



## A Lightweight Wireless Home Appliances Control

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### ABSTRACT

This paper proposes a system that gives users the convenience of controlling their home appliances from anywhere in the world as far as there have GSM coverage. This is with a view to minimizing energy wastage as well as preventing possible fire outbreaks in homes. The study is based on GSM network and a PIC16F877A microcontroller. Assembly language was used to develop a control program for the PIC. A circuit was constructed which constitutes of the microcontroller (PIC16F877A), LCD Module, SIM card and 4 relays (Darlington transistor). The SIM card was connected to a GM-47 module using a SIM holder. The LCD module was wired to the PIN21-28, PIN15-18, VDD, VSS of the PIC, while the relay module which performs the switching ON and OFF of the home appliances was connected to the RD0 and RD1 of the PIC. The GM-47 GSM module which holds the SIM card was connected to the RA3 and RA2 of the PIC through an operational amplifier such that when the user calls the SIM card, the microcontroller receives the signal and the control program changes the state of the relay. The control program was developed such that different call duration (3 seconds, 6 seconds and 9 seconds) changes the state of the three different relay hence, switches ON and OFF one and all the three power outlets. The project was tested by connecting the developed device to different loads (Fan, Electrical bulb and laptop etc.).

**Keywords:** Home Appliance Control, GSM Network, PIC16F877A, Energy Wastage..

### 1. INTRODUCTION

The future of mankind is dependent upon the technological growth in line with our daily needs. It is widely recognized that the next generation internet will be the Internet of Things (IoT) which provides the infrastructure of ubiquitous wireless sensing and identification systems with trillions of uniquely identifiable smart sensing devices to connect anything at anytime and anywhere [1]. The rapid growth and applications of technology have seen many new intelligent systems overriding the conventional methods to ease human life in many ways and one of the

implementations of such technology is Smart Home System [2]. The revolution in Smart Home applications creates high potential amount of users and is now becoming a trend in current homes. Generally, Smart Home is a house that uses information technology to monitor the environment of the house, controls electrical appliances and communicates with the outer world with some technological assistance [3]. It is an ordinary house embedded with extraordinary gadgets for better applications and increases the living standards of users. Smart Home System offers the prospect of significant improvement in our living standards for all levels of users especially the elderly and the wheelchair-dependents who are heavily reliant on home care. Smart Home concentrates and emphasizes on a few aspects such as safety, security, flexibility and comfort of users. On the other hand, wireless networks have become pervasive as the need for ubiquitous computing continues to raise hence the trend from “Internet of computers” to “Internet of things”. And as the need for homes to get smarter raise so is the need for things in homes get wireless.

Electrical appliances form part of our daily needs for development, comfort, information, enjoyment, services, growth, etc. As such needs are in a high demand users' requirement to access their electrical appliances in a more flexible and saver way is also in the increase. The most common access to electrical appliances is manual access (i.e. manual switching). Manual switching is done with human access according to instant needs. The Infra-Red (IR) remote control access is another method that has also become common. This technology is constrained by short distance of transmission, which, therefore, needs the user or operator to situate in the operating range of the device [4]. Lots of studies have been done in the area of home appliance control however, most of the works in literatures are still hampered by distance barriers, impracticability due to hardware and software complexity, complex framework, cost and security. This paper proposes a

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complete and limitless remote access whereby users can call through with their mobile phones to switch ON and OFF their electrical appliances via GSM network. Global System for Mobile Communications Modulator and demodulator (GSM Modem) enables a call commands to be received by a microcontroller.

The purpose of using GSM is to provide widest coverage at minimal cost. It will facilitate the control of electrical devices from any location with low maintenance, and independent of any physical or geographical boundary [5]. Another novel feature in this proposed system is that the user has the option of which devices to ON or OFF at any point in time from a distance. Because different devices have different periods its users' desire it to be ON or OFF. For instance, most users would prefer their home security lights to be ON by 7pm at night and OFF by 7am in the morning. This system supports this by allowing the user to use varying call duration to control the different loads connected to the control device. This system is designed to be flexible and enable the user to be aware of the latest status of their appliances at any time. This application is practicable because it uses simple hardware components and will benefit both domestic and industrial users from various levels of electrical applications without boundaries.

