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Intelligent Home Automation and Control Systems

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Abstract: *When connecting devices to a home control system using traditional cable-based methods to turn on/off electrical appliances, movement is required. Using a device and its components safely and efficiently in unclean surroundings wastes in particular, if the control switch is positioned far away from physically challenged and elderly persons, they will waste time and energy. However, a highly trustworthy, low-cost, high-efficiency, and user-friendly automated household appliance control system is required to overcome these obstacles and offer seamless, improved better living fun for all. This research employed a GSM module (SIM800L) to acquire and deliver control information to an Arduino Board (a microcontroller built with the Arduino Software) to operate specially chosen home equipment such as lighting, fans, and freezers. A set of switches for turning on and off electrical equipment was used to establish the device's control technique by converting 5VDC to 220V AC. Control messages could be sent to turn appliances on and off, saving time and lowering energy consumption, thanks to the convenience and high performance of a mobile phone.*

Keywords: *Arduino Uno; Fans; GSM-Module; home appliance; lighting; Refrigerators.*

1. INTRODUCTION

Home automation has come a long way in the last few years, and it will persist because the clamour for ICT has increased. Professionals and Information technology specialists already can envision and take advantage of wireless technology's potential at home. And thanks to the reassuring nature of this technology. By utilizing a technologically based control system, it is possible to lower labour costs while also saving time and energy [1]. GSM, Z-Wave, Bluetooth, ZigBee, EnOcean, X10, WI-FI, WiMAX, and INSTEON are some of the home automation control technologies available [2].

There are dos and don'ts for each of these technologies. Because of its wide coverage, reliability, and high-security infrastructure, GSM was chosen for the discussion of current research to be presented in the implementation of this proposed work. The innovation is internet-connected, allowing users to operate their home gadgets via SMS (Short Message Service) almost anywhere on the planet [2] via the AT command [3]. As a central controller, the GSM module was combined with an Arduino Uno. [4], The IDE is the microcontroller board's programming environment. The Arduino circuitry is open-source and free to use, and it can be used to create a home automation system. Relays are a switching mechanism that allows low-power signals to control high-power devices, and they are controlled by the Arduino Uno's digital output. Based on the AT command SMS sent [5], every one of the devices connected is managed and controlled by the 5V–8channel relays. The AT command SMS is sent via radio wave to the GSM module using a mobile device with a SIM (Subscriber Identification Number) card.

Home automation applications include appliance management and incorporation, temperature regulation, a coordinated illuminating management system, leakages, and detection systems, as well as automation for the elderly and disabled. This system enhances a broad array of applications and features, including help, convenience, and safety, to bring about positive change and create a life more interesting and pleasant [6], [7]. This smart home automation system is inexpensive and simple to set up. Adopting the principle of automation, different home appliances such as air conditioners, refrigerators, lighting sys-

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tems, and fans can be controlled. This technology can further extend to handle home security by automating doors, detecting fire outbreaks, controlling water showers, and even monitoring our environment [3]. The notion behind home automation is to outwit the electric hazard and make life convenient and suitable especially for disabled people by making home appliances more accessible and remotely controlled for them without seeking assistance from other people [8]. The concept of automation has long ago discovered by some students. These covers having two wires connected to the clock alarm so that an arrangement of battery and light bulb in a circuit can be closed. Based on this discovery, automated systems were developed by some companies that enable them to control actuators, alarms, sensors, and video cameras. Discovering this concept, the first automated building was made [9].

The following is how the rest of the paper is organized: The first part discussed briefly the overview; the second portion evaluated the existing architecture available in a home automation monitoring system; the third part described in detail the technique used to integrate the research study; the section four presented and explained the research work's expected outcome, and the fifth section briefly explained the conclusion.

2. RELATED WORK

Numerous home automation models have been developed by several scholars. The performance of a few of these architectures is examined and presented in the following section.

