PRINCIPLES OF DESIGNING ADAPTABLE SMART COMPUTERIZED SYSTEM

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Submitted by **Musaab Amer WAREED**

Approval of the Graduate School of Natural and Applied Sciences, Çankaya University.

Prof. Dr. Taner ALTUNOK
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Billur KAYMAKÇALAN
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Yuriy ALYEKSYEYENKOV
Supervisor

Examination Date: 06.11.2014

Examining Committee Members

Assist. Prof. Dr. Yuriy ALYEKSYEYENKOV (Çankaya Univ.)

Assoc. Prof. Dr. Fahd JARAD (THK Univ.)

Assoc. Prof. Dr. Hadi Hakan MARAŞ (Çankaya Univ.)

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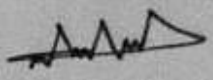
Signature : 

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ABSTRACT

PRINCIPLES OF DESIGNING ADAPTABLE SMART COMPUTERIZED SYSTEM

WAREED, Musaab Amer
M.Sc., Department of Mathematics and Computer Science
Supervisor: Assist. Prof. Dr. Yuriy ALYEKSYEYENKOV

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The aim of this thesis is to design and implement a smart system that used for controlling a number of electronic devices and sensors remotely and to receive alerts when fire, movement and abnormal temperature and humidity are detected by sensors. The controlling operation on devices will be by using a mobile phone through sending SMS to the smart system. Also the alerts will be received as SMS form from the system. Originally, the smart system contains two main parts which are Arduino microcontroller and GSM modem. The Arduino is responsible for controlling electronic devices and sensors which are interfaced with it. The main function of second main part that called GSM is to deliver SMS which exchanged between the mobile phone and microcontroller. The Arduino microcontroller reads the data of sensors, when it detects abnormal values it will inform the GSM which in its turn will send SMS to the mobile phone to inform the user of system about the situation. The smart system can be controlled from any mobile phone model and can be putted in any place. All in all, a security and easier life can be provided by this smart system.

Keywords: Arduino, GSM, AT Commands, Sensors, PIR, DHT22, Flame Sensor, GLCD, SD Card Reader.

ÖZ

UYARLANABİLİR AKILLI BİLGİSAYARLI SİSTEMİN TASARIM ESASLARI

WAREED, Musaab Amer
Yüksek Lisans, Matematik-Bilgisayar Anabilim Dalı
Tez Yöneticisi: Doç. Dr. Yuriy ALYEKSYEYENKOV

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Bu tezin amacı, çeşitli sayıda elektronik cihaz ve sensörü uzaktan kumanda edebilecek ve sensörler tarafından yangın, hareket ve anormal seviyelerde ısı ve nem tespit edildiğinde ikaz edilecek akıllı bir sistemin tasarlanması ve uygulanmasıdır. Cihazların kontrolü, cep telefonu üzerinden akıllı sisteme bir SMS gönderilmesi ile sağlanacaktır. Sistem ikazları da aynı şekilde SMS olarak telefona gönderilecektir. Orijinal hali ile, akıllı sistem içerisinde iki ana parça vardır. Bunlar Arduino mikro denetleyici ve GSM modemdir. Arduino'nun görevi, kendisi ile ağa bağlanan elektronik cihazlar ve sensörleri kontrol etmektir. GSM olarak adlandırılan ikinci ana parçanın temel fonksiyonu, cep telefonu ve mikro denetleyici arasındaki SMS alış verişini gerçekleştirmektir. Arduino mikro denetleyici anormal değerler tespit ettiğinde sensör verilerini okur, GSM'i bilgilendirir, GSM ise cep telefonuna SMS göndererek sistem kullanıcısını durum hakkında bilgilendirir. Akıllı sistem her hangi modelde bir cep telefonundan kontrol edilebilir ve herhangi bir yere konulabilir. Özet olarak, bu akıllı sistem daha emniyetli ve kolay bir hayat sağlamaktadır.

Anahtar Kelimeler: Arduino, GSM, AT Commands, Sensorlar, PIR, DHT22, Alev Sensoru, GLCD, SD Kart Okuyucu.

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LIST OF ABBREVIATIONS

GSM	Global System for Mobile Communication
SMS	Short Message Service
SCADA	Supervisory Control and Data Acquisition
RTU	Remote Terminal Unit
HMI	Human Machine Interface
PLC	Programmable Logic Controller
RFID	Radio Frequency Identification
LCD	Liquid Crystal Display
GPS	Global Positioning System
SD	Secure Digital
GLCD	Graphical Liquid Crystal Display
USB	Universal Serial Bus
ICSPC	In Circuit Serial Programming
EEPROM	Electrically Erasable Programmable Read Only Memory
SRAM	Static Random Access Memory
ADC	Analog to Digital Converter
PWM	Pulse Width Modulation
CMOS	Complementary Metal Oxide Semiconductor
RISC	Reduced Instruction Set Computing
LED	Light Emitting Diode
MIPS	Millions Instructions Per Second
RTC	Real Time Counter
USART	Universal Asynchronous Receiver/Transmitter
SPI	Serial Peripheral Interface
CPU	Central Processing Unit
ALU	Arithmetic Logic Unit
SP	Stack Pointer

SIM	Subscriber Identity Module
MS	Mobile Station
ME	Mobile Equipment
SMSC	Short Message Service Center
GPRS	General Packet Radio Service
FTP	File Transfer Protocol
PTP	Point to Point
PTM	Point to Multipoint
CDMA	Code Division Multiple Access
LIDAR	Light Detection and Ranging
PCB	Printed Circuit Board
OTP	One Time Programmable
MCU	Microcontroller Unit
PIR	Passive Infrared
MISO	Master In Slave Out
MOSI	Master Out Slave IN
SCK	Serial Clock
TIA	Telecommunication Industry Association
EIA	Electronic Industries Alliance
CR	Carriage Return

CHAPTER 1

INTRODUCTION AND LITERATURE SURVEY

1.1. Introduction

The advancement and development in the technology led to big changes in the life style, thinking and behaviour of human. In this era the human start searching about smart systems that make their life more comfortable and easier whether in home or in work because they controlled and monitored remotely instead of conventional systems that need to be controlled and supervised closely. Moreover the advancement in technology has increased the level of safety and security of people and their assets. For example, large numbers of homes have changed from simple home to smart home because the robbery has increased. Also because of busy life style of human the necessity of controlling the home appliances remotely has appeared.

Today most types of mobile phones became as small computer because they can be used for different purposes not just for calls and sending SMS. They used for playing games, surfing the internet, capturing photos, controlling, etc. Mobile phone can participate in implementation of smart system by using it with GSM technology for controlling and receiving alarms by SMS.

Smart systems can be found in the markets, but with specific specifications, number of sensors and number of devices that can be controlled. Therefore the idea of developing a smart system is appeared to solve the problem of these limitations. When a person designs a smart system by his hand he can determine the types and number of sensors, the number of devices and other characteristics as he needed.

The cost of smart system depends on hardware devices that have been used by the developer in the designing of system. There is another type of smart system called SCADA system which based on computer systems in its work. The main differences between the GSM based smart system and SCADA system will be mentioned later in this chapter.

In this thesis GSM based smart system has implemented and it is used for two purposes which are controlling and monitoring. For controlling, the system used to control number of electronic devices and sensors which can be switched on/off remotely by sending SMS message from mobile phone to a GSM which interfaced to Arduino Mega board. GSM considered as a communication medium between mobile phone and Arduino board which sensors and devices that will be controlled are connected to it. The connection of sensors with Arduino will be directly whereas, the devices connected to Arduino through a relays shield. For monitoring, the system can produce a security, if there is a motion or fire in the environment in which the system is placed the GSM will send SMS to the mobile phone to alert the user of system about the flame or motion. The system contains three sensors which are flame sensor, motion detector sensor and temperature and humidity sensor. The number of devices that will be controlled remotely in this system is eight.

Many developers may prefer GSM based smart systems that depend on sending and receiving SMS between GSM and mobile phone in their work because SMSs provide widest coverage with low cost.

1.2. Literature Survey

This section includes an introduction about SCADA systems and in which environments they can be used. Also, this section contains the differences between SCADA systems and GSM network that used in this thesis. Finally, it contains some works that related to using GSM network in smart systems that they have performed by other developers in the past.

The term SCADA is the abbreviation of supervisory control and data acquisition. SCADA systems used for controlling and monitoring the processes in the different environments and they depend on computer systems in their work. The processes can be monitored or controlled by computer systems. The SCADA systems appeared about six decades ago but, the advancement in the technology led to developments in the SCADA systems. These systems were closed proprietary systems but, later they became open system, this transformation enabled the designers to choose the gears that used for designing their systems. General communication protocols are used in SCADA system for transmitting data from field of devices to the controller of the system such as Ethernet and TCP/IP. SCACA system consists of RTUs (Remote Terminal units), the master of station HMI (Human Machine interfaces), PLCs (Programmable logic controllers), control devices and communication systems. The RTU and PLC of SCADA system used to provide an interface to the instruments and control devices of the process. The path that used for transmitting data between RTU/PLC and the master station is provided by the communication system which can be connected wire or wireless. HMI used to show the data in a clear graphical form keeps the received data, forward operator control and sends alarm [1].

SCADA system includes three levels. The level 1 contains number of devices and called device network, level 2 contains PLCs/ RTUs and called control network, level three just contains the master station. The tracking and monitoring of changes in SCADA system must be closely [2]. SCADA systems used to provide an active control on critical applications such as: water pipeline, factories and weapon systems. These computer based systems can run the hospital air conditioning, cities traffic lights and prisons gates [3].