## 2. Related Works

A lot of research has been carried out over the years in the area of home appliance control. According to [6], home appliance control research targeted many needs; some applications fulfil the sophisticated and luxury requirements; other focuses the special needs like elderly and the disabled etc. For instance, [7], developed a single Infra-red (IR) remote control for controlling several home appliances like television, DVD, set top box, home theatre and air conditioner. The remote controller is based on SAMSUNG-S3F80PB microcontroller. The programming is done in assembly language using openice 2000 assembler. EZ updater was used to download different code set that represented different carrier signal for each of the appliances to be controlled by the single remote control. The S3F80PB microcontroller with the aid of the control program differentiated the IR signals and the signals were viewed using an Ax logic Analyzer. The cheapest way to remotely control a device within a visible range is via Infrared light however, the limitation with Infrared remote control of home appliances is short range, blockage by materials and lower transmission speed hence, does not address the issue of home appliances control away from home.

Moreover, In 2014, [8] did a simulation study on the control of electrical appliances using voice recognition. They used Hidden Markov Model (HMM) to develop a "Voice

Input Voice Output Communication Aid (VIVOCA) which can be used by the disabled and elderly to control their home appliances. They formulated a voice recognition algorithm and used it to perform a simulation where the algorithm uses the HMM probabilistic function to compute a sequence of user voice data and switches ON and OFF appliances using a PulseWidth Modulation (PWM). They also used the PWM to regulate the speed of home appliance such as fan by varying the output voltage to appliances. Spoken words: "ONE", "TWO" and "FOUR" were used in the simulation to control speed in rpm as follows: One – 500 rpm, Two – 1000 rpm and Four – 1500 rpm. The work focus on how the elderly and disabled can use voice to control their home appliance using speech recognition algorithm hence, opening up and addressing the another issue in home appliance control – security. [9], developed a PC based home appliance control system. They used a serial communication method which involves the use of serial port. Serial port is a simple and inexpensive tool for building computer controlled devices and projects. The simplicity and ease of program makes serials port widely used. The development of the control signal is carried out using commands in form of message from the PC. This message is decoded by a message chip which then sends a high or low signal to the relay that controls appliances via the relay driver IC. The driver IC used in this system is the ULN2003 because it is capable of handling high current and voltage applications especially in industries. An LCD is used to display what is been typed on the system's HyperTerminal. The major disadvantages with the PC based are the short range, bulky and can only control appliances when the user is at home.

[10] developed a Bluetooth based home automation system; the hardware interface component of the Bluetooth based home automation system consists of a Microcontroller–Transducer interface through I2C bus and an RS232 link between the microcontroller and the Bluetooth. Thus the microcontroller acts as a DC and a temperature-sensor/fan-controller IC act as ADs. The firmware for the microcontroller was developed using assembly and C language. The drawback of Bluetooth based home appliance control is that Bluetooth can only work in less than 100m distance and also it inevitably eats the battery of the devices.

In 2013, [6] proposed a device which control home appliances through voice commands. As shown in Fig 1, they integrated Zigbee, Bluetooth and a mobile application that converts the user voice command to SMS and send through GSM network. The application was developed using java for mobile technology and MPLAB for microchip family of controller. The user with android OS based mobile speaks voice commands, the mobile application converts the voice command in to text and payload the command on GSM network via SMS. Their

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Hardware design is subdivided into three parts. In the first part which is the heart of the work is an assembly language program controlled microcontroller (PIC16F877A) based control unit; it initializes the devices that were attached to it which are Bluetooth (BTM 222) module and Zigbee transceiver. After this, it waits for the command and when it is received, it simply transfers the command to the remote unit. The remote unit checks for the incoming command when it is received, it switches on home appliances using an MOC3021 - an optical triac and a BTA 16 triac and sends a feedback to the user. The drawback with Zigbee based is that it can only work with one person's voice and require a strong microphone at the mobile unit. Whereas this model proffers a solution to the problem of control of home appliances from a far distance, it may be impracticable in terms of cost due to its hardware complexity.

