Design and Implementation of GSM-Based Automation of Household Appliances

Georgewill M.Onengiye, Ezeofor J. Chukwunazo

Abstract— In this paper, GSM-Based Automation of Electrical Household Appliances is presented. The problem of paying huge electricity bills generated by various household Electrical & Electronic appliances at home/office is alarming. To help reduce the total number of energy use and amount to be spent on electricity bills, GSM-Based Automation of Electrical Household Appliances is proposed. The system is designed to allow the user to control the switching ON/OFF of his/her electrical home appliances via mobile phone anywhere at any time. The system consists of hardware and software .Any household appliances can be switched ON by sending an SMS with the keyword 'LL1 or LL2 or LL3 ...etc.' from the user's mobile phone to the receiver panel at home, the receiver antenna picks the signal and forward it to microcontroller which decodes the keywords and command the instructions to trigger any device connected to the system ports. When the device (s) is/are switched ON, the system sends a feedback message back to the user stating the status of the device(s). Also user can switch OFF any of the appliances by sending an SMS with the keyword 'LL0' and the instruction would be carried out and message returned back to the sender.The system is implemented , program written and tested with accurate results.

Index Terms— GSM Modem, Arduino Uno Microcontroller, Liquid Crystal Display, Household appliance, SMS Message, MAX232, Embedded C.

1 INTRODUCTION

In our various homes, offices and industries, it has been observed that manual switching ON/OFF of electrical appliances like bulbs, television, refrigerator, fan etc., are very stressful process since the distance of these devices from the users are far off. Users must move to the location where electrical appliances are kept and plugged them on the mains to put them ON/OFF any time. As the world is turning into Automation, there is need for home automatic control system that would be capable of controlling every electrical device wirelessly from a distance. This research work is proposed to overcome the challenges of manual switching of household appliances with GSM technology through Short Message Service (SMS).The idea of using the short message service is to establish communication network routes between receiver (Controller unit) and transmitter (GSM) for the purpose of safety

2 RELATED WORKS

Conte and Scaradozzi worked on home automation system as multiple-agent Systems (MAS) were considered. In their work, home automation system was proposed that includes home appliances and devices that are controlled and maintained for home management. Their major contribution to knowledge was to improve on home automation, without minding the cost of the entire system [1].

In a related work, Alkar and Buhur proposed an Internet Based Wireless Home Automation System for Multifunctional devices with low cost and flexible web-based solution but this system has some limitations such as the range and power failure [2]. Delgado et al. considered problems with the implementation of home automation systems. Furthermore, the possible solutions were devised through various network technologies. Several issues affecting home automation systems such as lack of robustness, compatibility issue and acceptability among the old and disabled people were also discussed [7]. Ciubotaru-Petrescu et al., discussed design and implementation of SMS based control for monitoring systems was presented. Their paper has three modules involving sensing unit for monitoring the complex applications, a processing unit that is the microcontroller and a communication module that uses General Packet Radio Service (GPRS) modem or cell phone via serial port RS-232. The SMS is used for status reporting such as power failure [5].

Murthy explored on the primary health-care management for the rural population. His solution proposed the use of the mobile web-technologies for providing the Primary Health Care (PHC) services to the rural population. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication [10]. In [8], Jawarkar et al proposed remote monitoring through mobile phone involving the use of spoken commands. The spoken commands are generated and sent in the form of text SMS to the control system and then the microcontroller on the basis of SMS takes a decision of a particular task. But the drawback of all the related works is the cost of the design, the reliability, and the use of foreign materials. In this research, localized materials are used for the design, making it more reliable and portable with less cost. Microcontroller, relays, and mobile phones, GSM modem etc. are deployed to achieve research objectives.

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3 MATERIAL AND METHODOLOGY

The design involves both hardware and software. The hardware is implemented using modular design method while the software developed using embedded C language. The GSM-based automation of household appliances block diagram is shown in fig.1.

