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REDUCING WASTAGE IN ELECTRICITY USAGE THROUGH THE USE OF ADVANCEMENT IN GSM TECHNOLOGY

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Abstract— Due to the epileptic nature of electricity in developing economies like Nigeria, people have their electrical loads on mistakenly when leaving homes for offices or offices for homes; and this normally resulting in energy wastages and inefficiencies. These wastages are very detrimental to industrial development; therefore, there is a need to make use of advancement in technology to reduce wastage in electricity usage. To that effect, this paper proposes a device that can control home appliances via the Global System for Mobile Communication network to minimize electrical energy wastages and,

consequently, enhance industrial sector growth. Besides, the proposed device will inform the user when utility board restores electricity on the user's mobile line, display on the mobile line of the user the states of all the connected appliances and receive an appropriate command from the user to either switch ON or OFF specified appliance(s). The different results obtained when the proposed device was tested revealed that it worked according to the design specifications.

I. Introduction

Home or office automation is the control of any or all electrical appliances in-home or office, whether the owners are around or not. Hundreds of devices are available today that allow controlling of appliances automatically; and consequently manage home energy efficiently, either by remote control or voice command [1]. One of them is Global System for Mobile Communications (GSM) based Home Energy Automatic System (HAS), which smartly controls lighting systems, heating, ventilation, and air conditioning appliances (HVAC), and other systems in a home or office in which it is installed. HAS is needed because people normally leave their electrical (or electronics) based appliances on unconsciously when leaving their homes or offices, due to epileptic supply of electricity in developing economy like Nigeria; and this results typically in energy wastages, and may also lead to fire outbreak. It is not always possible to be physically present or near the vicinity of the home (or office); therefore, much effort should be put in place to remotely switch off unused electrical (or electronics) appliances which are on; and

this singular act will lead to a reduction in the electrical energy wastage, reduction in the outrageous electricity bills, and increase in the life span of electrical (or electronics) appliances [2]. In Nigeria, these wastages are very detrimental to industrial Development; consequently, available technologies need to be more widely introduced to reduce these wastages in electricity usage.

The concept of home automation or smart home or intelligent home is not new; it has been in existence for many years. It is all about the networking of homes' appliances and devices [3]. Some of these HASs centrally control lighting, HVAC appliances, security locks of gates, and doors, to provide comfort, energy efficiency, and security [4]. The device could also be found useful and efficient especially for the disabled and the elderly, by reducing the stress they may pass through; and even the energy that might be wasted whenever the power supply is restored. Several wireless communication technologies that can support some forms of remote sensing and control, remote data transfer and monitoring such as Wireless Fidelity (WiFi), Radio Frequency Identification (RFID), Internet of Things (IoT), Bluetooth, mobile telephony (GSM) have been used to actualize various levels of intelligence in homes.

The feasibility of Bluetooth technology in HASs using Android smartphones without internet control has been reported in Ming et al. [5]. The devices were connected to a bluetooth sub-controller, accessed and controlled by the smartphone via a mobile application using built-in bluetooth connectivity. The technology developed by Ming et al. [5] is geographically limited in application. The HAS developed by Ahmed et al. [6] use WiFi technology. The system consists of three main components; web server, which presents system core that controls, and monitors users' home and hardware interface

module (Arduino PCB ready-made), WiFi shield PCB, 3 input alarms PCB and 3 output actuators PCB, which provide an appropriate interface to sensors and actuators of a home automation system. From scalability and flexibility point of view, the work of Ahmed et al. [6] is better than the commercially available HASs. The user may use the same technology to log on to the server web-based application. It can be achieved with the availability of the following facilities: internet connectivity, appropriate browsers, proper hardware components such as a dedicated computer system, and Android Phone with internet compatibility. The overall cost of all these facilities and the hardware components made the HAS proposed by Ahmed et al. [6] to be costly for the domestic user.