[10], designed a Bluetooth-based home automation system to aid the control of various home gadgets by the elderly and disabled. An Android phone, an Arduino board, and a Bluetooth device were used to create the concept. They came to the understanding that the control scheme is less efficient and profitable to everyone. According to them, further features for a controller, including SMS, can be included. [11], implemented a system that remotely controlled and gain access to home appliances using Arduino Mega 2560 microcontroller embedded with micro-web server, connected with IP camera. The Bluetooth Android or Web application installed on the mobile phone was used to control the devices. They, however, stated that, a dedicated server PC was not needed for the proposed system and that, this system provides better functionality of monitoring and control. Furthermore, the system was feasible and effective in combination with switching light, motion sensor, temperature sensor, power plug, and gas sensor. [12], presented the Internet of Things and how it was used to actualize a smart home automation system. Android mobile application and Arduino board connected with relays were considered for the implantation.

They designed two different home automation models by first employing a Bluetooth app in an enclosed setting and then second employing Ethernet in an outdoor setting. The problem associated with Bluetooth such as distance limitation (short-range wireless communication) was overcome with a model designed with Ethernet technology. [13], proposed and implemented different types of home automation systems with low cost and superior capability. Arduino Uno microcontroller with automatic monitoring and controlling ability of appliances from sensors signals were used. The proposed work was implemented in the MATLAB-GUI platform to support the effectiveness and dependability of the system. They concluded that the proposed techniques are simple, flexible, and have a lower cost. [14], compared different techniques of wireless communication for the implementation of home automation. Features of Bluetooth, ZigBee, EnOcean, WI-FI, and GSM were compared to allow the designers of home automation to determine the best approach for their work.

The advantages and disadvantages of each technique were also stated. [15], considered Raspberry Pi and GSM with the help of switching relays for the development of their work. The operation of Raspberry Pi was developed using Python programming. The code generated in the python environment achieved greater standard and flexibility. They concluded that using Raspberry Pi to implement home automation is smarter, economical, provided an efficient platform and the technique is measured to be superior to any other home automation technique. [16], built a home automation architecture based on GSM for controlling home appliances, GSM Mobile Device (with SIM), ATmega 2560 Controller Circuit, Relay Switch, Ultrasonic Sensors, and a safety mechanism, MQ7 (to detect carbon-monoxide gas), MQ2 (to detect gas leakage), Android application, Arduino, and buzzer, were used to create the design (App Inventor). In the event of a gas leak, fire, or theft, this design could sound an alarm and relay a notification message to the person. [2], as well as a journal article on an intelligent Smart home system using GSM technology. They discussed ZigBee, X10, GSM, and Z-Wave, among other home automation technologies. For their implementation, they chose GSM technology, which enables SMS to operate household appliances via AT instructions. To relay information, the AT89s52 controller was paired with a GSM and a smartphone.

The control scheme was economical, easy to install, and offered feedback on the functioning of the home appliances, according to their research. [17], conducted additional studies and developed a smart-home automated system to manage lighting and fans to reduce energy waste and save money on energy costs. The Bluetooth (HC-05) module was used to connect a smartphone to an Arduino Uno, allowing users to operate their electrical gadgets from a remote place.

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They determined that the control system properly managed the light and fan, and they recommended that Bluetooth be replaced with Wi-Fi for improved coverage. [3], built a GSM-based android application to operate appliances as well as a security system in the same year. Senior elderly and handicapped people gain more as a result. Two distinct entities designed the control system. For interface with gadgets, the hardware comprises an Arduino (MEGA 2560) coded in embedded C, controllers, and relays for device control, as well as a GSM module (SIM900A) for transmission based on availability, service, and safety.

There is also an Android application that enables access and control to electronics devices and safety systems and even if the internet is unavailable. When tested, they concluded that the outcome was reasonable. [18]. A paper on home automation was also studied to demonstrate the importance of mobile communication technologies in the automation field. They developed a low-cost, dependable home control system based on mobile phone applications for remotely accessing and controlling household appliances. The system was built using an Arduino Board, a Wi-Fi component for equipment surveillance, a Smartphone, and a switch circuit. They concluded that this technology improves the quality of life at home by reducing human effort, increasing energy efficiency, and saving time. This technology also improves the lives of impaired persons by allowing them to accomplish their goals at home. [19], Home automation was created with an Arduino Uno to make life easier for people and to make a substantial contribution to the growth of society. An Arduino Board R3, a Bluetooth module (HC 05), switches, and a mobile phone were used to construct the project. The device enables customers to control their home appliances by pairing an Arduino BT with their smartphone. After putting the controller to trial, it was revealed that interaction between both the Arduino BT and the smartphone was restricted. [20], utilizing Arduino and Android applications to create a smart home automation system.