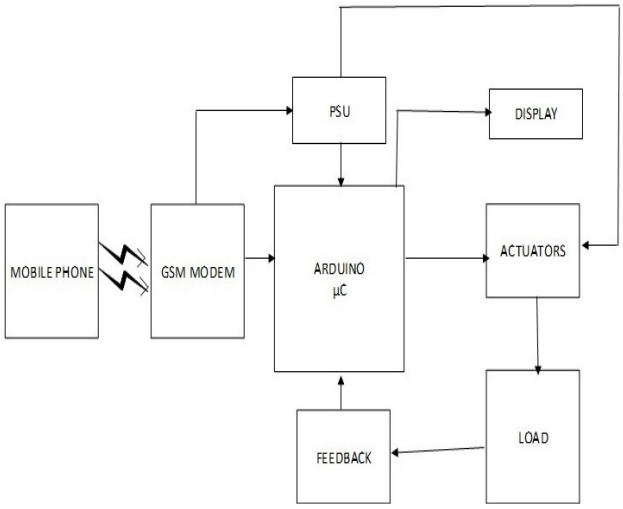

Fig.1: System Design block diagram

3.1 Hardware Design

The hardware of the GSM-Based automation of household appliances system is made up of four sections namely: the input, control, actuators and the output sections. The input comprises of the power supply unit, GSM modem that receives SMS from the user's GSM phone and transmits it serially to the control unit to initiate action based on the user request. The control unit co-ordinates all control actions with respect to what is sent by the user. All control actions are carried out using Arduino uno microcontroller. The output section relates to the outside world via LCD. The display (liquid crystal display) unit will be used to make the system user friendly to indicate the status of the system at all time. The lamp is the load being controlled based on the received input command.

Power Supply: The system requires power source of +5V and +12V DC. One techniques to generate +5V and +12V DC is the use of one or more 9V batteries connected in series and rectified to produce continuous power supply. In this research work, rectified A.C voltage is used. To obtain +5V and +12V D.C from the mains 220V A.C, 50/60Hz requires scaling down of the voltages using a step down transformer and converting from alternating current to pulsating direct current, using a bridge rectifier. A smoothing filter (usually a capacitor) is used to convert the pulsating direct current DC to direct current. The voltage is regulated using 7805 and 7812 voltage regulators to ensure constant +5V and +12V D.C supply to the circuits as shown in fig. 2.

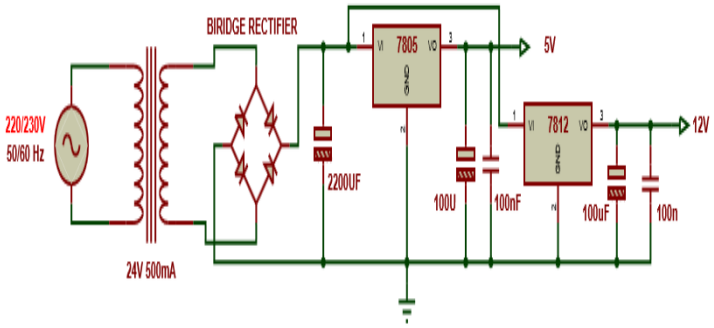

Fig.2: Circuit Diagram of a complete +5V& +12Vregulated DC power supply

GSM MODEM (sim900): This module communicates to the control section when the user requests to switch any load wirelessly by sending a SMS message to the system via sim900 modem. The modem is connected to communicate with the Arduino microcontroller via max232 level converter using AT command instruction set of SIM900 GSM/GPRS modem. The max232 is used to make the Arduino controller and the Sim900 modem signal compatible. The TX (Transmit) pin of the modem is connected to the RS-232 input pin (R1IN) of the max232 and the T1OUT of max232 to the RX (receive) pin of the Arduino uno controller. The RX (receive) pin of the modem is connected to the RS-232 output pin of the max232 and the T1IN to the TX (transmit) pin of the microcontroller. With this connection, the modem and the controller are able to exchange data successfully as shown in fig.3.