SCADA systems are considered as smart system, but they are not the only kind of smart systems. There are many other smart systems that can be designed using GSM network. Although SCADA systems and GSM smart systems both can be used for controlling and monitoring, but there are differences between these kinds of systems. SCADA systems based on computer systems in their work, the monitoring and controlling operations in SCADA systems must be closely by the master station through screens and computers, while GSM based smart system depends on SMS

that sent from mobile phone to GSM which interfaced with a microcontroller to control the system, the GSM smart systems can be controlled and monitored from any place in the world [1, 2].

There are many smart systems in which GSM has been used. These systems performed by other developers previously, some of these systems will be explained in the following paragraphs.

The system that designed by [4] is a finger print smart system used to monitor the attendance of students, it is GSM based system. The parents will know if their sons have attended the class or not through this system because, after taking the fingerprints of students by the system it will send the attendance to their parents' mobile phones through the GSM via an SMS.

GSM technology based smart system which performed by [5] is an energy meter system that sends a message to consumer about the consumption of power in watts. Also it will send a message if the minimum amount of power is reached to alert the consumer to recharge the credit of electricity.

The smart system that developed by [6] is used to obtain electrical remote parameters such as voltage, frequency and current from the electrical station and send the values of these parameters with the temperature of station through GSM network in form of SMS. The user can know the values of parameters by sending command in SMS. In the other hand the system can send parameters values automatically to the user based on time setting. In addition an alarm will be sent by the system if the voltage and current exceed the predefined limits.

In [7] a locker security system is developed depending on GMS and RFID (Radio Frequency Identification) the aim of using RFID and GSM is to make the system more secured. Locker security system consists of RFID reader, GSM, microcontroller, LCD (Liquid Crystal Display) to show "access granted" message and keyboard. The id number will be read from the passive tag and sent to the microcontroller by RFID to check if the person is valid or not by checking data

which stored in the microcontroller memory. If the validation of id number is approved the microcontroller will send a demand in form of SMS to person's phone through GSM to get the original password to open the locker. When the microcontroller receives the password from the person it will compare the received password with the password that has entered by the keyboard. If there is a match between the two passwords the locker will open otherwise it remains in locked position.

Much time may be taken to find parking slot for the vehicle in commercial parks. The vehicle parking system which designed by [8] can be used to solve this problem. In this system the person sends SMS message to the GSM which located in the end of the park. Then the GSM will send the number of slot with a password if empty slots are available. The password used to allow or prevent accessing the park area at the entrance and exit. IR sensor with a green light is used for the indication of empty slot. The validity of empty slot will be for a specific period of time, if the person did not come in a specific time, the priority will be given to another person. Also the RFID technology is used in this system to monitor entering and leaving the park area and to debit the amount of parking charges through RFID tag.

Some harmful emissions emits from coal mines such as CO2 and LPG. The system that developed by [9] is used to monitor these emissions by using a gas sensor. In the same time the system monitors temperature and humidity. Humidity monitored by a humidity sensor and temperature monitored by a temperature sensor. The location of system will be in the coal mines. When a fire or poison gases are detected the sensors which connected to the microcontroller will give a buzzer for alert and sends the data through Zigbee, the receiver Zigbee will receive the information which sent to the emergency services and higher authorities by the GSM. These information contain details about the place which determined by GPS (Global Positioning System) in which the emissions have occurred.

CHAPTER 2

BACKGROUND THEORY OF THE SMART SYSTEM

The system consists of several components: mobile phone, microcontroller unit, GSM shield (SIM900_GPRS module), sensors, SD (Secure Digital) card reader, GLCD (Graphical LCD) screen and relay shield. Arduino Mega is used as microcontroller board. Mobile phone transmits and receives data in order to control the system. Arduino is used to control different parts in the system and it is considered the brain that organizes system works. SIM900-GPRS module is used as interface connection between the microcontroller unit and mobile phone. Before using the hardware devices and sensors, it is important to know the physical components of them to take an idea about how do they work?

2.1. Arduino Board

Arduino is an open source physical computing platform. It depends on microcontroller and Arduino development environment which is used to write a code and upload it to microcontroller. The development environment is supported by Windows, Macintosh and Linux operating systems and based on AVR C programming language and can be extended through C++ libraries. Arduino is used to create different kinds of projects which are interested by hobbyists, engineers and artists. There are different kinds of Arduino boards such as Uno, Mega, etc [10].

2.1.1. Arduino Mega Board

Arduino Mega boards depend on ATmega2560 microcontroller. It consists of 16 analog input pins, 54 digital I/O pins, USB (Universal Serial Bus) port, jack power port, power pins (VIN, 5V, 3.3V,GND), 16 MHZ crystal waverer, ICSP header and reset button. Arduino Mega can either get its power from USB, or from jack power port to feed the Arduino through AC\DC adapter or a battery. The microcontroller of the board (ATMega2560) has a flash memory with 256 KB size, 4KB is used by EEPROM, 8KB is used for boot loader, and 8KB for SRAM [11].

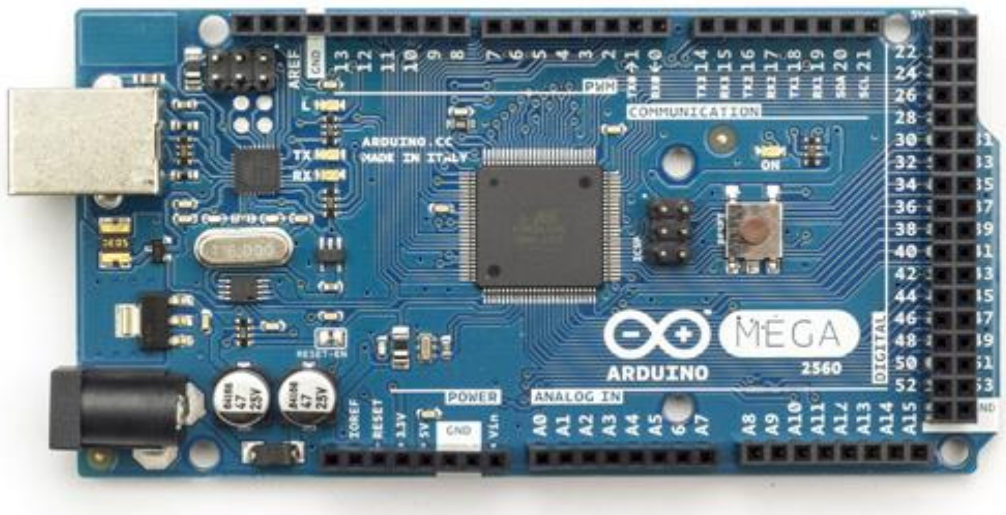

Figure 1: Arduino mega board

Figure 1 demonstrates Arduino Mega board; the pins from A0 to A15 are analog input pins which called ADC (Analog to Digital Converter).These pins provide 10 bit resolution (1024 different values), the pins from 0 to 53 are digital I\O pins. The digital pins with **PWM** (Pulse Width Modulation) symbol starts from 2 to 13 and from 44 to 46, that are used to trigger the analog output to control the brightness of LED, the speed of van or DC motor,... etc. In addition, The pins (RX and TX) pins are used to transmit (TX) and receive (RX) data [11].

2.1.2. ATmega2560 Microcontroller

Atmega2560 is low power consumption with 8bit CMOS (Complementary Metal Oxide Semiconductor) microcontroller; it depends on AVR development RISC (Reduced Instruction Set Computing) structure. The ATmega2560 will achieve 1 MIPS (Millions Instructions per Second) throughput per MHZ when sturdy instructions executed in a single clock cycle, that's allowing the designer of the system to optimize the power consumption against speed of processing [12].

