CHAPTER 1
INTRODUCTION
1.0 Introduction to Project

“GSM based Control System” implements the emerging applications of the GSM technology. Using GSM networks, a control system has been proposed that will act as an embedded system which can monitor and control appliances and other devices locally using built-in input and output peripherals.

Remotely the system allows the user to effectively monitor and control the house/office appliances and equipments via the mobile phone set by sending commands in the form of SMS messages and receiving the appliances status. The main concept behind the project is receiving the sent SMS and processing it further as required to perform several operations. The type of the operation to be performed depends on the nature of the SMS sent. The principle in which the project is based is fairly simple. First, the sent SMS is stored and polled from the receiver mobile station and then the required control signal is generated and sent to the intermediate hardware that we have designed according to the command received in form of the sent message.

We have selected a particular Nokia mobile set (Nokia 3310) for our project. The messages are sent from the mobile set that contain commands in written form which are then processed accordingly to perform the required task. A microcontroller based system has been proposed for our project. There are several terminologies that are used extensively throughout this project report.

GSM (Global System for Mobile Communications): It is a cellular communication standard.

SMS (Short Message Service): It is a service available on most digital mobile phones that permit the sending of short messages (also known as text messaging service).
1.1 Background

The new age of technology has redefined communication. Most people nowadays have access to mobile phones and thus the world indeed has become a global village. At any given moment, any particular individual can be contacted with the mobile phone. But the application of mobile phone can not just be restricted to sending SMS or starting conversations. New innovations and ideas can be generated from it that can further enhance its capabilities. Technologies such as Infra-red, Bluetooth, etc which has developed in recent years goes to show the very fact that improvements are in fact possible and these improvements have eased our life and the way we live. Remote management of several home and office appliances is a subject of growing interest and in recent years we have seen many systems providing such controls.

These days, apart from supporting voice calls a mobile phone can be used to send text messages as well as multimedia messages (that may contain pictures, graphics, animations, etc). Sending written text messages is very popular among mobile phone users. Instant messaging, as it is also known, allows quick transmission of short messages that allow an individual to share ideas, opinions and other relevant information. We have used the very concept to design a system that acts a platform to receive messages which in fact are commands sent to control different appliances and devices connected to the platform. We have designed a control system which is based on the GSM technology that effectively allows control from a remote area to the desired location. The application of our suggested system is immense in the ever changing technological world. It allows a greater degree of freedom to an individual whether it is controlling the household appliances or office equipments. The need to be physically present in order to control appliances of a certain location is eliminated with the use of our system.
1.2 Problem Statement

Technology has advanced so much in the last decade or two that it has made life more efficient and comfortable. The comfort of being able to take control of devices from one particular location has become imperative as it saves a lot of time and effort. Therefore there arises a need to do so in a systematic manner which we have tried to implement with our system. The system we have proposed is an extended approach to automating a control system.

With the advancement and breakthroughs in technology over the years, the lives of people have become more complicated and thus they have become busier than before. With the adoption of our system, we can gain control over certain things that required constant attention. The application of our system comes in handy when people who forget to do simple things such as turn ON or OFF devices at their home or in their office, they can now do so without their presence by the transmission of a simple text message from their mobile phone. This development, we believe, will ultimately save a lot of time especially when people don’t have to come back for simple things such as to turn ON/OFF switches at their home or at their office once they set out for their respective work.

The objective of this project is to develop a device that allows for a user to remotely control and monitor multiple home/office appliances using a cellular phone. This system will be a powerful and flexible tool that will offer this service at any time, and from anywhere with the constraints of the technologies being applied. Possible target appliances include (but are not limited to) climate control system, security systems, lights; anything with an electrical interface.

The proposed approach for designing this system is to implement a microcontroller-based control module that receives its instructions and command from a cellular phone over the GSM network. The microcontroller then will carry out the issued commands and then communicate the status of a given appliance or device back to the cellular phone.
1.3 Block Diagram

Fig 1.3: System Block Diagram
1.4 **Description:**

The figure shown above is the simple block diagram of our project. It is a simple illustration of how we have implemented our project and the various parts involved in it. From the above representation, the first Mobile station is used as a transmitting section from which the subscriber sends text messages that contain commands and instructions to the second mobile station which is based on a specific area where our control system is located. The mobile phone as indicated in the block diagram is a Nokia 3310 mobile set. The received SMS message is stored in the SIM memory of the phone and then extracted by the microcontroller and processed accordingly to carry out specific operations. The relay driver (BUFFER ULN2003) is used to drive the relay circuits which switches the different appliances connected to the interface. The LCD is used to indicate the status of the operation performed by the microcontroller and also its inclusion makes the overall system user-friendly.