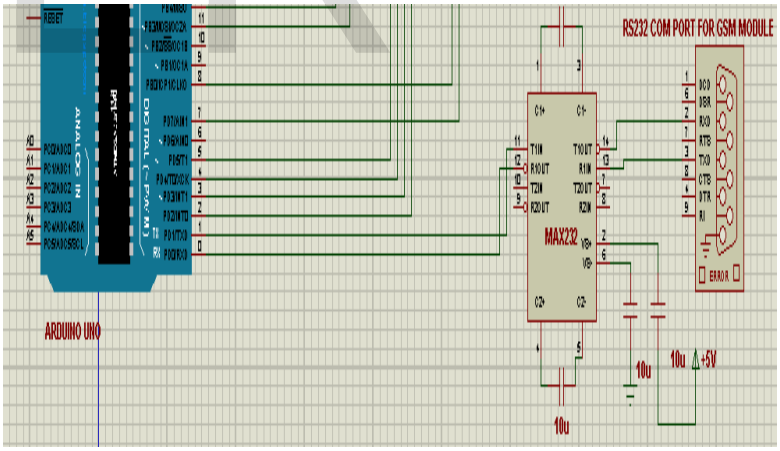

Fig.3: GSM Modem interfaced with Arduino Controller via MAX 232

A. Mobile Phone: A Cellular Mobile phone containing SIM (Subscriber's Identifying Module) card has a specific number through which communication takes place. The mode of communication is wireless and mechanism works on the GSM (Global System for Mobile communication) Technology. The GSM is used as a transceiver to send SMS message to the control system and to receive SMS from the control system. The mobile phone used in this work is shown in fig.4. It can work with any mobile phone.

Fig.4: Mobile Phone (Transceiver device)

Arduino Uno microcontroller (ATMEGA 328P-PU): The Arduino Uno board is embedded systems which contains ATMEGA328P microcontroller series, 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It can simply be powered by connecting it to a computer with a USB cable or powered with an AC-to-DC adapter. However, in this work a separate power supply unit is built to power it. The Arduino Uno microcontroller is programmed using embedded C-language in the Arduino Integrated Development Environment (IDE). The IDE handles the compiling and linking of the source code in which the hex file is uploaded to the memory of the controller. Arduino Uno microcontroller (ATMEGA 328P-PU) is selected to effectively carry out the co-ordination of the system due to some properties such as, flexibility, the RAM size, number of programmable I/O lines, programmable serial channel, etc. The control unit makes use of Arduino uno microcontroller chip whose function is to switch a load (lamp) through a transistor via a relay on reception of valid data from the GSM modem and send back the status of the load to the user through the TX (transmit) pin of the controller via the GSM modem. All input sensors and detectors are connected in the I/O pins of the microcontroller. The picture of the Arduino board with ATMEGA 328P-PU is as shown in fig.5.