This system regulates a variety of household appliances to reduce energy usage and improve human health. The Bluetooth module, Arduino, relay, servo motor, and LCD were used to control electrical equipment in the design. They found that the control system was low-cost, small, and offered superior efficiency and reliability for water, as well as reduced electricity use and improved people's lifestyles. A home automation system using mobile phone applications and Bluetooth technology to control home gadgets such as water pumping machines, lighting systems, smoke detection, and garage door motor was described. The system makes use of a microcontroller (Arduino), a Bluetooth module, and a smartphone as the major components of the design to connect the appliances, transfer signals, and regulate home appliances [8]. [21], considered and realized Bluetooth control home automation system based on android application and microcontroller (Arduino Uno). This system makes use of smartphone technology coupled with a Bluetooth application to control load in the home, offices, lighting system, water pump, and garage door motor. This was implemented to make life convenient and comfortable for the physical challenge and ageing people. An adaptable and safe home automation system was considered and executed centred on a cloud computing system based on the ESP Arduino microcontroller. The addition of a camera coupled with GSM technology made the home more secure even without an internet connection. Three sensors were used to monitor motion movement, temperature, and gas leakages. The sensor maintained the measurement and conveyed measured data to a cloud server programmed with Apache and MySQL web servers. The system achieved high efficiency, security, and quick real-time response [22] [23], created and implemented a user-friendly and customizable home automation system. An Arduino controller unit (ATMEGA 328) programmed in C++, a Bluetooth device (HC-06), and an Android with voice commands, triacs, and switches made up the control mechanism (for switching purposes).

The android application, Bluetooth module, and voice prompt were used to operate the household appliances. The technology was created to automatically turn off appliances after a 12-hour delay, making the application simple to control using a smartphone. They did, however, conclude that the control system was extremely reliable, accessible, and capable of supporting elderly or disabled people.

However, as part of our research, we developed an intelligent home control system that uses an AT SMS command to operate lighting, fans, and freezers. The GSM module, an Arduino Uno, a set of relays, and a cellphone were all utilized in conjunction with Arduino IDE software. This innovation enabled the development of a low-cost, intelligent control system.

3. METHODOLOGY AND PROCEDURES

The block diagram (figure 1) depicts the design and configuration of a home automation system. Inside the research lab, the produced application's software, hardware implementation, and overall testing were completed. The system is more user-friendly, versatile, and customizable. The overall system is made up of two major components: software design and hardware architecture. The GSM module, Arduino board, and Relay module are the three primary components of the hardware part. The Arduino Software Development Kit for coding development, as well as a smartphone for radio interface between the customer and the Communication unit, make up the software element.

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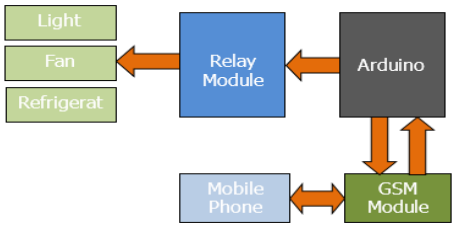

Figure 1 System's block diagram

The GSM component allows the system and thus the user to communicate via SMS. The microcontroller will extract predetermined commands from the SMS. The command is sent as a text message to the GSM module through the public GSM networks. The Arduino microcontroller will decode and execute the commands supplied by the GSM module once it gets the message. The system will decipher the commands and use the relay module to switch the appliances on and off as needed. The entire system is depicted in Figure 2 as a flowchart.

