Design and Implementation of a Short Message Service Based Remote Controller

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Abstract

Safeguarding our home appliances has become an issue when dealing with an advancement and growth of an economy. This research focuses on the controlling of home appliances remotely when the user is away from the house. The system is Short Message Service (SMS) based and uses wireless technology to revolutionize the standards of living. It provides ideal solution to certain problems faced by home owners in daily life. Due to its wireless nature, it is more adaptable and cost-effective. The research is divided into two sections; the hardware and the software sections. The hardware section consists of the Global System for Mobile Communications (GSM) modem module, The Control module, the Appliance module, the Liquid Crystal Display (LCD) module and the power supply module. The GSM modem receives the message sent by the person who wishes to operate any of the connected appliances, it then forwards it to the microcontroller, and the microcontroller decodes the message, switches on or switches off the appropriate appliance, updates the LCD and sends a feedback to the mobile phone via the GSM modem. Overall, the work employs The ATmega16 microcontroller, relays, a programmer to program the microcontroller, a mobile phones and a GSM modem. The AT commands is used to handle communication between the modem and the ATmega16 microcontroller. Flow code is used for the programming of the microcontroller. The overall work was implemented with a constructed work, tested working and perfectly functional.
Keywords: Short Message Service, Global System for Mobile Communications, Remote Control, Electronic Circuit Design

1. Introduction

Safeguarding our home appliances has become an issue when dealing with an advancement and growth of an economy. Remote generally means far away in space or time, while control in simple definition way means to make something do what you want. A remote controller is a device used for controlling a piece of electrical or electronic equipment without having to touch it.

SMS Remote Controller is an electronic device that enables the user to control appliances remotely from a mobile phone from any part of the world. The microcontroller pulls the SMS received by phone, decodes it, recognizes the Mobile number, and then switches on the relays attached to its port to control the appliances. After successful operation, controller sends back the acknowledgement to the user's mobile through SMS. The SMS Remote Controller has a wide range of applications. It can be used to make an extended range control, operate able from any part of the world. In industry, it can be used to monitor a running machine, or if some threshold is surpassed. It can also be used to demobilize stolen cars. The first remote control called lazy bones was developed in 1950 by Zenith Electronic Corporations (known as zenith radio corporations) (Parker and Sybol, 1982). Lazy bones were a cable ran from the device to a TV set, then to the viewer. A motor operates the turner through the remote control. By push buttons on the remote control the user can rotate the turner clockwise or anti-clockwise, depending on whether he wanted to change the channel to a higher or lower number. The remote control also included buttons to turn the TV ON or OFF.

Zenith engineer Eugene Polley invented the "Flashmatic" which represented the country's first wireless TV remote. Introduced in 1955, the flashmatic operated by means of four photocells, one in each corner of the TV screen. The viewer used a highly directional flashlight to activate the four controls which turned the picture and sound ON and OFF, and changed channels. By 1990, the industry moved to infrared remote control technology (IR). The IR remote works by using a low frequency light beam, so low that the human eye cannot see it, but which can be detected by the receiver on the TV set.

Modern electronics is about embedded electronics (Mavino, 1997). This is the use of electronics for the purpose of controlling some devices. Its applications are numerous and more discoveries, innovations and inventions are expected in this new world of electronics and software engineering. The strong desire for research, innovations and inventions lead man to discover another means for wireless remote control using Short Message Service (SMS) (Lanconelli, 2007; Krishna, 2006) other than the IR technology.

The first SMS remote control was designed by Sera Sedis in 2001. In 2007, a Nigerian named Yakubu Mohammed redesigned the SMS remote control by Sera Sidis and he renamed the device as Mobile Phone / Personal Computer Remote Controlling (MPRC) Device.

There are times when a person would want to operate certain appliances when he/she is not at the location of that appliance, a means to control those appliances would be required in such situation hence the need for a remote controller. The home appliances control system with an affordable cost was thought to be built that should be mobile providing remote access to the appliances and allowing home security by extension. To this end, we design and implement a simple, cost effective and reliable SMS based remote controller to enable the control of appliances remotely, switching them on or off as desired by sending an SMS to the device using a GSM mobile phone.

For clarity and neatness of presentation, the article is outline in to five (5) sections. The First Section gives a general introduction of SMS based remote control. Work related to the topic of the research is presented in Section Two. In Section Three, we outline the design and implementation procedures. Section Four presents the experimental results and discussion of the results. In Section Five, we conclude the work with some recommendations. Finally, the references are presented at the end of the paper.

