

# **Chapter one**

## **INTRODUCTION**

### **1.1Background**

Building Automation System (BAS) describes the advanced functionality provided by the control system of a building. BAS is an example of a Distributed Control System (DCS). The control system is a computerized, intelligent network of electronic devices designed to monitor and control the mechanical, electronic and Electrical system in building .

A building controlled by a BAS is often referred to as an intelligent building or a smart home. A home automation system should at least be able to control Heating, Ventilation, Air Conditioning (HVAC) and lighting. In addition to that, it should collect sensor data, for example the temperature, for further processing or displaying. Some systems also support multimedia, health care and security applications. A home automation system enables the user to conveniently control his home via a user interface. This user interface can be a terminal, a personal computer, a remote control or, as discussed later, a mobile device. It is also possible that some processes of everyday life, for example the opening and closing of the window blinds, are automated. In most cases the system contains a central unit like a computer, a server or terminal to which all other units are connected.

For communication between the individual parts of a home automation system a variety of different technologies is used, as there is not yet an established standard. Wireless as well as wired solutions are applied. The wired systems are mainly bus systems. Though sometimes power line networking. In the following, some common as Wi-Fi and Bluetooth and some promising such as ZigBee, Z-Wave and 6LoWPAN wireless technologies will be presented.

### **1.2 Problem Statement**

It has been known that satisfying comfort with optimum energy consumption are the main factors that drive the design of new approach in controlling lighting and (HVAC) systems. Despite the advancement made in microprocessor, and later PC technologies, HVAC and lighting system operation in commercial and industrial

building is still an inefficient and high energy consumption process. Classical control technique used for these systems such as ON/OFF controller and the conventional Proportional-Integral-Derivative (PID) controllers are still very popular because of their low cost. However, in the long run, these controllers are expensive because they operate at very low energy efficiency levels. As mobile devices continue to grow in popularity and functionality, the demand for advanced ubiquitous mobile applications in our daily lives also increases. Designing a home automation system for monitoring and controlling various devices in remote locations is required.

### **1.3 Objectives:**

The main objectives of this study are to:

- Design a microcontroller control circuit, embedded with wireless technology to monitor the home devices easily.
- Simulate the system so as improve performance hardware to be implemented and tested.
- Implement and test the proposed system.

### **1.4 Methodology**

The study has been done in four phases namely, review of literature, design, implementation and testing.

**a) Literature review** – in this phase, collection of previews and current Information related to this thesis is carried out. Those materials are mostly Obtained from different books, internet, articles, and journals. The Collected materials are studied and reviewed so that this thesis can provide new solution to an identified problem that is not addressed in the previous works. The literature review is discussed in detail in Chapter two.

**b) Design** – this phase of the thesis work is divided into two parts: Hardware and software designs. The hardware design involves the Structuring, fabrication and installation of hardware components of the proposed system . The software design involves the design of the Lighting, security cooling Systems using microcontroller.

This also involves the configuration of the software used to run on the controller hardware.

**c) Implementation** – this part of the thesis work involves the Implementation of the hardware and software designs. The microcontroller atmega8 hardware, was interfaced with the controlled

**d) Testing** – This is the final phase of the thesis work involving the testing of the developed controller. The performance of the proposed system is finally observed whether it passes or not through critical examination of the experimental results. Whenever necessary the microcontroller is returned to obtain the better performance.

## **1.5 Layout**

This thesis is organized into six chapters. Chapter one contains the study problem statement, significance, thesis objectives and methodology. Chapter two contains literature survey on issues related to the HAS in general and Global System for Mobile Communication (GSM). This chapter also illustrates GSM techniques to design an intelligent home also briefly discussed here. The proposed system is discussed in chapter three. The detail of the prototype components and the implementation of the control strategy covering the hardware. Chapter four presents the software consideration. System implementation, experimental results and software testing are discussed in chapter five. Finally the conclusion of this thesis and some recommendation for future work are highlighted in chapter six.

## **Chapter Two**

### **Theoretical Background and Literature Review**

#### **2.1 Introduction**

Home automation system is the residential extension of "automation". It is automation of the home, housework or household activity. Home automation may include centralized control of lighting, may include centralized control of lighting, HVAC, appliances, and other systems, to provide improved convenience, Comfort, energy efficiency and security.

Home automation refers to the use of computer and information technology to control home appliances and features (such as windows or lighting). Systems can range from simple remote control of lighting through to complex computer/micro-controller based networks with varying degrees of intelligence and automation. Home automation is adopted for reasons of increasing comfort, security and intelligence of the system. Be-sides building automation, like controlling lights, it includes multi-media functionality, automation of recurring patterns, alarm functions, etc.

The ultimate goal of a home automation system is to make life more convenient. Traditional home automation systems typically consist of multiple hardware modules (i.e, inputs and outputs) that are controlled by a dedicated hardware controller. The controller receives input signals from the input modules and reacts by sending outputs to the output modules.

#### **2.2 Literature Review**

Concepts for home and building automation were around for decades before becoming reality and featured in the writing of the 19th century sci-fi author HG Wells, comics, and cartoons such as the Jetsons. American industrialist George Westinghouse helped to pioneer the AC (Alternating Current) electrical system – which the X10 home automation standard would later run over – and in 1966, the company that bears his name, Westinghouse Electric, employed an engineer who developed what could arguably be called the first computerized home automation

system – the ECHO IV. [Raspberry Pi Home Automation with Arduino, February 2013].

The Electronic Computing Home Operator (ECHO) was featured in the April 1968 edition of Popular Mechanics and had been expanded from a set of spare electronics - both in the physical and literal sense, to include computing its founder Jim Sutherland's family household finances and storing their shopping lists, amongst an array of other tasks. [Raspberry Pi Home Automation with Arduino, February 2013].

Throughout the 1960s and 1970s, pneumatic control systems are still in place in a majority of existing buildings, especially in established metropolitan areas. Analog electronic control devices became popular throughout the 1980s. They provided faster response and higher precision than pneumatics. However, it was not until digital control or DDC devices came on the scene in the 1990s that a true automation system was possible. However, as there were no established standards for this digital communication, various manufacturers, created their own (proprietary) communication methods.

In 1988, the term domotics was coined. “Domotics is the application of computer and robot technologies to domestic appliances. It is a portmanteau word formed from domus (Latin, meaning house) and robotics. A modern definition of Domotics could be the interaction of technologies and services applied to different buildings with the purpose of increasing security, comfort, communications and energy savings. Lately, it is being proved that Domotics has many interesting fields, and among them using remote-Controlled HASs to control the home network is one of the most challenging. The possibility of having ubiquitous access to many devices within a building at any time, from anywhere, resolves many of the problems that users often face when they return home, saving a significant amount of time. It also notably increases the security in any kind of building and it may even provide a backup control system for local system breakdowns. This ubiquitous access could be achieved from many different digital devices and it is known that the network hierarchy has been rapidly moving lower in the chain

towards smaller and more personal devices. Considering latest tendencies, everything points at prompt remote control standardization in home networks.

By the late 1990s and especially into the 2000s, movements were afoot to standardize on “open” communication systems. The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) developed the BACnet communication protocol that eventually became the industry open standard.

[<http://en.wikipedia.org/wiki/>,7 February 2013].

## 2.3 Home Automation elements

As shown in figure (2.1) elements of a home automation system include:

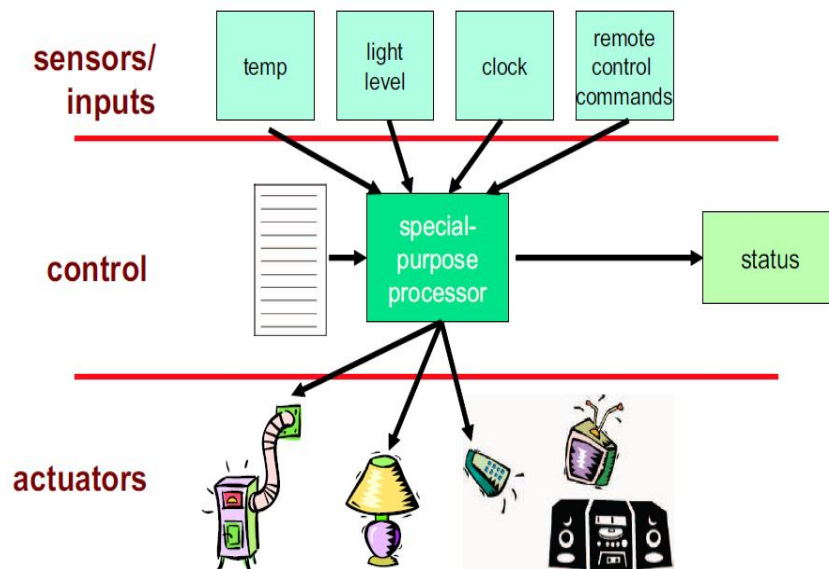


Figure (2.1) Home Automation elements

### 2.3.1 Sensors:

Sensor is a device which senses a variable that may be other than the controlled variable and over rides the main sensor. A sensing element provides a controller with information concerning changing conditions.

Analog sensors are used to monitor continuously changing conditions such as temperature or pressure. The analog sensor provides the controller with a varying signal such as 0 to 10V. A digital (two-position) sensor is used if the conditions represent affixed state such as a pump that is ON or OFF.