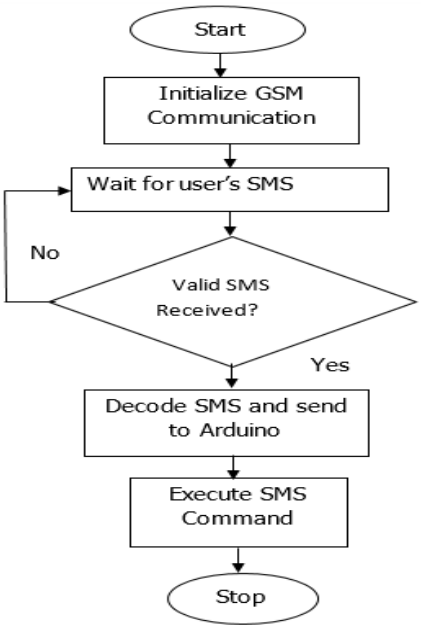

Figure 2 System flowchart

3.1 Hardware Description and Implementation

GSM module, Arduino board, and Relay module are the three hardware components of a home automation system. This project uses a mobile phone to communicate with the Arduino board through GSM technology for control reasons. GSM module (SIM800), Arduino Nano, and 8-channel 5-volt relay module were used in the hardware implementation.

SIM cards with a distinctive SIM (Subscriber's Identification Module) number are accepted by this GSM module (SIM800). The module communicated wirelessly; GSM was used throughout the procedure. As a result, the operator uses his or her mobile phone to transmit commands to the system to turn on or off home appliances.

Figure 3 GSM module (SIM800)

The main controller of the entire system is the Arduino Nano Microcontroller Board. When a user sends a text SMS, the words are compared to a predefined format that contains relevant directives in the program to turn on or off appliances.

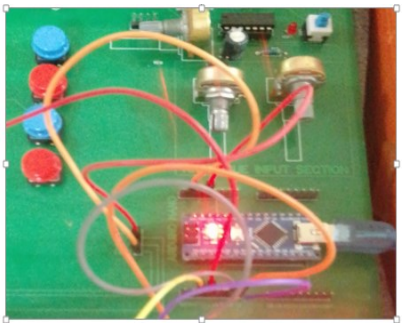

Figure 4 Shows the Arduino Nano board

The switch controls (switch mode ON/OFF) the device following an SMS command. The processor was in charge of the relay module. It enables a reduced 5V DC circuit to power on or off high-current equipment linked to a 220V power source, including a fan.

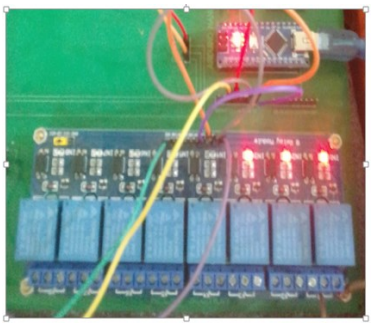

Figure 5 Hardware layouts for systems

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3.2 GSM Module Interconnecting with Arduino

A serial connection is used to connect the GSM module to the Arduino Nano. The GSM module was operated by an independent 12V power, and the GSM earth pin was connected to the Arduino ground pin. The Receiver pin of the Arduino was used to collect data from the unit, whereas the Transmitter pin was used to transmit information from the unit to the Microcontroller.

3.3 Software Architecture

As a free software environment, Arduino IDE was used in this investigation. Java was used to create the IDE, whereas the controller's routines were written in C. The Arduino IDE tool was used to complete the whole programming process, which involved writing code, building it, and uploading it to the Arduino I/O circuit. The Arduino Uno and the GSM module are connected through serial, the Baud rate was adjusted at 9600 bits per second. The Arduino IDE coding for switching on and off the lighting, fan, and refrigerator is shown in Figure 6.