The input from different sensors are feed to micro-controller and processed to operate respective task semi autonomously and autonomously.
GSM Based Control System

1.5 System Operation Flow Diagram

Fig 1.5 - System Operation Flow Diagram
GSM Based Control System

Assuming that the control unit is powered and operating properly, the process of controlling a device connected to the interface will proceed through the following steps:

- The remote user sends text messages including commands to the receiver.
- GSM receiver receives messages sent from the user cell phone.
- GSM receiver decodes the sent message and sends the commands to the microcontroller.
- Microcontroller issues commands to the appliances and the devices connected will switch ON/OFF.
CHAPTER 2
SYSTEM SPECIFICATION
2.0 Scopes and Purpose of System Specification

The system specification shows the description of the function and the performance of system and the user. The scope of our project “GSM Based control system” is immense. The future implications of the project are very great considering the amount of time and resources it saves. The project we have undertaken can be used as a reference or as a base for realizing a scheme to be implemented in other projects of greater level such as weather forecasting, temperature updates, device synchronization, etc. The project itself can be modified to achieve a complete Home Automation system which will then create a platform for the user to interface between himself and the household.

2.1 Goals and Objectives

The project “GSM based Control System” at the title suggests is aimed to construct a control system that enables the complete control of the interface on which it is based. General objectives of the project are defined as;

a. To co-ordinate appliances and other devices through Short Message Service (SMS).

b. To effectively receive and transmit data via SMS

c. To eliminate the need of being physically present in any location for tasks involving the operation of appliances within a household/office.

d. Minimize power and time wastage

2.2 Operating Environment

The control system will include two separate units: the cellular phone, and the control unit. There will therefore be two operating environments. The cellular phone will operate indoors and outdoors whereas the control unit will operate indoors within the temperature and humidity limits for proper operation of the hardware.
2.3 Intended Users and Uses

This system is aimed toward all the average users who wish to control their household/office appliances remotely from their cell phones provided that the appliances are electrically controllable. Example of feasible appliances and applications under consideration include; enable/disable security systems, fans, lights, kitchen appliances, and adjusting the temperatures settings of a heating/ventilation/air conditioning system.

2.4 Assumptions

Certain assumptions have to be made in order to implement our project. The list of assumptions for our project is;

a. The user and control unit will establish communication via GSM
b. The cell phone and service provider chosen will support text messaging service.
c. The user is familiar with the text messaging program on their cell phone.
d. All service charges (standard messaging rates) from the service provider apply.
e. The controlled appliances can and will have to have an electrical interface in order to be controlled by the microcontroller.

2.5 Major Constraints

Along the course of project completion we encountered various problems and obstacles. Not everything that we had planned went smoothly during the project development span. Also we had a limited amount of time for its completion so we were under a certain amount of pressure as well. We had to start from the research phase at the beginning and needed to gain knowledge on all the devices and components that we had intended to use for our project. Other phases of the project included coding, debugging, testing, documentation and implementation and it needed certain time for completion so we really had to manage the limited time available to us and work accordingly to finish the project within the schedule.
GSM Based Control System

2.6 Functional Requirements

The following is a list of functional requirements of the control unit/module.

a. The control unit will have the ability to connect to the cellular network automatically.
b. The control unit will be able to receive text messages and will be able to parse and interpret text messages and instructions to be sent to the microcontroller.
c. The microcontroller within the control unit will issue its command to the electrical appliances through a simple control circuit.
d. The control unit will control the electrical appliances.

2.7 Constraints Considerations

The following is a list of constraint Considerations

a. The controlled appliances will need an electrical control interface. This system is only capable of controlling electrical devices.
b. The control module will need to be shielded against electrostatic discharges. This will increase the reliability of the system.
c. Battery backup for controlling unit can be implemented in case of power disruption.

2.8 Technology Considerations

The considerations for this system will include a choice of networks, communication protocols and interfaces.

a. Cellular Networks: The widely available networks are based on GSM. This network provides wide area coverage and can be utilized more cost-effectively for this project.
b. Communication Protocols: The available communication protocol that we have used is SMS. The SMS is the most efficient because this project requires a cellular communication and limited data to be sent.

c. I/O interfaces between microcontroller and devices: Serial I/O is considered as options for connection between the GSM receiver and the microcontroller. Using the microcontroller, a control circuit will be implemented to control the electrical appliances.

2.9 Limitations

Our project has certain limitations and a list of such is mentioned below;

a. The receiver must reside in a location where a signal with sufficient strength can be received from a cellular phone network.

b. Only devices with electrical controlling input ports will be possible targets for control.

c. Operation of the controlling unit is only possible through a cell phone with SMS messaging capabilities.

d. The Controlling unit must be able to receive and decode SMS messages.
## 2.10 Gantt Chart

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<th>Finish</th>
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<td>09 Mar 2008</td>
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</tbody>
</table>

Table 2.10 – Gantt chart Table
2.11 Project Issues

2.11.1 Project Cost

Project cost can be divided in two ways and calculated as follows;

a. Hardware Cost:
Hardware cost for our project can be considered as a moderate amount of money spent. It does not fall under a cheap project neither it is a relatively smaller one. However, having said that, the cost of the hardware components implemented does amount to significant figures. We had to disrupt a Nokia 3310 phone set in order to connect to the F-Bus protocol of the mobile set. Other hardware expenses are not as significant when compared to it but they do accumulate to a considerable amount. But taking into consideration that this is a one time investment, the cost cannot be said to be too expensive.