WiFi technology is used in Nathan et al. [7] with the integration of mobile cellular networks such as 3G or 4G to access and control the HAS. If the WiFi connection is not available, mobile cellular networks such as 3G or 4G would be employed to obtain the HAS. It also uses a Google speech recognition engine to eliminate the need for an external voice recognition module. The proposed system does not require a dedicated server P.C. concerning similar systems and offers a novel communication protocol to monitor and control the home environment. However, the system proposed by Nathan et al. [7] does not support SMS alert; it can only work on Android phones and the internet facility. The system is, however, expensive to maintain.

The HASs proposed in Imran et al. [8] are based on IoT using Arduino Mega. The IoT-based architecture provides high-level flexibility communication and information. It is an approach that is relevant in many different environments, such as patient monitoring system, security, traffic signal control, or controlling various applications. The IoT projects provide a dominant and thorough study of all sensible functionalities, mechanisms, etc. Various

protocols are used for building IoT architectures. However, interconnections errors occur between all different IoT applications. User information is not secured; this may lead to cyber hack or frauds and thereby exposed the user to many cyber frauds. The user's hardware component is not mobile and straightforward. The HAS that is based on IoT and presented in [4] is very easy to install. The Arduino controller controls it. It alerts the user by given out sound through a buzzer and will record activities within the vicinity through an H.D. spy camera. As good as the HAS proposed by Amudha [4] is, it can only monitor the activities in the premises in which it is installed, it cannot report back to the user for prompt actions to be taken. Another shortcoming of this device is that it can only work where there is an internet facility, and it is expensive.

The HAS proposed by Tseng et al. [9] is based on the ZigBee, which uses the IoT to improve the convenience, safety, and power-saving of the house. In that unit, all sensors and actuators are connected to a ZigBee wireless network. A simple, smart socket is embedded which can be remotely controlled via ZigBee; a P.C. host is used as a data collector and the motion sensing, all sensing data are transferred to the volatile memory in the cloud. The user can use the P.C. or Android phone to monitor or control the power saving in the house through the Internet. The ZigBee technology employed by Tseng et al. [9] could not cover many areas when compared to GSM and others. As a result of the shortcoming of ZigBee, Kim et al. [10] used both wireless ZigBee and wired X10 technologies for his HAS. This system followed smart task scheduling with a heuristic for the Resource-constrained-scheduling problem. The mobile device can either be wired to the central controller through USB cable or communicates with it wirelessly within the home. Arduino contains the web server application that communicates through the HTTP protocol with the Web-based Android application. The system in Kim

et al. [10] is highly flexible, scalable, and expandable; but can only communicate within the scope of the home coverage area.

This paper harnesses the SMS data transfer service of the GSM to send and receive a command in as much as the user is within the network coverage area. The proposed HAS also reports to the user immediately whenever the utility restores the power supply through SMS. It also gives the status of gadgets, so that the user can take proper action(s) to control the load and thereby reduce energy wastage, and the bill to the utility. The GSM network is selected for the communication between the home devices and the user due to its broad spread coverage [11]-[12], highly shielded infrastructure, maximum accuracy [2], and its ability to prevent other people from observing the information being transmitted and received. The SMS is used as a means of monitoring and controlling the proposed HAS because it is the easiest and the most available technology with low-cost rate [13].

II. Materials And Methods

A low cost, efficient, and simple, smart HAS is proposed. It has two main modules: the hardware interface and the software communication modules.

A. Hardware Interface Module

Figures 1 and 2 present a block and schematic diagrams of the proposed HAS, respectively.