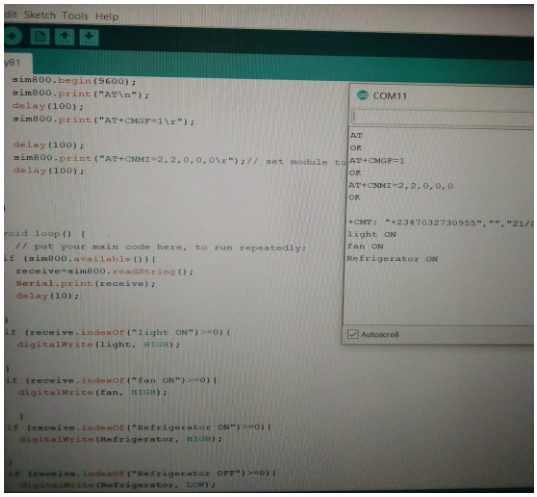

Figure 6 Arduino IDE

4. RESULTS AND DISCUSSION

As a result of this work, a smart home automation system is being built and developed. This device can easily operate home equipment such as fans, light bulbs, and refrigerators through GSM technology. The main components utilized were GSM modules, an 8-channel relay module, and an Arduino Nano. Figure 7 depicts the system's entire circuit layout with an appliance. As shown in figure 7, the GSM module's transmitter pin is connected to the microcontroller's receiver pin, and the GSM module's receiver pin is connected to the Arduino microcontroller's transmitter pin. The Arduino digital pins 8, 9, and 10 were connected to IN1, IN2, and IN3 of the relay module respectively. The bulb, fan, and refrigerator were attached to the relay's normally open (NO) port. The GSM module's Voltage source and Ground pins were linked to the Arduino microcontroller's VCC and GND pins, respectively. Table 1 depicts the operation of GSM technology.

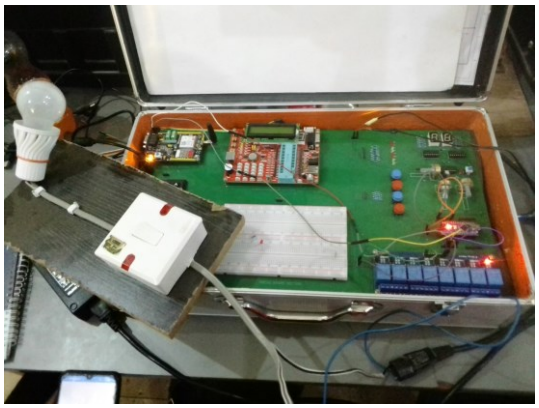

Figure 7 Overall system setup with appliance

TABLE I WORKING PRINCIPLE OF THE GSM MODULE

Hand held device (Mobile Phone)	Data (SMS) Received (GSM Module)	Data (SMS) Received (Micro-controller)	Operation (Electrical Appliances)
SEND Data (SMS)	Light ON	Digital Pin 8, HIGH	Switch ON Bulb
SEND Data (SMS)	Light OFF	Digital Pin 8, LOW	Switch OFF Bulb
SEND Data (SMS)	Fan ON	Digital Pin 9, HIGH	Switch ON Fan
SEND Data (SMS)	Fan OFF	Digital Pin 9, LOW	Switch OFF Fan
SEND Data (SMS)	Refrigerator ON	Digital Pin 10, HIGH	Switch ON Refrigerator
SEND Data (SMS)	Refrigerator OFF	Digital Pin 10, LOW	Switch OFF Refrigerator

Table 1 described signal transmission within the system. If the data (SMS) is given as 'Light ON', the GSM module will cause the microcontroller digital pin 8 to go HIGH which will activate any output load (Bulb) connected to it and make it turn ON. Similarly, if the data (SMS) is given as 'Light OFF', the GSM module will cause the microcontroller digital pin 8 to go LOW which will deactivate any output load (Bulb) connected to it and make it turn OFF. In the case of controlling the operation of a fan to go ON and OFF, microcontroller digital pin 9 was selected to operate. Microcontroller digital pin 10, was considered to control the operation of the refrigerator. Based on this principle, any electrical appliances can be remotely

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controlled using GSM as an interface.

5. CONCLUSION

The usability of a GSM technology was extended in this study to remote control of electrical home appliances such as fans and bulbs, among other things. This advancement allowed anyone to access and manage home appliances (turn ON/OFF) from anywhere. By delivering SMS (data) to the microcontroller via the GSM interface, electrical appliances can be controlled remotely. The home automation system's hardware setup was tested and deployed. Furthermore, a wireless connection between the mobile phone and the Arduino microcontroller was determined to be reliable at a baud rate of 92,600 bps. Such applications can be utilized for surveillance systems, smart farming, monitoring and conditioning system, monitoring and controlling environmental parameters, and other applications in addition to controlling residential appliances.

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