b. Software Cost:
Software cost includes the cost of the required soft wares for our project. We did not have to spend money in getting the necessary software for our project. The software we used for our system is the free edition version and thus no money was put in it. The involvement cost in our project is only the human labors, searching websites, visiting different places and locations for gathering locations and not to mention the cost of electricity that was consumed during the project completion time.
### 2.11.2 Cost Estimation Table

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</table>

Grand Total: Rs. 3814
CHAPTER 3
DESIGN
3.0 Circuit Components

3.0.1 Micro-Controller

a) Introduction:

An embedded microcontroller is a chip, which has a computer processor with all its support function (clocking and reset), memory (both program storage and RAM), and I/O (including bus interfaces) built into the device. These built in function minimize the need for external circuits and devices to the designed in the final applications.

The improvements in micro-controller technology has meant that it is often more cost-effective, faster and more efficient to develop an application using a micro-controller rather than discrete logic. Creating applications for micro-controllers is completely different than any other development job in computing and electronics. In most other applications, number of subsystems and interfaces are available but this is not the case for the micro-controller where the following responsibilities have to be taken.

- Power distribution
- System clocking
- Interface design and wiring
- System Programming
- Application programming
- Device programming

There are two types of micro-controller commonly in use. Embedded micro-controller is the micro-controller, which has the entire hardware requirement to run the application, provided on the chip. External memory micro-controller is the micro-controller that allows the connection of external memory when the program memory is insufficient for an application or during the work a separate ROM (or even RAM) will make the work easier.
b) ATMEL Micro-controller

The AT89C52 is a low-power; high performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel’s high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

The main features of this micro-controller are as follows;

- Compatible with MCS-51™ Products
- 8K Bytes of In-system reprogrammable Flash Memory
- Endurance: 1,000 write/erase cycles
- Fully static operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- 256 x 8-bit internal RAM
- 32 Programmable I/O lines
- Three 16-bit Timer/Counters
- Eight Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes
3.0.2 Relay

The relay driver is used to isolate both the controlling and the controlled device. The relay is an electromagnetic device, which consists of solenoid, moving contacts (switch) and restoring spring and consumes comparatively large amount of power. Hence it is possible for the interface IC to drive the relay satisfactorily. To enable this, a driver circuitry, which will act as a buffer circuit, is to be incorporated between them. The driver circuitry senses the presence of a “high” level at the input and drives the relay from another voltage source. Hence the relay is used to switch the electrical supply to the appliances.

From the figure when we connect the rated voltage across the coil the back emf opposes the current flow but after the short time the supplied voltage will overcome the back emf and the current flow through the coil increase. When the current is equal to the activating current of relay the core is magnetized and it attracts the moving contacts. Now the moving contact leaves from its initial position denoted “(N/C)” normally closed terminal which is a fixed terminal. The common contact or moving contact establishes the
connection with a new terminal which is indicated as a normally open terminal “(N/O)”. Whenever, the supply coil is withdrawn the magnetizing force is vanished. Now, the spring pulls the moving contact back to initial position, where it makes a connection makes with N/C terminal. However, it is also to be noted that at this time also a back emf is produced. The withdrawal time may be in microsecond, the back emf may be in the range of few kilovolts and in opposite polarity with the supplied terminals the voltage is known as surge voltage. It must be neutralized or else it may damage the system.

3.0.3 ULN2003 IC

The ULN2003 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. The collector-current rating of a single Darlington pairs 500mA. The Darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas Discharge), line drivers, and logic buffers. The ULN2003 has a 2.7kW series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices.

Features:

- 500mA rated collector current (Single output)
- High-voltage outputs: 50V
- Inputs compatible with various types of logic.
- Relay driver application.
Logical Diagram

Fig 3.0.3 (a) – ULN2003 Logic Diagram

Fig 3.0.3(b) - Schematic Diagram (Each Darlington Pair)
3.0.4 Liquid Crystal Display (LCD)

Fig 3.0.4: 2 x 16 LCD

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. JHD 162A is LCD that has following features:

- Number of characters: 16 characters*2 lines.
- Module dimension: 80.0mm*36.0mm*9.7mm.
- Area: 66.0mm*16.0mm.
- Active area: 56.2mm*11.5mm.
- Dot size: 0.55mm*0.65mm.
- Dot pitch: 0.60mm*0.70mm.
- Character size: 2.95mm*5.55mm.
- Character pitch: 3.55mm*5.95mm.
- LCD Type: Positive, Reflective, Yellow Green.
3.0.5 Temperature Sensor

The two main types of semiconductor temperature sensors are temperature sensitive voltage sources and temperature-sensitive current sources. An example of the first type is the National LM35. The voltage output from this circuit increases by 10 mV for each degree centigrade that its temperature is increased. If the output is connected to a negative reference voltageVs, the sensor will give a meaningful output for temperature range of -55 to +150 degree centigrade. The output is adjusted to 0V for 0 degree centigrade. The output voltage can be amplified to give the voltage range we need for a particular application. The accuracy of this device is about 1 degree centigrade.