The digital sensor provides the controller with a discrete signal such as open or closed contacts. Some electronic sensors use an inherent attribute of their material (e.g., wire resistance) to provide a signal and can be directly connected to the electronic controller. Other sensors require conversion of the sensor signal to a type or level that can be used by the electronic controller. For example, a sensor that detects pressure requires a transducer or transmitter to convert the pressure signal to a voltage or current signal usable by the electronic controller. Example of building automation system Devices:

*\*Surveillance systems* (Surveillance camera, Recognition device).

*Motion detection device* (Intrusion detection, Window systems, detection device, Door monitoring device, Perimeter detection device).

*\*Fire Detection and alarm Systems* (Smoke detector device, Heat detector device, Duct smoke detector device, Flame detector device, Fire-Gas detector device, Pull Station device, Monitoring device, Notification device (audible, visible, Intelligent)).

*\*Environment control systems* (HVAC control device, Thermostat control device, Lighting control device).

*\*Special systems* (Nurse Call, RFID Tracking, Public address (PA) system).

The automation of a building requires a huge number of cables that highly increase the installation costs. At the physical level, wireless plays an important role towards flexibility and self configuration in building automation. With the use of wireless technologies it is expected to reduce total costs of ownership and maintenance in new building automation systems. Wireless systems could easily provide old buildings with relatively low cost, automation functionalities.

The emerging technology of wireless sensors promises to enhance better monitoring in and around buildings. Wireless data communication between the sensor and a viewing or storage location opens up a range of possibilities, not only because of the ease and the low cost of sensors deployment, but also due to the true self-reconfiguration of a system without any rewiring that becomes possible as never did before. Wireless sensors can provide more information about the conditions within and around the building for security agents.

Using a variety of sensors in the environment of the building allows leverage a wide range of parameters interest to engineers, researchers, investigators or maintenance personnel. The most significant are such as temperature, relative humidity, light, carbon dioxide, carbon monoxide, energy consumption (power), smoking, occupation and flow rate.

### **2.3.2 Controllers**

Controllers are essentially small, purpose-built computers with input and output capabilities. These controllers come in a range of sizes and capabilities to control devices commonly found in buildings, and to control sub-networks of controllers.

Inputs allow a controller to read temperatures, humidity, pressure, current flow, air flow, and other essential factors. The outputs allow the controller to send command and control signals to slave devices, and to other parts of the system. Inputs and outputs can be either digital or analog. Digital outputs are also sometimes called discrete depending on manufacturer.

These controllers' measure signals from sensors, perform control routines in software programs, and take corrective action in the form of output signals to actuators. Since the programs are in digital form, the controllers perform what is known as direct digital control (DDC).

Home automation systems work by managing the electric power of the equipment being automatically controlled. The degree of 'intelligence' and how it is distributed between the elements of the home automation system varies with the design and with the manufacturer.

Controllers used for building automation can be grouped in 3 categories. Programmable Logic Controllers (PLCs), System/Network controllers, and Terminal Unit controllers. However an additional device can also exist in order to integrate 3rd party systems (i.e. a stand-alone AC system) into a central Building automation system).

PLC's provide the most responsiveness and processing power, but at a unit cost typically 2 to 3 times that of a System/Network controller intended for BAS applications. Terminal Unit controllers are usually the least expensive and least



powerful. PLC's may be used to automate high-end applications such as clean rooms or hospitals where the cost of the controllers is less of a concern. In office buildings, supermarkets, malls, and other common automated buildings the systems will use System/Network controllers rather than PLC's. Most System controllers provide general purpose feedback loops, as well as digital circuits, but lack the millisecond response time that PLC's provide.

System/Network controllers may be applied to control one or more mechanical systems such as an Air Handler Unit (AHU), boiler, chiller, etc., or they may supervise a sub-network of controllers.

Terminal Unit controllers usually are suited for control of lighting and/or simpler devices such as a package rooftop unit, heat pump, VAV box, or fan coil, etc. The installer typically selects one of the available pre-programmed personalities best suited to the device to be controlled, and does not have to create new control logic such as microcontroller.

A microcontroller is an inexpensive single chip computer. Single chip computer means that the entire computer system lie within the confines of the integrated circuit chip. The microcontroller on a small square of silicon has features smaller than those of our standard personal computer. Primary, the microcontroller is capable of storing and running a program.

The microcontroller contains a Central Processing Unit (CPU), Random Access Memory (RAM), Read Only Memory (ROM), input/output (I/O) lines, serial and parallel ports, timers, and sometimes other built-in peripherals such as analog-to-digital (A/D) and digital to analog (D/A) converters.

Microcontroller's ability to store and run unique programs makes it extremely versatile. Microcontrollers add a lot of power, control, and options at a little cost. It therefore becomes essential that the electronics engineer or hobbyist learn to program these microcontrollers to maintain a level of competence and to gain the advantages microcontrollers provide in his or her own circuit designs either determined by the requirements.

Microcontrollers are designed to be used for small or dedicated applications.

The Suitable programming Languages are: JAVA, C++ , C, Assembly and BASCOM languages.

### **2.3.3 Actuators:**

An actuator is a device that converts electric or pneumatic energy into a rotary or linear action. An actuator creates a change in the controlled variable by operating a variety of final control devices such as valves and dampers.

In general, pneumatic actuators provide proportioning or modulating action, which means they can hold any position in their stroke as a function of the pressure of the air delivered to them. Two-position or on/off action requires relays to switch from zero air pressure to full air pressure to the actuator. Electric control actuators are two-position, floating, or proportional (refer to CONTROL MODES). Electronic actuators are proportional electric control actuators that require an electronic input. Electric actuators are bidirectional, which means they rotate one way to open the valve or damper, and the other way to close the valve or damper. Some electric actuators require power for each direction of travel. Pneumatic and some electric actuators are powered in one direction and store energy in a spring for return travel. Actuator is a device used to position control devices. Actuators consist of valve/damper actuators, , relays, motor , contactors, limit switch and others.

Control valve: A device used to control the flow of fluids such as steam or water.

Motors: Electric actuators consist of an electric motor coupled to a gear train and output shaft. In some actuators the motor is electrically reversible by the controller.

Relay: A device consisting of a solenoid coil which operates load-carrying switching contacts when the coil is energized. Relays can have single or multiple contacts.

Damper: A device used to control the flow of air in a duct or through a wall louver. They are powered by low or line voltage, depending on the circuit requirements.

## 2.4 Home Automation System Networks

There have been many attempts to standardize the forms of hardware, electronic and communication interfaces needed to construct a home automation system. Some standards use additional communication and control wiring, some embed signals in the existing power circuit of the house, some use radio frequency (RF) signals, and some use a combination of several methods. Control wiring is hardest to retrofit into an existing house. Some appliances include a USB port that is used for control and connection to a domotics network. Protocol bridges translate information from one standard to another, e.g., from X10 to European Installation Bus.

Home monitoring system uses the RF technology to monitor the status and control the electric device. The system has been developed to save energy. The system is implemented using modules which are capable of communicating with each other. Some of the home automation control system has used internet and wireless technology to communicate and control the appliances. Others have used the Bluetooth or GSM technology to send the command for controlling the home appliances. The Internet, which is seen as a data highway that connects millions of computers into a single large network, is now extending to smaller computerized technical equipment. This trend is one part of increasing machine-to machine (M2M) communication. An enormous number of microprocessors are at work in intelligent devices worldwide, which could be linked to the Internet, and many of them are located in buildings, and serve a part of the building systems. For instance, various control devices such as building and home automation systems, security and fire alarm equipment, water, energy and electric meters, and heating, ventilating and air-conditioning (HVAC) systems often operate as stand-alone systems, without any connection to the outside world. If these systems could be connected to the Internet, the controlling and monitoring of their operations would be radically changed. A prerequisite to the industry is that all this connection must be done at low cost.

Remote control via the Internet is not a new feature in building or HAS. It has

already been utilized commercially for years. In hierarchical automation systems consisting of different buses for field automation, and management, the natural access to the Internet is via the upper level bus, which is usually a Local Area Network (LAN). While in small systems the access takes place directly from the field bus (lowest level bus). Innovative communication technology in buildings, and especially in homes, involves a lot of new technology and has brought the Internet closer to the user and his/her everyday life. In offices, the Wireless Local Area Network (WLAN) has become a competitive choice in networking and offers fast connection to the Internet. Most of these options provide at least one standard home or building automation bus for interfacing to new equipment. However, although technically feasible, these alternatives are currently too expensive for linking a single device to the Internet. Adding a new piece of equipment to an existing home network may be an economical decision, but setting up a totally new network or home bus for only one domestic appliance is currently prohibitively expensive.

Cell phones are very common these days and almost everyone can make a call very easily. That's why cell phone is used in this system that makes it real world application. It is free from the geographical boundaries and can be used from anywhere where GSM is available. The proposed solution is to implement the HACS through voice command that controls the home appliances by making a call from the preconfigured number to system and receive the voice message from the system to preconfigured number about the status of appliances over the GSM network. AT commands are used to automatically receive the call on system from the preconfigured number and system also sends the voice message to preconfigured number about the status of appliances and intrusion through AT commands.

## **2.5 Global system for mobile communication (GSM):**

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system

operating at 900 MHz It is estimated that many countries outside of Europe will join the GSM partnership. One of the most popular GSM services is the Short Message Service (SMS).[ MOBILE MESSAGING TECHNOLOGIES AND SERVICES SMS, EMS and MMS, 2<sup>nd</sup> edition ].

### 2.5.1 GSM Architecture

Main components of GSM as shown in figure (2.3) are :

- The mobile station (MS)
- BSS Base Station Subsystem (BTS+BSC)
- MSS Mobile Station Subsystem (MSC/HLR...)