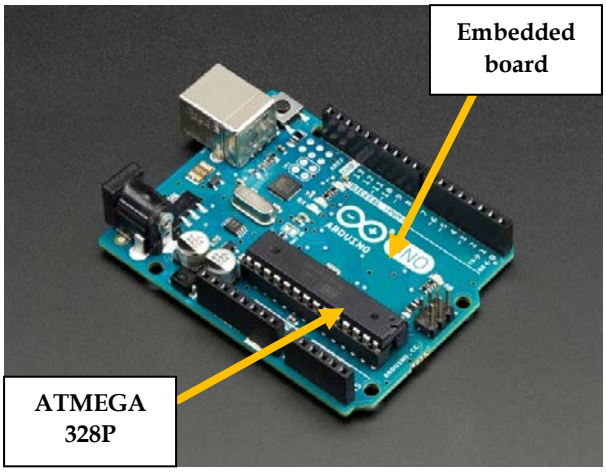

Fig.5: Arduino Uno Board with ATMEGA 328P

System Liquid Crystal Display (LCD): The LCD is used to interact with the user by indicating the state of controlled load(s). The interfacing of the 16X2 LCD to the system control unit is shown in fig.6. From the circuit, a 10k pot is connected between the power source (5V) and the wiper to pin 3 of the display unit that is used to adjust the display contrast. Data are sent from the controller to the display in a 4-bits mode to minimize I/O port usage and that is why there are four lines connecting the display to the controller in the other of (RD0-D4, RD1-D5, RD2-D6, and RD3-D7). The remaining two lines (RS and E) are the control lines of the LCD which are also connected.

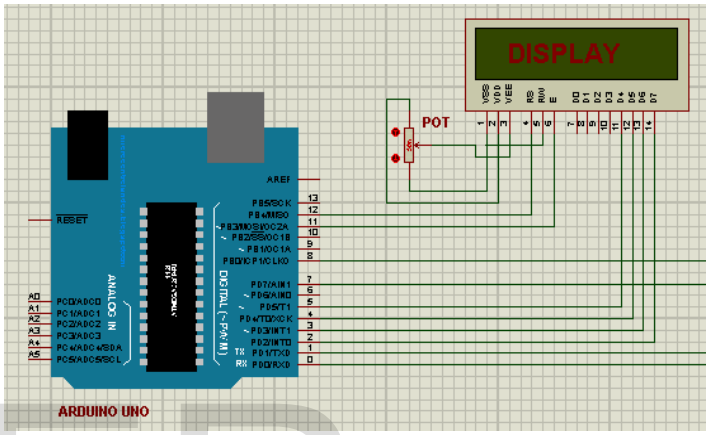

Fig.6: Arduino board interface with 16x2 LCD

Electromagnetic Relay: A relay is essentially an electromagnetic device used to switch ON/OFF a load. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. In this work, 12V relay is used to switch ON/ OFF load connected to it. The current of the relay is calculated from Ohm's law. The circuit supplies the current required by the relay coil. The connection is as shown in fig.9.

3.2 Software Design flow chart

The flow chart in fig.7 shows the step by step process that the microcontroller uses in executing instructions. It can also be taken as the signal flow process of the system. The program is written to follow the flow chart process. When the user sends command using his/her mobile phone; on receiving a command, the system is expected to switch ON/OFF the load at the remote end and send back a feedback message reviewing the status of the load it has activated to the user.