A thermocouple junction made of iron and constantan, commonly called a J thermocouple, has a useful temperature range of about -184 to 760 degree centigrade. Thermocouples can be made small, rugged and stable, however, they have problems like the output is very small and must be amplified a great deal to bring it up into range where it can drive an A/D converter. So, we used LM35 in our system.

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in deg Celsius). LM35 temperature sensor can measure more accurately than using a thermistor. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. It has an output voltage that is proportional to the Celsius temperature. The scale factor is 0.01V/deg Celsius. Another important characteristic of LM35 is that it draws only 60 micro amps from its supply and possesses a low self heating capability. The sensor self heating causes less than 0.1 deg Celsius temperature rise in still air.
For this project, temperature sensor used: LM35 with output accuracy 10mV/°C. The basic connection for temperature sensor is shown as figure below:

![Basic connection of Temperature sensor](image)

For calculation, the following equation has been used to get the number in degree Celsius.

\[
\text{Temperature} = \frac{AD \text{ value} \times 300}{1024}
\]

AD value is 10 bit ADC result.

Features

- Calibrated directly in °Celsius (centigrade)
- Linear +10.0 mV/°C scale factor
- 0.5 °C accuracy guarantee able (at +25 °C)
- Rated for full -55° to +150 °C range
- Suitable for remote applications
- Low cost due to water-level trimming
- Operates from 4 to 30 volts
- Less than 60μA current drain
- Low self-heating 0.08 °C in still air.
- Non linearity only +/- 0.75°C typical low impedance output, 0.1 (Ohm) for 1mA load.
There are different types of temperature sensors like semiconductor devices, thermocouples, RTDs and thermistors.

3.0.6 Nokia 3310

Most Nokia phones have F-Bus and M-Bus connections that can be used to connect a phone to a PC or in our case a microcontroller. The connection can be used for controlling just about all functions of the phone. This bus will allow us to send and receive SMS messages. The very popular Nokia 3310/3315 has the F/M Bus connection under the battery holder. The picture below shows the 4 gold pads used for the F and M Bus.

Fig: 3.0.6 Nokia F Bus and M Bus
CHAPTER 4
GSM TECHNOLOGY AND SHORT MESSAGING SERVICE
GSM Based Control System

4.0 GSM TECHNOLOGY

GSM is a global system for mobile communication. GSM is an international digital cellular telecommunication. The GSM standard was released by ETSI (European Standard Telecommunication Standard) back in 1989. The first commercial services were launched in 1991 and after its early introduction in Europe; the standard went global in 1992. Since then, GSM has become the most widely adopted and fastest-growing digital cellular standard, and it is positioned to become the world’s dominant cellular standard.

Today’s second-generation GSM networks deliver high quality and secure mobile voice and data services (such as SMS/Text Messaging) with full roaming capabilities across the world.

GSM platform is a hugely successful technology and an unprecedented story of global achievement. In less than ten years since the first GSM network was commercially launched, it became the world’s leading and fastest-growing mobile standard, spanning over 173 countries. Today, GSM technology is in use by more than one in ten of the world’s population and growth continues to sour with the number of subscriber worldwide expected to surpass one billion by through end of 2003.

Today’s GSM platform is living, growing and evolving and already offers an expanded and feature-rich ‘family’ of voice and enabling services.

The Global System for Mobile Communication (GSM) network is a cellular telecommunication network with a versatile architecture complying with the ETSI GSM 900/GSM 1800 standard. Siemen’s implementation is the digital cellular mobile communication system D900/1800/1900 that uses the very latest technology to meet every requirement of the standard.
GSM Based Control System

Fig 4.0 GSM Architecture
4.0.1 Basic Specification in GSM

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<td>2</td>
<td>Forward Channel frequency</td>
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<td>Tx/Rx Frequency Spacing</td>
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<td>Tx/Rx Time Slot Spacing</td>
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<td>Modulation Data Rate</td>
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<td>6</td>
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Table: 4.0.1 GSM Air Interface Specifications.
4.0.2 GSM Services

GSM services follow ISDN guidelines and classified as either tele services or data services. Tele services may be divided into three major categories:

- Telephone services, include emergency calling and facsimile. GSM also supports Videotex and Teletex, through they are not integral parts of the GSM standard.
- Bearer services or Data services, which are limited to layers 1, 2 and 3 of the OSI reference model. Data may be transmitted using either a transparent mode or nontransparent mode.
- Supplementary ISDN services, are digital in nature, and include call diversion, closed user group, and caller identification. Supplementary services also include the short message service (SMS).
4.1 SHORT MESSAGE SERVICE

SMS stands for Short Message Service. It is a technology that enables the sending and receiving of message between mobile phones. SMS first appeared in Europe in 1992. It was included in the GSM (Global System for Mobile Communication) standards right at the beginning. Later it was ported to wireless technologies like CDMA and TDMA. The GSM and SMS standards were originally developed by ETSI. ETSI is the abbreviation for European Telecommunication Standard Institute. Now the 3GPP (Third Generation Partnership Project) is responsible for the development and maintenance of the GSM and SMS standards.

