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Full Length Research Paper

Design and simulation of an SMS driven microcontroller for home automation using proteus software

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Technology has moved from a level at which a user is always present in a place before he/she can control or do anything at the place. Imagine what television used to be before the inception of remote control. With the inception of remote control, the television can be controlled while lying on the bed or sitting down on the chair. You do not have to move towards it and press the button on it before you can control it. Now envision how it will be, being able to control your entire home appliances automatically and even remotely. Different types of technology are available to do this but this paper looks at designing and simulating the usage of an SMS from mobile phone together with microcontroller (PIC16F876) in communicating with and controlling home appliances. The firmware is written in C language and translated into a Hexadecimal file using Custom Computer Services (CCS) Compiler. The translated Hexadecimal file is loaded into the microcontroller and the microcontroller is then interfaced with the mobile phone such that when this phone receives SMS, it gives the detail of the state of the home appliances remotely. SMS can be sent to instruct the system to do some specific tasks like switching on or off of any of the appliances in the home, switching on the pumping machine to pump water and monitor it. Anytime one feels like stopping an invoked action, it can be done remotely without being in the vicinity of the equipment.

Key words: Home automation, short message service, custom computer services compiler, simulation, microcontroller, general packet radio system networks, proteus software, firmware.

INTRODUCTION

The design and implementation of an embedded system using an SMS-driven microcontroller for home automation involves strong interrelationship of both hardware and software to produce what will perform simple, specific and repeatable tasks; often with little or no input from the user. Most experiments/tasks performed today normally require the physical presence of the operator in order to monitor and run the task. Imagine what it will be like to be able to perform other activities elsewhere while still carrying out and monitoring an important task where one is.

This work designs and simulates a system using Proteus software that will act as mobile interface between a machine and the user or operator such that simple, specific and repeatable task could be performed by users without being on the same location with the machine.

REVIEW OF PREVIOUS WORKS

Embedded computer

Barr (2001) says an embedded computer is frequently a computer that is implemented for a particular purpose. In contrast, an average personal computer (PC) usually serves a number of purposes: Checking email, surfing the internet, listening to music, word processing, programming different applications, etc. However,

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embedded systems usually only have a single task, or a very small number of related tasks that they are programmed to perform.

Real time operating system

From an implementation viewpoint, there is a major difference between a computer and an embedded system. Embedded systems are often required to provide real-time response. A real-time system is defined as a system whose correctness depends on the timeliness of its response. Barr (2001) gave examples of such systems: flight control systems of an aircraft, sensor systems in nuclear reactors and power plants. For these systems, delay in response is a fatal error. A more relaxed version of real-time systems is the one where timely response with small delay is acceptable. Example of such a system would be the Scheduling Display System on the railway platforms.

Programming embedded system using C programming language

Henbury (2001) emphasizes the fact that C programming language remains a very popular language for micro-controller developers due to the code efficiency and reduced overhead and development time. C offers low-level control and is considered more readable than assembly language.

Interfacing

The system is the combination of both hardware and software. And these two parts of the system have to be interfaced. Aula (2012) states that the hardware is an electronic circuit that matches with PC's port protocol signal, and the software is the programming of the PC to manage all input/output signals from its ports.

IEEE Live Project (2012) also presents the controlling of appliances through SMS. The usage of microcontroller was highlighted as a powerful element that provides a highly flexible and cost-effective solution to many embedded control applications. Sami (1998) recommends the use of both the internet and mobile communication devices in controlling home appliances.

METHODOLOGY

The design flow of the embedded system reported here begins with design/requirements specification, followed by hardware design. This is followed by the software (firmware) design in order to optimize design result and still satisfy the requirements. Hardware and software integration is done after hardware/software detail design. Finally, system testing is carried out.