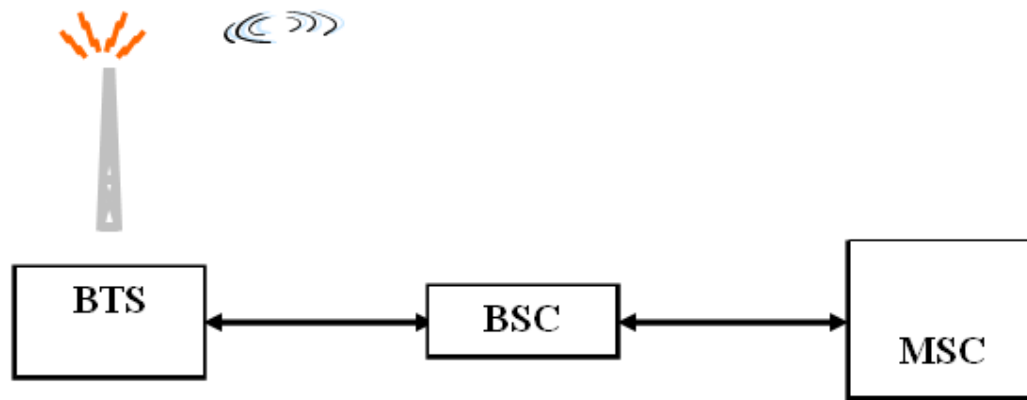


Figure (2.2) GSM Architecture

### 2.5.2 GSM Modem

Global System for Mobile Communications (GSM) modems are specialized types of modems that operate over subscription based wireless networks, similar to a mobile phone. A GSM modem accepts a Subscriber Identity Module (SIM) card, and basically acts like a mobile phone for a computer. Such a modem can even be dedicated mobile phone that the computer uses for GSM network capabilities.

Traditional modems are attached to computers to allow dial-up connections to other computer systems. A GSM modem operates in a similar fashion, except that it sends and receives data through radio waves rather than a telephone line. This type of modem may be an external device connected via a Universal Serial Bus

(USB) cable or a serial cable. More commonly, however, it is a small device that plugs directly into the USB port or card slot on a computer or laptop.

A GSM modem is a generic communication device just like its wired ancestors, but since the service is subscription-based, it must have a SIM card installed. This card connects the modem to the proper provider and identifies the user of the device to the carrier network. In this way, the GSM modem operates just like a cellular phone; in fact, many cellular phones also use SIM cards for the same purpose. Since the SIM card actually contains all the subscription, membership, and user data, these cards are usually interchangeable between GSM modems and GSM cell phone.

Some GSM Modems also has GPRS feature that allows transmission of data over TCP/IP (internet). To transmit data using GSM Modem, there are various methods that can be used ,such as:

SMS

CSD or HSCSD

GPRS / UMTS

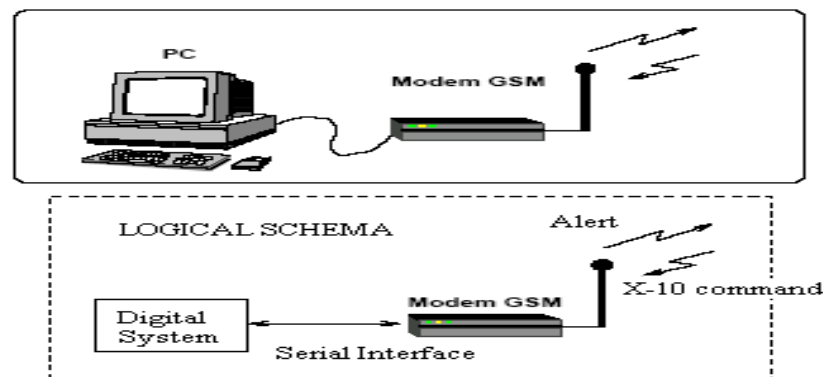


Figure (2.3) GSM modem connection

### 2.5.3 HAS Based GSM

As the integrated circuits and microprocessors become more and more accessible and the Internet communication is a fact of today with the improved availability of cellular networks, these advancements naturally should find use in modern home

automation systems. These systems provide the consumers increased security and safety, economic benefits and convenience by giving them control over all the appliances in the house.

Designing a home automation system for monitoring and controlling various devices in remote locations can be done through a variety of communication options such as wireless LAN technologies, dial-up modems, private radio networks, satellite communication, Internet, cellular network and so on. Example of a Machine-to-Machine (M2M) system using Global System for Mobile Communication (GSM) cellular communication network for remote controlling .The real time monitoring has been an important feature that can be used in the home automation systems. As a change in the status of the devices occurs, the user can be informed in real time. Thus, our main objective for using GSM network for the communication between the home and the user is its wide spread coverage which makes the whole system online for almost all the time. Another advantage of using the GSM network in home automation is its high security infrastructure which provides maximum reliability so that the information sent or received cannot be monitored by an eavesdropper.

A GSM modem is connected to the home automation server. The communication between the home automation server and the GSM modem is carried out by the Attention (AT) commands. Sending and receiving SMS messages are all performed in the Protocol Description Unit (PDU) mode since the text mode may not be available on all GSM modules.

For the mobile part, interactive software has been developed. This software can be used in any mobile phone that supports Java. By using this software, the user can interact with the house simply by choosing the right commands from the menus.

## **2.6 Attention Command (AT)**

The AT command set is a command language with a series of short text strings, which combine together to output complete commands for different operations such as hanging up, dialing and changing connection parameters for modems. A majority of personal computer modems follow the AT command set specifications.

AT commands are instructions used to control a modem. AT is the abbreviation of Attention. Every command line starts with "AT" or "at". That's why modem commands are called AT commands. There are two types of AT commands:

i- Basic commands are AT commands that do not start with a "+".

For example: D (Dial), A (Answer) , H (Hook control , and O (Return to online data state) are the basic commands.

ii- Extended commands are AT commands that start with a "+". All GSM AT commands are extended commands.

For example: +CMGS (Send SMS message), +CMGL (List SMS messages, and +CMGR (Read SMS messages) are extended commands as shown in table (2.1).

Command	Description
AT	Check if serial interface and GSM modem is working.
ATE0	Turn echo off, less traffic on serial line.
AT+CNMI	Display of new incoming SMS.
AT+CPMS	Selection of SMS memory.
AT+CMGF	SMS string format, how they are compressed.
AT+CMGR	Read new message from a given memory location.
AT+CMGS	Send message to a given recipient.
AT+CMGD	Delete message.

Table (2.1) AT-Command set overview

## 2.7 Benefits of Home Automation

As already referred, home automation can offer many benefits. In this section some examples will be presented that illustrate how home automation can be used to better manage consumption of energy and other resources. Several measures can be taken in order to reduce consumption, reduce the cost of energy and achieve a better balance between expenditure and comfort.

As a first example, consider home lighting. This can account for a significant part of the electric bill, particularly if common lamps are used instead of high



efficiency ones. With home automation it is easy to monitor which lights are on and turn them off in places that became vacant.

Regarding outside lighting (important, for example, in a detached house), time programming can be used in conjunction with intensity monitoring and presence detection, to provide a good functionality and also increased security.

The measures described can contribute to significant savings while keeping adequate levels of comfort. Heating and cooling is, typically, one of the areas with more impact in energy consumption. In this domain, home automation can also offer many benefits as it can perform an intelligent control taking into account the required comfort levels, which rooms are occupied and vacant, outside weather conditions and hour of the day.

As an example, let's consider a winter situation and a home that needs to be heated. A common heating system allows the users to define set points for different rooms and little else. With home automation, and an adequate control algorithm, many more possibilities exist the system can behave differently according to the type of room and hour of the day. For example, in the bedroom the system may assure the required temperature some time before wake time, to allow people to get out of bed in an agreeable environment. After people leave the bedroom, the temperature can be allowed to drop significantly. This situation can be maintained until time to go to bed approaches. During the night, the temperature can be reduced a bit while people are sleeping.

In a child's bedroom the behavior would be different and take into consideration arrival time from school and periods dedicated to playing and studying. In the case of the living room, the temperature could drop significantly when people are out working and during the night when people are sleeping. The examples given can be extrapolated to other rooms in the house and enhanced with other factors, allowing adequate levels of comfort and significant savings.

Home automation can also manage other sources of energy, such as solar water heaters, that can be used to pre-heat the water before it enters a gas or oil-fired heater. In terms of cooling, home automation can be used to control air conditioners in a smart way .Other area where a home automation system can help

reduce the energy bill relates to the ability to program the working times of appliances such as washing machines and dishwashers, allowing taking advantage of electricity lower rates during "off-peak" hours.

## Chapter Three

### SYSTEM DESIGN

#### 3.1 System Description:

GSM based home automation system is an electrical and communication system designed to control home appliances using cell-phone and GSM modem. In this study, the GSM network represents the link over which digital data are transmitted or received from the far end control unit (the mobile phone) to the end user application (GSM module + micro Controller +general purposes input/output module + actuators ). Figure (3.1) shows the proposed system.