One SMS message can contain at most 140 bytes (1120 bits) of data, so one SMS message can contain up to:

- 160 characters if 7-bit character encoding is used. (7-bit character encoding is suitable for encoding Latin characters like English alphabets.)
- 70 characters if 16-bit Unicode UCS2 character encoding is used. (SMS text messages containing non-Latin characters like Chinese character should use 16-bit character encoding.)

Once the message is sent the message is received by SMSC, which must then get it to the appropriate mobile device. To do this the SMSC sends a SMS request to Home Location Register (HLR) to find the roaming customer. Once HLR receives the request, it responds to the SMSC with the subscriber’s status:

1. Inactive or active
2. Where subscriber is roaming.

If the response is “inactive“, then the SMSC will hold onto the message for a period of time. When the subscriber access his device, the HLR sends a SMS notification to the SMSC and the SMSC will attempt delivery.
The SMSC transfers the message in a Short Message Delivery Point to Point format to the serving system. The system pages the device, and if it responds, the message gets delivered. The SMSC receives verification that the message was received by the end user, then categorizes the message as “sent” and will not attempt to send again.

SMS provides a mechanism for transmitting short messages to and from wireless devices. The service makes use of an SMSC, which acts as a store and forward system for short messages.

One major advantage of SMS is that it is supported by 100% GSM mobile phones. Almost all subscription plans provided by wireless carriers include inexpensive SMS messaging service.

4.1.1 What makes SMS messaging so successful worldwide?

SMS is so successful all over the world. SMS messaging is now one of the most important revenue sources of wireless carriers. Some of the reasons are discussed below.

- SMS Messages can be sent and read at any time
- SMS Message can be sent to an offline Mobile Phone.
- SMS Messaging is less disturbing while you can still stay in touch.
- SMS are supported by 100% GSM Mobile Phones and they can be Exchanged between different wireless carriers

4.1.2 SMS Service Providers (SMS Gateway Providers, SMS Resellers, SMS Brokers)

There is a demand for SMS connectivity from applications that do not require the sending or receiving of large amounts of SMS messages. One example is a remote monitoring system. If the remote monitoring system finds that a certain server is not
responding, it will send an SMS alert to the system administrator mobile phone. This remote monitoring system will have a very small amount of SMS traffic per month since the servers being monitored should be working fine most of the time.

Since a wireless carrier usually doesn’t provide direct SMSC or SMS gateway access to user without a large amount of SMS traffic, some companies come out to fill the gap. These companies are called SMS service providers.

SMS service providers are also known as SMS gateway providers, SMS resellers and SMS brokers because of the following reasons:

- **SMS gateway providers**: An SMS service provider provides an SMS gateway for its user to send SMS message to. This SMS gateway will then route the SMS message to another SMS gateway or SMSC.
- **SMS reseller and SMS broker**: SMS service provider buy a large amount of SMS message from a lot of wireless carrier at low price per SMS message. They then sell the SMS message at a price higher than the cost.

Another advantage of using the SMS connectivity services of SMS service providers is that their network coverage is very good. They work hard to cover as many wireless networks as possible so as to make their services attractive.

### 4.1.3 Short Message Service Center (SMSC)

SMSC is a combination of hardware and software responsible for the relaying and storing and forwarding of short message between an SME and mobile device.

The SMSC must have high reliability, subscriber capacity, and message throughput. In addition, the system should be easily scalable to accommodate growing demand for SMS in the network.
Normally, an IN-based solution will allow for a lower entry cost compared to point solutions because it can support other applications on single hardware platform and share resources, thereby spreading the deployment cost over several services and applications.

Another factor to be considered is the ease of operation and maintenance of the application, as well as the flexibility to activate new services and upgrade to new software releases.

Nepal has two mobile companies

- Nepal telecommunication
- Spice Nepal Pvt.Ltd.

Both companies have their own SMSC. Nepal telecommunication has +9779851028801. Similarly Spice Nepal Pvt. Ltd. has +9779800009000

4.1.4 Short Message Peer to Peer Protocol

The short message peer to peer protocol (SMPP) is a protocol for exchanging SMS messages between SMS peer entities such as message service centers. It is often used to allow third parties (e.g. content suppliers like news organizations) to submit messages, often in bulk.

The protocol is based on complimentary pairs of request / response PDUs exchanged over OSI layer 4 (TCP/IP session or X.25 SVC3) connections. PDUs are binary encoded for efficiency.
CHAPTER 5
SOFTWARE DEVELOPMENT
5.0 SOFTWARE INTRODUCTION

The software for our project was developed using a simple high level language tool in C. The software extracts the sent message from the SIM location at a regular interval and processes it to control the different appliances connected within the interface. We have made use of the Nokia F-Bus protocol 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 our case a microcontroller. The connection can be used for controlling just about all functions of the phone, as well as uploading new firmware etc. This bus will allow us to send and receive SMS messages.