Hardware used

The following, are the components and devices used in the circuit design and their functions:

- Transformer (TRAN-2P2S); it is a magnetic (inductive) device, it receives AC from power supply.
- Rectifier (2W005G); It converts AC to DC.
- Capacitor; Stores and releases electrical charge. It filters unwanted signals.
- Transistors; act like switches. It is used in general-purpose switching and amplification. The arrow in the NPN transistor symbol is on the emitter leg and points in the direction of the conventional current flow when the device is in forward active mode.
- Resistors; pass current in proportion to voltage.
- Diodes; conducts electricity easily in one direction.
- Crystal; a ceramics crystal used to generate precise frequencies. It filters high frequencies e.t.c.

Software used

The program used in controlling the system is written using C programming language. After the program has been written in C, it was compiled on Custom Computer Services (CCS) compiler in order to generate the microcontroller compatible HEX files. Figure 1 shows a portion of the HEX file generated by the CCS compiler; the compiler that provides a complete integrated tool suite for developing and debugging embedded applications running on Microchip PIC.

Theory of operation

The hardware was designed on the Proteus software. The Proteus is a simulation package tool that permits real time debugging of codes and circuit on the system. This Proteus VSM tool even permits the real interface of the mobile station / modem with the computer system, permitting all necessary tests to be performed. The circuit was drawn on the Proteus and the HEX file generated from the code compilation on CCS compiler (Figure 1), is written into the microcontroller in the circuit (Figure 2). This microcontroller is embedded in the circuit designed on the Proteus simulation package.

The mobile station (phone) is interfaced with the computer via Bluetooth in order to communicate with the microcontroller embedded in the circuit and the port number on the UART port is changed to the COM port number on the phone. The message (instruction command) is sent from the remote phone to the phone, interfaced with the computer system and the running button on the simulation package is pressed to start the simulation. The microcontroller fetches the SMS from phone, decodes it, recognizes the phone number and switches on the relays that are responsible for controlling the appliances. The microcontroller also sends back the report to the remote phone through an SMS.

RESULTS AND DISCUSSION

Figure 2 shows the circuit before the simulation is carried out. The pumping machine is not working, it is in its OFF state. The temperature sensor is also not working as well as the LEDs that indicate whether the devices (home appliances) are in ON or OFF state. In order to test the functionality of this system, there are two mobile stations