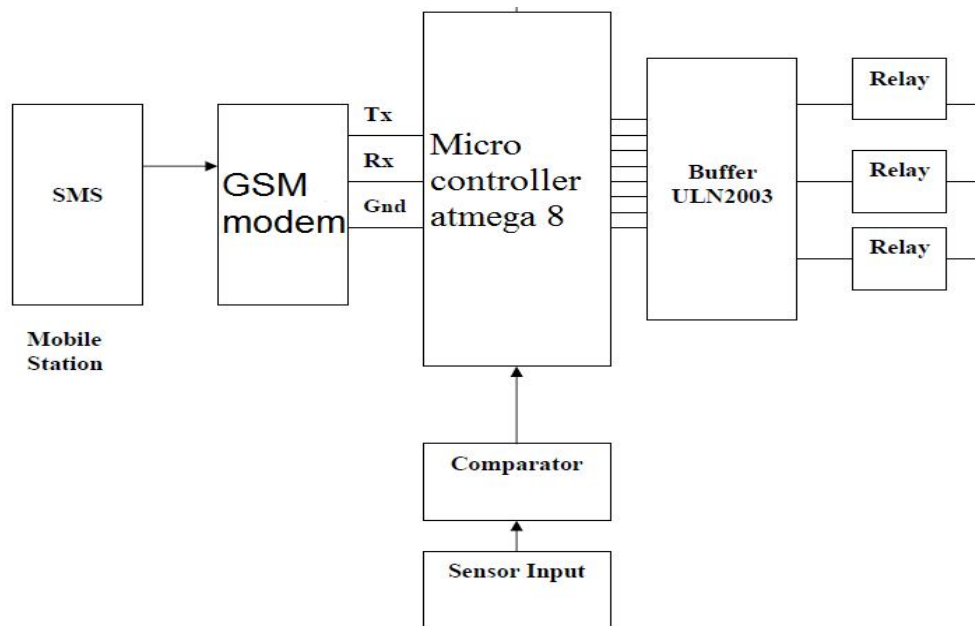


Figure (3.1) System block diagram

Refer to Figure(3.1) , 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 received SMS message is stored in the SIM memory in GSM modem 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 led used to indicate the status of the operation performed by the microcontroller . The input from different sensors ( switches) are feed to micro controller and processed to operate respective task semi autonomously and autonomously.

### 3.2 System Operation Flow Diagram

Figure(3.2) shows the flow diagram of system operation. 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.
- The feedback status is an essential building block of the home automation system. For example, if a motion is detected, this information is sent from the motion sensor directly to the home automation server. Then a warning SMS message is created and sent immediately to the registered GSM number in the system..

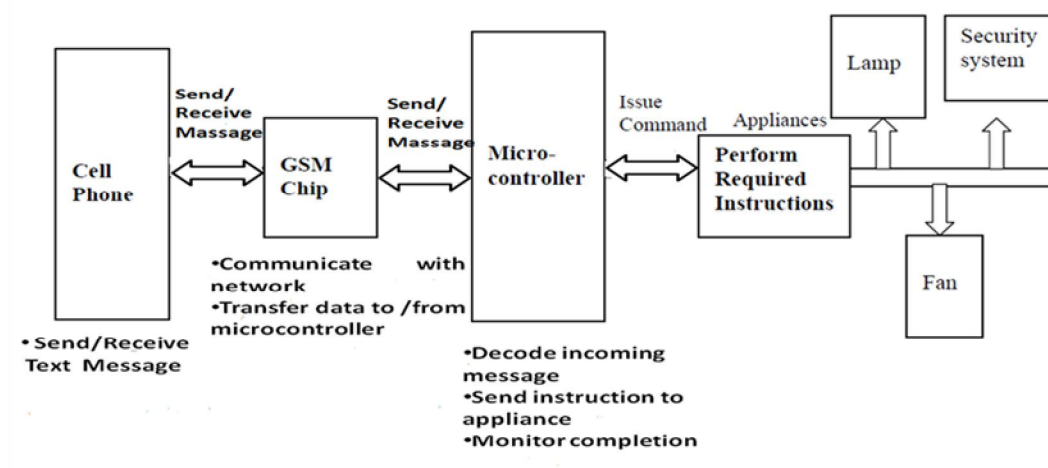


Figure (3.2)System Operation Flow Diagram

### 3.3 System Components

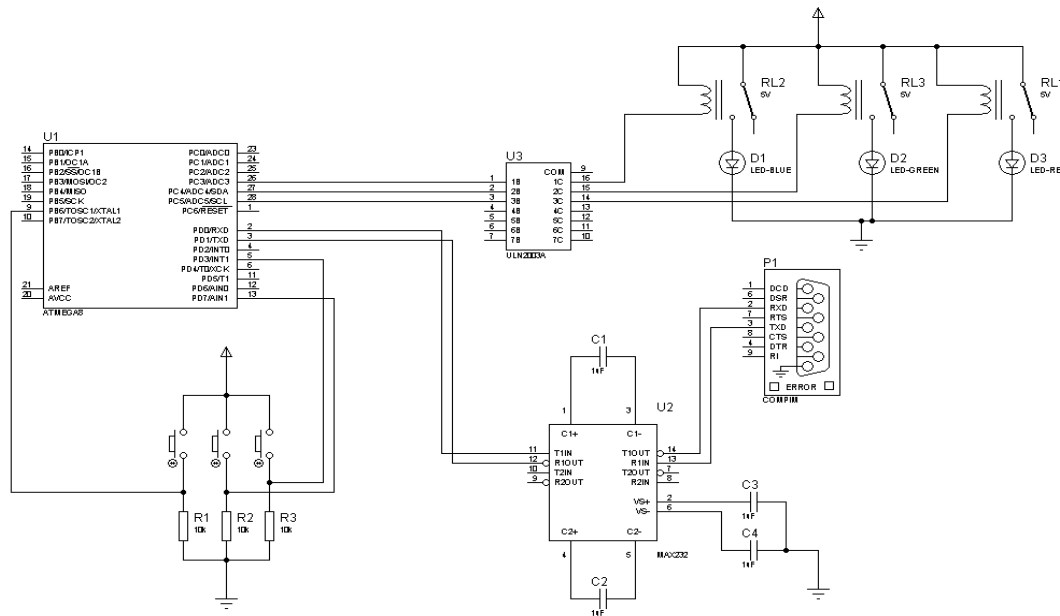


Figure (3.3) single line diagram of proposed system

#### 3.3.1 Atmel AVR microcontroller

The family of AVR microcontrollers includes differently equipped controllers - from a simple 8-pin microcontroller up to a high-end microcontroller with a large internal memory. The Harvard architecture addresses memories up to 8 MB directly. The register file is "dual mapped" and can be addressed as part of the on-chip SRAM, whereby fast context switches are possible. All AVR microcontrollers are based on Atmel's low-power nonvolatile CMOS technology. The on-chip in-system programmable (ISP), downloadable flash memory permits devices on the user's circuit board to be reprogrammed via SPI or with the help of a conventional programming device. By combining the efficient architecture with the downloadable flash memory on the same chip, the AVR microcontrollers represent an efficient approach to applications in the "Embedded Controller" .

In this study, atmega 8 is used. The Atmel AVR ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs

approaching 1MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed. It chosen based on the properties needed. The ATmega8 provides the following features:

8 Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1 Kbyte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next Interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. Pin Configurations shown below in fig(3.3):

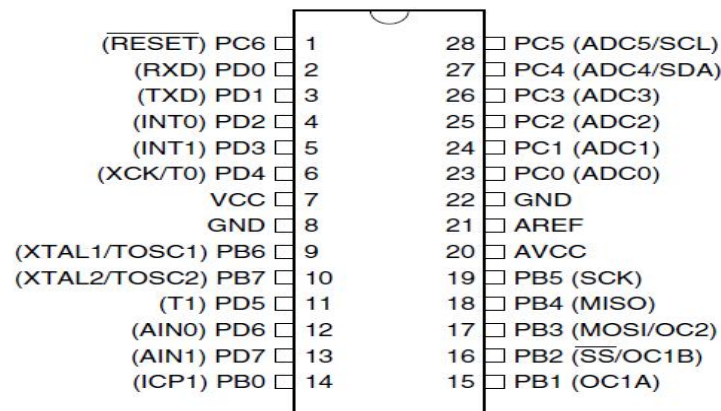


Figure (3.4)8-bit Atmel microcontroller

### 3.3.2 MAX 232:

The MAX232 as shown in figure (3.4) is an integrated circuit, first created by Maxim Integrated Products, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx.  $\pm 7.5$  V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as  $\pm 25$  V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V. The later MAX232A is backwards compatible with the original MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1  $\mu$ F in place of the 1.0  $\mu$ F capacitors used with the original device.

The newer MAX3232 is also backwards compatible, but operates at a broader voltage range, from 3 to 5.5 V.