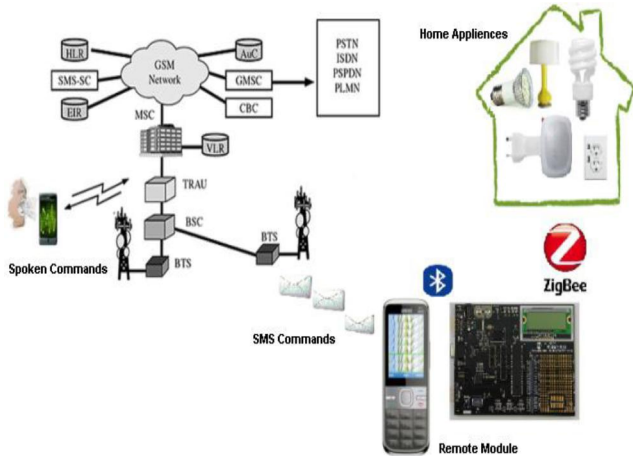


Fig. 1. System Architecture for Zigbee-Bluetooth based home appliance control (Source: [6])

### 3. Methodology

Two separate GSM receiver modules (GM47 chip) and two SIM card holders were used. While the first GSM module (when given flash call) is responsible for the energizing of the relay solenoids thereby sending power to the electrical equipment/device connected to its output, the second GSM module (when given flash call) is responsible for the de-energizing of the solenoids, cutting off power supply from the electrical equipment/devices connected to its output. It should be noted however at this juncture that the master control acts like a physical power cut-out or power switch/gear box such that regardless of the status of the controlled devices (devices 1 to 3), once the master control switches OFF in response to the long flash call of more than 9 seconds applied to the second GSM receiver module, all appliance goes OFF. Conversely to put devices in a state of individual control, the master OFF control must be set to ON. Figure 2 shows a block diagram of the

system. Signal from a GSM handset is sent to a receiver GSM module in form of precision call with pre-programmed or more appropriately, a known call duration (which is generally called a flash call). Upon the reception of this “flash call” the receiver GSM module’s in-built ring tone is automatically activated and therefore generates audible tones in response. The length or duration of this seemingly audible tone (or the amount of ac voltage produced as a result of this action) is dependent on the duration of the call made. While very short flash of less than 3 seconds connote signal that would be responsible for the switching of the electrical device-1, flash call of between 4 and 6 seconds is for electrical device-2, flash call of between 7 and 9 seconds would be responsible for the switching of the electrical device-3 and flash call greater than 9 seconds is for the master control. This is done because home appliances control is complex – beyond just switching ON or OFF the control switch at home as various appliances have specific times their owners want them to go ON and OFF for instance, a user may like to ON his home security lights when it 7pm or so. The only condition here is for the user to be in an area with GSM network.

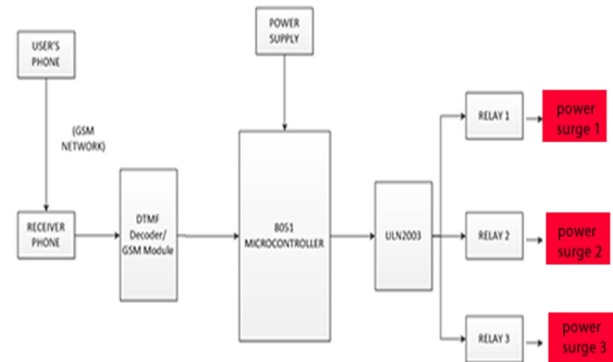


Fig. 2. Block diagram of the proposed system

#### 3.1. Hardware Development

This circuit as shown in Fig. 3 constitutes of a PIC microcontroller (PIC16F877A) that works at 4MHz, the GM-47 GSM module, LCD Module, a SIM card and 4 relays. The GM-47 module works at 3.3V and is powered by the voltage regulator LM1117T3.3 which takes in 12V as input and regulates it to 3.3V. The micro-controller PIC16F877A can work with power from 2.7V-5.5V when the frequency is under 10MHz. So we power it at 3.3V because this is the voltage level that works with the GM-47 module. The data connection between GM-47 and the microcontroller was connected to the RA3 and RA2 of the PIC16F877A through an operational amplifier. The PIN layout of the GM-47 is shown in Fig. 4 while the SIM connection to the GM-47 is shown in Fig. 5. The voltage level for this communication is 3.3V from PIC side and 2.75V from GM-47 side. Because of this voltage

