Transmitter (USART) protocol. The transmit and receive pins of the module require a 3 V logic level, while the MCU requires a 5V logic level. Hence, a means of converting the levels is required, and diodes and resistors were used. The transmit pin of the MCU is connected to the receive pin of the module via three diodes (D_1 to D_3) and a resistor (R_7). The diodes drop 0.7 V x 3 from the incoming 5 V, giving a 2.9 V logic level. R_7 acts as a fuse to protect the module or circuit from short circuits. On the other hand, the transmit pin of the module is connected to the receive pin of the MCU via diode D_6 pulled up by resistor R_6; the figure 5 depicts the connection of the GPRS/GSM module.

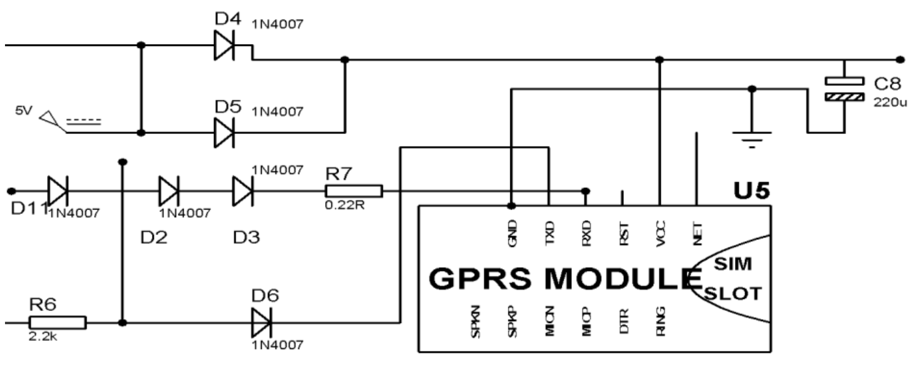

Figure 5: GSM/GPRS module

3.2 Software Implementation

The firmware was developed in MikroBasic Pro for PIC18F4620 and uploaded using PICkit2. The developed firmware handles GSM command parsing, EEPROM management for registered numbers, relay toggling, and message formatting for WhatsApp feedback. At the most basic level, whenever the MCU needs a file hosted on the server, the browser requests the file via HTTP. When the request reaches the correct (hardware) server, the (software) HTTP server accepts the request, finds the requested document, and sends it back to the browser or MCU, also through HTTP. If the server cannot find the requested document, it returns a 404 response instead. Upon receiving a call, a microcontroller processes the caller ID to identify authorized users and triggers the corresponding appliance through the GSM/GPRS module, and the format of the data is as follows:

REGSTARTS2348068307225 2348031170172 2348130653692 9837608 6096893 4541993 REGENDS

The microcontroller (MCU) is integrated with WhatsApp via a GSM/GPRS module for internet connectivity, and the MCU is configured to send HTTP requests to the cloud server. The cloud server acts as a medium, using the WhatsApp API to services like Twilio or Gupshup to forward status messages or alerts to a WhatsApp user. This indirect method allows the microcontroller to trigger real-time WhatsApp notifications based on sensor input or control actions.

3.3 WhatsApp Integration

The system uses a cloud-hosted WhatsApp API endpoint that is configured to receive HTTP GET requests from the MCU (via a GSM data connection). Upon toggling any appliance, the PIC generates a message indicating the status of each output and triggers an HTTP request via AT commands. This updates the user through WhatsApp with near real-time feedback. Only authenticated user numbers stored in EEPROM are granted access to control appliances and receive WhatsApp feedback.

The format for the line of command for the registered line is as follows:

https://api.callmebot.com/whatsapp.php?phone=+23480xxxxxxx&text=This+is+a+test&apikey=6096893

4. IMPLEMENTATION, RESULT, AND DISCUSSION

4.1 Implementation of the developed system

The developed system was built on a prototyping board and housed in a transparent plastic case as depicted in figure 6, and LCD was mounted externally for visibility. The controller was tested using a bulb and fan connected to three separate output lines. The load sockets were fixed on a wooden board for practical testing which was connected to the output line of the controller.

When an authorized number initiates a call to the SIM card in the GSM module, the microcontroller toggles the associated relay and updates immediately to reflect the new status of the appliance via WhatsApp and the LCD.