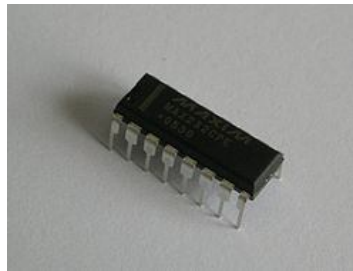


Figure (3.5) MAX 232

### 3.3.3 Relay driver IC ULN 2003

ULN 2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs (figure 3.6 shows the Darlington Pair) that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 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 2.7k $\Omega$  series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices. Figure 3.7 shows ULN2003 Logic Diagram

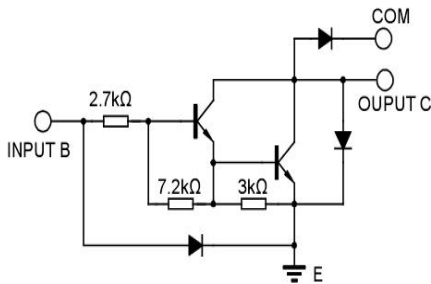


Figure (3.6): Schematic Diagram  
(Each Darlington Pair)

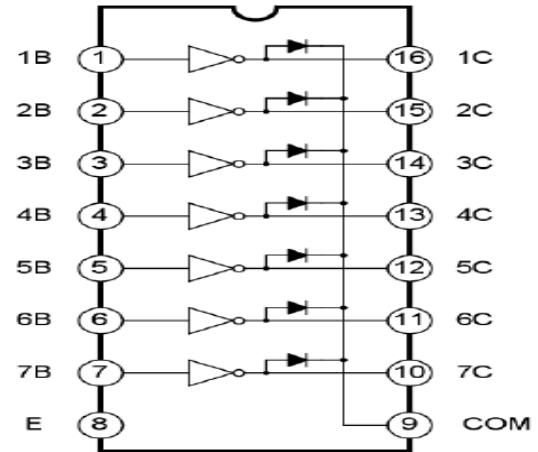


Figure (3.7) ULN2003 Logic Diagram

### 3.3.4 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(3.8) when the rated voltage is connected 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 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.

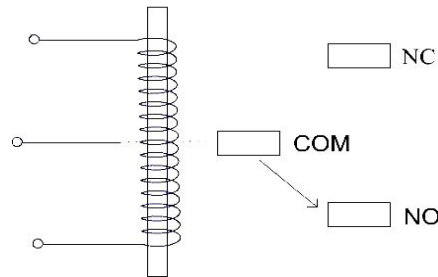


Figure (3.8) Relay

### 3.2.5 GSM Modem SIM900

This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem is to use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls. It can also be used in GPRS mode to connect to internet and do many applications for data logging and control. In GPRS mode also can connected to any remote FTP server and upload files for data logging.

This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications. Supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack figure (3.8) show the GSM modem Sim900.

#### Applications

- SMS based Remote Control and Alerts
- Security Applications

- Sensor Monitoring
- GPRS Mode Remote Data Logging

### **Features**

- Highly Reliable for 24x7 operation with Matched Antenna
- Status of Modem Indicated by LED
- Simple to Use and Low Cost
- Quad Band Modem supports all GSM operator SIM cards.



Figure (3.9) Sim900

# **Chapter Four**

## **SOFTWARE CONSIDERATION**

### **4.1 Introduction**

BASCOM is an Integrated Development Environment (IDE) that supports the 8051 family of microcontrollers and some derivatives as well as Atmel's AVR microcontrollers. Two products are available for the various microcontrollers - BASCOM-8051 and BASCOM-AVR.

BASCOM-AVR is not only a BASIC Compiler, but also a comfortable IDE running under Windows 95 and Windows NT. Such a development environment supports the whole process from coding and testing a program to programming the used microcontroller. In all cases where a distinction is necessary, a few changes only are required to make the program work with the other family of microcontrollers. This is one important advantage of high-level languages. Of importance is that BASCOM also supports the mixing of BASIC and Assembler.

### **4.2 Programming of Home Automation**

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

### **4.3 Software Programming**

In proposed system there are three sensors(switches) for heat (sw1) , motin ( sw2) , and smoke detector (sw3). In this study atmega 8 microcontroller is interfaced with SIM900 module modem to decode the received message and do the required action. The protocol used for the communication between the two is AT command. The microcontroller pulls the SMS received by phone, decodes it, recognizes the

Mobile number, and then switches ON/OFF the relays( relay1, relay2 relay3) attached to its port to control the appliances.

The programming code written in BASCOM:

```
$regfile "m8def.dat"
$crystal = 8000000
$baud = 9600
Config Portd.7 = Input
Config Portb.6 = Input
Config Portd.3 = Input
Config Portc = Output
Config Portb.0 = Output
Config Portb.1 = Output
Config Portb.2 = Output
Config Portb.3 = Output
Portb.3 = 1
Dim Y As String * 80 , I As Integer , J As Integer
Sw1 Alias Pind.7
Sw2 Alias Pinb.6
Sw3 Alias Pind.3

Relay1 Alias Portc.5
Relay2 Alias Portc.4
Relay3 Alias Portc.3

Dim Led As Byte

For Led = 1 To 10
Portb.3 = 0
Wait 1
Portb.3 = 1
```

```

Wait 1
Next
Portb.3 = 1
Dim li As Byte
Dim B As Byte
Dim Sret As String * 200
Dim Phone As String * 15
Dim W As Word
Dim S1 As String * 10
Dim S2 As String * 200
Dim Res As Long
Dim S As String * 200
Dim Jj As Byte

Dim X As Byte

Dim T As Byte
T = 0

Declare Sub Flushbuf()
Declare Sub Showsms(s As String )

Print "AT+CMGD=1"
Waitms 200
Print "ATE0"
Waitms 200

Print "AT"
Waitms 200
Print "AT+CMGF=1"
Waitms 200

```

```

Print "AT+CMGS=" ; Chr(34) ; "0127032880" ; Chr(34) ; Chr(13)
Waitms 200
Print "SYSTEM START" ; Chr(26)

Do

If Sw1 = 1 Then
Portb.0 = 1
Print "AT"
Waitms 200
Print "AT+CMGF=1"
Waitms 200
Print "AT+CMGS=" ; Chr(34) ; "0127032880" ; Chr(34) ; Chr(13)
Waitms 200
Print "FAN OPEN " ; Chr(26)
Wait 5

End If

If Sw2 = 1 Then
Portb.1 = 1
Print "AT"
Waitms 200
Print "AT+CMGF=1"
Waitms 200
Print "AT+CMGS=" ; Chr(34) ; "0127032880" ; Chr(34) ; Chr(13)
Waitms 200
Print "LIGHT ON " ; Chr(26)
Wait 5
End If

```

```

If Sw3 = 1 Then
Portb.2 = 1
Print "AT"
Waitms 200
Print "AT+CMGF=1"
Waitms 200
Print "AT+CMGS=" ; Chr(34) ; "0127032880" ; Chr(34) ; Chr(13)
Waitms 200
Print "SMOKE FOUND " ; Chr(26)
Wait 5
End If
'*****

Print "AT+CMGR=1" ; Chr(13)
Gosub Ss

Waitms 100

Ii = Instr(s, ":")

If Ii > 0 Then

Phone = Left(s, Ii)
Select Case Phone
Case "+CMGR:" : Showsms S

End Select
End If
Loop
'*****

Sub Showsms(s As String )
Portb.3 = 1

```

```

Wait 2
Portb.3 = 0
Ii = Ii + 6
Phone = Mid(s , Ii , 9)

Ii = 0
Ii = Ii + 67

Print "AT+CMGR=1" ; Chr(13)
Gosub Sss
S2 = Mid(s , 67 , 3)
Waitms 100
If S2 = "1:1" Then
Relay1 = 1
Elseif S2 = "1:0" Then
Relay1 = 0
Elseif S2 = "2:1" Then

Relay2 = 1
Elseif S2 = "2:0" Then

Relay2 = 0
Elseif S2 = "3:1" Then

Relay3 = 1
Elseif S2 = "3:0" Then

Relay3 = 0
End If

Print "AT+CMGF=1" ; Chr(13)

```



Waitms 200

Print "AT+CMGS=" ; Chr(34) ; Chr(48) ; Phone ; Chr(34) ; Chr(13)

Waitms 200

Print "ACTION COMPLETED" ; Chr(26)

Flushbuf

Print "AT+CMGD=1"

Gosub Ss

S = ""

li = 0

B = 0

Sret = ""

Phone = ""

W = 0

S1 = ""

S2 = ""

End Sub

'+++++

-----

'SUB 2 (GET RECEIVED SMS)

Sss:

S = ""

Do

B = Inkey()

S = S + Chr(b)

S1 = Chr(b)

If S1 = "K" Then Exit Do

Loop

Return

Ss:

,

S = ""

Do

B = Inkey()

Select Case B

Case 0

Case 13 : If S <> "" Then Exit Do

Case 10 : If S <> "" Then Exit Do

Case Else

S = S + Chr(b)

End Select

Loop

Cls

Return

'-----

'+++++

'SUB 3 (CLEAR)

Sub Flushbuf()

Waitms 50

Do

B = Inkey()

Loop Until B = 0

End Sub

'+++++

## **4.4 Simulation of home automation system using LabVIEW**

### **4.4.1 Labview**

Lab VIEW stands for Laboratory Virtual Instrumentation Engineering Workbench. It started in 1983 by a company National Instruments which famously stands for NI. Like C, JAVA, the Lab VIEW software is known as "G" language. Labview is mainly designed for complex problems.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution.

Lab VIEW is a graphical programming language used to create programs called VI which are in a pictorial form called a block diagram, which eliminates a lot of the syntactical details of other programming languages like C and MATLAB that use a text based programming approach. Lab VIEW is available for all the major platforms and is easily portable across platforms. It is simple and flexible, since it is a graphical approach no need of writing programs of 100 lines like other program languages. Each VI has two windows-Front Panel and Block Diagram windows. Front Panel is user interface which has controls and indicators. Block Diagram is program code which shows data travels on wires from controls through functions to indicators.

### **4.4.2 Design and Simulation**

Lab View takes various input from connected sensors and processes it according to defined program and then it provides logical output to whole house power system. The Lab VIEW in this study controls lighting, temperature, fire alarm systems figures (4.1) and (4.2) show the Block Diagram and Front Panels of the proposed system.