2. Related Work

The idea of using the short message service to establish routes in communication networks between receivers and transmitters for the purpose of safety and guaranty of service is not new, but the application, cost, design method and reliability of the system varies. In (Conte and Scaradozzi, 2003), home automation systems as multiple agent Systems (MAS) were considered. in their work, home automation system was proposed that includes home appliances and devices that are controlled and maintained for home management. Their major contribution to knowledge was to improve home automation, but not minding the cost of the entire system.

In a related work, Alkar and Buhur (2005) in their paper also proposed an Internet Based Wireless Home Automation System for Multifunctional Devices. They proposed a low cost and flexible web-based solution but this system has some limitations such as the range and power failure.

In (Delgado et al., 2006) problems with the implementation of home automation systems were considered. Furthermore the possible solutions were devised through various network technologies. Several issues affecting home automation systems such as lack of robustness, compatibility issue and acceptability among the old and disabled people were also discussed.

In (Ciubotaru-Petrescu et al., 2006), a design and implementation of SMS based control for monitoring systems was presented. The paper has three modules involving sensing unit for monitoring the complex applications, a processing unit that is the microcontroller and a communication module that uses General Packet Radio Service (GPRS) modem or cell phone via serial port RS-232. The SMS is used for status reporting such as power failure.

Murthy (2008) explores primary health-care management for the rural population. A solution proposes the use of the mobile web-technologies providing the Primary Health Care (PHC) services to the rural

population. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication.

In a related work, Jawarkar et al. (2008) proposed remote monitoring through mobile phone involving the use of spoken commands. The spoken commands are generated and sent in the form of text SMS to the control system and then the microcontroller on the basis of SMS takes a decision of a particular task. But the drawback of all the related work is the cost of the design, the reliability, and the use of foreign materials. In this research, we utilize locally available materials for our design purpose, making it more reliable and portable with less cost. We employ microcontroller, relays, and a programmer for the microcontroller, a mobile phones and a GSM modem.

3. Design and Implementation

This section will discuss the design procedure of the SMS based Remote Controller and how it was implemented. The section is divided into two basic sections; the hardware section and the software section. These are further divided into sub-sections.

3.1 Hardware Section

This section deals with the physical component that was used in SMS Remote Controller. This section is divided into five sub-sections; the GSM modem module, the LCD module, the appliance module, the control module and the power supply module.

3.1.1 GSM Modem Module

The Sim340Z GSM modem manufactured by Siemens is used as a modem. TheSim340Z has a communication port (inbuilt GSM modem) that can be programmed using AT Command Set. The signal names for the GSM modem communication port include the following; audio input and output pins (for connecting external hands free audio devices), mute control pin, flash programming signal pins, external power pins, and receiver and transmitter pins.

The SMS Remote Controller will only emphasize on the receiver (RX) and transmitter (TX) pins otherwise called the serial port. The serial port is TTL (Transistor-Transistor Logic) compactable, and is directly interfaced to the ATmega8515 microcontroller without a driver. The serial port of the modem operates at 115200 baud rate, 8bit data, 1start bit, 1stop bit and no parity bit.

3.1.2 LCD Module

This module is use to display the status of the appliances, it consist of a 16 X 2 character LCD, a 10K ohms, and a 100 Ohm resistors.
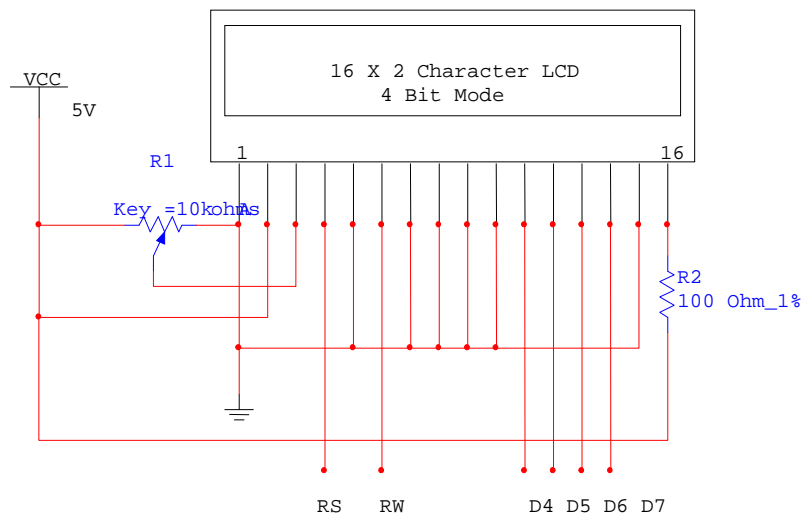
Figure 1. LCD configuration in 4 Bit mode

From the figure above, the variable resistor (10k ohms), is used to change the brightness of the LCD, while the 100 ohms resistor is use as a current limiter for the back light of the LCD.