The very popular Nokia 3310/3315 has the F Bus and M Bus connection under the battery holder. This is a bit of a pain to get to and requires a special cable to make the connection.

5.1 Differences between F-Bus and M-Bus Protocol

M-Bus is a one pin bi-directional bus for both transmitting and receiving data from the phone. It is slow (9600bps) and only half-duplex. Only two pins on the phone are used. One ground and one data. M-Bus runs at 9600bps, 8 data bits, odd parity, and one stop bit. The data terminal ready (DTR) pin must be cleared with the request to send (RTS). This powers the electronics in the cable and I think it sets it for M-Bus operation.

F-Bus is the later high-speed full-duplex bus. It uses one pin for transmitting data and one pin for receiving data plus the ground pin. Very much like a standard serial port. It is fast 115,200bps, 8 data bits, no parity, and one stop bit. For F-Bus the data terminal ready (DTR) pin must be set and the request to send (RTS) pin cleared.

5.2 F-Bus Protocol and Commands

The F-Bus is bi-directional serial type bus running at 115,200bps, 8 data bits. The serial cable contains electronics for level conversion and therefore requires power. The first
thing to do is supply power to the cable electronics and this is done by setting the DTR (Data Terminal Ready) pin and clearing the RTS (Request to Send) pin. The DTR pin has to be connected to a +3 to 12 volt supply and RTS to a -3 to -12 V supply. An easy approach to achieve this is by using a Max232 or similar transceiver for the RS232 Tx and Rx pins and then connecting the DTR pin on the serial cable to the V+ pin on the Max232. The same should be done to the RTS but it should be connected to the V- pin on the Max232. The V+ and V- pins are derived from internal charge pumps that double the input voltage i.e. for a 5V Max232, the V+ will produce +10V and the V- will be -10V.

Sample frame sent to the Nokia 3310 (showed as a Hex dump)

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
Data: 1E 00 0C D1 00 07 00 01 00 03 00 01 60 00 72 D5

This sample frame is used to get the hardware and software version from a Nokia phone. It is a good starting point to test if our implementation of the protocol is working.

Byte 0: All frames sent by cable will start with the character 0x1E first. This is the F-Bus Frame ID. Cable is 0x1E and Infrared is 0x1C.

Byte 1: This is the destination address. When sending data, it's the phone's device ID byte. In our case it's always 00 for the phone.

Byte 2: This is the source address. When sending data, it's the PC's device ID byte. In our case it's always 0x0C (Terminal).

Byte 3: This is the message type or 'command'. 0xD1 is Get HW & SW version.

Byte 4 & 5: Byte 4 & 5 is the message length. In our case it is 7 bytes long. Byte 4 is the MSB and byte 5 is the LSB.
Byte 6: The data segment starts here and goes for 7 bytes in our case. As The Nokia is a 16 bit phone and therefore requires an even number of bytes. As for our project, it is odd and thus the last byte will be a padding byte and the message will end at location 13. The last byte in the data segment (Byte 12 above) is the sequence number. The last 3 bits of these byte increments from 0 to 7 for each frame. This part needs to be sent back to the phone in the acknowledge frame. The other bits we are unsure about what they mean.

Bytes 14 & 15: The second to last byte is always the odd checksum byte and the last byte is the even checksum byte. The checksum is calculated by XORing all the odd bytes and placing the result in the odd Checksum location and then XORing the even bytes and then placing the result in the even byte.

The phone receives and shows reply with the following data

```
1E 0C 00 7F 00 02 D1 00 CF 71
1E 0C 00 D2 00 26 01 00 00 03 56 20 30 34 2E 34 35 0A 32 31
2D 30 36 2D 30 31 0A 4E 4D 2D 35 0A 28 63 29 20 4E 4D
50 2E 00 01 41 3F A4
```

The first line is an Acknowledge command frame. The destination and source addresses are now swapped. This is because the Nokia phone is now talking. This message is two bytes long with the two bytes representing the message type received (0xD1) and the sequence number (0x00). The last two bytes are the checksum and should be checked to make sure the data is correct. The 3310 will be waiting for an acknowledge frame after these two frames were sent. If the acknowledge frame is not sent the 3310 will retry sending the data. The 3310 will only send the data 3 times and then gives up.

The second frame from our Nokia 3310 is the data we requested. The message type is 0xD2. This is 'receive Get HW&SW version'. This 38-byte (0x26) message should show 0x0003 "V" "firmware\n" "firmware date\n" "model\n" "(c) NMP." The last byte in the
data is the sequence number. As with standard F-bus frames, the last two bytes in the frame are checksum bytes.

The received data without f-bus frame

01 00 00 03 56 20 30 34 2E 34 35 0A 32 31 2D 30 36 2D 30 31
OA 4E 48 4D 2D 35 0A 28 63 29 20 4E 4D 50 2E 00 01 41

0003 V     0  4  .  4  5  
 2  1  /  0  6  /  0  1  \n N
H M - 5  \n (  c  )     N M P .    Sequence no.

Now we need to send the acknowledge frame back to the phone

1E 00 0C 7F 00 02 D2 01 C0 7C

0x7F is the acknowledge frame's command. We are only required to send a two-byte message so length is set to 0x02. The message contains the acknowledged message type (0xD2) and the sequence no. (0x01). The sequence number is made from the last 3 bits of the sequence number in the previous frame. The checksum needs to be calculated and sent.

