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Design and Implementation of a GSM based Electronic Appliances Monitoring and Controlling System

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Abstract: This paper presents a GSM based electronic appliances monitoring and controlling system. This enables individuals to connect their home or office electronic appliances to the developed system which in turn enables them to remotely monitor and control these appliances through a Short Message Service (SMS). In remotely controlling the connected electronic appliances, users can determine the status of the electronic appliances remotely and decide whether to either switch any of the connected electronic appliances on or off. The uniqueness of the approach introduced is further revealed in the way the GSM module of the developed system was integrated with the PIC16F877A microcontroller to give a single and more compact system. Also, the SMS format used in monitoring and controlling the connected electronic appliances allows users to control their electronic appliances from anywhere provided there is a GSM network; hence, distance was not a barrier. The SMS format used is not lengthy and is simple to understand which makes it attractive to its users. The performance of the developed system was evaluated by connecting twelve (12) electronic appliances with it and the developed system shows the capability to remotely monitor and control them.

Keywords: Electronic Appliances Control, Remote Home Automation, Mobile Phone, Micro- Controller, Short Message Service (SMS), PIC16F877A, Global System for Mobile Communication (GSM).

1. INTRODUCTION

Now-a-days homes and offices are equipped with various electronic machines and equipment. Most are always controlled manually using either hand held remote control device or manually switching them ON or OFF. However, this may not be possible all the time as the operator may not be at home. In some instance, it is possible to have forgotten to either switch the appliances OFF or ON and this means the operator needs to travel down to where the appliances are in order to control them. Hence, there is a growing desire to have a device or mechanism which allows users to remotely monitor and control these electronic appliances without distance being a barrier. This work presents an innovative way to solving the problem discussed above by designing and implementing a GSM based electronic appliances control and monitoring system which uses the concept of SMS made available by hand held mobile devices. The uniqueness of this approach is that the GSM module is incorporated into the switching unit which gives a single compact unit.

2. RELATED WORKS

Many researchers have worked in the field of home appliances automation with many contributing in a useful way. Some of their contributions are discussed in this section. [6] Presented a system for smart-home control of appliances based on timer and speech interaction.

The paper presented two major approaches to control home appliances, the first involves controlling home appliances using timer option whereby the expected time within which the electronic appliances will work would have been set. The second approach is to control home appliances using voice command. [8] designed and implemented an infrared (IR) remote control signal decoder which can be used for various home control applications. The approach introduced improved on the distance within which the electronic appliances can be controlled. A Telephone Based Wireless Remote Controller for Home Appliances was designed by [9].

The system developed used a telephone as the remote controller; the telephone generates a Dual Tone Multi frequency (DTMF) signal corresponding to each dialed digit which is converted to a BCD code by the Telephone interface circuit. This is given as input to the transmitter module which is then used to control various home appliances through a receiver module. Data processing stages of the transmitter and receiver modules was implemented using digital components, thereby avoiding possible use of conventional devices like monostable multivibrators. [4] developed a GSM based household power management system which allows users to control connected electronic appliances remotely. In their work, a Nokia6100 phone was interfaced with a microcontroller

and an SMS received by the Nokia phone will be interpreted by the microcontroller which in turns carried out the specified instruction contained in the SMS sent by the users.[3] developed a Cell Phone based Remote Control System for Controlling Home and Office Appliances, the end user has to connect his/her cellphone to the system via headset. To activate the cellular phone unit on the system a call is to be made and as the call is answered, in response the user would enter a two/three digit password to access the system to control devices. As the caller press the specific password, it results in turning ON or OFF specific device. [1] studied various remote-controlled home automation systems with different network technologies and submitted that the best home automation systems must be flexible and must be controllable from any distance and they submitted that an IP based remote control system is preferable. [2] designed and implemented a smart house control system using LABVIEW, the smart house has two interfaces, computer interfacing, and remote control unit interfacing. Computer device that provided with LabVIEW software is the main controller unit for all systems in the house. It receives data from house sensors, process information and updates data for the difference systems, and transmit controlling signal to house systems and switching output devices.[7] developed an ATMEL AT89S52 microcontroller Based Home Automation System With Security, the developed system includes features like Password Based Locking System, Counter dependent automatic switching system, Temperature controlled cooling system, Light saving system and Fire and Smoke sensor. This paper introduces a GSM based electronic appliances monitoring and controlling system which uses SMS.

SMS based system because of the following facts:

(i)SMS is supported by 100% GSM mobile phones and at least 60% of people in developing countries can afford the cheapest mobile phone which can be used to send SMS and this makes SMS the most accessible medium of communication.

(ii)Almost all subscription plans provided by wireless carriers include inexpensive

SMS messaging service which makes SMS more affordable by all mobile phone users.