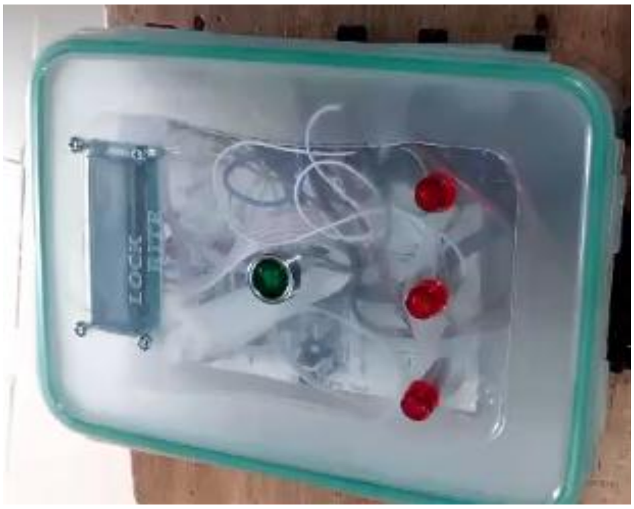

Figure 6: Appearance of Home Automation System

Figure 7 depicts the demonstration board connected to the appliance to be controlled and monitored, and Figure 8 depicts the completed developed mobile phone-enabled smart home automation control system.

Figure 7: Board for demosntration

Figure 8: Mobile Phone Enabled Smart Home Automation System with Demonstration Board

4.2 Results Analysis

The developed system with the device to be controlled are coupled together and put to the test to ascertain the level of conformity with the design objectives as depicted in Figure 9. The output units of the developed system are connected to the input appliance of the device to be controlled. When the phone number on the developed system is called, signals are sent to the microcontroller to process to either turn ON or OFF the appliance, and further signals are sent to the WhatsApp API to display the current status of the appliance. In addition, the activities around the controller are also monitored using a liquid crystal display. The system was tested under a real-world scenario to evaluate its functionality, performance, and responsiveness. The system's behavior was observed, including response time, reliability of SMS registration, and WhatsApp feedback, which were assessed. The analysis includes measurements from two communication channels: GSM call activation and WhatsApp-based feedback, and hardware-level status reporting through an LCD.

Figure 9: Bulb Switched from OFF TO ON

4.2.1 Microcontroller Response Time

The time between initiating a call from an authorized number and the corresponding activation of an appliance by the controller was recorded. Table I depicts that the average response time from GSM call reception to relay switching was approximately 10 seconds, which includes time for GSM processing, microcontroller decision-making, and relay actuation.

This level of responsiveness is acceptable for non-time-critical home automation tasks such as switching lights, fans, or appliances.

Table I: Time Delay Between GSM Call and Feedback

S/N	Time to microcontroller (secs)	Time to WhatsApp (secs)
1	10.51	22.21
2	10.45	22.89
3	10.75	22.27
4	10.12	21.30
5	10.34	21.65

4.2.2 WhatsApp Feedback Delay

After each control action, the status notifications of the appliance controlled are sent to the registered user's WhatsApp via the cloud API. The measured delay, primarily due to mobile network latency and API processing time, averaged 22.06 seconds. Figure 10 illustrate the displayed status via WhatsApp platform when command for either ON or OFF was sent.

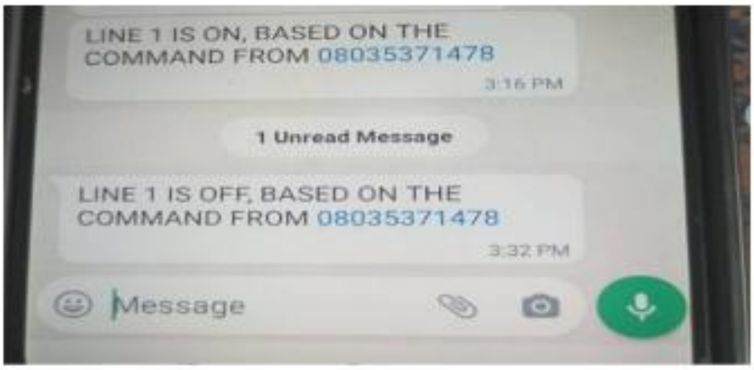

Figure 10: Status Notification on WhatsApp ON/OFF

4.2.3 SMS Registration Functionality and MCU Authentication

The SMS-based registration mechanism successfully allowed only authorized users to control appliances. All four phone numbers sent in the required format were registered correctly and stored in EEPROM.

Upon sending the registration SMS in the correct format, the microcontroller responded with:

"THE DATA: 081xxxxxxxx 081xxxxxxxx 080xxxxxxxx 080xxxxxxxx HAS BEEN REGISTERED SUCCESSFULLY" Unauthorized numbers were rejected, confirming the reliability of the system's basic security model.

This proves the success of EEPROM writing and retrieval functions for user authentication.

4.2.4 User Authentication and Security

The system utilizes an SMS-based registration process to store authorized phone numbers in EEPROM. During testing, only the registered numbers were able to trigger device control, confirming successful implementation of access control. Attempts from unauthorized numbers were ignored by the system, validating its reliability in restricting access.