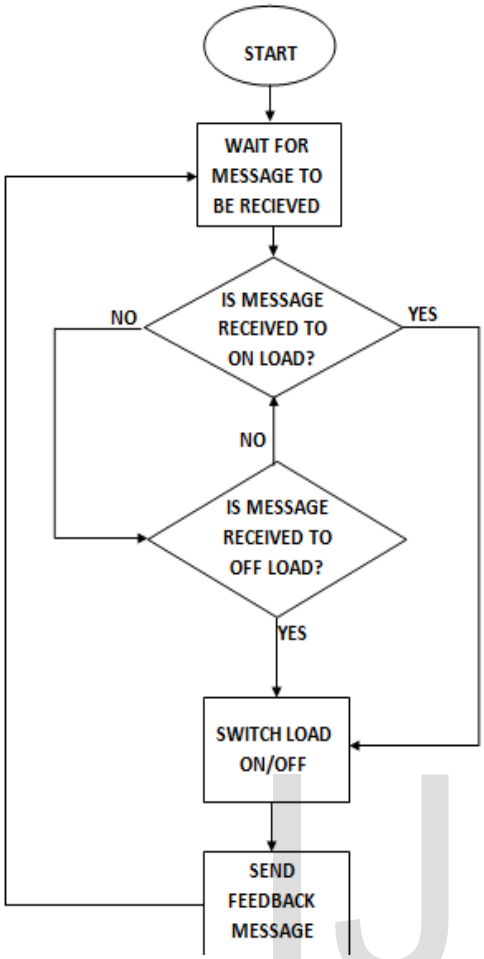

Fig.7: Software Design flow chart diagram

3.3 Microcontroller Embedded Language

The source code of this work is programmed in Arduino integrated development environment (IDE) and compiled. The hex file is loaded in microcontroller's Flash memory. The microcontroller executes the hex file generated by the compiler. The executable code comprised of sequence of zeros and ones organized in 12-, 14- or 16-bit wide words, depending on the microcontroller's architecture. Every word is considered by the CPU as a command being executed during its operation. For practical reasons, as it is much easier for us to deal with hexadecimal number system, the executable code is often represented as a sequence of hexadecimal numbers called a Hex code. As for Arduino microcontrollers, programming word comprised of 14 bits wide. The main advantage of C languages is its simplicity, It is no longer possible to know exactly how each command executes when using C compiler. The snapshot of the Arduino compiler window is shown in fig.8.

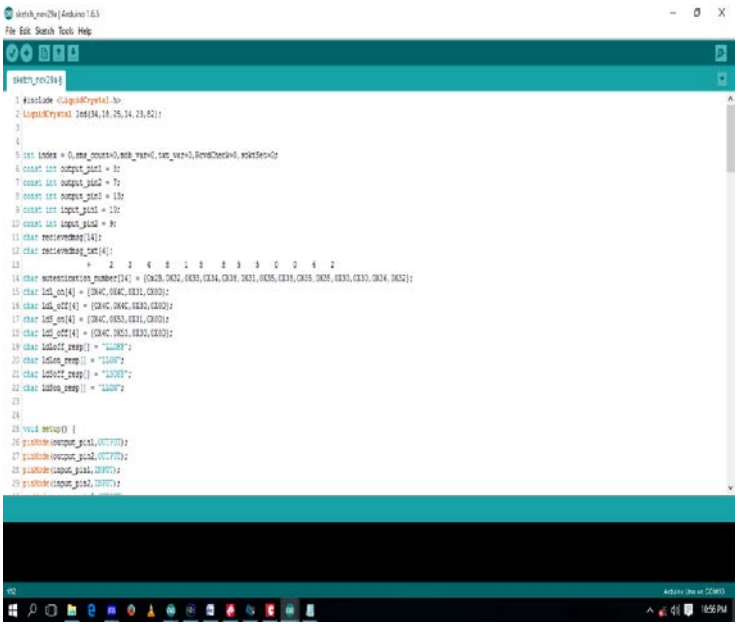

Fig.8: Arduino Source code Integrated Development Environment (IDE)

3.4 System Circuit Diagram & Operations

When the system is powered, the regulated 5V and 12V supply power to the microcontroller, MAX232 IC, relay and LCD. The, written program initialized LCD. When SMS (LL1) message is sent as a command via mobile phone to the GSM modem, the GSM modem on receiving the signal through its antenna also sends a signal to the microcontroller. The MAX232 IC that links the GSM modem with Microcontroller is used as a dual converter to convert the RS232 signal (-15V) from the modem to TTL signal (5V) that the microcontroller operates with and vice versa The microcontroller on receiving this signal interprets, process and sends a command signals via pin 7 and pin 8 to the transistor respectively which triggers the relay to switches ON any load connected to the pin. The system then sends a feedback message indicating the status of the load to the user via the GSM modem. Furthermore, when SMS (LL0) message is sent as a command via mobile phone to the GSM modem, the GSM modem on receiving the signal through its antenna also sends a signal to the microcontroller. The microcontroller on receiving this signal interprets process and sends a command signals via pin 7 and pin 8 to the transistor respectively which triggers the relay to switches OFF any load connected to the pin. The system then sends a feedback message indicating the status of the load to the user via the GSM modem. The system circuit diagram is shown in fig.9.