(iii)SMS are easier to send from any one phone to the other infact SMS can be sent to an offline mobile phone which will be received immediately the mobile phone is ON.

III. SYSTEM ARCHITECTURE OF THE DEVELOPED SYSTEM

Figure 1 shows the architecture of the developed system. The system consists of two main units: a control and a switching unit.

A) The control unit

This is made up of a mobile phone from which a SMS Is sent. The SMS will be in a specific format and the content of the SMS will be interpreted by the microcontroller embedded into the interface unit.

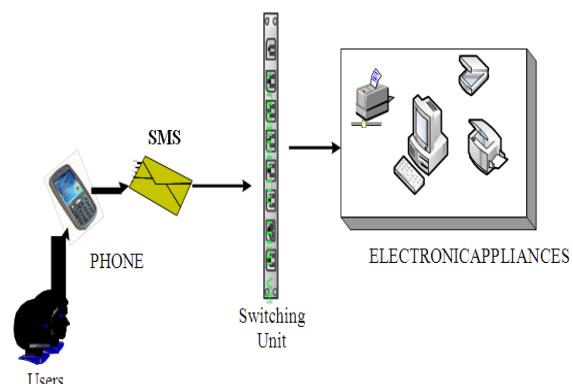


Figure1: Architecture of the Developed System

For example, sending,, STATUS "to the interface will send back a SMS indicating the status of the connected devices whether they are ON or OFF. An SMS containing,, 6666ONSW1ONSW2OFFSW3" sent to the interface when interpreted by the embedded microcontroller will make the appliances connected to switch one and two to be switched ON while those connected to the third switch will be switched OFF.

B) The switching unit

This is made up of an embedded microcontroller with a SIM slot that hosts a SIM card of any network and a relay switch board.

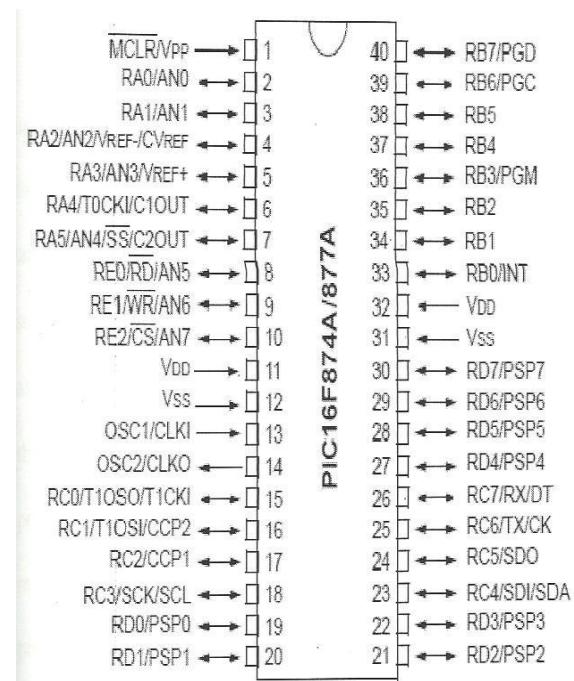


Figure 2: Pin Configuration of PIC16F877A microcontroller

i)The microcontroller used is PIC16F877A; the PIC16F877A microcontroller is a 40-pin dual in-line package (DIP) with internal peripherals. The 40 pins make it easier to use the peripherals as the functions are spread out over the pins. It has a central processing unit (CPU) that is simple and contains a limited instruction set. It has only one accumulator and a hardware stack where return

addresses are stored. The PIC16F877A microcontroller used also has a Data memory space which is the processor read-write memory. The data memory is often referred to as the register and is a non-volatile and thus can retain its content even when power is turned off. The pin configuration of the PIC16F877A microcontroller used is shown in figure2.

ii) The relay switch board

The switching on and off of the various electrical appliances connected to the switching unit will be done through a relay switch board as shown in Figure3. The microcontroller controls the state of the devices at any point in time while the relay switch board does the final switching on and off of the devices based on the signal received from the microcontroller. Relays, Resistors, Diodes and Transistors (BC547)make up the relay switch board.