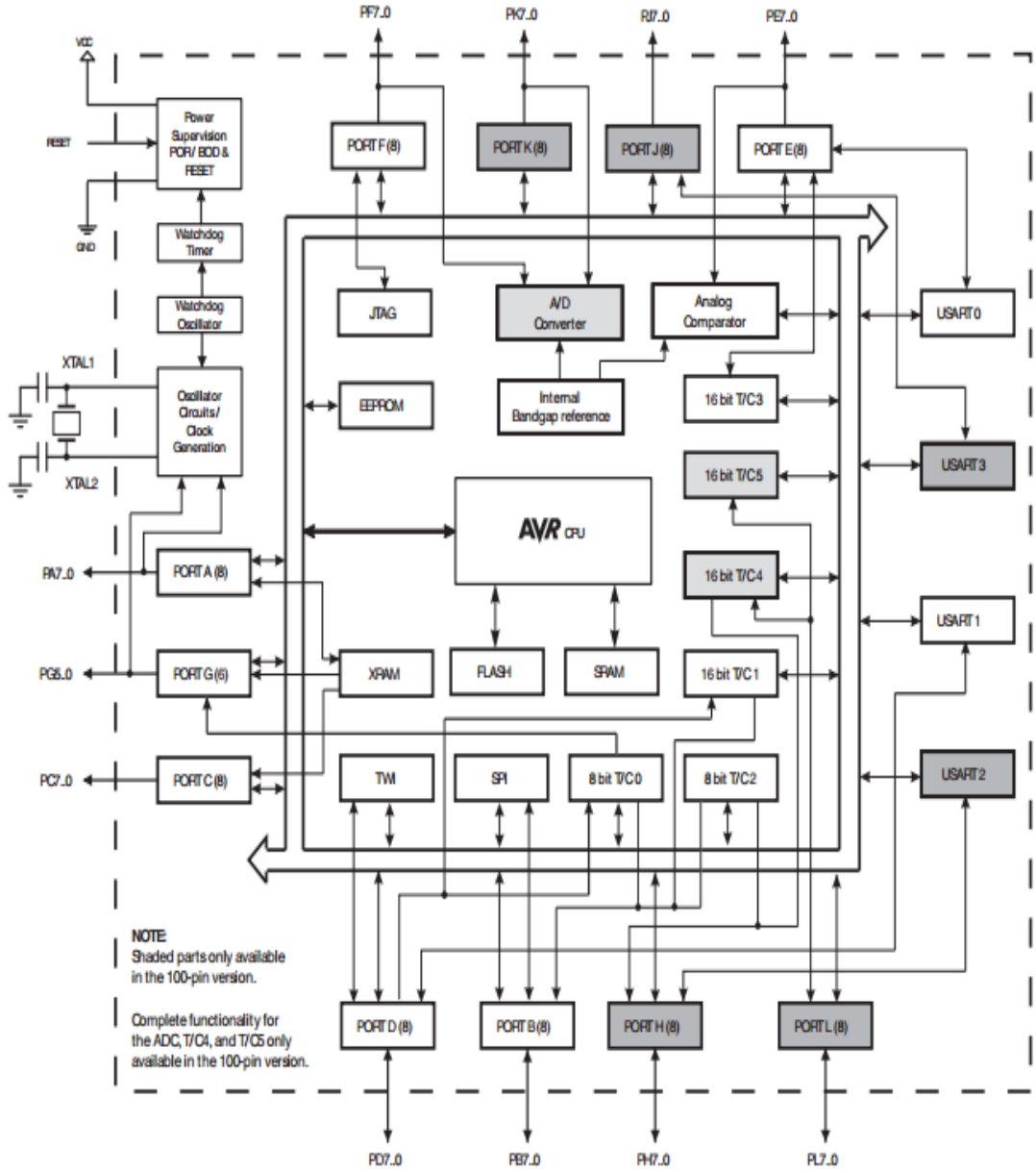

Figure 2 : Atmega2560 block diagram

Figure 2 demonstrates the block diagram of Atmega2560 microcontroller structure. The Atmega2560 provides the following features: 256 KB of in system programmable flash with read and write capabilities, 54/86 general propose I/O lines, 32 general purpose working register, RTC(Real Time Counter), six flexible timer/counters with compare modes and PWM, four USARTs, a byte oriented 2-wire serial interface, 16 channels, 10 bits ADC with optional differential input stage with programmable gain, programmable watchdog timer with internal oscillator, SPI(Serial Peripheral Interface) serial port, and six software selectable power saving modes. In the Idle mode the CPU will stop whereas the mode allowing the SRAM, SPI port, timer/counters, and interrupt system to complete functions. The Power down mode saves the contents of register, freezes the oscillator, disables the other functions of the chip till the next interrupt or hardware is reset. In Power save mode the asynchronous timer is persistent to run, the user can maintain the base of timer while the rest of device in a slumber situation [12]. In ADC noise reduction mode the CPU and all I/O modules will stop except the ADC and asynchronous timer to reduce the noise of converting during ADC conversions. In Standby mode the oscillator will run, but the rest of device will be slumber. That's will lead to high speed in start-up and low power exhaustion. In Extended standby mode oscillator and asynchronous timer are persistent to run. The following figure demonstrates the block diagram of AVR CPU structure. The CPU considered as the brain of the microcontroller. Tracking the execution of the program to ensure that program correctly running is the main task of the CPU. The CPU should be able to control peripherals, manage interrupts, implement calculations, and access the memory. The AVR uses Harvard architecture with independent memories and buses for programs and data to increase the performance and parallelism. Instructions in the program memory will be executed in a single level of pipelining. When the current instruction is being executed, the next instruction is pre-fetched from the program memory [13].

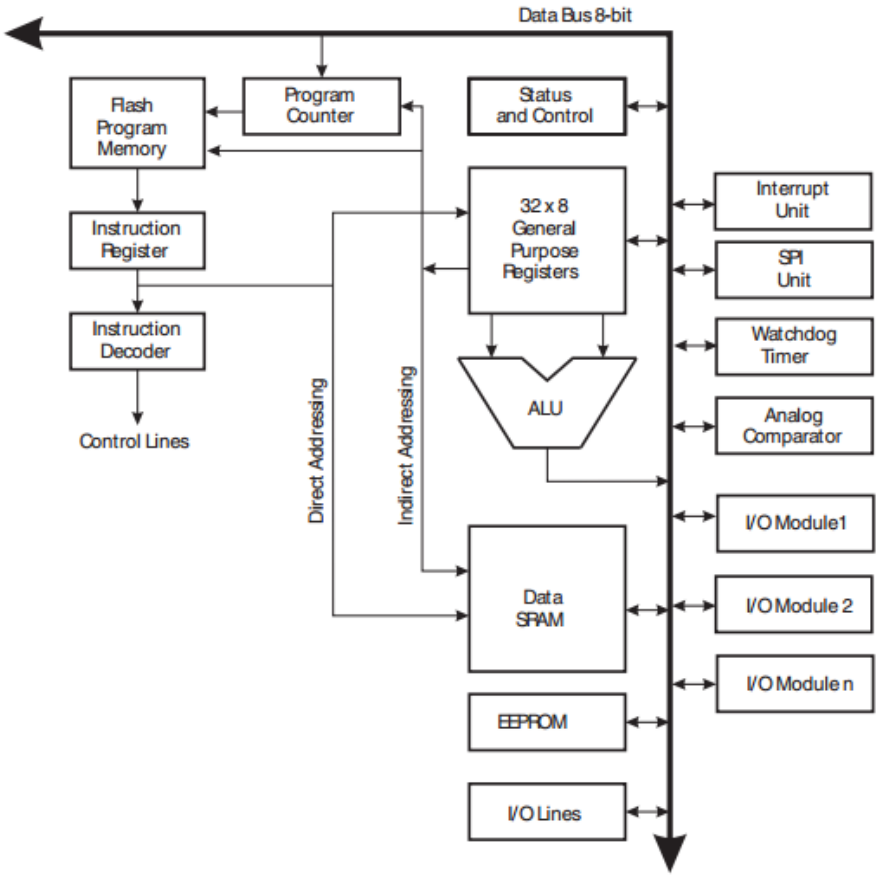

Figure 3 : AVR CPU block diagram

The fast access register file contains 32 x 8 bit general purpose working registers with a single clock cycle access time, this lead to single cycle Arithmetic Logic Unit (ALU).ALU responsible of arithmetic and logic operations between registers or between a register and a constant. Also, the operations of single register can be executed in ALU. The status register is updated after an arithmetic operation to give information about the result of the operation. Program flash memory consists of two sections, the first section is Boot program and the second section is Application program. The stack saves the program counter (PC) during interrupts and subroutine calls and it is allocated in the general data SRAM. SRAM size and the space that used from the SRAM limit the size of stack. The SP (Stack Pointer) must be initialized by the user programs before the execution of interrupts and subroutines.In AVR structure the data SRAM can be accessed through five different addressing modes [13].

2.2. GPRS/ GSM Network

GSM is the abbreviation of Global System for Mobile Communication. The GSM is considered as example of digital cellular network. CEPT (The European Conference of Postal and Telecommunications Administrations) developed the GSM. The European DCS-1800 which works in the band of 1.8 GHZ, and the American GSM-1900 which works in the band of 1.9 GHZ are cellular networks depend on GSM technology. The difference between GSM and analog mobile networks is the mobile equipment and subscription in the GSM are isolated while in the analog mobile networks they are not isolated. SIM (Subscriber Identity Module) is a smart card belonging to a subscriber which manages and stores the data of the subscriber. The mobile station (MS) includes two parts, ME (Mobile Equipment) and SIM; MS=ME+SIM. Paging service is one of the services that the GSM provides which called SMS (Short Message Service). Sending messages with a limited size to/from MS provided by point to point SMS. SMSC (Short Message Service Center) represents a store and forward center for short messages. When the subscriber transmits a short message, first of all, the message is forwarded to SMSC. Second, the destination phone number is extracted from the message by the SMSC. Then SMSC sends the message to the destination [14].

The GPRS (General Packet Radio Service) is considered as one major development in the GSM standard that depends on packet switched techniques to provide mobile subscribers with high speed (High bit rates) to transmit the bursty data [15]. Telnet, World Wide Web, E-mails, and FTP are examples about applications that lead to bursty traffic [16]. GPRS subscribers can use more than one time slot at the same time with bit rate up to 170 Kbit per second. GPRS services belong to one of two types of services, PTP (Point To Point) or PTM (Point to Multipoint) services [15].The difference between the GSM and the GPRS is the GSM supports circuit-switched services only whereas the GPRS supports circuit-switched and public-switched services [16].

2.2.1. GSM/GPRS SIM900D Module

SIM900D is an ultra-compact and reliable wireless module manufactured by SIM com. It is an entire quad band GSM/GPRS module in the SMT (Surface Mount Technology) which can be embedded in the customer application. The SIM900D has the following features: it can deliver GSM/GPRS 850/900/1800/1900 MHZ for voice, SMS, data and fax with low consumption of power. It is 33mm x 33mm x 3mm module. SIM900D is almost suitable for all requirements of M2M applications [17].

AT (Attention) or Hayes commands are created in the early of 1980s by Hayes Microsystems and they are used to control the modem. The other manufacturers taken these commands and use them as standard for modem controlling. There are AT commands in the TS 27.007 and TS 27.005 standards which are used to get a large amount of information from sim cards and GSM phones. The TIA/EIA/IS-707 standard consists of AT commands for Code Division Multiple Access (CDMA) phones. AT commands can extract information from mobile easily, also they can control mobile phones behaviours [18]. Moreover the AT commands are used to control the GPRS/GSM modem. In spite of each command begin with "AT" but it is not considered as part of the command name, it is just a prefix by which the modem knows it is the start of the command line. For examples, in ATD the character "D" (Dial) represents the real command name, in AT+CMGR the real command name is '+CMGR' (Read SMS Messages) [19].