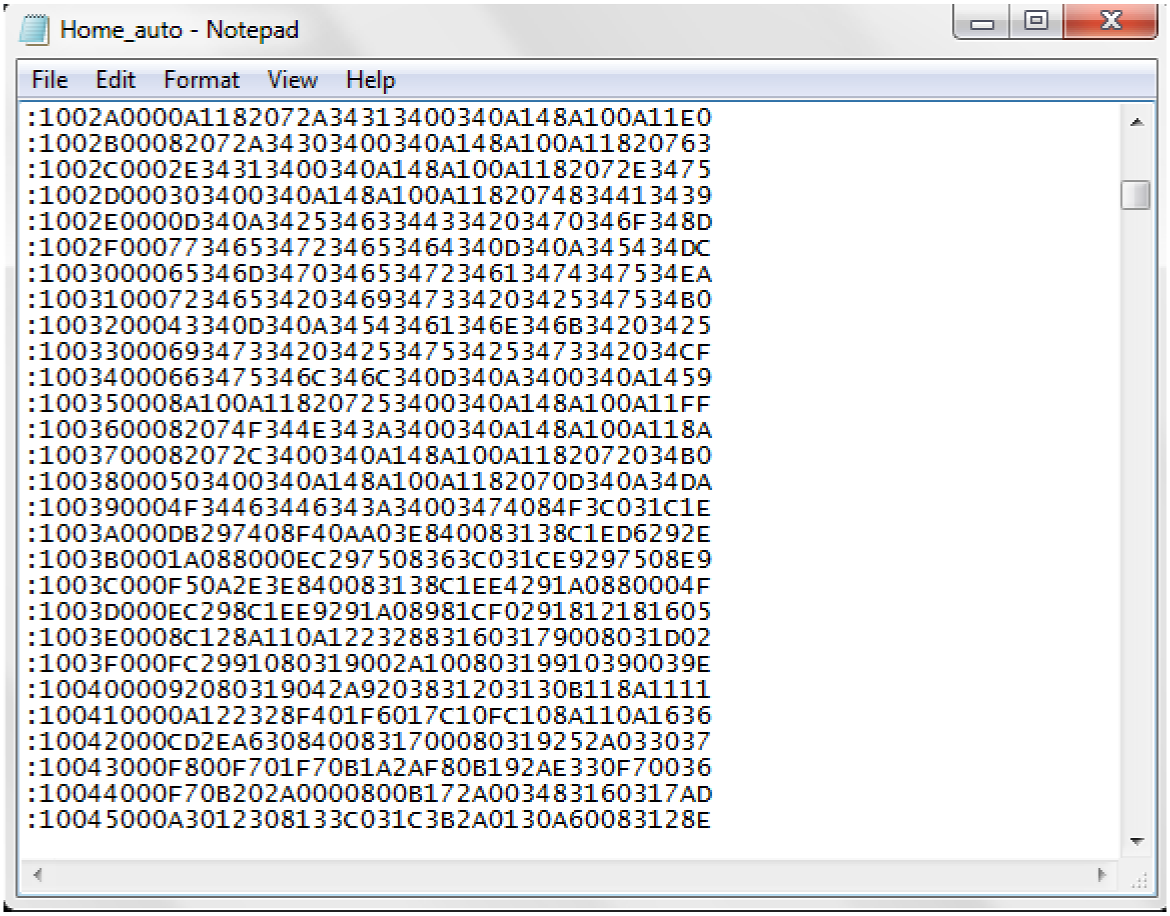

Figure 1. A portion of the HEX file generated by the CCS compiler.

(phones): the remote one, that sends command and the one that is interfaced with the system, that recieves the command. After the connection between the mobile station and the computer system has been established, the simulation button is triggered on and the simulation starts. Then the mobile station from a remote area is used to send the instructions(commands) to the mobile station connected with the system. The command is either to turn ON or OFF the home appliances. If it is to turn ON the home appliances, the command is like this:

HA
D.1*1.2*1.3*1.4*1
P.1
R.1#.

The command could also be to turn OFF those appliances and if it is to turn them OFF, the command goes thus:

HA
D.1*0.2*0.3*0.4*0
P.1
R.1#.

There are two virtual terminals that appear on the surface of the Proteus showing the way the two mobile stations and the microcontroller on the circuit are communicating. One of these virtual terminals is for the microcontroller in the circuit and the other virtual terminal is for the mobile station that is interfaced with the system. These two virtual terminals show how the instruction received by the phone interfaced with the system from the remote phone is read and carried out by the microcontroller in the circuit. The two of them communicated well and they both carried out the instructions given to them. The terminals are shown in Figures 3a and b and each of the command generated is discussed one after the other:

- The “at” shown on the microcontroller virtual terminal is attention command to call the attention of the mobile phone interfaced with the system (something like handshake).
- The “at+cmgf =0” command is talking about how to read the command sent whether it will be read on text mode or protocol data unit mode (PDU). In PDU mode, all SMS