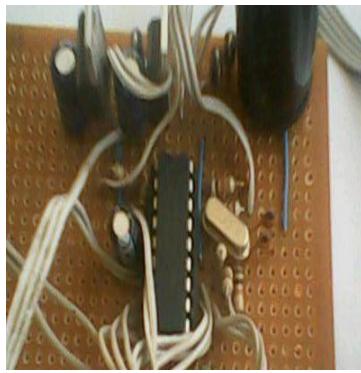


Figure 3: The Relay Switch Board

□ Relay

According to [5], a relay is simply an electrically powered switch. Relays enable one circuit to switch a second circuit which is usually separated from the first. For example a low voltage battery circuit can use a relay to switch a 230VAC mains circuits. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical (which explains why the relay is described as an electromechanical device). In the choice of the relay, the coil resistances were taken into consideration, this is important because the circuit must be able to supply the current required by the relay coil. From Ohm's law, the current through the coil is given by

$$\text{Relay coil current} = \frac{\text{supply voltage}}{\text{coil resistance}}$$

A 12V supply was used to power the relay. Assuming a coil resistance of 400 ohms, the current needed would be

$$\text{Current} = \frac{12\text{v}}{400\Omega} = 30\text{mA}$$

□ Resistors

Resistors are passive electronic components that limit the flow of current through an electrical device. This current limiting ability is very important because most electrical devices may get burn if their maximum current rating is exceeded. The resistors needed to control the amount of current through these devices. Resistors would be used to protect the transistors and the LEDs in the relay switch board.

□ Diodes

Diodes are one way devices offering low resistance when forward biased and behaving almost as an insulator when reverse biased. Electrons can go through the diode in one direction but not in the other. Since relay coils have a large amount of inductance, they generate a very large voltage spike when released which can destroy the transistor, the microcontroller and other electronic elements. Hence, to prevent these damages a protection diode which is reversed biased was connected across the relay coil.

□ Power Supply Unit

For this particular design, the power supply that employs the use of the voltage regulator IC 78L05 was used since the PIC16F877 A microcontroller requires a 5-volt DC supply. Hence, A regulated dc voltage is obtained from the mains 220 VAC as shown in Figure 4. A step down transformer is used to step down the 220V AC to 12V AC. The 12VAC is rectified to obtain a dc voltage required to power the digital circuitry and the transistor switching stage which requires 12V DC. Also, a voltage regulator (78L05) is used to regulate the rectified, filtered Using a 240 V transformer on a 50Hz supply and transformer secondary r.m.s voltage output is 12V.

$$\text{Peak Voltage, } V_p = V_{rms} \times \sqrt{2}$$

$$V_p = \sqrt{2} = 16.97\text{v}$$

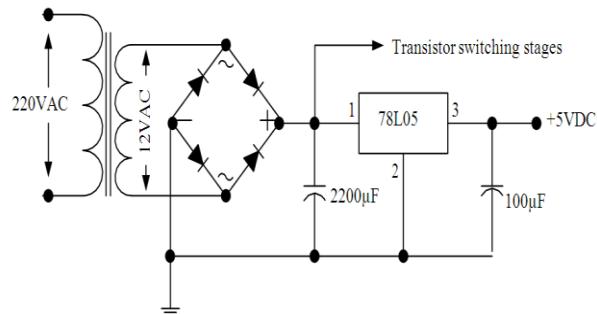


Figure 4: Circuit diagram for rectifying the power supply

$$\text{Simply frequency, } f = \frac{1}{\text{Period (T)}} = 50\text{Hz}$$

$$\text{Period, } T = \frac{1}{f} = \frac{1}{50} = 0.02\text{s} = 20\text{ms}$$

The total voltage drop, V_d , for the two diodes involved in the rectification process in either of positive or negative cycles,

$$V_d = 2V_{BE} \quad [V_{BE} = 0.7\text{v} \text{ for a silicon diode}]$$

$$V_d = 2 \times 0.7\text{v} = 1.4\text{ v}$$

Actual peak voltage value,

$$\begin{aligned} V_{Lm} &= (V_m - 2V_{BE}) \text{ v} \\ V_{Lm} &= (16.97 - 1.4) \text{ v} \\ V_{Lm} &= 15.57 \text{ v} \end{aligned}$$

Change in peak voltage value over the discharge period, δV

$$= V_{Lm} - V_{dc}$$

$$V_{dc} = 10 \text{ v}$$

The filter capacitor should not discharged own to 6V in accordance with the input voltage specification of the voltage regulator.

$$\delta V = (15.57 - 10.0) = 5.57 \text{ V}$$

Change in time over the discharge period, $\delta t = 10\text{ms}$ Total current consumption for this design is not expected to exceed 600mA Hence the value of the filter capacitor is obtained thus:

$$C = \frac{600 \text{ mA} \times 10 \text{ ms}}{5.57V} = 1077.20 \mu\text{F}$$

To provide a safety margin, the capacitor value chosen is twice the calculated value which implies a value of $2154.4\mu\text{F}$. The nearest available capacitor value of $2,200\mu\text{F}$ is used as the filter capacitor.

□ LED

Light Emitting Diodes (LED) which gives off visible light when it is energized through the process of electroluminescence issued to determine the state of the relay switch. When the relay switch is active a green light blinks at intervals of five seconds and when the switching unit is active the LED emits a red light.