There are two kinds of AT commands which are Extended commands and Basic commands. The commands which begin with "+" called Extended commands such as +CMGS (Send SMS Messages), +CMGL (List SMS Messages) and '+CMGR' (Read SMS Messages). The AT commands which do not begin with "+" called Basic commands such as A (Answer), O (Return to online data state), H (Hook) and D (Dial). There is a specific syntax for AT command. Below there are some rules to write the syntax of AT command [19]:

1- The command must begin with AT and end with <CR> (carriage Return).

2- If there are more than one AT command in the same command line, the first command only prefixed with AT and the names of commands must be isolated with semicolons. For example, to know the manufacturer and model number the command line will be written as AT +CGMI; +CGMM <CR>.
3- Each string must be put between double quotes. For example, the string "ALL" in the following command line will be used to read all SMS messages from the storage of messages in the SMS text mode. AT +CMGL ="ALL" <CR>.
4- The codes of result and information responses always begin and end with <CR> and a linefeed character.

2.3. Sensors

Sensors are devices which used to convert physical quantities such as pressure into signals that used for systems controlling [20]. Each sensor must be able to sense signals such as motion, sound, touch, or light. The sensors should have the ability of changing the input parameters if there is increase or decrease in the value of the parameter regardless in which direction the value changes. Sensors can be divided into two types: passive sensors and active sensors based on the power or energy that sensors require. Active sensors need a power supply such as LiDAR (Light Detection and Ranging) and photoconductive cell, while passive sensors do not need a power supply. Passive sensors can get the power from devices that they are connected to, for example film photography and radiometer [21].

Sensors applications will be classified depending on places in which the sensors are used. For example, they can be classified as [22]:

- Biosensors, these sensors based on electrochemical technology and combine physicochemical detection with biological components. They are used for testing, water testing, medical devices, and biological warfare agent detection.
- Motion detectors, which are based on ultrasonic, radar, and infrared technology. They are used in security, video games, simulations, and light activation when there is a motion.

- Image sensors, which are based on CMOS (Complementary Metal Oxide Semiconductor) technology. They are used in security and traffic surveillance, biometrics and PC imaging.
- Accelerometers, which are based on micro-electromechanically sensor technology. They are used in patient monitoring.

There are several properties related to sensor and effect on sensor performance, such as response time and recovery time, reproducibility, aging, stability, sensitivity and resolution, dynamic range, selectivity, size, weight and cost. The time that needed by the sensor to get 90% of its steady state value called response time, while the time that needed by the sensor to be within 10% of value which it had before the exposure to the measurand called recovery time. The sensor is considered as a good sensor if it has less response time and recovery time. The reproducibility is the ability of sensor to produce the same characteristic depending on the repeated exposure to a particular measurand. If the sensor has excellent reproducibility that means it will has the same response time and recovery time, also it will has the same response time to a particular measurand. Aging is the time taken by the sensor for the degradation. The resolution is the smallest change in the measurand which can be detected by a sensor. The change in the output of measurand called sensitivity. The most important properties of the sensor depend on the application in which the sensor is used. For example, if the sensor used to detect the highly toxic gas, the sensitivity is the important property for the sensor, reproducibility and aging are important properties in online system in which the measurand exposed repeatedly, weight and size are important properties in the application related to implantation of biosensor in the animals [19].

The sensors that have the ability to process, acquire and output the measurements in a single package over a data bus called smart sensors. The capabilities of smart sensors have some features such as radio communication and remote manageability to deliver the system of smart sensors. Smart sensors can incorporate the functions of sensing with a microcontroller which has an integrated ADC (Analog to Digital Converter), analog interface circuit and I/O bus interface in a single integrated package. The components of smart sensors are integrated onto the same PCB (Printed Circuit Board); this integration will increase the reliability and performance

and reduce the costs of production testing. The systems that used to extend the smart sensors capabilities called sensor systems. Sensor systems add more capabilities to the smart sensors such as security, wired or wireless communications, preparation, and remote manageability [22].

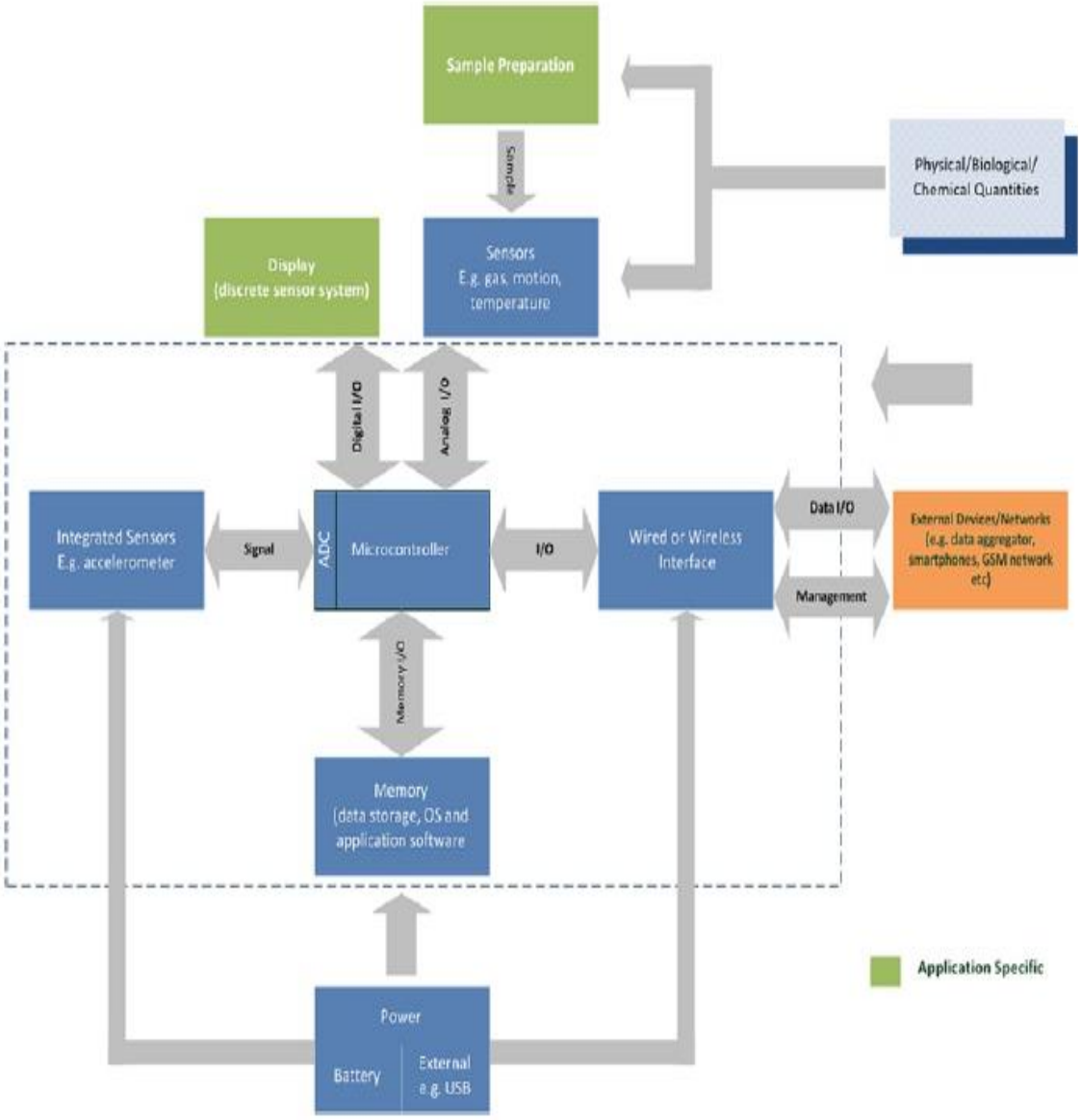

Figure 4 : Sensor system architecture

Sensor systems consist of several functional layers, including signal processing (Filtering, Conditioning, and ADC conversion), data processing, sensing and transduction, data integrity checking, signal transmission and display, and in some sensor systems there is another layer called remote device manageability [22].

The sensors that have been used in the project are PIR (Passive Infrared) sensor, temperature and humidity sensor (DHT22/AM2302), and flame sensor.

2.3.1. Temperature and Humidity Sensor (DHT22)

DHT22 sensor used to monitor the temperature and humidity. The temperature is measured by thermistor and the humidity by the means of capacitive. DHT22 sensor has the ability of measuring temperature from -40°C to 80°C and from 0 to 100% for the humidity, and produces one measurement every two seconds [23].