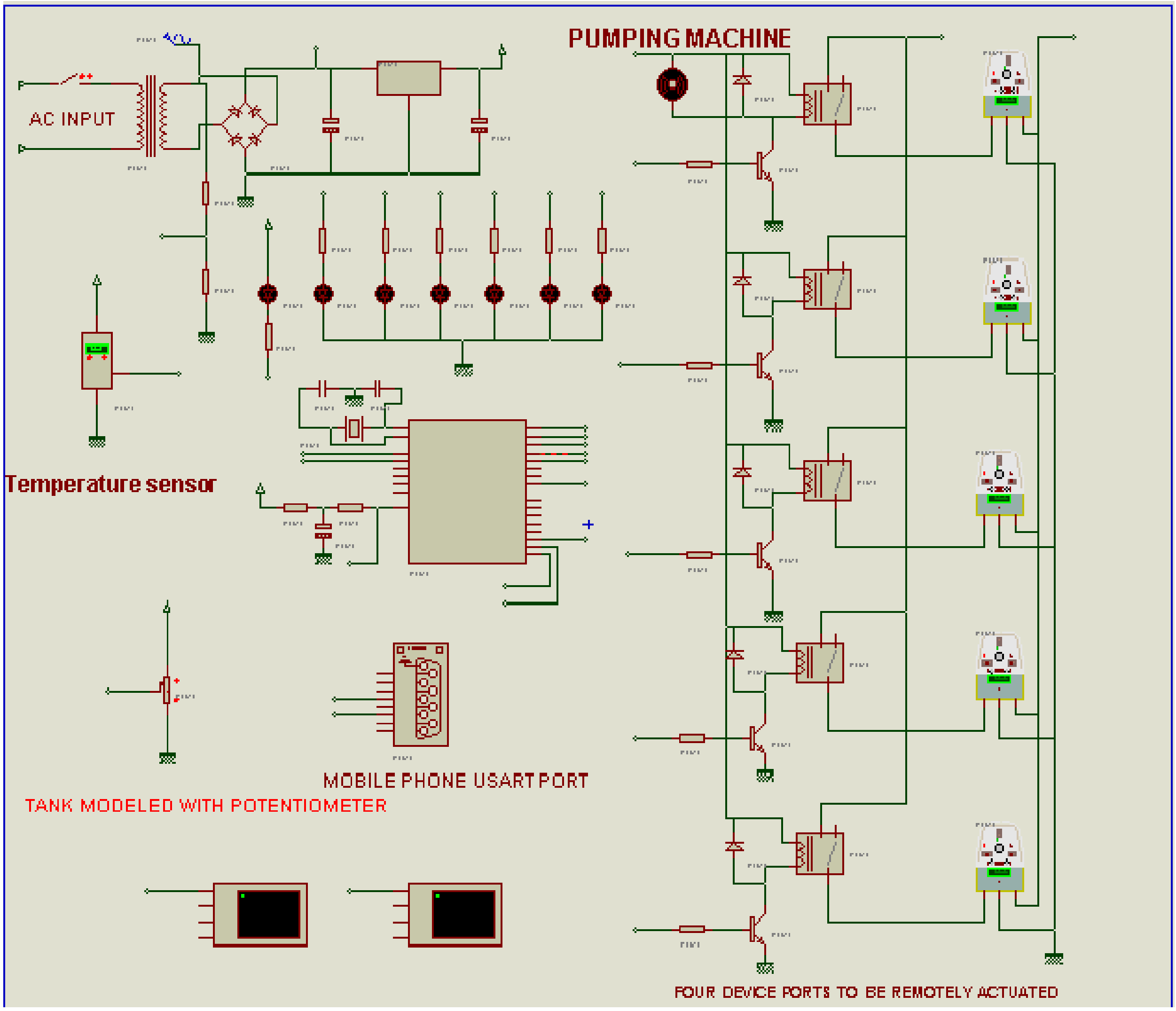

Figure 2. Diagram of the circuit on Proteus software before the simulation is carried out.

messages are represented as binary strings encoded in hexadecimal character; like, while in text mode, SMS messages are represented as readable text. If the data is to be read on text mode, the command will be "at+cmgf =1" and if it is in PDU mode, the command is "at+cmgf =0". The phone connected to the system can only read the message in PDU mode, that is why the microcontroller gave the aforementioned command; that is, " at+cmgf =0".

- The "at+ cmps =ME,ME,ME" tells the controller to read either from phone memory or SIM memory. The first ME means saving, the second one means reading and the third one means deleting.
- The "at+ cmgr =1" means the controller is reading the SMS (short message service) sent remotely to the mobile station connected to it from memory location 1 of the phone.
- The "at+ cmgr =2" means the controller is reading the SMS sent remotely to the mobile station connected to it from memory location 2 of the phone.
- The "at+ cmgs = "08057418758"" command on the controller virtual terminal is telling the mobile station connected to it that it should send the message shown subsequently to the remote mobile station in order to tell the state of the appliances at home.

