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DEVELOPMENT OF A GSM-BASED REMOTE CONTROL SYSTEM FOR HOME ELECTRICAL APPLIANCES

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Abstract: *Electrical power is often used as a source of power to operate electrical appliances. However, inconsistent of electricity supply leads to obliviousness of the users to switch off their home appliances; thereby, resulting in energy wastage or eventual damage to appliances when power is restored. Meanwhile, developments in information technology could be used to eliminate this problem. Consequently, a GSM based remote control system has been developed to control and monitor electrical devices that required constant attention using mobile phone. This system is very handy when users forget to turn ON/OFF the electrical appliances at their home or office after they have set out. They can now control or monitor such appliances remotely by sending a text message from their mobile phone. This development ultimately saves a lot of time and effort. Likewise, daily electrical energy savings is made more efficient and effective. In constructing this system, basic components like mobile phones, SIM card, Liquid Crystal Display, relays and microcontroller were used to develop a cost-effective and adaptable system.*

Keywords: *GSM, Microcontroller, Electrical, appliance, hardware, software, relay and Switch*

INTRODUCTION

Nowadays, most people have access to mobile phone so that at any given moment, a specific person can be contacted by making voice call or sending a text message. Instant text messaging allows quick transmission of Short Message Services (SMS), and this allows individual to share relevant info. Nonetheless, the applications of mobile phone cannot be restricted to sending text message or making conversations. New innovation can still be derived which can further expand its scope of applications.

Currently, electrical power is regularly used as one of the key source of energy to power electrical appliances. However, erratic power supply leads to forgetfulness of electricity's users to switch off their home appliances when they were set out for their respective work and this always cause a lot of hazard to environ and energy wastage on power restoration. Therefore, there arises a need to develop and implement a system that will allow user to be able to control and monitor their home appliances ubiquitously and also provide security on detection of intrusion via SMS using GSM technology.

Remote management of several household electrical appliances using Global System for Mobile communications (GSM) technology is a subject of growing interest which has found its application in different areas. Tan, Lee, and Mok, 2007 developed an automatic power meter reading system using GSM network. It utilizes the network to send power usage reading to an authorized office to generate the billing cost and send back the cost to the respective consumer through SMS. This concept has been used to develop a GSM-based remote control system which acts as a platform to receive SMS sent from a user mobile phone to control and monitor electrical appliances. The system allows control from a remote area to the desired location so that the need to be physically present in order to control household electrical appliances or office equipment is eliminated.

The approach used in designing this system is implementation of a microcontroller-based control module that will receive command from a user's mobile phone over GSM network and then carry out the issued command and communicate the status of a given device back to the user's handset.

SYSTEM DESCRIPTION

System block diagram of the developed GSM-Based Remote Control System is shown in Figure 1, which is a simple illustration of how the system and the various parts involved had been implemented. The system has two main parts, namely: hardware and software.

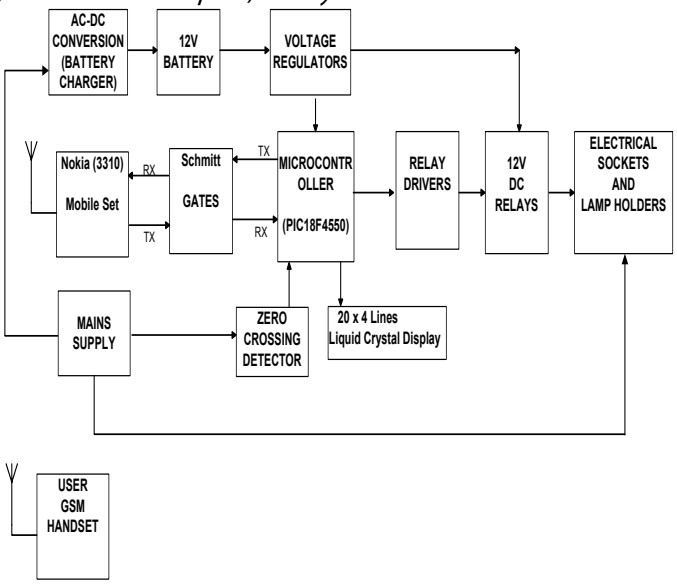

Figure 1. *System Block Diagram*

The hardware architecture consists of a stand-alone embedded system that is based on 8-bit microcontroller (PIC18F4550), GSM

handsets, driver circuit and DC relays. The GSM handsets provide the communication medium between user and system by means of SMS which consist of command to be executed. The SMS message is sent to the receiver GSM handset via the GSM cellular networks as a text message with a specific predefined format.