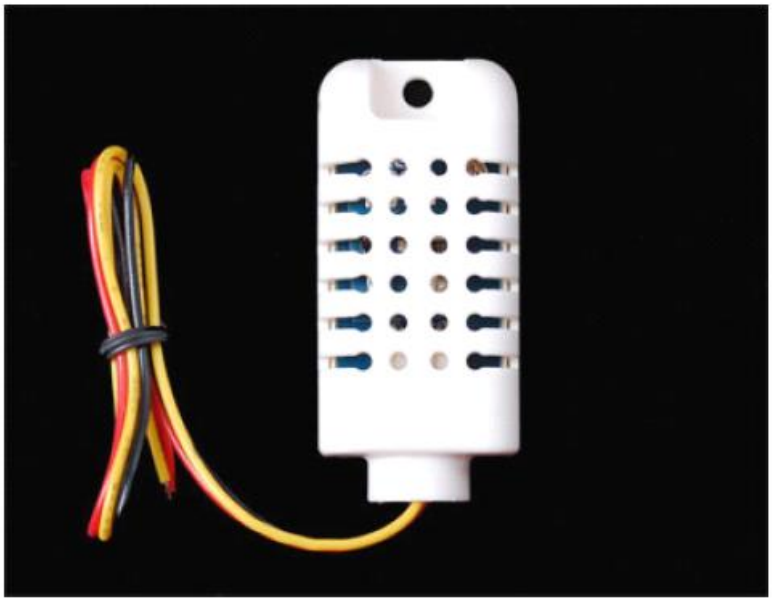

Figure 5 : DHT22 sensor

DHT22 output calibrated digital signal. The sensing elements of DHT22 are connected with 8-bit single chip computer. Every sensor of this model is calibrated accurate calibration chamber, the calibration coefficient will be saved in type of program in OTP memory, coefficient will cited from memory when the sensor detects [24].

The features of DHT22 are shown below [24]:

- Capacitive type
- High precision
- Calibrated digital signals

- Relative temperature and humidity measurement
- Low power consumption
- Long transmission distance up to 100 meters
- Extra components not needed (Small case of DHT22)
- 4 pins package fully interchangeable (Small case of DHT22)
- Small size

The small size, low consumption of power, long transmission distance up to 100 meters made DHT22 suitable for all kinds of harsh application. Single row packaged with four pins will make the connection very convenient. DHT22 has three wires, red wire for power supply, black wire for GND and yellow wire for data output. There is a small case of DHT22 which has four pins is shown below [24]:

Figure 6 : Small case of DHT22 sensor

Starting from left to right direction, the first pin for power supply, the second pin for data output, the third pin is useless and the fourth pin for GND. The power supply voltage must be 3.3V-5.5V DC. DHT22 must be wired to MCU to start working. When DHT22 receives start signal from the MCU the status of DHT22 will change from standby status to running status. When the operation of sending start signal from MCU to DHT22 is finished, the DHT22 will send a response signal to the MCU. The response signal contains 40 bits of data that reflect the values of relative humidity and temperature to MCU. Without start signal from MCU, the DHT22 will not send a response signal to MCU. DHT22 will return to standby status when

collecting of data is finished, unless it receives another start signal from the MCU [24].

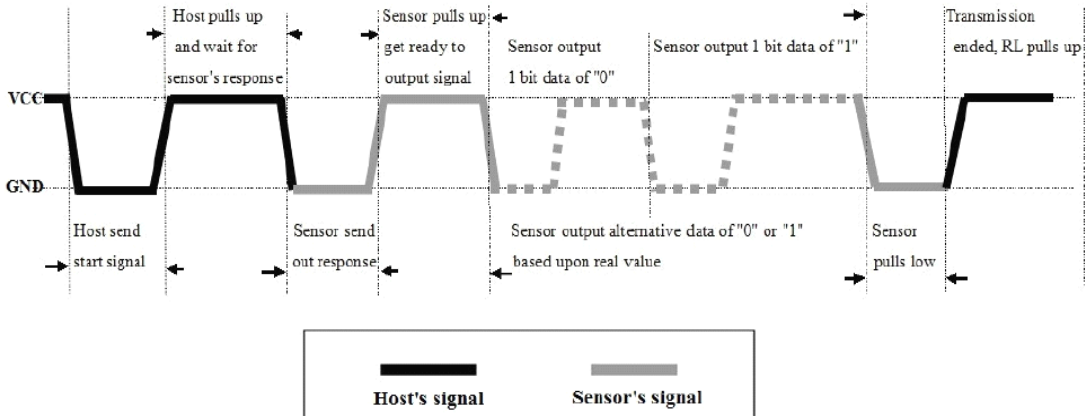

Figure 7 : Overall communication process between MUC and DHT22

When the communication between MUC and DHT22 starts, the MCU will pull low the data bus for a period of time between 1ms and 10ms to ensure that the DHT22 could detect the start signal of MCU. After that the MCU will pull up the data bus and wait 2-40us for response from DHT22. When the start signal is detected by DHT22, the DHT22 will pull low the data bus 80us to prepare the response signal. Then the DHT22 will pull up the bus as preparation to send data [24].

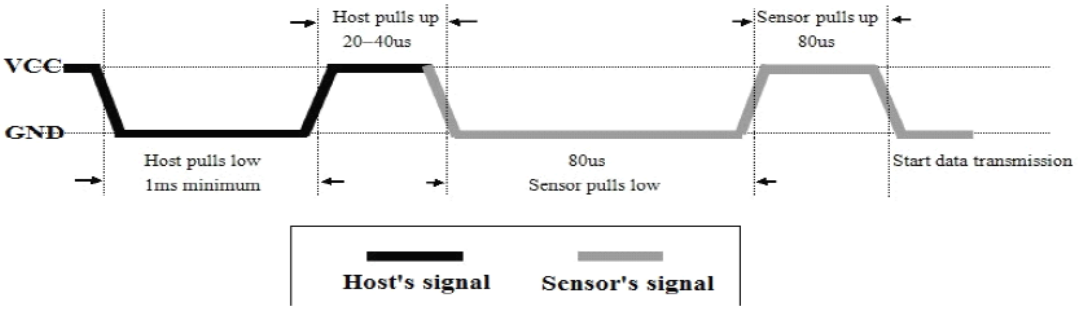

Figure 8 : Sending start signal and response signal between MCU and DHT22

When DHT22 sends the bits of data to MCU, every bit's transmission begin with low level of voltage that last 50us, the following high voltage level signal's length decides the bit is 1 or 0 [24].

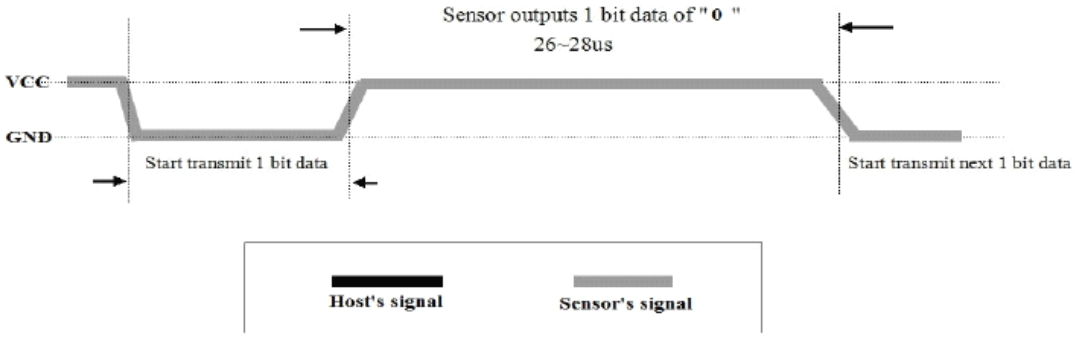

Figure 9 : Sending "1" bit data of "0" from DHT22 to MCU

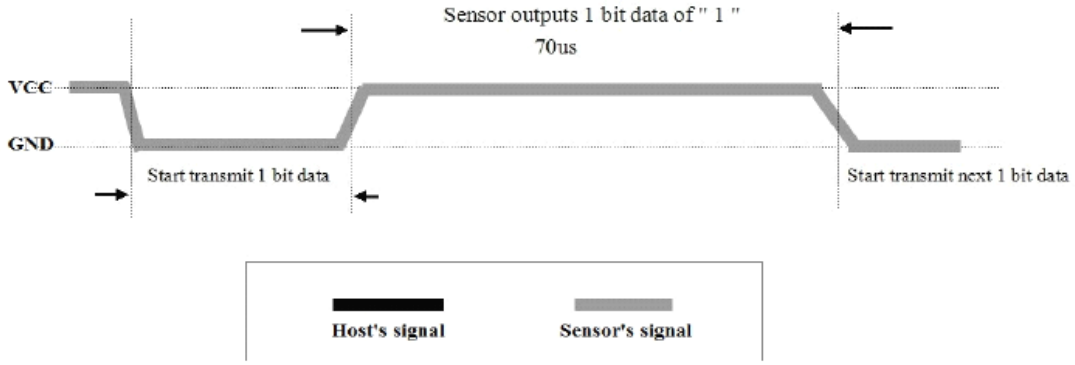

Figure 10 : Sending "1" bit data of "1" from DHT22 to MCU

2.3.2. Passive Infrared Sensor (PIR)

Every object can emit a thermal energy (heat) when it has a temperature more than zero, the thermal energy will be in form of radiation. The human radiates at wavelength of 9-10 micrometers. The radiation will be invisible for the human but it can be detected by electronic devices such as passive infrared (PIR) sensors. The word passive means the PIR sensors will not release any energy for purposes of

detection, but they detect the energy generated by the objects. The PIR sensor sends an alarm when there are changes in the level of radiation [25].

Figure 11 : Passive infrared sensor

The PIR detector has Frensel lens which located jointly on a PCB (Printed Circuit Board) with an analog IC (Integrated Circuit) and other components to form the PIR sensor module [25].