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difference, a transistor is used to do the voltage level adaptation. The connection of the SIM card with the GM-47 is being made by the SIM-holder and the presence of the SIM card in the SIM-holder is done by the switch SW on SIM-holder. The LCD MODULE was connected to the PIN 21-28, PIN 15-18, VDD, and VSS. The relay module which is performing the switching was connected to the RD0 and RD1 of the PIC. The GM-47 has digital and analog inputs-outputs itself but they were not used to avoid a malfunction and the danger of destroying the GSM module.

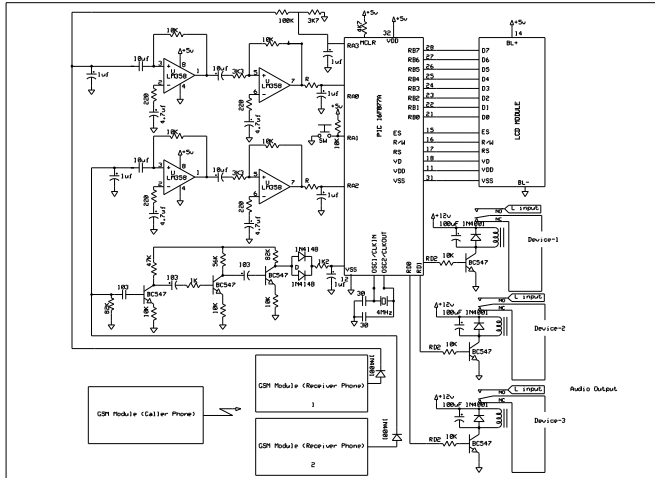


Fig. 3. Circuit diagram of the proposed system

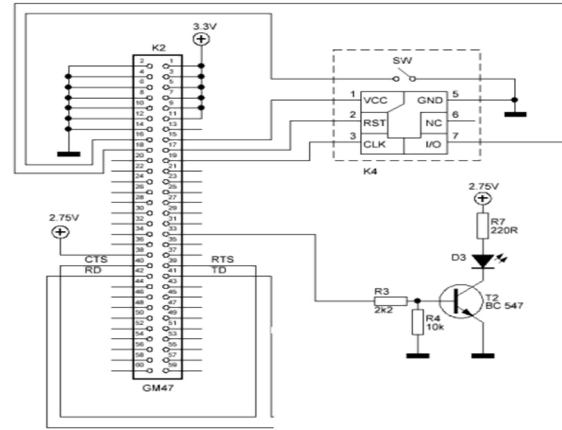


Fig. 4. Pin layout of the GM-47

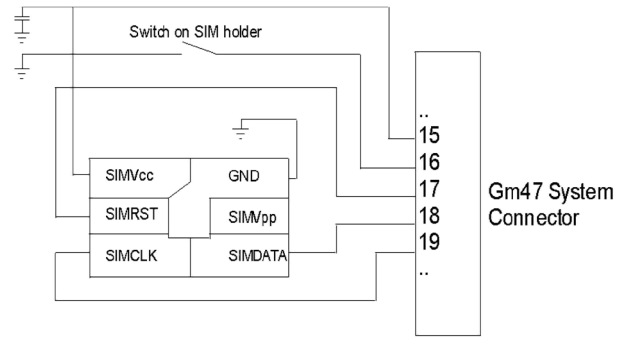


Fig. 5. SIM connection to GM-47 pins

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### 3.2 Software Development

The software was developed using Assembly Language. With the control program the microcontroller extracts the Call put through from the SIM location at a regular interval and processes it to control the different appliances connected within the interface. The algorithm for the control program is depicted in Fig. 6. Nokia F-Bus protocol was used to communicate with the mobile phone set. Most Nokia phones have F-Bus and M-Bus connections that can be used to connect a phone to a PC or in this case a microcontroller. The connection can be used for controlling just about all functions of the phone, as well as uploading new firmware. This bus allows incoming and outgoing calls.