IV. HARDWARE DESIGN OF THE SYSTEM

In this section, we present the details about how the construction of the interface box was achieved which includes the soldering and coupling together of the components on the Vero- boards and how the whole system was cased .The circuit diagram of the system is shown in Figure5.

A) SOLDERING

The various circuits and components in this project were soldered in tandem to meet desired workability of the project. The power supply stage was first soldered before the microcontroller, LED display and transistor switching stages were done. The soldering of the project was carried out on a Vero boards. The Vero board contains the power supply unit, the microcontroller, the transistors, the switching unit and the LED.

B) CASING AND BOXING.

After soldering all the components on the vero board, the components was packed into a case as shown in Figure6. The casing material used was a plastic material specially designed to have perforations for proper ventilation.



Figure 6: The complete components coupled in a plastic casing

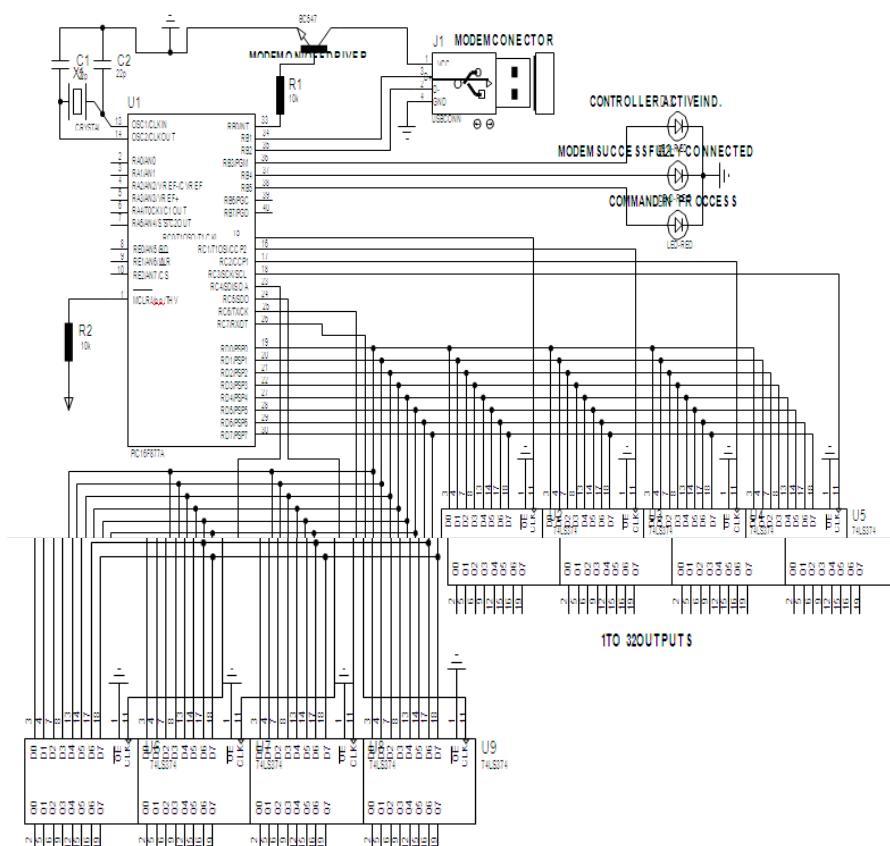


Figure5: Circuit Diagram of the Whole System

V. SYSTEM TESTING

Stage by stage testing was done according at different implementation stages of the projects using several testing equipment as discussed below:

A) Bench Power Supply: This was used to supply voltage to the various stages of the circuit during the bread board test before the power supply in the project was soldered. Also during the soldering of the project the power supply was still used to test various stages before they were finally soldered.

B) Oscilloscope: The oscilloscope was used to observe the ripples in the power supply waveform and to ensure that all wave forms were correct and their frequencies accurate. The waveform of the oscillation of the crystal oscillator used was monitor to ensure proper oscillation at 4MHz.

C. Digital Multi-meter: The digital multi-meter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor. The process of implementation of the design on the board required the measurement of parameters like, voltage, continuity, current and resistance values of the components and in some cases frequency measurement. The digital multimeter was used to check the output of the voltage regulators used int his project.

VI. CONCLUSION AND FUTURE WORKS

The GSM unit integrated with the microcontroller to give a single compact unit makes the project an adorable one and the idea of controlling one "home appliances just by sending an SMS was an attractive innovation to users who reviewed the developed system. The cost of sending the SMS is relatively cheap depending on the charges of the preferred mobile network. Further research work can be tailored towards developing similar system that can remotely control complex electronic systems with high voltage equirements .Also, research efforts can also be geared towards developing similar systems that can be controlled remotely using voice prompts through calls instead of SMS.

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