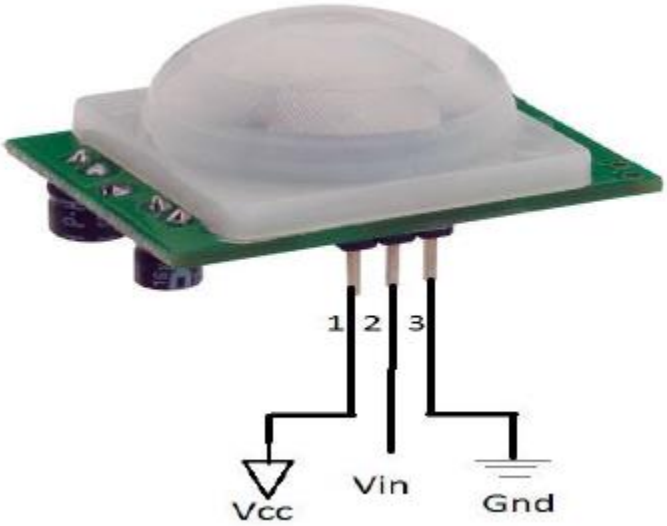

Figure 12 : Description of PIR sensor pins

Pin1 is used to provide the PIR sensor with power, pin2 represents I/O pin which used for sending and receiving signals, pin3 used as ground [25]. PIR sensor contains pyroelectric materials which represent the heart of PIR and used to detect the motion. Pyroelectric means generating an electricity power by heating or cooling materials.

PIR sensor includes two slots each one of them contains a pyroelectric material that has the ability to sense the infrared radiations. The two slots of PIR detect the same amount of infrared radiation when the sensor is inactive [26]. The PIR sensor will give value 1 if it detects a motion of body, but PIR will trigger value 0 if there is no motion [27].

The features of PIR sensor are shown below [28]:-

- It can output single bit
- 3.3V&5V operating voltages
- Small size makes it easy to hide
- The detection range is up to 30 feet
- Easy interface to any microcontroller
- It has three wires interface

PIR sensor can be used in motion sensing applications such as automated control of door and automated on/off of light. In spite of the PIR sensor is used in various types of applications it may trigger a false alarm because of some external effects such as sudden changes in temperature in the detection environment, direct sun light and other sources of light, but the lens and sensitive elements of PIR sensor can reduce the amount of false alarms [29].

2.3.3. Flame sensor

The flame sensor module can sense the flame of fire and radiation. Also it has the ability of detecting the ordinary source of light which has a wavelength between 720nm and 1100nm. This module has two types of output which are digital (0 or 1) and analog; it can be used as flame alarm or in robots which fight the fire [30].

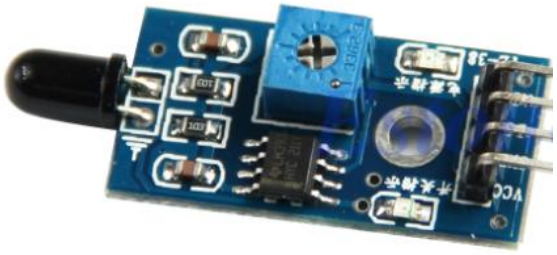

Figure 13 : Flame sensor

The features of flame sensor are shown below [30]:-

- It has digital (Do) and analog (Ao) outputs
- The operating voltages are 3.3V and 5V
- The detection range up to 100cm
- It has four wires interface

Flame sensor can be interfaced to different type of microcontrollers such as Arduino, PIR (Peripheral Interface Controller) and SK18B [31].

2.4. GLCD (Graphical LCD)

GLCD screen with 128 x 64 dimensions developed depending on ks0108 controller module which manufactured by Samsung electronics. It has 20 pins 8 pins of them used for I/O, the other 12 pins used for power and control [32]. The GLCD can be interfaced to the microcontrollers through 20 pins. The following table illustrates the pins of GLCD with their function [33]:-

Table 1: GLCD 128x64 Pins Description

Pin number	Pin name	Function
1	CSA or CS1	Chip select for controller number 1
2	CSB or CS2	Chip select for controller number 2
3	VSS	GND (ground)
4	VDD	+5V
5	V0	Contrast adjustment
6	D/I	Register select
7	R/W	Read or write
8	E	Enable
9	DB0	Data bus for bit 0
10	DB1	Data bus for bit 1
11	DB2	Data bus for bit 2
12	DB3	Data bus for bit 3
13	DB4	Data bus for bit 4
14	DB5	Data bus for bit 5
15	DB6	Data bus for bit 6
16	DB7	Data bus for bit 7
17	RST	Reset the GLCD
18	VEE	Negative voltage
19	A	LED +4.2V
20	K	LED ground

The GLCD includes two segments; the CSA and CSB signals control determine which segment must be enabled in any time. The pin V0 is responsible for adjusting the disparity of graphical LCD, for this purpose a potentiometer with 10KB is needed. The wiper hand of potentiometer must be connected to pin V0 and the other two hands must be connected to VEE and ground. The pin D/I (Data/Instruction) called register select pin. D/I will be in data mode if the logic is high, but it will be in instruction mode if the logic is low. The R/W (Read/Write) pin will be in read mode if the logic is high, but it will be in write mode if the logic is low. The pins from DB0 to DB7 represent data bus pins. For the RST (Reset) pin, the GLCD will reset if the RST pin stays in a low mode for at least 100ns. Through the reset operation the GLCD controller will not execute any command because the GLCD will be off.

The VEE pin is a negative voltage output pin which used in operation of disparity adjustment. The pin K is ground pin which must be connected to ground pin of microcontroller. The A pin is a power supply pin and this pin should be connected to the +5V pin of the microcontroller through 10ohm resistor [33].

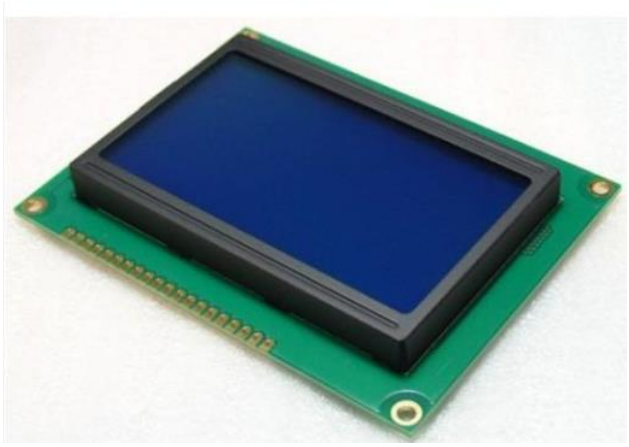

Figure 14: Graphical LCD screen

GLCD used to display texts and graphics by using a set of functions which can be used in the graphical LCD library, each function of these functions has a specific job for example, the function DrawLine is used to draw line on the GLCD screen, DrawCircle to draw a circle and DrawBitmap to draw an image [34]. Many panels of common GLCD screens can display can display 8 lines with 20 characters for each line in addition to graphics. GLCD screens have an internal light called backlight to light the display [35].

2.5. SD Card Holder

SD (Secure Digital) card is an external memory used to store data. There are SD cards with high space capacity which not used for storing data only, but they also used to store different types of files such as sounds, videos and pictures. SD card has a library which used to make an interface between SD card and microcontroller. The library of SD card contains two classes of functions which are main SD class functions and file class functions that used to read from and write to files that stored in the SD card. The dealing with SD card library will be in the same way whether we

used an external SD card shield or the SD card reader which built into Arduino Ethernet board. Fat16 and FAT32 file systems are supported by SD card library [34].

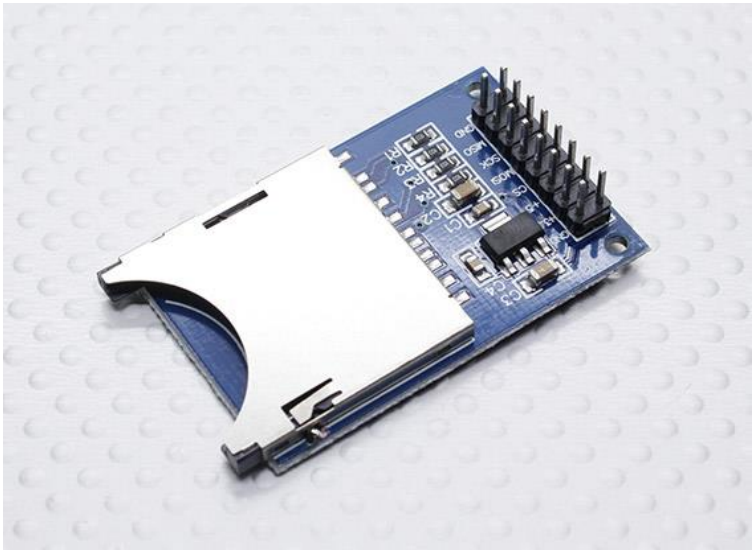

Figure 15: SD card holder

The SD card can be interfaced with the microcontroller through the SPI (Serial Peripheral Interface). The SPI used to make a communication between microcontroller and one or more devices for example, between Arduino microcontroller and SD card holder. Also it can provide a communication between two microcontrollers. There is a master device (Microcontroller) which controls other devices in each SPI connection. Each device connects to microcontroller through SPI contains four lines (MISO, MOSI, SCK and SS) such as SD card holder. MISO (Master In Slave Out) is Peripheral device line used to send data to the master. MOSI (Master Out Slave In) is master line used to send data to peripheral devices. SCK (serial clock) is pulses of clock which used to synchronize the transmission of data that generated by the master [36].

Slave Select (SS) used by the master to enable or disable devices. The lines (MISO, MOSI and SCK) will be common to all devices that connected to the master, while SS will be specific for each device [28].

The lines (MISO, MOSI and SCK) in SD card holder take place on digital pins (50, 51 and52) in Arduino Mega or (11, 12 and 13) in most Arduino boards, while the line SS pin which used to select the SD card; takes a digital pin number 10 in most Arduino boards or pin 53 in Arduino Mega [37].