3.1.3 Appliances Module

Home appliances cannot be directly interfaced to microcontrollers; this is because they are AC operated devices while microcontrollers are low voltage DC operated devices. Therefore to control AC operated devices from DC voltage, a relay or a traic is used. When using a relay to control AC operated devices, a relay driver is required; this is because the voltage ratings for most relays are between 6V to 24V dc, which is higher than the output voltage from most microcontrollers. The circuit diagram of a simple relay driver is shown below.
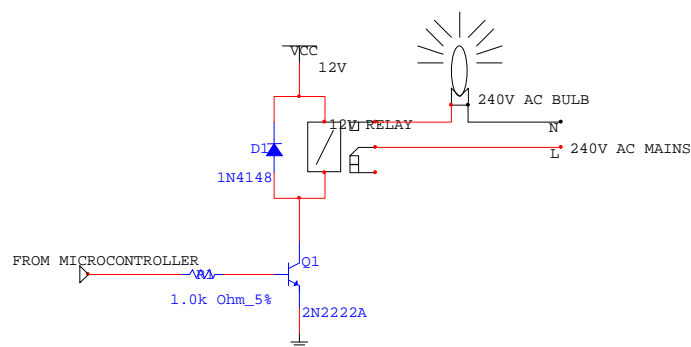
Figure 2. Appliance interface circuitry

From the circuitry above, the diode is connected across the relay (DC terminals), to prevent the switching transistor from the charge reversal of the relay inductance. Mathematically the values for R1 and Q1 are justified as soon below.

1. Transistor maximum collector current must be greater than the load current Ic

Recall that,   V=IR

(1)

Therefore, $I = \dfrac{V}{R}$

(2)

Hence, $\text{load current } = \dfrac{\text{supply voltage}}{\text{load resistance}}$

(3)

Where Load current=?

Supply voltage = Relay voltage rating = 12V

Load resistance = Relay resistance = 400 ohms, therefore

From Equation (2),

$$\text{Load current} = \dfrac{12}{400} \quad = 0.03\,\text{A}$$

2. The transistor minimum current gain hfe must be greater than five times the load current divided by maximum output current from the drive voltage.

$hfe > \dfrac{5 x load\ current}{drive\ current}$

(4)

Where load current = 0.03 A

Drive current = output current of ATmega16 = 40 mA, therefore

From equation (4),

$hfe = \dfrac{5 \times 0.03}{40mA} = 3.75$

From the calculations above, a transistor whose maximum collector current Ic is greater than 0.03A and the minimum current gain hfe is greater than 3.75 can be used for switching a 12V, 400 Ohms relay. One of the NPN transistors that satisfied these conditions is 2N2222. The 2N2222 transistor has a maximum collector current $Ic = 0.8A$, and the $hfe = 300$.

3. From equation (5), the base resistor should be equal to the drive voltage multiplied by hfe, divided by five times the maximum collector current of the switching transistor.

$$Base\ \text{resistor} = \dfrac{drive\ \text{voltage X current gain}}{5\ X\ \text{maximum collector current}}$$

(5)

Where drive voltage = ATmega16 output voltage = 5V

Maximum collector current = maximum collector current for 2N2222 = 0.8A

Current gain = current gain for 2N2222= 300, therefore

$$Base\ resistor = \frac{5 \times 300}{5 \times 0.8} = 375\ ohms$$

From the calculation above, a resistor whose resistance is greater than 375 Ohm can be used as the base resistor.

3.1.4 Control Module

This module is the brain of the SMS Remote Controller. Its main component is the ATmega16 microcontroller,

There are different microcontrollers available in the market from different manufactures. In order to choose an appropriate microcontroller, several microcontrollers were considered using their architecture. The architecture considered are the 8051, AVR and PIC, and the comparison was based on the cost availability speed built-in peripherals and tools and resources.