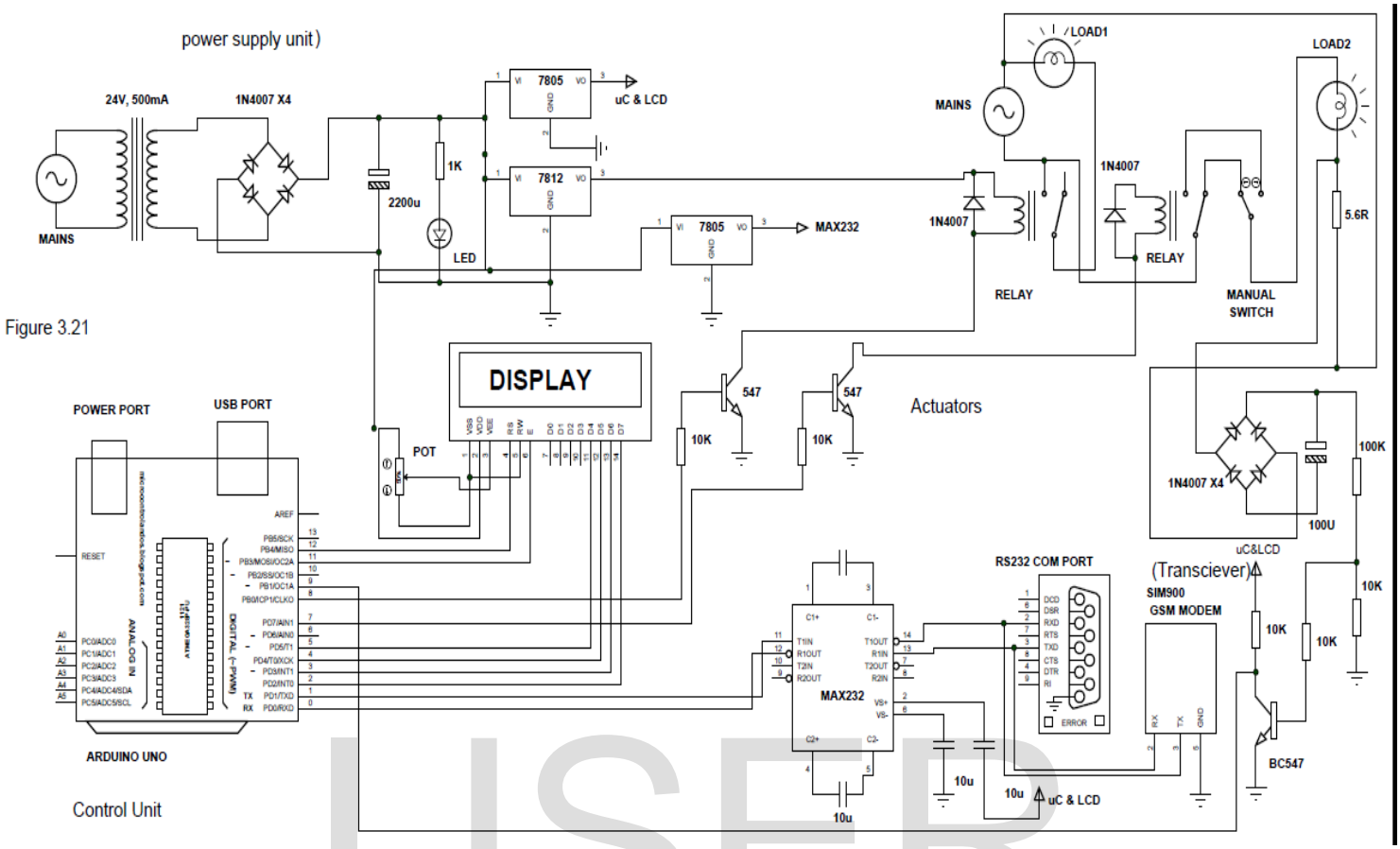

Figure 3.21

Fig.9: The system circuit diagram

4 Test, Results and Discussion

4.1. Components Test

Each section/unit of the system is tested, simulated and integrated. The step-by-step test process is as follows:

- *Step down Transformer test*

The transformer parameters are written on its body, indicating the primary voltage with its current rating and the corresponding secondary voltage. The transformer has a primary voltage of 220V AC and 12V AC-0V-12V AC secondary voltage. Connect the two wires of the primary to the mains and connect the secondary wires using the red and black probes of the multi-meter. The multi-meter indicates low resistance value, although the primary resistance value is higher than that of secondary for step down transformer. The meter is set properly on AC and reading taken which is found within the voltage ratings of the transformer as specified.

- Sim900 GSM Modem and MAX232 Test

The modem is plugged and powered directly from the mains supply. It is allowed for 5 seconds to get it ready for communication. The RSIN, TOUT, TIN and RSOUT of the max232 were tested using a digital multi-meter for appropriate voltage level (-15V and +15V – RS-232 signal and 0V and 5V – TTL signal). Table 1 shows the voltage signals gotten from the output of the test conducted.

TABLE 1
RESULTS OF VOLTAGE SIGNALS TESTED FOR TRANSMISSION AND RECEPTION BETWEEN THE MODEM AND THE MICROCONTROLLER.

Message bit	T1IN	TOUT	RSIN	RSOUT
Bit "0" from controller	0V	+7.85V	5V	-8.01V
Bit "1" from controller	5V	-8.01V	0V	+7.88V
Bit "0" from modem	5V	-8.01V	+7.88V	0V
Bit "1" from modem	0V	+7.88V	-8.01V	5V

4.2 Complete System test

Before the system integration, each module was first tested separately, and then sequentially each time a new unit is connected. Finally, the integrated work was tested before and after packing. This indeed ensured ease of location of dry and week solder joints and affirmed the working condition of all components off and on board. After the various sections have been integrated, the system was tested to see how it works by powering it using a three-toothed plug connected to 220V AC mains. After each part of the circuit was tested and integrated.

The overall result test conducted is shown in table 2. The system is now packaged and the pictures of the system views are shown in fig.10a and fig.10b.

TABLE 2
RESULTS GOTTEN AFTER PACKAGING OF THE CIRCUIT

Process	component	Action
Power is turned ON in the circuit.	Power indicator led	LED turns ON
Switch on load from the system	Lamp	Load turns ON and status of load on the screen changes from "OFF" to "ON"
Switch load through sms "LL1"	Lamp	Load switches OFF and status of load on the screen change from "ON" to "OFF"
Wait for feedback	Mobile phone	sms feedback text: "LL1 OFF"
Switch load ON/OFF through sms "LL0"	Lamp	Load switch ON and status of load on the screen change from "OFF" to "ON"
Wait for feedback	Mobile phone	sms feedback text: "LL0 ON"
Switch load ON through sms "LS1"	Socket	Load switches ON
Switch load ON through sms "LS0"	Socket	Load switches OFF

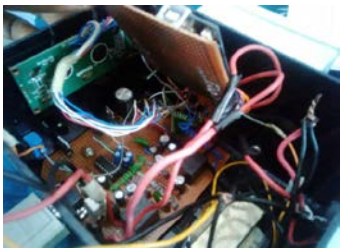

Fig.10a: system interior view

Fig.10b: System Exterior view

4 CONCLUSION

The design, simulation and implementation of GSM-Based automation of household appliances became more complex due to the addition of newer ideas that keeps improving the system. The combination of communication and control system in automation of household appliances are indeed a huge boost in home security trends. The work has further expanded into embedded system design technology.
Its uniqueness in automatic control is an added advantage which ultimately increases the life sperm of every household appliance, thereby reduces the rate of electrical fire outbreak resulting from sudden power surge. It also provides more comfortable stress free means of operation.

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