CHAPTER 3

DESIGNING AND DEVELOPMENT OF SMART SYSTEM

3.1. The Design of Smart System

The system consists of two main parts which are GSM and Arduino board that represents a microcontroller of the system. The GSM used to deliver the commands that control the electronic devices and sensors at the same time it receives the response from the system. The purpose of GSM is to make an interface between the mobile phone and the microcontroller; it does not used for controlling. The microcontroller is the heart of the system that responsible for controlling devices and sensors and processing information that collected from each unit in the system. The system includes other hardware such as GLCD screen, SD card reader and relays shield.

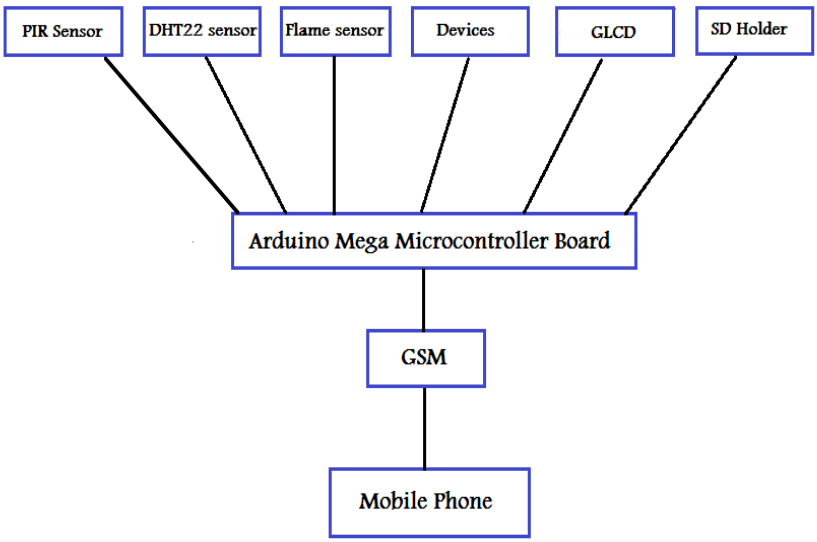

Figure 16: Block diagram of smart system before implementing

3.2. Interfacing and Implementing Sensors

To monitor various environments such as house and office remotely a number of sensors should be used. The sensors can be used in different applications according to necessity of human. For the system which developed in this thesis three types of sensors are used to monitor the motion of strangers, flame, temperature and humidity. An alert will be sent to the mobile phone of owner if a motion, flame are detected. Also the alert will be transmitted to the owner if the temperature and humidity reach the critical point. The functions of sensors are managed by software and they are interfaced depending on output and other specifications.

3.2.1. Interfacing and Implementing of Motion Sensor

Motion or PIR sensor used to detect the motion in the environment. When the passive infrared sensor detects a motion in a restricted area it will trigger an alert. The motion sensor consists of three pins which are VCC, GND and output pin. These three pins interfaced to Arduino board. The VCC and GND pin interfaced to 5V and GND pin in Arduino. The output pin connected to digital I/O pin. The output voltage of PIR sensor will be 1 (High) when the sensor detects a motion while, it will be 0 (Low) if the sensor does not detect a motion.

Table 2: Description of PIR Sensor Pins

Pins	Descriptions
GND	It is a ground pin (0V).
VCC	It is a power supply pin to provide PIR with 5V.
Output	This pin will give the result as 1 or 0.

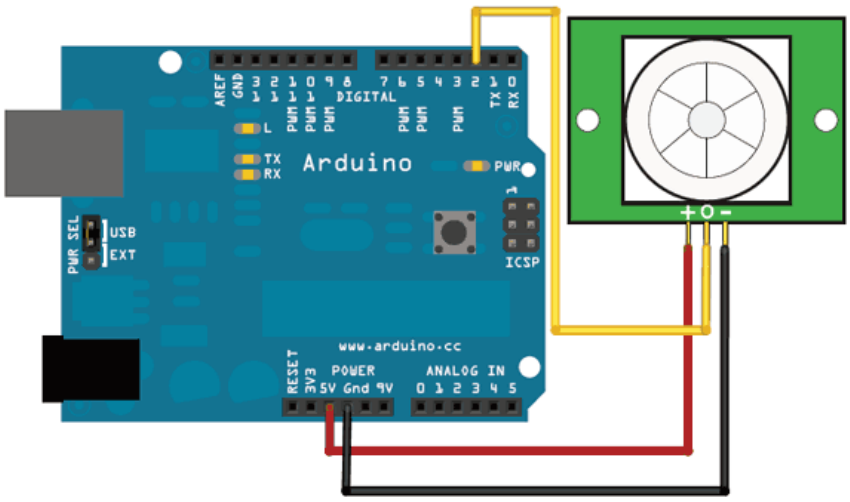

Figure 17: Interfacing PIR sensor to Arduino

Figure 18 illustrates how to connect PIR sensor with Arduino. The symbol (-) represents a GND pin, (+) is 5V pin and (o) is output pin. The output pin of PIR sensor can be connected to any I/O digital pin in Arduino with changing the configuration of the code.

3.2.2. Interfacing and Implementing of DHT22 Sensor

DHT22 sensor is a temperature and humidity sensor that used to measure temperature and humidity in the environment. It has the ability of measuring temperature and humidity at the same time. This sensor will trigger an alert if the value of temperature or humidity reaches the critical point. The big case of DHT22 sensor is used in the system because it has high accuracy and coverage. It contains three wires which are red, black and yellow.

Table 3: DHT22 Sensor Wires Description

Wires	Descriptions
Black	It is a ground wire (0V).
Red	This wire provides DHT22 with 5V.
Yellow	This wire used to read the data of temperature and humidity.

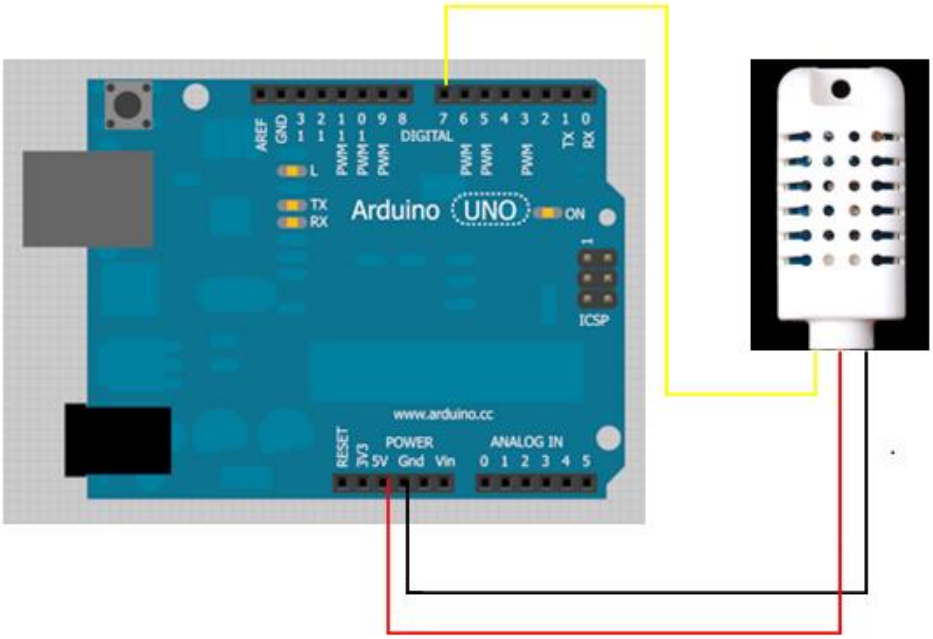

Figure 18: Interfacing DHT22 Sensor to Arduino

Figure 18 demonstrates the interfacing of DHT22 sensor to Arduino board. As shown from this figure the black wire has interfaced with GND pin of Arduino, red wire with 5V pin and yellow wire with digital I/O pin.

3.2.3. Interfacing and Implementing of Flame Sensor

Flame sensor used to detect the flame of fire in the area. It has two LEDs one of them is red that turn on automatically after connecting the sensor with the Arduino, while another one is green it will blink when flame of fire is detected. In the system which developed in this thesis an alert will be triggered when a flame of fire is detected. There are four pins embedded with flame sensor which are GND, VCC, Do and Ao.

Table 4: Flame Sensor Pins Description

Pins	Descriptions
VCC	Power supply pin to provide sensor with 5V.
GND	Represents the ground pin of sensor (0V).
Ao	Analog output, the output value between 0 and 1023.
Do	Digital output, the output value either 0 (Low) or 1 (High).