Having compared the different microcontroller architectures, the ATmega16 from AVR architecture was chosen. The ATmega16 microcontroller from Atmel corporations has a Reduced Instruction Set Computer (RISC) core running single cycle instructions and a well defined Input/output structure that limits the need for external components. Some of the features found on the ATmega16 are; Internal oscillators, Universal Synchronous Asynchronous Receiver Transmitter (USART) , Serial Peripheral Interface (SPI), Pulse Width Modulation (PWM) ,Watch-dog Timers etc. The circuit below shows how an AVR microcontroller is hardware configured.
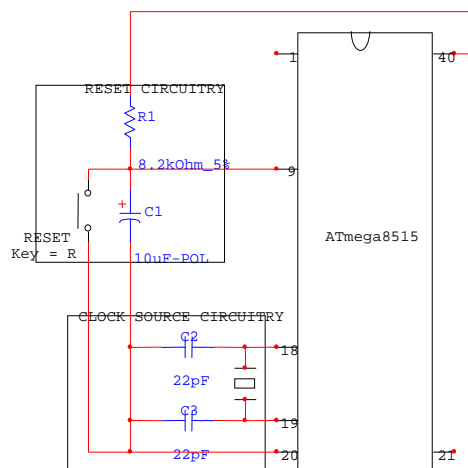
Figure 3. ATmega16 configuration circuitry

The clock source generates the appropriate clock signal for the microcontroller to execute its instruction set. The condition for selecting C1 and C2 are

$$C1 = C2 = (30 \pm 10) in\ pf$$

$$X1 \leq speed\ of\ atmega\ 16\ in\ hz$$

Note: With a crystal value of 8MHz, the microcontroller will be able to execute 8 million instructions per

second.

The reset circuitry is used to manually reset the microcontroller. The microcontroller cannot function without a firmware loaded into its code or program memory (FLASH EEPROM). The design of the firmware will be discussed in the software design section. The ATmega16 can be used without being hardware configured; this is because it has a calibrated internal RC oscillator that can be enabled when programming the chip. The selectable frequencies, when enabling the calibrated internal RC oscillator are, 4MHz and 8MHz. The SMS Remote Controller will be using the 8MHz calibrated internal oscillator.

3.1.5 Power Supply Module

This power supply module is necessary for the provision of regulated (step-down rectified) DC power supply from AC mains to circuit components (ICs, relays, microcontroller etc.) The maximum and minimum voltage ratings of the circuit component were taken into consideration while designing the power supply unit;

ATmega16 *microcontroller:* The voltage rating for the ATmega8515 is between 1.8V to 5.5V dc.

GSM modem: The voltage rating for the Simcom304 GSM modem is around 3.4V to 4.5V dc.

Relay: Different relays have different voltage ratings around 4V to 1000V dc. This work will be using a 12V relay; this is due to its availability.

Other Circuit Component: Other circuit components like the 2N2222 transistor can withstand 12Vdc without drawing two much current.

From the above consideration, it was concluded that a power supply of three different voltage levels was needed. The ATmega16 can be operated with a 5Vdc supply, the GSM modem can be operated with a 4.2V supply, and the 12V relays and other circuit components can be operated with a 12V supply.
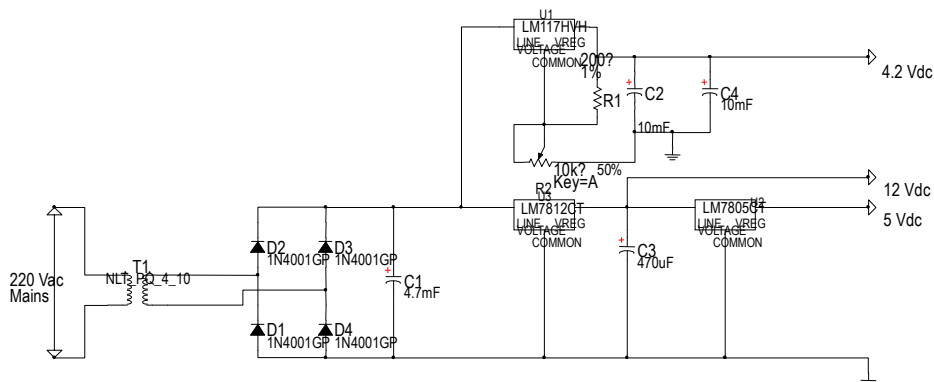