"HA
AC Powered
Temperature is 53°C
Tank is 70% full
ON: P.1.2.3.4
OFF: "

- The HA means Home Automation.

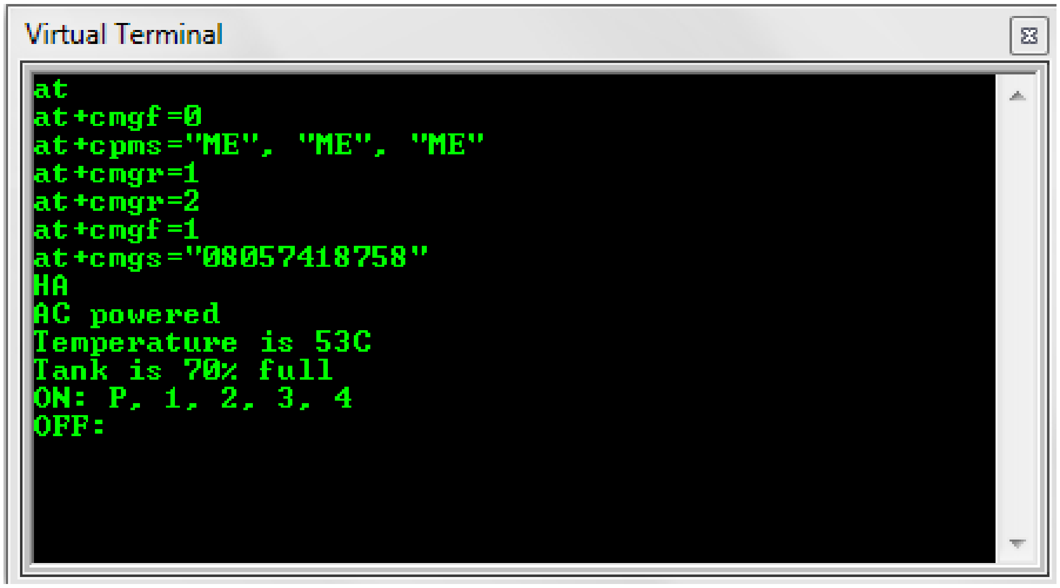

Figure 3a. Virtual terminal for microcontroller.