The principle in which the system is based is fairly simple; user GSM handset (Nokia 3310) is used as a transmitting station from which the user sends text messages that contain commands and instructions to receiver GSM handset that is integrated into the developed system. The received SMS is stored in the Subscriber's Identifying Module (SIM) memory of the phone; then, extracted by the microcontroller and processed accordingly to operate appliances via the power switching module. The brief description of individual module in the system is as follows:

A. ***User GSM Handset**: Mobile phone through which communication takes place via GSM network. The user sends command through the set to control and monitor electrical appliances in form of SMS. Making call to the system's dedicated line also allows user to make enquiries about the status of the system.*

B. ***Receiver GSM Handset**: The mobile phone (Nokia 3310) integrated into the developed system is used to receive calls and the SMS sent by the owner and then to transmit the status of electrical appliance to the user's mobile phone.*

C. ***Battery Charger**: This comprises 230V-15V step-down transformer, high-current bridge rectifier, and LM317-based voltage regulator circuit. The regulator's output is designed to have a constant value of 13.8V. This constant voltage keeps a 12V, 7 Ah sealed lead-acid battery on float charge. This is very important to provide power back-up for the system in case of power outage.*

D. ***Microcontroller**: This is an 8-bit high-performance RISC microcontroller from Microchip Technology. The microcontroller is selected since it has an enhanced USART which can be configured at baud rate of 115200 bps, large Flash Program and data memory. To read a message, the microcontroller sends the appropriate FBUS command to the Receiver GSM handset (Nokia 3310). The handset then responds with the message and the microcontroller will store the message in the RAM. The microcontroller sends another FBUS command to delete the message, in order to free mobile memory, after which the message is interpreted and the instruction from user is extracted. Based on the received instruction, the appropriate controlling signals are then sent to the relay driver and the system status is updated. Also, the microcontroller sends a command to the Nokia 3310 to query the phone if there is an incoming call. If there is an incoming call, the caller's mobile number will be extracted and the call is subsequently terminated. The mains status (mains utility availability) is then sent via an SMS to the extracted callers' mobile number.*

E. ***Relay driver**: The relay driver is controlled by the microcontroller. It allows a low- power circuit to switch a relatively high current on/off according to the command sent through the SMS. The relay driver is basically ULN2003A, which is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. It is used to drive the relay circuits which switches different appliances connected to the interface.*

F. ***Liquid Crystal Display**: The Liquid Crystal Display (LCD) is used to indicate the last message received from the user, and therefore indicate the cause of the operation performed by the microcontroller and also its inclusion makes the overall system user-friendly.*

G. ***Zero Crossing Detector**: This is basically a step-down transformer with a small bridge rectifier. The output of the rectifier is attenuated using a potential dividing network. The scaled rectified mains supply is fed to the microcontroller through an Operational Amplifier that is configured as voltage follower, to determine availability of utility supply. Thus when the users try to call the mobile number integrated into the system, the system send an SMS to indicate mains status automatically.*

The complete circuit diagram of the control system is as shown in Figure 3.

FIRMWARE OVERVIEW

The system operates as depicted in the flowchart of Figure 2.