Figure 4. Power Supply circuitry

From the circuit above, the AC mains will be step-down using a 240V/15V transformer; the output of the transformer will then feed to a bridge rectifier and a 12V voltage regulator will be connected to the output of the rectifier. The Output of the 12V voltage regulator will then be feed to a 5V voltage regulator. The capacitors are necessary for removing the pulsating dc. The complete circuit diagram for the SMS remote
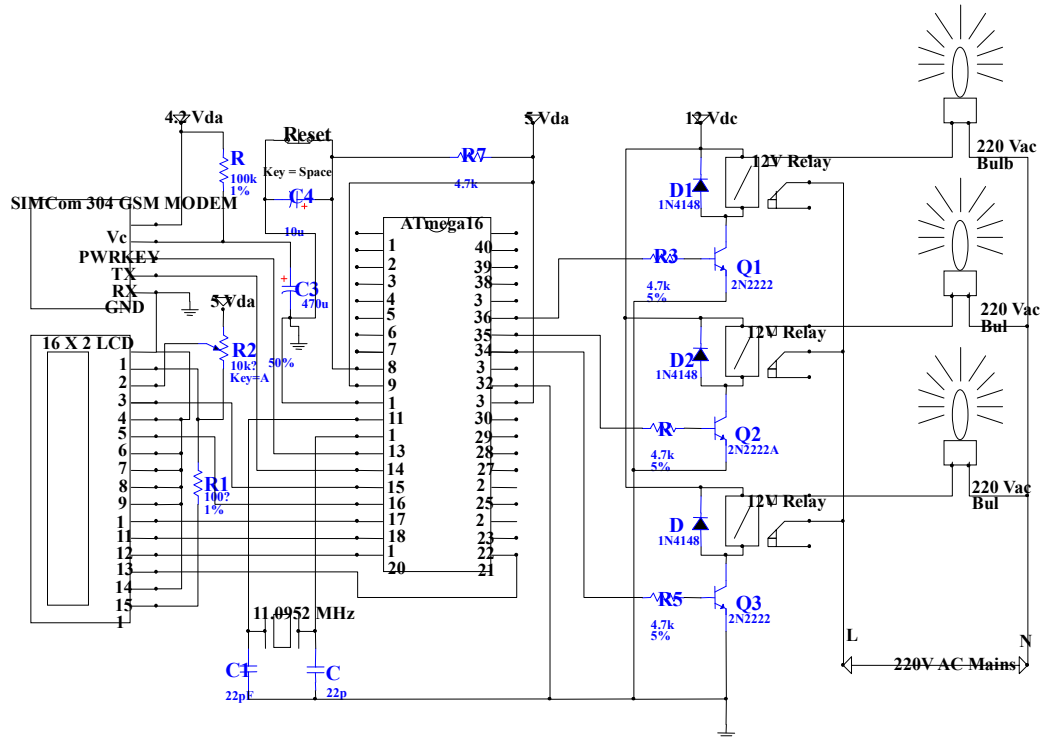
controller is shown below

Figure 5. Circuit diagram for the SMS remote controller

3.2 Software Section

This section describes the software development for the SMS Remote Controller. It is divided into two sub-sections; these are the software development and uploading.

3.2.1 ATmega16 Software Development

The SMS Remote Controller software was developed in AVR Studio4 Integrated Development Environment (IDE) using assembly language. The table below shows the pin assignment for the ATmega16 I/Os as used in the SMS Remote Controller.

Table 1. ATmega16 I/O pin assignment

ATmega16 I/O pin	Device Connected to	Description of the ATmega16I/O
Pin21 (PB7)	LCD pin14 (D7)	use for sending data to the LCD (4 bit mode)
Pin20 (PB6)	LCD pin13 (D6)	use for sending data to the LCD (4 bit mode)
Pin19 (PB5)	LCD pin12 (D5)	use for sending data to the LCD (4 bit mode)
Pin18 (PB4)	LCD pin11 (D4)	use for sending data to the LCD (4 bit mode)
Pin17 (PB3)	LCD pin (RS)	use for selecting LCD register
Pin16 (PB2)	LCD pin (EN)	use to enable the LCD
Pin35 (PB1)	Relay Driver1	use to switch *ON* and *OFF* of appliance1
Pin34(PB0)	Relay Driver2	use to switch *ON* and *OFF* of appliance 2
Pin33(PD7)	Relay Driver3	use to switch *ON* and *OFF* of appliance 3
Pin14 (PD0)	GSM Modem (TX)	use to receive data from Gsm modem
Pin15 (PD1)	GSM Modem (RX)	use to transmit data to Gsm modem