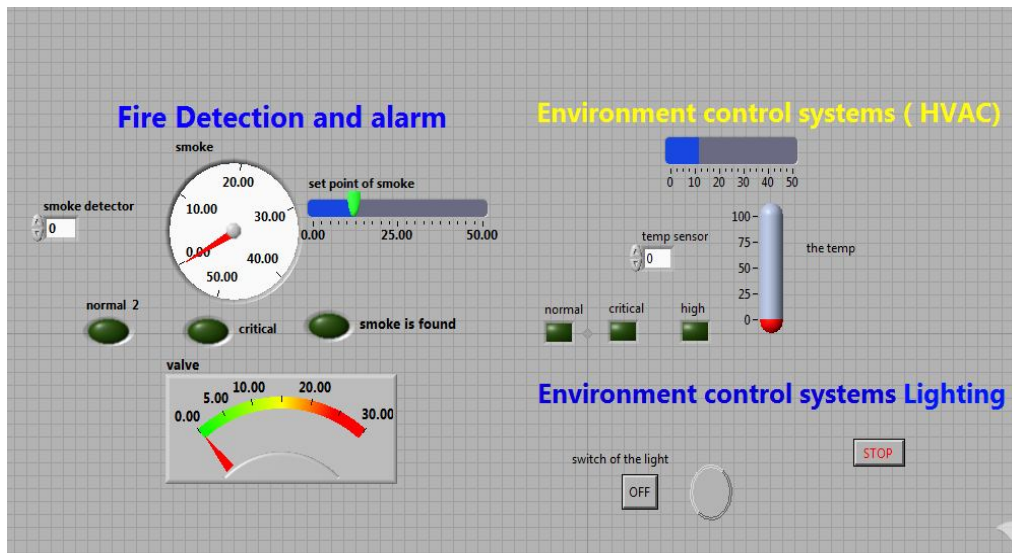


Figure (4.1) Home automation system LabVIEW Front Panel

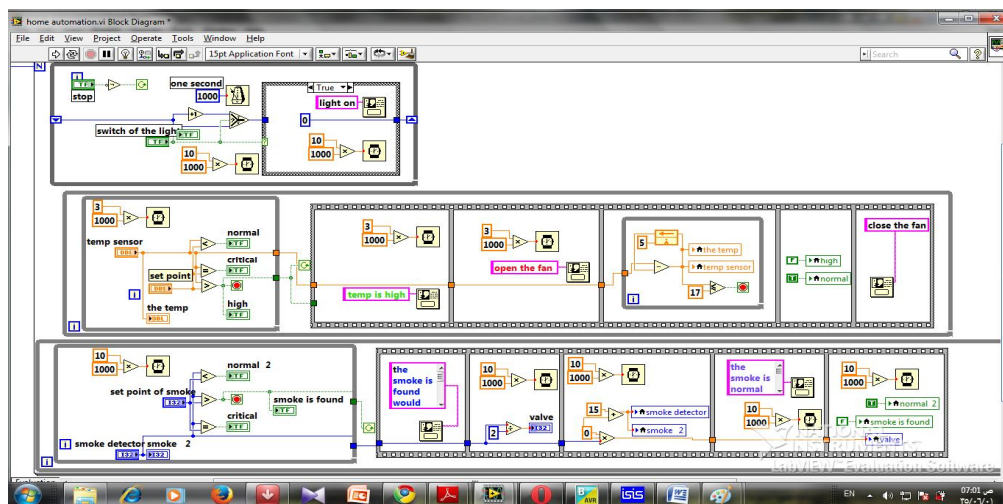


Figure (4.2) Home automation system LabVIEW Block Diagram

#### 4.4.2.1 Fire Alarm System

The home alarm system is created in lab view by setting a suitable code for alarm to work that code is fixed. LabVIEW will receive the signal from smoke detector. After processing the input data, LabVIEW will send a set signal to the valve to cut off the flow of smoke . In addition, the system will send a (SMS) to house owner to inform him of the existence of fire. figure (4.3) and (4.4) show the block diagram and Front Panel .

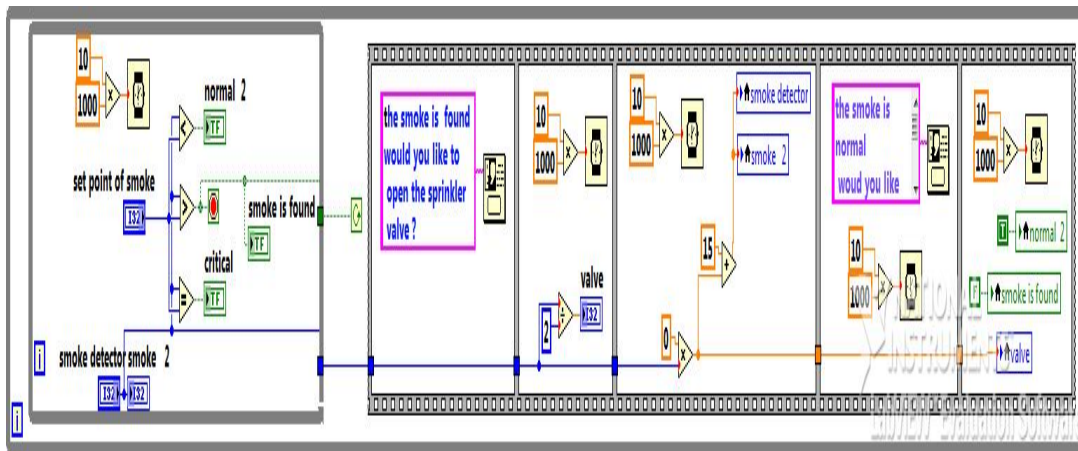


Figure (4.3) LabVIEW Fire Alarm System Block Diagram

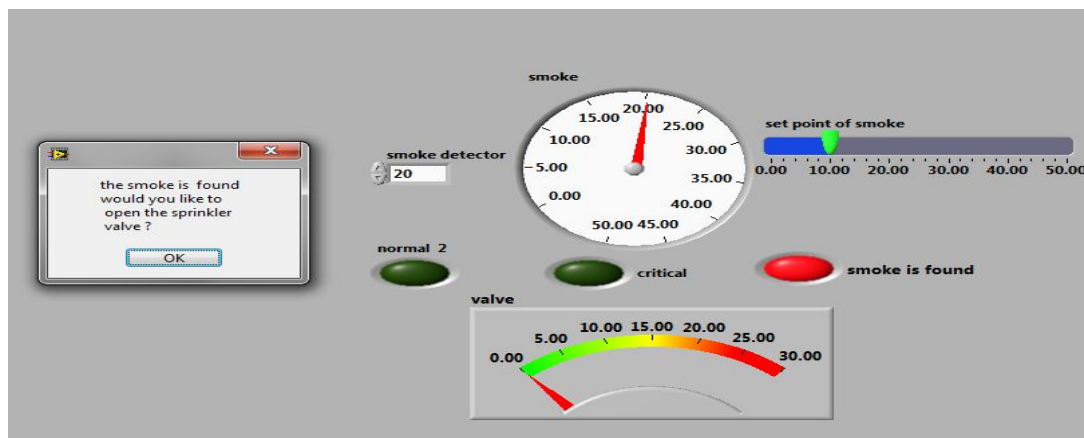


Figure (4.4 ) Fire Alarm System LabVIEW Front Panel Monitor Screen

#### 4.4.2.2 Temperature System

The basic element in temperature system is the reading of temperature value from temperature sensor. After processing the structure in the program, LabVIEW will send a cooling or heating signal to the system, depending on the value of the sensor and the critical value of temperature that required. When the room temperature sensed value is greater than or less than the critical temperature, then labVIEW sends the signal to the device to cool or hot it up to the critical temperature and then maintain constant critical temperature. Figure (4.5) and (4.6) show the block diagram and Front Panel of temperature system in labview .