5.3 Full SMS message Frame

Sample frame sent to my Nokia 3310 (showed as a Hex dump) 98 Bytes

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
27 28 29 30 31 32 33 34 35

Data: 1E 00 0C 02 00 59 00 01 00 01 02 00 07 91 16 14 91 09 10 F0 00 00 00 00 15 00
00 00 33 0A 81 40 30 87 00 47

SMS                               message centre --   Phone number -
GSM Based Control System

Byte: 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62
63 64 65 66 67 68 69 70 71
Data: 00 00 00 00 A7 00 00 00 00 00 C8 34 28 C8 66 BB 40 54 74 7A 0E 6A 97
E7 F3 F0 B9 0C BA 87 E7 A0 79 D9
Start of Message - Hi All. This message was sent through F-Bus.

Byte: 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
Data: 4D 07 D1 D1 F2 77 FD 8C 06 19 5B C2 FA DC 05 1A BE DF EC 50 08 01 43 00
7A 52
F-Bus Frame Header
Byte 0: F-Bus Frame ID. We are on Cable (0x1E).
Byte 1: Destination address.
Byte 2: Source address.
Byte 3: Message Type or 'command'. 0x02 (SMS Handling).
Byte 4 & 5: Message length. In our case it is 0x0059 bytes long or 89 bytes in decimal.

(SMS) Short Message Service Frame Header
Byte 6 to 8: Start of the SMS Frame Header. 0x00, 0x01, 0x00
Byte 9 to 11: 0x01, 0x02, 0x00 = Send SMS Message

(SMSC) Short Message Service Centre (12 Bytes)
Byte 12: SMS Centre number length. 0x07 is 7 bytes long. This includes SMSC Number
Type and SMS Centre Phone Number
Byte 13: SMSC number type e.g. 0x81-unknown 0x91-international 0xa1-national

1XXX IIII: Where I is the Numbering-plan-identification
1TTT XXXX: Where T is the Type-of-number
Byte 14 to 23: (Octet format) SMS Centre Phone Number for example +61 411990010
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(TPDU) Transfer Protocol Data Unit

Byte 24: Message Type

XXXX XXX1 = SMS Submit - The short message is transmitted from the Mobile Station (MS) to the Service Centre (SC).

XXXX XXX0 = SMS Deliver - The short message is transmitted from the SC to the MS.

(Refer to GSM 03.40 - 9.2.3 Definition of the TPDU parameters) In our case it is 0x15 = 0001 0101 in binary. The message is SMS Submit, Reject Duplicates, and Validity Indicator present.

Byte 25: Message Reference if SMS Deliver & Validity Indicator used (Not used in this case).

Byte 26: Protocol ID.

Byte 27: Data Coding Scheme.

Byte 28: Message Size is 0x33 in hex or 51 bytes long in decimal. This is the size of the unpacked message.

Destination's Phone Number (12 Bytes)

Byte 29: Destination's number length. Is this correct?

Byte 30: Number type e.g. 0x81-unknown 0x91-international 0xa1-national

Byte 31 to 40: (Octet format) Destination's Phone Number

Validity Period (VP)

Byte 41: Validity-Period Code. Time period during which the originator considers the short message to be valid.

Byte 42 to 47: Service Centre Time Stamp. For SMS-Deliver.

The SMS Message (SMS-SUBMIT)

Byte 48 to 92: This is the SMS message packed into 7 bit characters. SMS Point-to-Point Character Packing

Byte 93: Always 0x00
The F-Bus usual ending
Byte 94: Packet Sequence Number
Byte 95: Padding Byte - String is odd and requires to be even!
Byte 96 & 97: Odd & even checksum bytes.

If the phone receives a valid frame it should reply with something like this below, to say it got the message.
Reply frame sent from my Nokia 3310 (showed as a Hex dump)
Byte: 00 01 02 03 04 05 06 07 08 09
Data: 1E 0C 00 7F 00 02 02 03 1C 72

This is just like the above Acknowledge command frame. The destination and source addresses are swapped, as this is a frame from the phone to the microcontroller. This message is two bytes long with the first byte representing the message type received (0x02) and the next byte, the sequence number (0x03). The last two bytes are the checksum and should be checked to make sure the data is correct.

After a short time the phone will reply with a 'Message sent' frame shown below.

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17
Data: 1E 0C 00 02 00 09 01 08 00 02 64 12 00 01 44 00 3F 1E
Byte 03: Message Type = 0x02 - SMS Handing
Byte 04 & 05: Message Length = 0x0009 - 9 Bytes long
Byte 09: 0x02 = Message Sent
Byte 10 to 14: N/A

The Microcontroller must then acknowledge the frame.