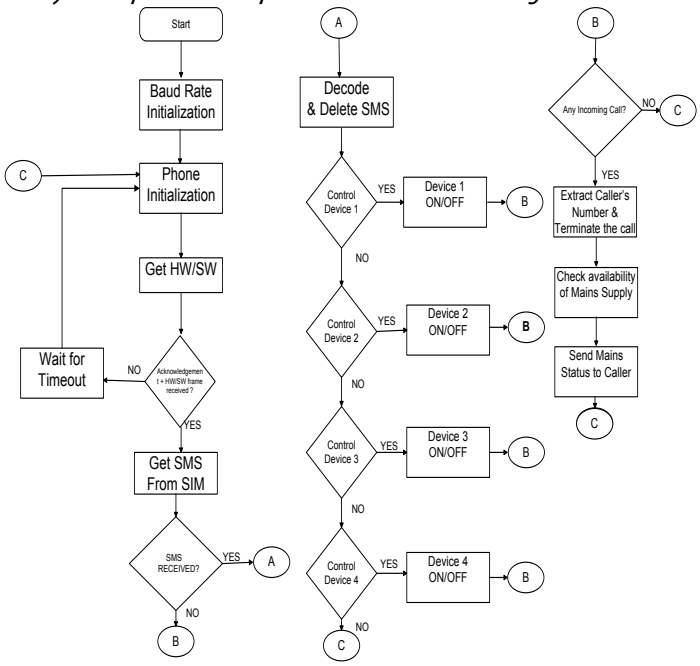

***Figure 2** – Program Flow Chart of the GSM Based Remote Control System NOKIA FBUS INTERFACE*

The firmware for this system was developed using high level language tool in C that is-MPLAB C18. The program is structured to extract the sent message from the Nokia 3310 at a regular interval

and processes it to control the specific appliances connected to the system. The Nokia 3310 has the F Bus connection that can be used to interface a phone to a microcontroller. Hence, the Nokia F-Bus protocol has been used to communicate with the mobile phone. This bus allows exchange of sent and received SMS messages between the microcontroller and the connected mobile phone.

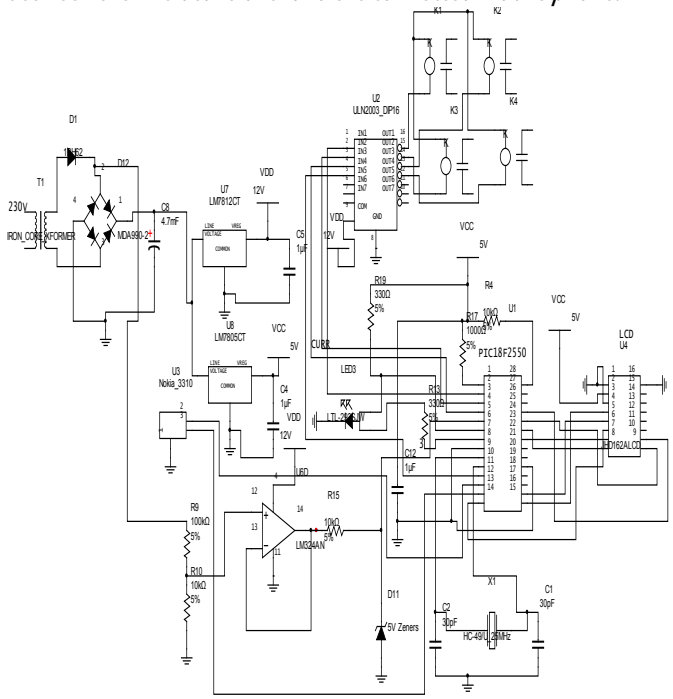

Figure 3. *Complete Circuit Diagram of a GSM-Based Home Appliances Control System*

FIRMWARE DEVELOPMENT AND CONSTRUCTION

Firmware Development

The Microchip MPLAB Integrated Development Environment (IDE) was used for the firmware development. MPLAB IDE is a Windows Operating System (OS) software program that runs on a PC and contains all the components needed to design and deploy embedded systems applications.

A development system for embedded controllers is a system of programs running on a desktop PC to help write, edit, debug and program code - the intelligence of embedded systems applications - into a microcontroller.

Procedures required for developing an embedded controller application are as follows:

i. Create the high level design. From the features and performance desired, decide which PIC Microcontroller Unit or dsPIC Digital Signal Processor device is best suited to the application, then design the associated hardware circuitry. After determining which peripherals and pins control the hardware, write the firmware that will control the hardware parts of the embedded application. A language tool such as an assembler, which is directly translatable into machine code, or a compiler that allows a more natural language for creating programs, is then used to write and edit code.

ii. Compile, assemble and link the software using the assembler and/or compiler and linker to convert code into binary number - machine code for the PIC MCUs. This machine code will eventually become the firmware (code programmed into the microcontroller).

iii. Test the code. Generally a complex program does not work exactly the way imagined, therefore "bugs" must be removed from the design to get desired results. The debugger allows one to see the program execute, related to the source code written.

iv. "Burn" the code into a microcontroller and verify that it executes correctly in the finished application.

Construction

The programmed microcontroller was tested in a breadboard with its associated sensing/control circuits. Extensive tests were performed on all the components used in each of the subsystems to ensure that they are working reliably.