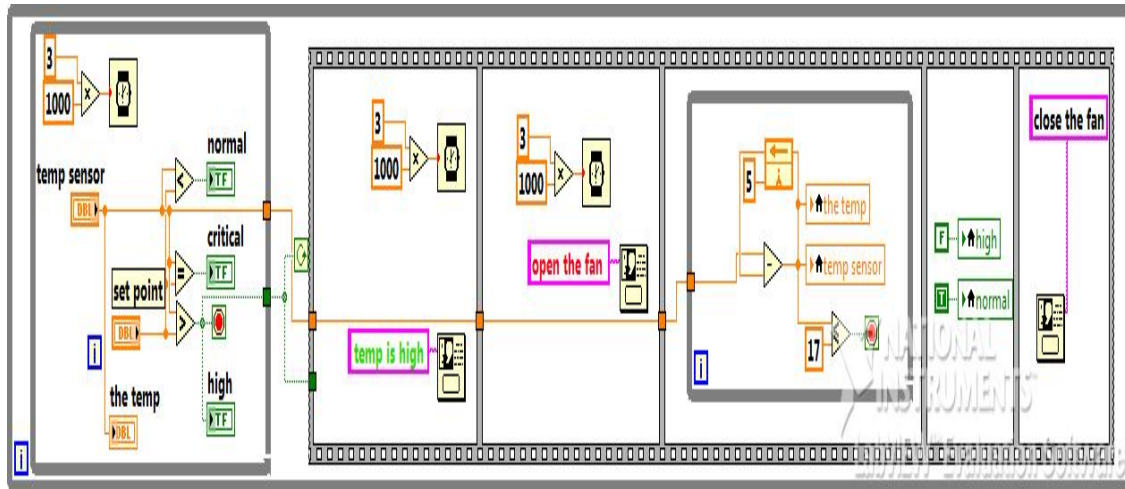


Figure (4.5) Block Diagram of Temperature System

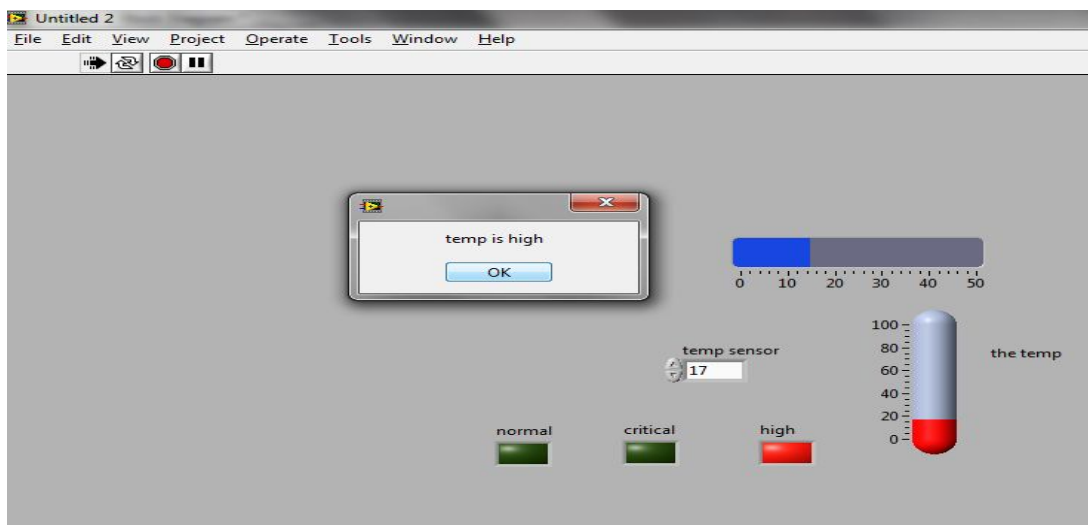


Figure (4.6) Temperature System LabVIEW Front Panel

#### 4.4.2.3 lighting System

The internal lighting system consists of a motion sensor and lamps which are connected to the LabVIEW software program. This system will make an automatic lighting in the home when there is any movement inside it. The motion sensor detects whether there is any human presence in the building or not. If not, it will send a signal to LabVIEW and it will switch off the device in the building. If there is

The screenshot shows a LabVIEW application window titled "lighting system.vi". The interface includes a menu bar with "File", "Edit", "View", "Project", "Operate", "Tools", "Window", and "Help". Below the menu bar is a toolbar with icons for running, connecting, and stopping. The main workspace is a gray panel containing a text label "motion sensor switch the light", a button labeled "ON", and a yellow circular light icon. A modal dialog box is open in the foreground, displaying the text "light on" and an "OK" button.

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# Chapter FIVE

## SYSTEM IMPLIMENTATION AND TESTING

### 5.1 System implementation

This section describes the implemented system. Several testing has been performed to ensure it's executed and produce the intended result. The prototype system is designed to receive or send SMS from or to user mobile phone to or from GSM modem connected to the atmega8microcontroller. Figure (5.1) shows the Prototype System.

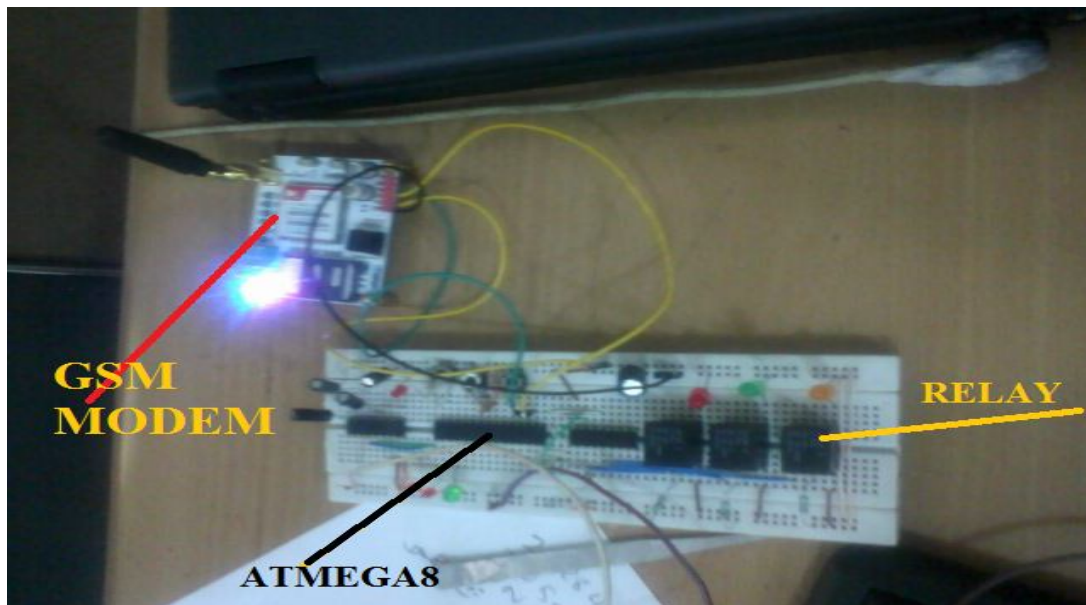


Figure (5.1): Prototype System

### 5.2 System Testing

Due to the modular nature of the design of the HAS, it was straight forward to test each module individually.

#### 5.2.1 Hardware Testing

Hardware connections were checked. Microcontroller and GSM modems have Transmit Data (TXD) serial output and Receive Data (RXD) serial input. Normally therefore TXD was connected to TXD, RXD to RXD. Always datasheets is checked. Power supply also is tested .



### 5.2.1.1 power supply testing

The power supply section was switched on, a multi-meter was used to measure voltages at different terminals in the power supply section.



Figure (5.2) Power Supply Testing

### 5.2.1.2 Appliance Interface Test

The appliance interface section was tested manually. An ULN2003 buffer was connected to the relays, and the power supply was switched on. The relay was connected to VCC and also to GND. When the relay will be energized the bulb will be ON and when connected to GND, the relay will de-energize and the bulb will be OFF. The LEDs denote the output components of the system. Figure(5.3) shows that.

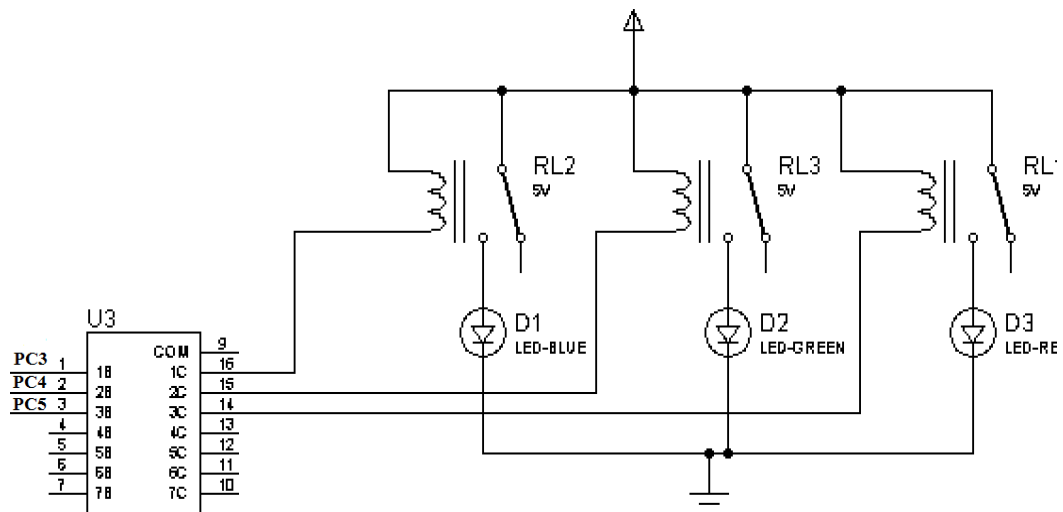


Figure (5.3) Power Circuit

### 5.2.1.3 Serial Unit Test

The serial unit consists of:

- \* RS232-TTL logic converter using MAX232 buffer transceiver IC.
- \* And provides DB9F socket for PC serial communication.
- \* 4 Capacitors included also. Those 4 Capacitors used as Voltage Doubler.

The AVR microcontroller has built in hardware to handle RS232 communications, the lines involved are portd.0 (RXD) and portd.1 (TXD). These two data lines however cannot be directly connected to RS232 port because the RS232 specification does not use 5V and 0V, but -12V as a zero and +12V as a one. Therefore some interface circuitry is required, the MAX232 is common device used for this. A connector (DB9-Female) is required. The important feature of IC MAX in this unit is to convert 12V to 5V to match between GSM modem and microcontroller , and vice versa, it can convert 5V to 12V to match between microcontroller and GSM modem . Figure (5.3) shows the Schematic diagram of serial RS232 unit

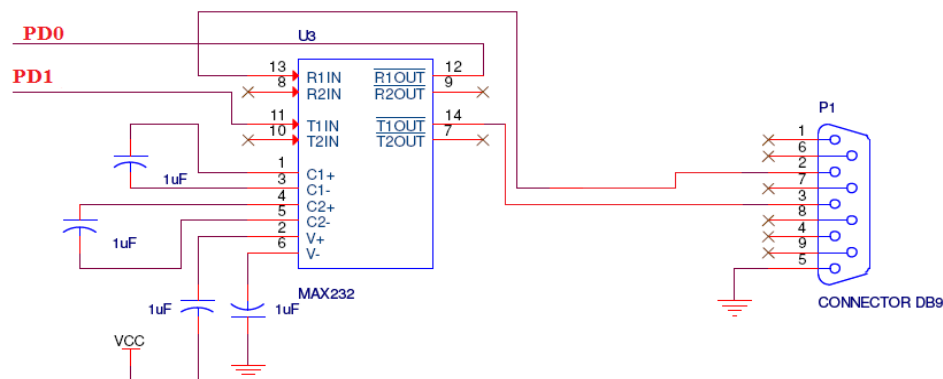


Figure (5.4) Serial RS232 unit.