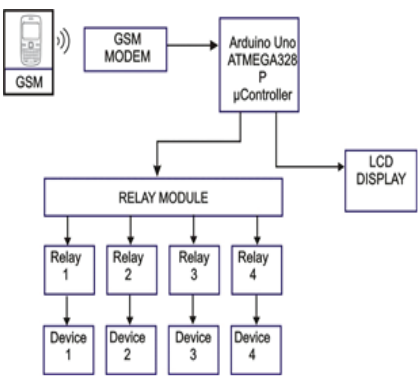

Figure 1: Block diagram of the proposed device

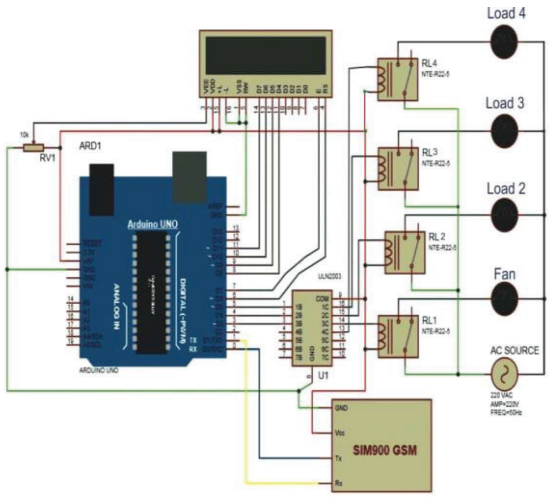

Figure 2: The schematic diagram of the proposed device

- Hardware Requirements

Some of the hardware used in the implementation of the proposed HAS, as shown in Figure 2, are Arduino Uno, SIM module, 12 V relay, and relay driver-ULN2003, JHD162A Liquid Crystal Display (L.C. D) and power supply unit. The interconnection of these hardware achieves the overall objective of this work.

The Arduino Uno R3 board, which is presented in Figure 3, is a microcontroller board based ATmega328P. It has fourteen digital input/output pins of which can be used as PWM outputs, six analog inputs, 16 MHz quartz crystal, USB connection, a power jack, an ICSP header, and a reset button [4]. It is powered with an AC-to-DC adapter.

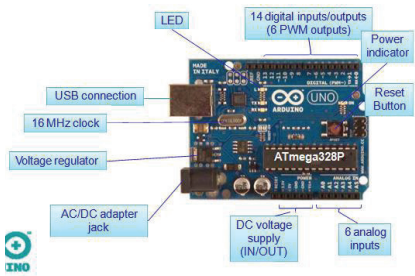

Figure 3: Arduino Uno Board

A GSM SIM900 module, Figure 4, is a specialized type of module; which accepts a SIM card and operates over a subscription to the mobile operator [14]. The micro-controller communicates over the mobile network via the GSM module. In this paper, the

module is used to send and receive SMS messages.

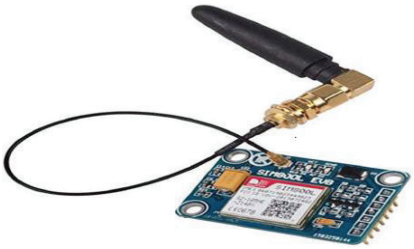

Figure 4: GSM SIM Module

Relay is an electromagnetic switch which is used to turn an electrical load on and off by applying a voltage across its contacts. A 12 V 4-channel relay, as shown in Figure 5, is used. The relay driver is used not only to drive the relay circuits that switch different appliances connected to the interface, ON, and OFF but also to protect the microcontroller from relay kick back with the help of integrated clamping diodes. It has seven high current Darlington arrays, each containing seven open collectors Darlington pairs with standard emitters.

In this paper, JHD162A, which is an advanced version of HD44780 based LCD, was used; and it is used to display the states of all connected loads locally.

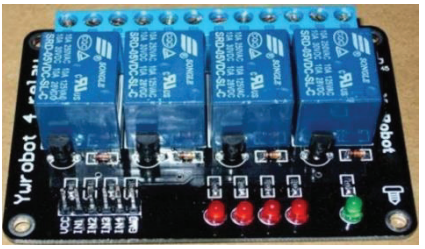

Figure 5: Four-Channel Relay

B. Software Requirements

Arduino programming has two main parts; setup and loop functions, as established in the IDE code development [14]. The first is the function that is executed only the first time that application runs, whereas the second one is executed as a loop. For this application, additional functions are included in the segment and make the program more efficient. There is a function for each mode of service that provides for the necessary control loops. At the beginning of the Arduino code, all the components are delimited: type, the pin to which is associated, and the operation mode. Besides, it is also declared the global variables and the libraries which will be used in the whole code [15].