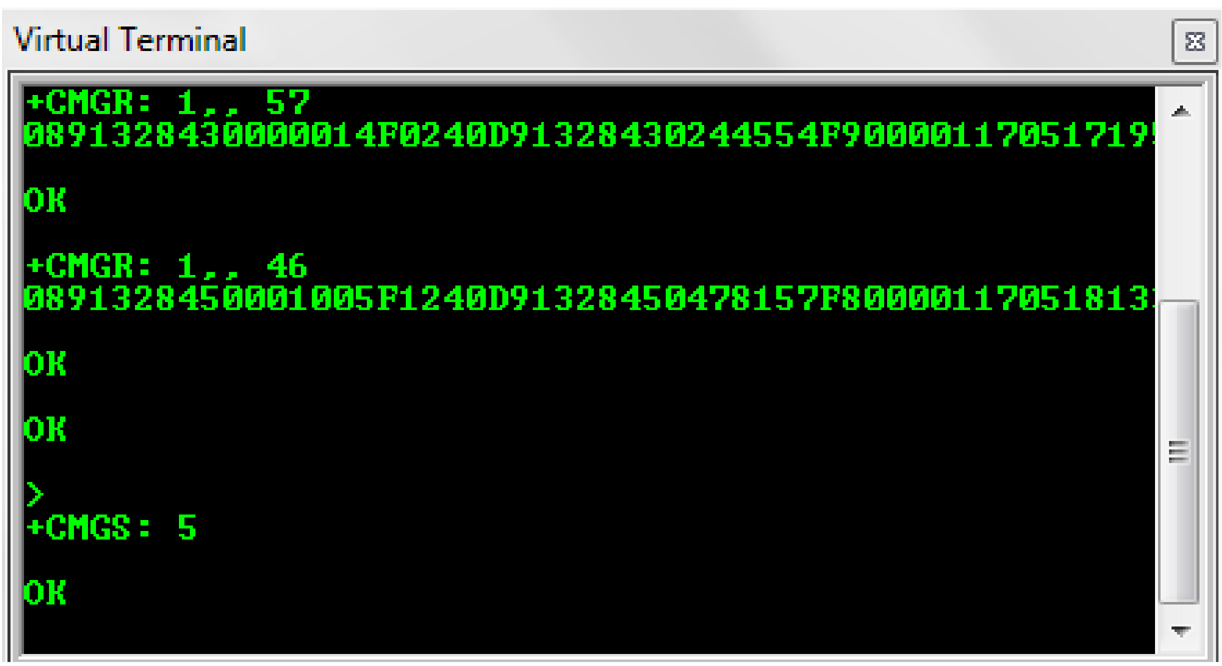

Figure 3b. Virtual terminal for mobile station connected to the system.

- AC Powered means the system is using AC power supply.
- Temperature is 53°C means the house temperature is 53°C. If the temperature is too high for you and you are about coming home from work, you can send an SMS to the machine to turn on the AC at home before you get home.
- Tank is 70% full means the level of water in the tank is 70%, so the pumping machine has to be turned on in order to pump water into the water tank; but if the water level is about 95%, the controller will turn off the pumping machine immediately because the water level has reached its maximum level.
- ON: P.1.2.3.4 means the pumping machine is on, the devices connected to the sockets 1, 2, 3 and 4 are also on.