### 5.2.1.4 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 . 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. If not then ‘ERROR’ is returned. When the data is sent, the microcontroller will turn on the LED at output port (portb.3) indicate that the data has been sent figure(5.4) shows that.

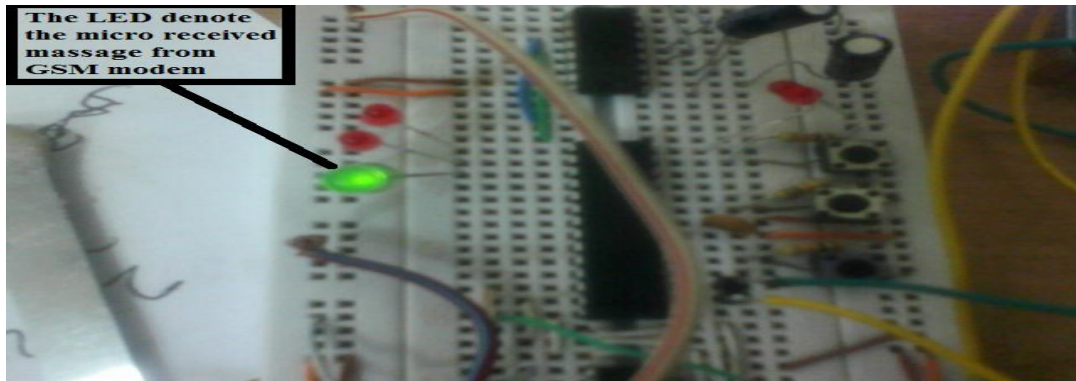
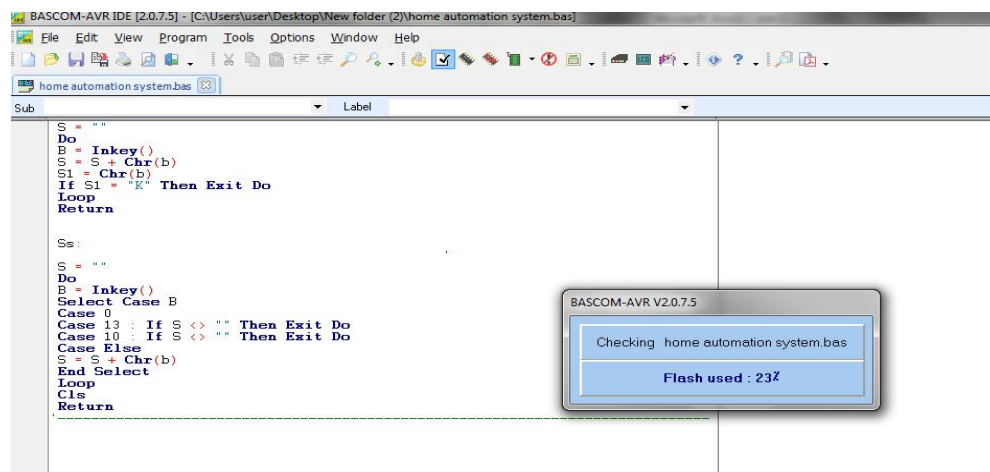


Figure (5.5) Operation Mode

### 5.2.2 Software Testing

The microcontroller coding was done through Bascom. To start the compiler press F7 or the black IC picture in the toolbar. This will change high-level BASIC program into low-level machine code. If the program is in error then a compilation will not complete and an error box will appear. Then double click on the error to get to the line which has the problem figure(5.6) and (5.7) show that.



Figure(5.6) Cheching the code of the program for any error

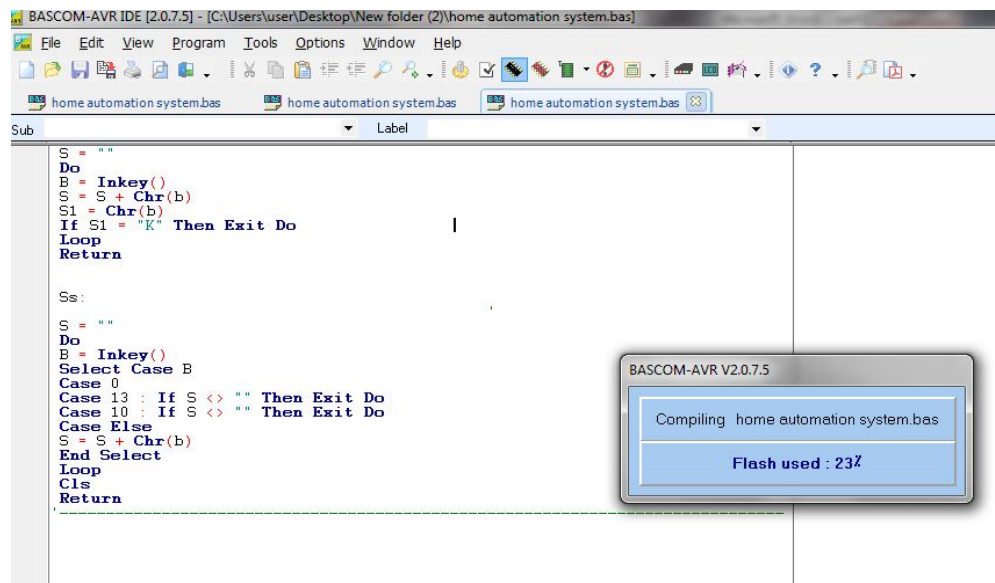


Figure (5.7) Compiling the codes of the program

The BASCOM program source file is generate into machine code (hex file) to program into the microcontroller as shown in figure (5.8) and automatically resets the microcontroller to start execution of program.

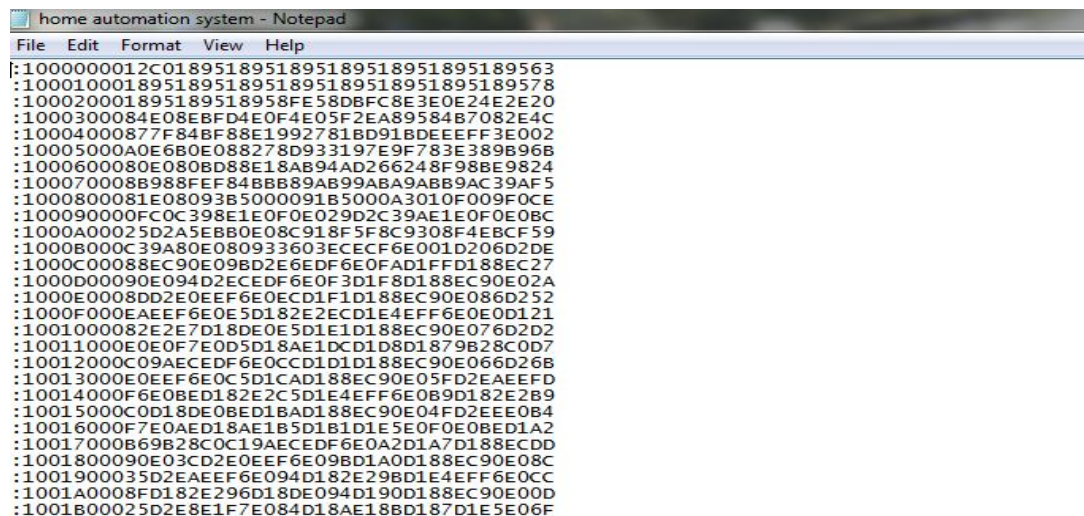


Figure (5.8) The BASCOM program source file in hex format

### 5.3 RESULT

The system will check various GSM hardware tests and will run to check the hardware support . The system then open the serial port for communication with the GSM module . On successful port opens the system communication with GSM module but if fail system does not communicate .The system checks support for battery level , signal strength and GSM Module SMS sending and receiving capability . The remote user sent SMS with security code from a cell phone on the home appliances control system that to turn on/off the specified appliance and the system performed the respective function by simulating the appliance on/off as directed by the user.

Table(5.1) shows The results of home appliance control system :

Appliance	SMS sent by user	System Response
Fan	1:1	Fan button simulated to on
	1:0	Fan button simulated to off
Light	2:1	Light button simulated to on
	2:0	Light button simulated to off
Fire Alarm	3:1	Buzzer on
	3:0	Buzzer off

Table (5.1)

## **CHAPTER SIX**

### **CONCLUSION AND RECOMENDATIONS**

#### **6.1 Conclusion**

This study was aimed at design and implementation of an SMS based remote control system using GSM technique. 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.

#### **6.2 Recommendations**

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 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. I feel very happy to work in such a challenging project which has tremendous application and possibilities.

I 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 cannot believe how much knowledge he/she gains.

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