Byte: 00 01 02 03 04 05 06 07 08 09
Data: 1E 00 0C 7F 00 02 02 04 10 79
5.4 Receiving SMS message

The following frame should be sent from the microcontroller to Nokia phone.

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 4A 5C
Data: 1E 0C 00 02 00 59 01 08 00 10 02 10 00 07 91 16 14 91 09 10 F0 00 10 19 38 04 00 00 33 0B 91 16 04 73 08 70 F4 70 40 32 25 30 30 82 22 74 45 4C 25 30 30 82 22 74 45 4C 74 7A 0E 6A 97 E7 F3 F0 B9 0C BA 87 E7 A0 79 D9
Byte 03: Message Type = 0x02 - SMS Handing
Byte 04 & 05: Message Length = 0x0059 - 89 Bytes long
Byte 09: 0x10 = SMS Message received
Byte 10: 0x02 = Memory Type = SIM
Byte 11: 0x10 = Location where SMS message stored - required to delete SMS message

(TPDU) Transfer Protocol Data Unit
Byte 24: 0x38
Byte 25: 0x04
Byte 26: Protocol ID
Byte 27: Data Coding Scheme
Byte 28: Message Length. 0x33 = 51 Bytes long.
The microcontroller must then acknowledge this frame like normal.

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Data: 1E 00 0C 14 00 08 00 01 00 0A 02 02 01 41 11 54

5.5 Deleting Message from the Phone

When the phone gets sent a SMS message it sends a 'SMS Message Received Frame' with the message attached. In this frame is the location where the message is stored. All we have to do is tell the phone to delete it.

Byte: 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Data: 1E 00 0C 14 00 08 00 01 00 0A 02 02 01 41 11 54

Byte 03: Message Type = 0x14 - SMS Functions
Byte 04 & 05: Message Length = 0x0008 - 08 Bytes long
Byte 6 to 8: Start of the SMS Frame Header. 0x00, 0x01, 0x00
Byte 9: 0x0A Delete SMS Message
Byte 10: 0x02 = Memory Type = SIM - Make sure message is store in this type (0x03 = phone)
Byte 11: 0x02 = Location where SMS message stored. This location can be found in the 'receive SMS frame' (Byte 11)
Byte 12: 0x01
Byte 13: Packet Sequence Number
Byte 14 & 15: Odd & even checksum bytes.
5.6 ALGORITHM

Step 1: Start
Step 2: Phone initialization
Step 3: Get Hardware Software
Step 4: Poll SMS from mobile phone
Step 5: If new SMS received go to step3 else, go to step1
Step 6: Receive SMS
Step 7: Check SMS pattern
Step 8: Control the device based on status
Step 9: Notify end user
Step 10: Go to step1
5.7 Flowchart

Fig 5.7 – Program Flow Chart
CHAPTER 6
RECOMMENDATIONS, CONCLUSIONS AND FUTURE ENHANCEMENTS
6.0 Recommendation

This project is a small implication of our concept in automating and monitoring a system. The practical applications of this project are immense and can have vast level of implementation. This small concept can be used in fields such as weather forecasting, remote sensing, robotics, aeronautics, home automation, and many other related fields where continuous monitoring and regulation is needed. So this is not the end of the project but rather is a step towards exploring other possibilities that it brings with it. We feel very happy to work in such a challenging project which has tremendous application and possibilities.

We recommend our brothers and sisters to work in such field, which actually gives a lot of satisfaction while working. The project work in the fact gives a lot of confidence to fight out in this challenging world. As one proceeds one can not believe how much knowledge he/she gains and the teamwork, which the project work teaches, really will have a new experience.

6.1 Future Improvements

The future implications of the project are very great considering the amount of time and resources it saves.

The project we have undertaken can be used as a reference or as a base for realizing a scheme to be implemented in other projects of greater level such as weather forecasting, temperature updates, device synchronization, etc.

The project itself can be modified to achieve a complete Home Automation System which will then create a platform for the user to interface between himself and his household.
GSM Based Control System

6.2 Problems Faced

Initially we had problems connecting the mobile phone with the computer. Since we didn’t have an internal modem in our mobile phone set (Nokia 3310). We also faced difficulty in setting baud rate at 115200 bauds. Also we had problems regarding receiving and storing acknowledgement from the mobile phone.

Other problems we faced was retrieving the received SMS message from the phone itself. We had little and insufficient protocol information regarding our mobile phone and so we weren’t able to re-transmit status message from the device to the phone.

6.3 Conclusion

The project we have undertaken has helped us gain a better perspective on various aspects related to our course of study as well as practical knowledge of electronic equipments and communication. We became familiar with software analysis, designing, implementation, testing and maintenance concerned with our project.

The extensive capabilities of this system are what make it so interesting. From the convenience of a simple cell phone, a user is able to control and monitor virtually any electrical devices. This makes it possible for users to rest assured that their belongings are secure and that the television and other electrical appliances was not left running when they left the house to just list a few of the many uses of this system.

The end product will have a simplistic design making it easy for users to interact with. This will be essential because of the wide range of technical knowledge that homeowners have.
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