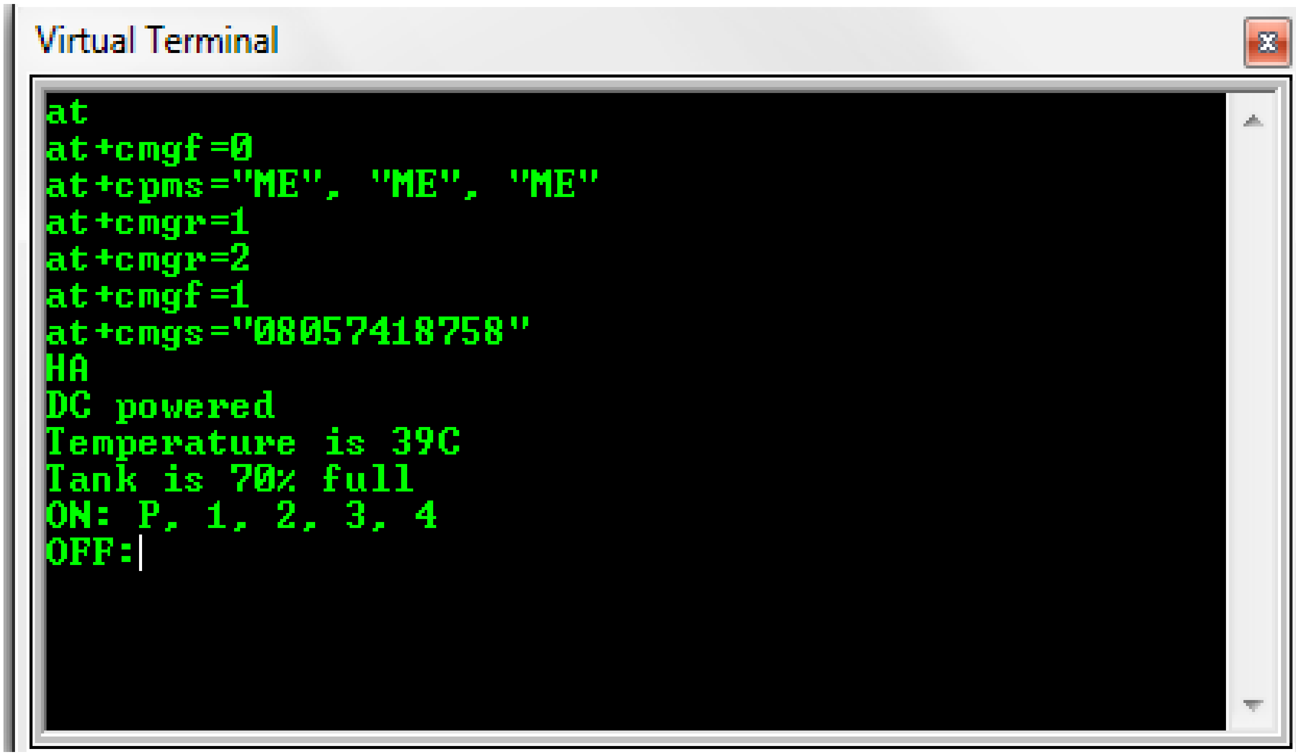

Figure 4. Microcontroller virtual terminal showing that the system is being powered by DC power supply.

- OFF: means no device is turned off.

The following are the commands shown on the mobile station virtual terminal:

"OK
+CMGR: 1, , 57
089132843000001………….
OK
+CMGR: 1, , 46
089132843000001………….
OK
+CMGS: 5"

- The OK is responding to the controller that it has been connected.
- +CMGR: 1, , 57 means the SMS was read from the memory location 1 of the remote mobile station and the phone still have about 57 capacity to hold SMS.
- 089132843000001………….: this is telling us the first number that remotely sent the command.
- +CMGR: 1, , 46 means the SMS was read from the memory location 1 of the second remote mobile station and the phone still has about 46 memory capacity to hold SMS.
- +CMGR: 5" is telling the phone to send the reply (message on its memory location 5) to the remote mobile station.

The power supply can be from DC supply also because of the battery connected in parallel to the rectifier, as shown in Figure 4. This battery is being charged when the AC supply is powering the system and automatically switches over to the DC supply when there is power outage. Even though the DC supply cannot trigger the appliances to work but the SMS sent will be stored in the memory of the controller so that when the AC supply comes up, the system continues from where it stopped.
The command sent remotely through the mobile station to turn on some of the home appliances actually turns them on and the snap shot of it is shown in Figure 5. The pumping machine and the LEDs indicating the aplliances were turned ON after the command has been sent to the mobile station, these are the blue colour shown on pumping machine and red colours shown on the LEDs. The MS sent the read SMS to the microcontroller and the microcontroller carried out the instruction accordingly by turning ON the appliances. The appliances can be turned OFF as well by sending the instruction to do that. The green light on one of the LEDs shows the phone is connected to the controller.

DISCUSSION

The operation of the system is confirmed (tested) by sending an SMS from the sending MS (Mobile Station) to