4.2.5 LCD Display Feedback

The 16x2 LCD provided immediate on-site feedback following each control operation. The status of each line (ON/OFF) was updated in real-time, with no observable lag or display errors. This supports the system's usability in environments where internet access is limited.

During each control action, the 16x2 LCD updated instantly to reflect the new status of connected devices. No latency or display flicker was observed, confirming the stability of the LCD interface and power supply filtering.

4.2.6 Power Unit Testing and Performance

The power unit successfully converted 220V AC to 12V DC, with a further regulated output of 5V DC using voltage regulators. Measurements indicated:

- Expected Output: 12.00 V
- Actual Measured Output: 12.10 V

The measured output was slightly above the target but within the safe operating range for all components. No system restarts or signal losses were recorded, even under repeated operation cycles.

4.3 Discussion

The results shows that the proposed system successfully addresses the limitations of existing GSM-only and Wi-Fi-only home automation systems. While purely internet-based systems offer faster response (e.g., ESP32 via MQTT or HTTP), they suffer from dependency on stable connectivity. This hybrid model ensures offline operability via GSM calls while offering modern feedback through WhatsApp, balancing reliability and user convenience.

The system is especially suited for use in semi-urban and rural areas, where GSM coverage is typically more reliable than broadband internet. Furthermore, the use of EEPROM-stored authentication and real-time LCD display distinguishes this project from previous models, such as those by [6] or [15], which either lacked feedback or required full internet reliance.

5. COMPARISON WITH PREVIOUS WORKS

The proposed system was compared with previous and similar works in the literature as illustrated in Table II. The proposed system provides a hybrid display model, which is its core innovation. Compared to [15] who rely entirely on the internet (Wi-Fi) and the ESP32's cloud capability, the PIC18F4620 system provides control independent of internet availability by leveraging GSM calls, while still enabling internet-based feedback through WhatsApp messaging. Compared to [7], which only automates heating locally, and [21], whose system is limited to Bluetooth connectivity and short-range control, this work supports wide-area remote access through GSM and user notification from virtually any location making it more suitable for rural or remote environments.

While [3] offers superior speed through Wi-Fi and cloud dashboards, their reliance on stable internet access can be a limitation in rural or underdeveloped regions. This system mitigates that by using GSM calls for core control, ensuring basic functionality without internet, and WhatsApp API only for extended monitoring. Additionally, the WhatsApp feedback mechanism is novel, providing a familiar and highly adopted platform for user interaction. None of the reviewed systems offer this dual approach to control and feedback.

Table II: Provides a summary of results of the comparison.

Study	Microcontroller	Control Method	Feedback System	Response Time	Internet/Network Dependency	Security	Unique Features	Highlights	Control Coverage
This Work (2025)	PIC18F4620	GSM Call and WhatsAPP API	WhatsApp + LCD	MCU: ~10s, WA: ~22s	Partial (WhatsApp only)	SMS registration & EEPROM	Dual-mode control + feedback	GSM + Internet hybrid model	Global (GSM range
[6]	Arduino UNO	GSM (SMS)	None	~12s	No	None	Basic GSM switching	Low cost, easy to implement	Global (GSM range)
[15]	ESP32	WhatsApp API	WhatsApp only	~8–10s	Yes	Number validation only	Real-time messaging via WhatsApp	Fast, cloud-connected	Internet-dependent
[3]	Raspberry Pi	Wi-Fi (MQTT)	Web Dashboard	~2–5s	Yes	User login credentials	IoT cloud dashboard	High-speed interaction	Wi-Fi limited (~30m)
[7]	PIC16F877A	Temperature Sensor	LCD (local)	~15–20s	No	None	Autonomous control	Standalone operation	On-device only
[21]	Arduino UNO	Bluetooth	LCD	~3s (short-range)	No	None	Bluetooth technology	Cost-effective, short-range home control	GSM (SMS)
[20]	PIC16F877A	SMS (GSM)	None	~19 sec	Yes	None	SMS Command	Wireless communication	GSM (SMS)

6. CONCLUSION AND RECOMMENDATION

In this paper, a home automation system was developed which demonstrates the feasibility of a WhatsApp-enabled GSM smart home controller for real-time automation and monitoring. With sub-20-second operational cycles, the system proves suitable for remote management of appliances, especially in developing nations. Its dual-mode operation makes it especially suitable for environments with partial internet availability. The use of a PIC18F4620 allows for scalable expansion, and the EEPROM-based access control improves system security. Future work may include integration of power metering, battery backup, and mobile app interface.

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