Figure 6 presents a flow chart for the programming of the Arduino. The flow chart and the

code for the operation of the Arduino are developed from this algorithm:

1. Start
2. Configuration of the Input / Output pins
3. Configuration of input /output pins for the Arduino Uno
4. Input the Receipt Mobile Number
5. Configuration of LCD and Relay Drivers
6. Check the energy source to the device
7. Is the device energized? No, Go to 6
8. Yes, send "Attention PHCN is restored" to the user's mobile line;
9. Define the outlet for each load
10. Is the user interested in knowing the state of load(s)? No, go to 13
11. Yes, send the appropriate command, go to 9 and return
12. Display the state of load(s) on LCD and User's mobile line;
13. End

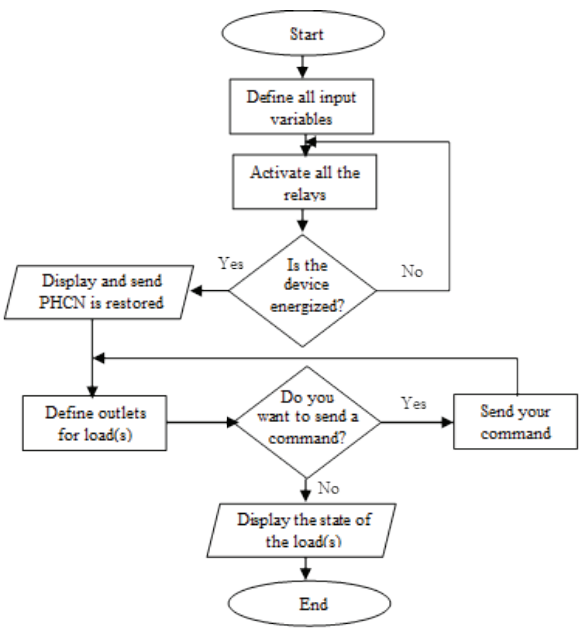

Figure 6: Flow Chart for the programming of the Arduino

C. The Proposed Device

Figure 7 shows the photographic (internal) view of the proposed HAS. The external view of the proposed HAS is presented in Figure 8. The casing is made from furniture and fiber material. It is compact, light in weight, and cheap.

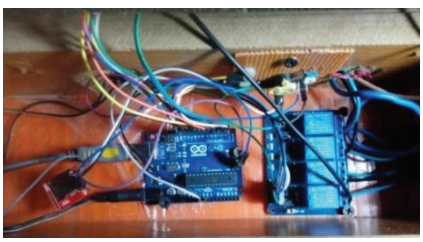

Figure 7: Completed proposed (HAS) (internal part)

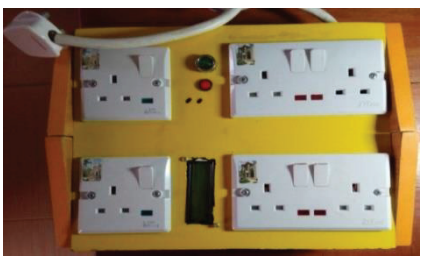

Figure 8: Completed proposed (HAS) (external part)

III. Result

This section presents the performance assessment of the proposed device when tested and the results obtained. The experimental set up to evaluate the performance of the proposed device when four electrical loads were connected to it, and power was ON is presented in Figure 9.

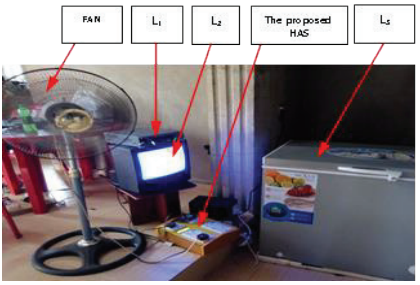

Figure 9: A proposed device with the connected loads

The proposed device is powered through the push button; after a delay of two seconds, the message displayed on LCD is as shown in Figure 10; this indicates that the system is ready. The system changes message status on LCD has shown in Figure 11 after a delay of another five seconds to indicate outlet status.

Figure 10: HAS system in Ready Mode

Figure 11: Outlet Status

Upon completion of the setup, the proposed HAS can send an SMS (Attention: PHCN is restored) remotely via the GSM network to the owner for prompt actions, as shown in Figure 12.