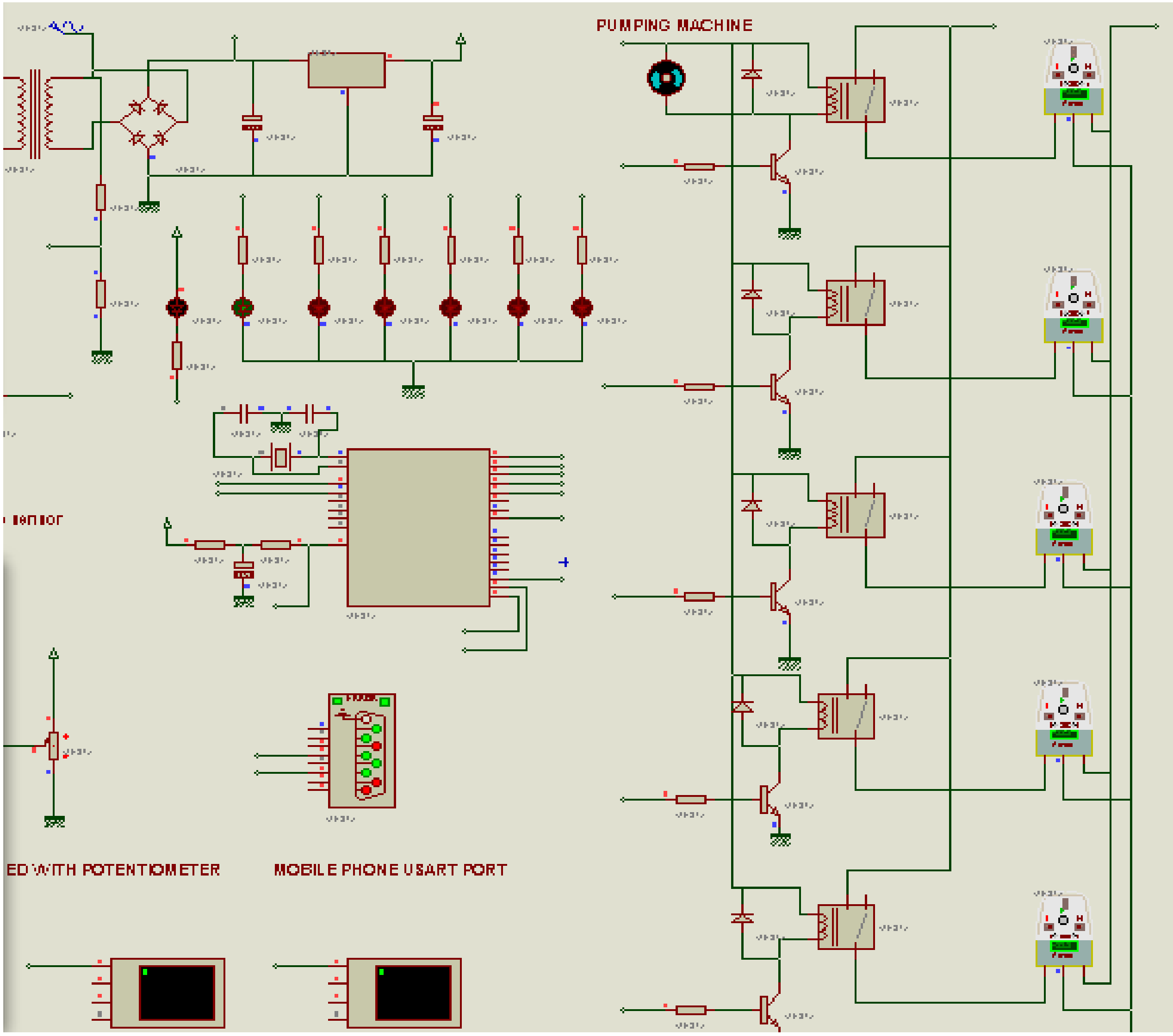

Figure 5. Diagram showing how the command sent remotely turned on the appliances.

trigger and to stop the operation of the appliance. The use of mobile communication system has the advantage of controlling the appliances remotely and it also makes life easy for the user. For example, the user can get alerts anywhere through the GSM technology thus making the system location independent.

Also, an SMS driven microcontroller for home automation is cost effective because you do not have to spend so much before you can control your appliances remotely. Once you have enough credit on your mobile system that can allow you to send the instructions to the mobile phone, connected to the system and the phone interfaced with the system also has credit that can allow it to send you back the reply.

A lot of people have used similar methodology to control appliances, but this work does not only control the appliances, it also monitors the appliances. For example, the system monitors the level of water in the tank in order to know when to turn ON or OFF the pumping machine and monitors the home temperature, so that it will know when to switch on an Air Conditioner or not.

Conclusion

In this work, the possibility of minimizing the stress of wanting to be physically present at home while one is at work or elsewhere before being able to control and monitor what is going on in the home is looked into. A system is designed that allows one to send message remotely and get the instructions carried out. In achieving this goal, some design steps were followed and the implementation of the system was carried out. The system was validated through testing and found to be working perfectly well.

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