Having worked satisfactorily, the microcontroller and the associated components were then transferred and soldered on veroboard following light duty soldering techniques; and the entire board was properly connected to accessories. Soldering has been firmly done to reduce loose connection and short circuit. All safety measures are taken to prevent electric hazard.

The whole arrangement was then housed in a plastic enclosure as shown in Figure 4.

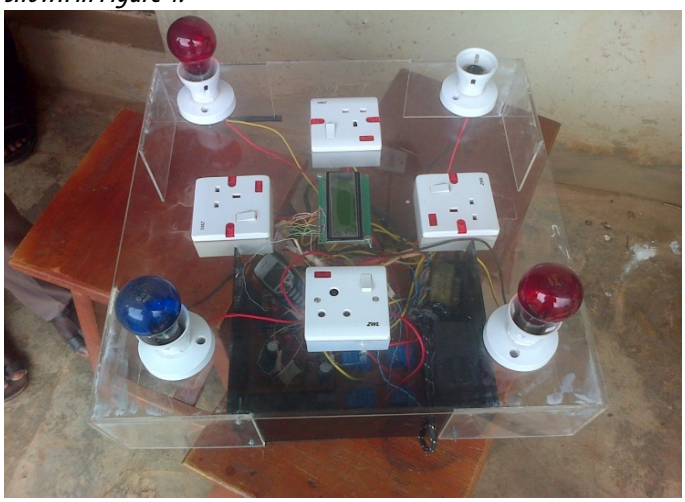

Figure 4 *. GSM-Based remote control system*

RESULT AND DISCUSSION

When the system is powered several tests were carried out to ensure proper accomplishment of the intended result. The system was designed to receive SMS text (commands) from user handset via a receiver handset connected to the microcontroller circuit. These tests were carried out by sending SMS to the receiver handset. The SMS in the receiver are retrieved by the microcontroller and processed to carry out specific task stated in the SMS instruction. The system then replies by sending an SMS to user mobile phone reporting the current status of the appliances. The incoming message is displayed on the LCD by the microcontroller upon completion of the requested task and the message is erased in the connected mobile phone.

Table 1 shows the summary of the typical commands sent by the users and the corresponding responses by the control system. When a command like "Oscotech13 Turn ON Device 1 WOR" is issued, the device(s) corresponding to the number(s) indicated in the command is turned ON. In the commands in Table 1, all messages start with Oscotech13; this is the configured password for this particular system. It is expected that the password is known to only the authorized user. The password can only be changed from the firmware. Then Turn ON or Turn OFF can be issued to respectively turn on or off a specific device. Multiple devices can be controlled by using "&". The last WR or WOR represent WITH REPLY or WITHOUT REPLY respectively. The commands are case-insensitive and spaces between words do not interfere with command interpretation.

***Table 1**: Test result*

Commands from user mobile phone	Operations carried out by the microcontroller	Status report to user mobile phone
Oscotech13 Turn On Device 1 WOR	Device 1 is turned ON	NO REPLY
Oscotech13 Turn OFF Device 1 WR	Device 1 is turned OFF	Device 1 status is OFF
Oscotech13 Turn ON Device 1&2&3 WR	Device 1, 2 and 3 are turned ON	Device 1, 2 and 3 status are ON
Oscotech13 Turn OFF Device 4&5&6 WOR	Device 2, 3 and 5 are turned OFF	Device 2, 3 and 5 status are ON
Oscotech13 Turn OFF Device 2&3&7 WR	Device 2, 3 and 7 are turned OFF	Device 2, 3 and 7 status are OFF
Oscotech13 Turn ON Device 1&4&6&7 WOR	Device 1,4, 6 and 7 are turned ON	NO REPLY
Oscotech13 Turn ON ALL WOR	Device 1,2,3,4,5 6 and 7 are turned ON	NO REPLY
Oscotech13 Turn OFF ALL WR	Device 1,2,3,4,5 6 and 7 are turned OFF	Device 1,2,3,4,5 6 and 7 status are OFF

CONCLUSION

This paper presents a low cost, user- friendly, secured, ubiquitously accessible, auto-configurable, remotely controlled solution for automation of homes. From convenience of a simple handset phone, a user is able to control and monitor nearly any electrical appliances. This allows users to control their home appliances from anywhere in the world; and to be assured that their appliances are not left running when they have left home.

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