The following sub-routine was adopted in the design of the SMS Remote controller

1. Initializing Registers and I/Os: This sub-routine was used to initialize all the SRAM and I/Os to the initial expected state. For example when the device is first powered, it is expected that the entire appliance should be OFF. This can be done as shown below

<center>cbi PB1, PORTB   ;off relay1</center>

2. Setting UART baud rate: The default baud rate for the GSM modem is 115200, therefore for the ATmega16 microcontrollers baud rate has to be set to 115200 to be able to communicate with the modem. To achieve this, the following USART registers has to be initialized as shown below.

Table 2. Serial port initialization data

Register Name	Register Data (hex)	Description
UBRH	0x00	Set baud rate to 115,200
UBRL	0x38	Set baud rate to 115,200
UCSRA	0x06	Set serial port @8bit data, 1 start and stop bit, no parity bit
UCSRB	0x18	Set serial port @8bit data, 1 start and stop bit, no parity bit
UCSRC	0x00	Enables ATmega16 serial port as Asynchronous mode

3. Setting Preferred message storage: To set the preferred message storage in the GSM modem, the following is sent to the modem.

AT+CPMS ="ME","ME","ME"

The above code will enable the use of GSM modem memory for reading, sending and deleting SMS.

4. Read SMS: To read a message from the 15th memory in the preferred message storage, the following code is sent to the GSM modem.

<center>*AT+CMGR = 15*</center>

<center>114</center>

5. Delete SMS: To delete a message from the 15th memory in the preferred message storage, the following code is sent to the GSM modem.

AT+CMGD = 15

6. Send SMS: To send a message from the 15th memory in the preferred message storage, the following code is sent to the GSM modem.

AT+CMGS = 15

7. Update Relay driver: To ON or OFF the appliances the respective relay driver is set or cleared eg.

cbi PB1, PORTB   ;off relay1

sbi PB1, PORTB   ;on relay1

8. Update LCD: To write or update the LCD, the following step is taken,

1. Send LCD command

2. Send LCD data

9. Loop: The loop subroutine will loop through no 4 to 8

The flowchart that was adopted in the software development is shown below, for simplicity some processes were ignored.
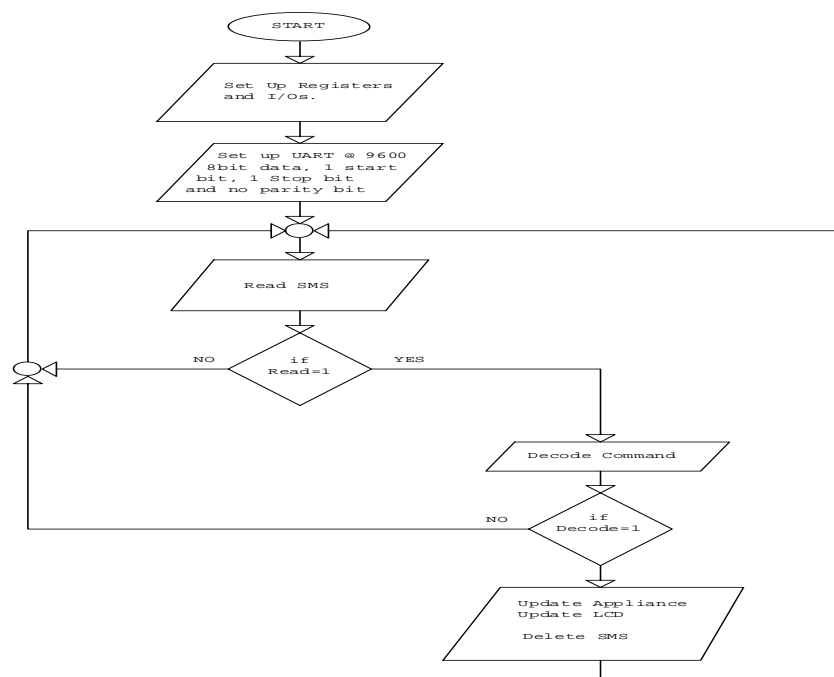

Figure 6. Flowchart for SMS Remote Controller

3.2.2 ATmega16 Software Uploading

The SMS Remote Controller software was uploaded into the ATmega16 microcontroller code or program memory using an EasyAVR6 programmer. The EasyAVR6 programmer is a full featured AVR Development Board manufactured by Mikroelektronika. The programmer connects to the Personal Computer (PC) via a Universal Serial Bus (USB) port.