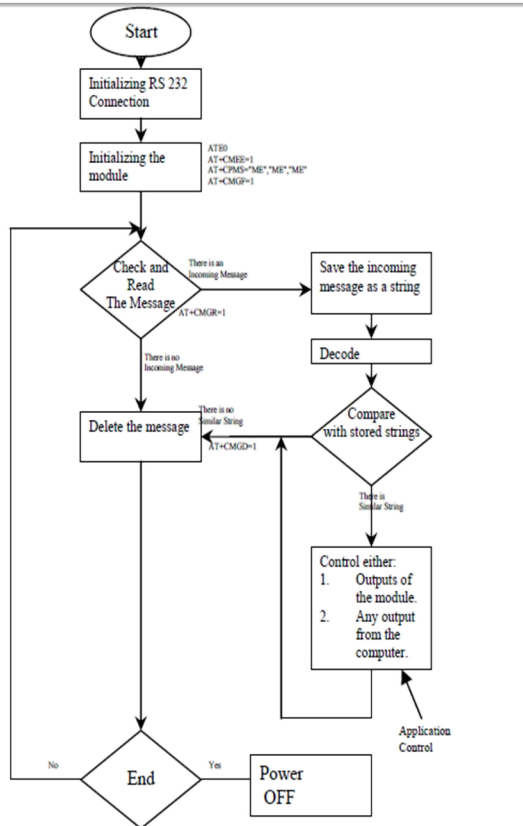


Fig. 6. Algorithm for the control program

### 4. Result and Discussion

Pre-implementation test was carried out on the components before they were soldered to the board. This is to ensure that each component is in good working condition before they are finally soldered to the board. The

components used in this design are grouped into two – Discrete components e.g. resistors, light emitting diodes, capacitors, transistors and ICs. The discrete components were tested with a multi-meter by switching the meter to the required value and range corresponding to each discrete component to check for continuity.

After implementing the circuit on the project board, the different sections of the complete system were tested to ensure that they were in good operating condition. The continuity test carried out is to ensure that the circuit or components are properly linked together. This test was carried out before power was supplied to the circuit. Finally, the system was powered and then loaded with different home appliances ranging from 25 watts to 200 watts of power to check if the circuit can carry it without any effect to the circuit. After all the test and observations, the circuit was certified ready for packaging as can be seen in Fig. 7.

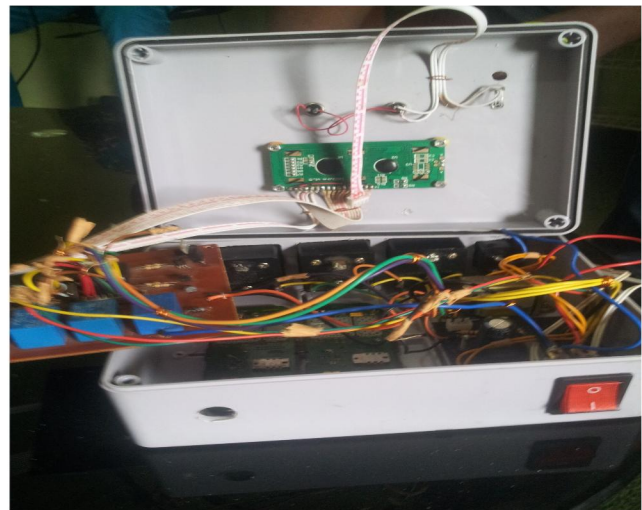


Fig. 7. Packaging of the Control device

### 5. Conclusions

This paper presented a low cost, wireless system that can be used in controlling home appliances remotely from the home and even a country as long as the user has GSM network. It is meant to be used not just for the convenience of the users but for their safety and economy since it ensures no wastage of power as well as prevent possible fire outbreaks. However, it is suggested that future research focus more on security because with this device any intruder or enemy with knowledge of the phone or SIM number of the system can unwantedly switch ON and OFF home appliances and may spoil rather than prevent or save energy at home.

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