Figure 12: Screenshot of the SMS on the Phone

Upon receiving the SMS (Attention: PHCN is restored), SMS command *A.status# was sent to the proposed HAS to check the status of all the loads; and the result obtained on LCD is as shown in Figure 11; whereas the screenshot of the SMS received on the phone is shown in Figure 13, and the physical state of all connected loads is shown in Figure 9. The SMS command *A. fanoff# was sent to the proposed HAS, to put off the fan. The result obtained on LCD is as shown in Figure 14; whereas the screenshot of the SMS received on the phone is as shown in Figure 15, and the physical state of all connected loads is presented in Figure 16.

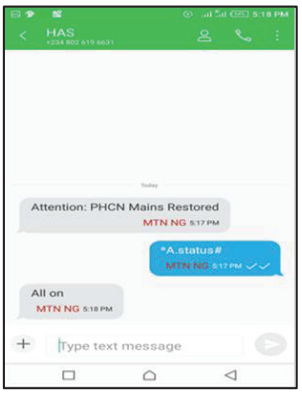

Figure 13: Screenshot of the SMS on the mobile phone when a command *A.status# was sent

Figure 14: Screenshot on LCD when Command *A.1fanoff# was sent to the proposed HAS

Some useful SMS commands and the possible loads that can be remotely controlled by the proposed HAS are presented in Table 1 for easy selection of the loads.

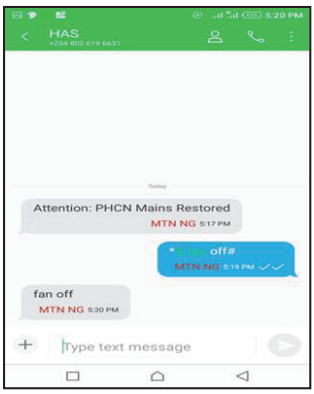

Figure 15: Screenshot of the SMS on the Phone when a command *A.1fanoff# was sent to the proposed HAS

Figure 16: The proposed device with the connected loads when a command *A.1fanoff# was sent to the proposed HAS

Table 1: SMS Commands and Load Switching

Command	Load Switching
*A.all off#	To switch OFF all the connected loads
*A.all on#	To switch ON all the connected loads
*A.status#	To check the status of all the loads
*A.fan off#	To switch OFF fan
*A.fan on#	To switch ON fan
*A.l1 off#	To switch OFF load connected to line 1
*A.l2 off#	To switch OFF load connected to line 2
*A.l1 on#	To switch ON load connected to line 1
*A.l2 on#	To switch ON load connected to line 2
*A.l3off#	To switch OFF load connected to line 3
*A.l3 on#	To switch ON load connected to line 3

IV. Discussion

The various results obtained when the proposed HAS was tested revealed that it worked according to the design specifications. This shows that HVACs and other electrical appliances can be switched ON or OFF through the proposed HAS, in as much as, the loads are connected to the utility supply through the proposed HAS, and the user and proposed HAS are in-network coverage

area. The total cost of production of the proposed device is $34.58, but it will cost less if it is manufactured in large quantities.

V. Conclusion

This paper proposes a device that can inform the user when the utility board restores electricity on the mobile line and display on the same mobile line the states of all the connected appliances; to reduce energy wastages and to prevent the possibility of fire outbreak. Besides, it receives an appropriate command from the user to either switch ON or OFF specified appliances.

The proposed HAS is recommended for homes and offices as one of the solutions to reduce energy wastages, to ensure the protection of homes or offices from fire disaster, and to cut down a considerable amount of money that is being spent on electricity bills. The efficient and practical application of the proposed HAS will not only improve industrialization in developing countries like Nigeria. Still, it will also prevent loss of lives and properties that often occur at homes and offices due to the negligence of utility users.

Several possible extensions can be done to this work, such as increasing the number of outlets to accommodate more loads, the inclusion of multi-media devices and services through Multimedia Message Service (MMS), which is already embedded in GSM module.

VI. Acknowledgement

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