4. Experimental Results and Discussions

In this section, we itemized the steps and stages of procedure taken to verify the mathematical calculated results through the real time experimental results.

4.1 Power Supply Test

The power supply section was switched on; a multimeter was used to measure voltages at different terminals in the power supply section. The result obtained was recorded and compared with their respective theoretical values.

Table 3. Power Supply Test result

	Theoretical Value	Experimental Value
AC Mains (V_{ac})	240.00	195.50
Transformer Output (V_{ac})	15.00	12.50
Rectifier Output (V_{dc})	13.60	15.00
LM7812 Output (V_{dc})	12.00	12.05
LM7805 Output (V_{dc})	5.00	5.05
LM317 Output (V_{dc})	3-17	4.20

From the power supply test results above, the experimental results were slightly different from the theoretical values; these could be attributed to some of the following reasons:

1. Percentage error of the measuring instrument used

2. Low battery of the measuring instrument used

3. Human error which cannot be totally eliminated

4.2 Appliance Interface Test

The appliance interface section was tested manually. A bulb was connected to one of the relays, and the power supply was switched on. A jumper was used to connect the base of the transistor (*NPN*) driving the relay to VCC and also to GND. It was observed that when the transistor's base is connected to VCC, the relay will be energized and the bulb will be ON and when connected to GND, the relay will de-energized and the bulb will be OFF. This test was repeated for the other appliance interface, and the observation was the same. This observation conformed to the theory of switching ON and OFF of an NPN transistor.

4.3 GSM Modem Test

The GSM modem was test on a personal computer. The serial port of the modem was connected to the COM1 port of the personal computer using an RS232 converter. The hyper terminal program on the PC was started, and the baud rate was set to 11,000, 8 data bit, 1 start bit, 1 stop bit and no parity bit. When an "AT" is typed and sent to the GSM Modem, it was observed that the modem responded with "OK". According to the AT command set for the modem, the modem should return an "OK" when an "AT" is sent to it. This observation reveals the modem is working properly. Other command tested are shown in the table below

Table 4. AT command and the respective responds

S/N	Command	Meaning	Responds
1	AT	Attention	OK
2	AT+CPMS="SM","SM","SM"	Select SIM memory	+CPMS: 0,15,0,15, 0,15
3	AT+CMGR=1	Read message on SIM memory location 15	+CMGR: 0,12 <PDU> OK
4	AT+CMGD=1	Delete message on SIM memory location 1	OK

4.4 SMS Remote Controller Test

A bulb was connected to the appliance interface connector of the SMS Remote controller, and the power switch was switched on. A phone was used to send the SMS command needed to activate the bulb. The time between the reception of the SMS command and the execution is about 1 to 4 seconds. The time between sending and reception of the SMS command depends solely on the GSM network. For documentation purpose, it took about 4-6 seconds when the network is good and about 20-45 minutes when the network is bad. This is one of the limitations of the SMS Remote Controller.

Table 5. SMS Remote Controller Commands

S/N	SMS Command	Description
1	BB ON1	Switch ON bulb1
2	BB OF1	Switch OFF bulb1
3	BB ON2	Switch ON bulb2
4	BB OF2	Switch OFF bulb2
5	BB ON3	Switch ON bulb3
2	BB OF3	Switch OFF bulb3

5. Conclusion

This research was aimed at design and implementation of an SMS based remote control system. The results obtained are presented and fully discussed. After carrying out the necessary test, it was observed that the aim of the work was achieved. The SMS Remote Controller was discovered to be efficient in remote controlling of home appliances. The system has many advantages such as remote controlling of home appliances, availability and ease to users. The user can get alerts anywhere through the GSM technology thus making the system location independent. The system contains low cost components easily available which cuts down the overall system cost. Moreover, the system alerts user about breach via SMS providing home security, and also allows secure access due to pre-configured number. The ease of deployment is due to wireless mode of communication. GSM technology provides the benefit that the system is accessible in remote areas as well. The system reliability increases due to the useful features such as battery level checking, charging status and signal strength indicating the system about threats. in future, we intend to look into some newly design computers that does not supports parallel or serial ports by improving our design to support USB (Universal Serial Bus) port for diagnostic.

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