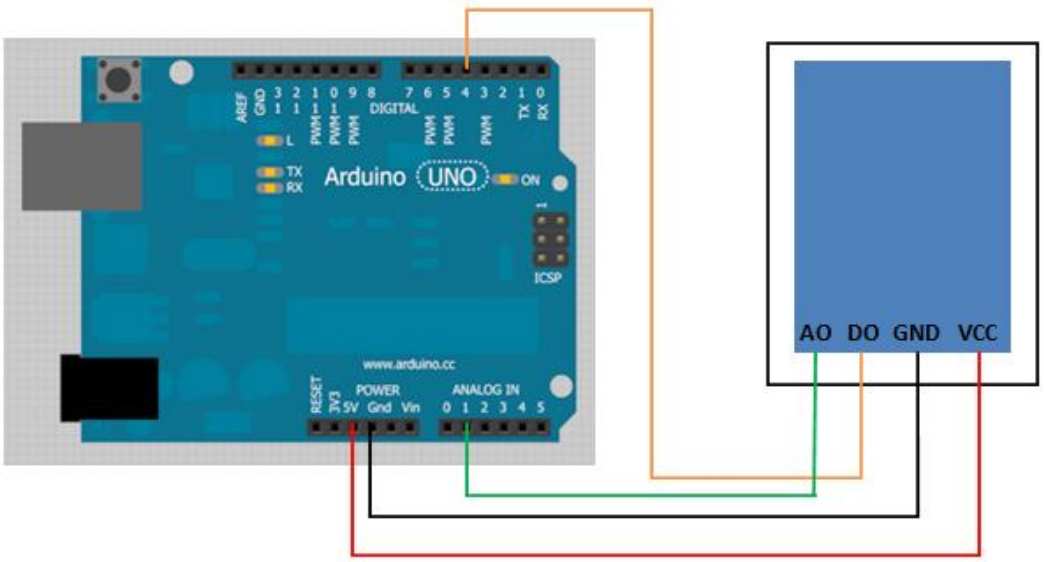

Figure 19: Interfacing flame sensor to Arduino

Figure 19 explains the wiring of flame sensor with Arduino board. Do (Digital output) and Ao (Analog output) have been used in the interfacing operation with Arduino as illustrated in the figure, but either Do or Ao will be active and give the output value that depends on the which code has uploaded to microcontroller of Arduino. If the code that related to Do pin is uploaded then this pin considered as the active pin and vice versa. In the case of Do the output value either 0 or 1, while in Ao output value will be between 0 and 1023.

3.3. Interfacing and Implementing of Electronic Devices

Electronic devices will be interfaced to Arduino board through relays shield which contains a number of relays. Each relay on the relays shield has a red LED. When the red LED in ON that means the devices is turned on and vice versa. Each electronic device needs 220V, but Arduino provides 5V only for this reason a relays shield will be available between Arduino and electronic devices. Each relay provides 10 AMPs. In the other hand an external power supply is embedded with the system to prevent the voltage regulator of Arduino from damage because the Arduino interfaced with high voltage devices.

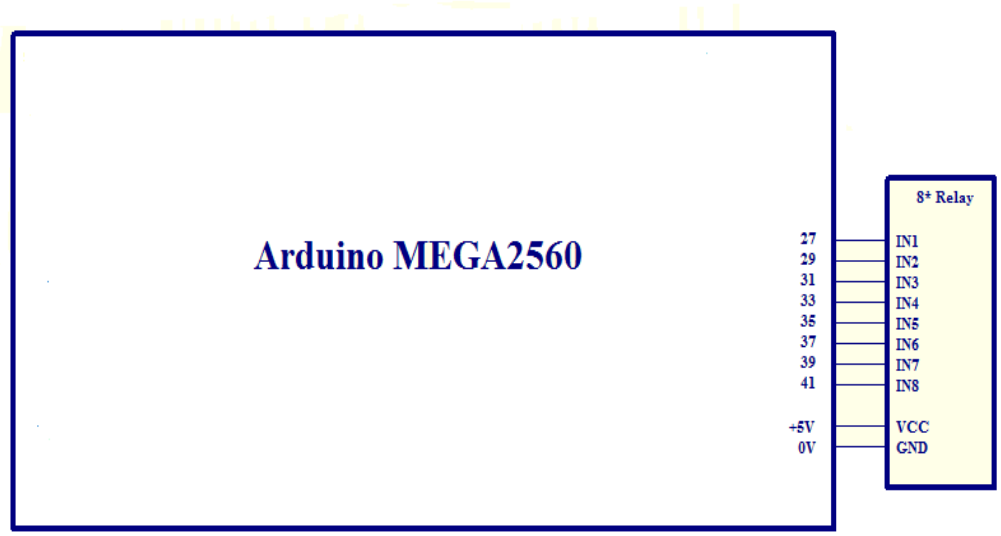

Figure 20 : Interfacing relay shield to Arduino

Figure 20 explains the interfacing of relay shield with Arduino board, as shown in this figure the relay shield contains 10 pins. The pins IN1-IN8 represent the output pins for relays and they have connected to digital I/O pins of Arduino. In this project eight electronic devices will be controlled remotely for this reason a relays shield that contains eight relays has used. The output for each relay will be either 1 (High) or 0 (Low). High means the device is ON, while low indicates to device that switched off.

3.4. Interfacing and Implementing of GLCD Screen

GLCD screen has been used in the designing of system to display graphics, texts and other details. GLCD with 192 x 64 dimensions is used because it can show more graphics and texts. It contains 20 pins through them the GLCD will connect with Arduino board.

Table 5: GLCD 192x64 Pins Description

Pins	Descriptions
A_LED	Black light power supply +5V
V	Negative voltage I/O
CS3	Chip 3 select
CS2	Chip 2 select
RES	Reset signal

CS1	Chip 1 select
D7	Data bus line 7
D6	Data bus line 6
D5	Data bus line 5
D4	Data bus line 4
D3	Data bus line 3
D2	Data bus line 2
D1	Data bus line 1
D0	Data bus line 0
EN	Enable signal
R/W	Read data/ Write data
DI	Data or instruction select
V0	Operating voltage of GLCD screen
VCC	Power supply for logic
GND	Ground

Arduino Mega board is used in the system because GLCD screen has 20 pins and cannot be connected to other types of Arduino boards because they have little number of digital I/O pins, while Mega board has 54 digital I/O pins.

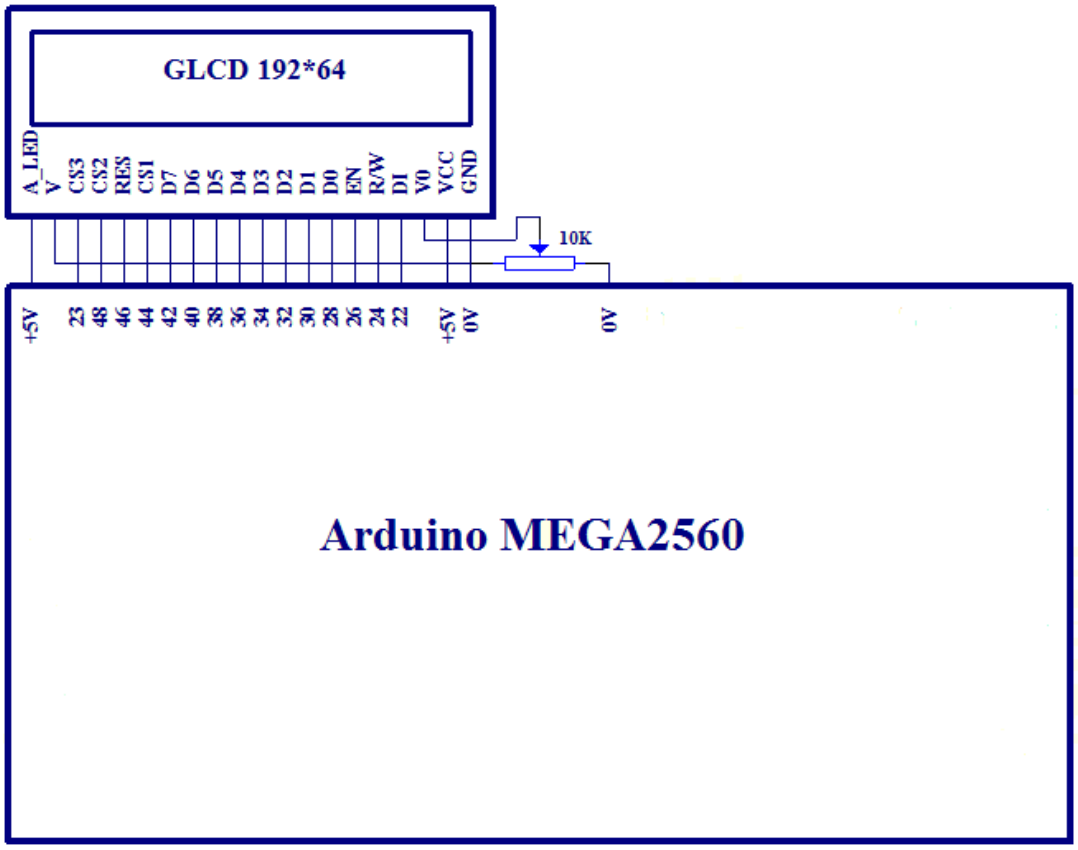

Figure 21 : Interfacing GLCD to Arduino

In the system which developed in this thesis the GLCD displays the state of connection, it will display "power on" when the GSM reads the SIM card successfully, otherwise "Power off" will be displayed. Also GLCD displays the name of communication company, date and time, sensors values, mobile phone number that sent the command, the name of command that has sent and the state of SD card reader.

3.5. Interfacing and Implementing of SD Card Reader

In this project SD card reader has merged with the system to save the details that related to each SMS that will be sent from the mobile phone in a text file such as command name, the result of the command, the date, the day and the time. In addition the details that belong to each SMS which received by the mobile phone will be saved like the name of command, the phone number that transmitted the command, the date, the day and time. The SD card reader holds a SD card. A text file

will be created in SD card by using SD card library functions. SD cared reader consists of 18 pins but only six pins which are (MISO, MOSI, VCC, GND, CS and SCK) will be used in connecting with Arduino board.

Table 6: SD card Reader Pins Description

Pins	Description
VCC	Power supply pin +5V
CS	Chip Select
MISO	Master In Slave Out
MOSI	Master Out Slave In
SCK	Serial clock
GND	Ground pin

MISO pin used to transfer data from peripherals devices to microcontroller, MOSI for transmitting data from microcontroller to devices which connected to it, CS represents as an output pin that utilized to determine the SD card reader and SCK to synchronize the transmission of data.

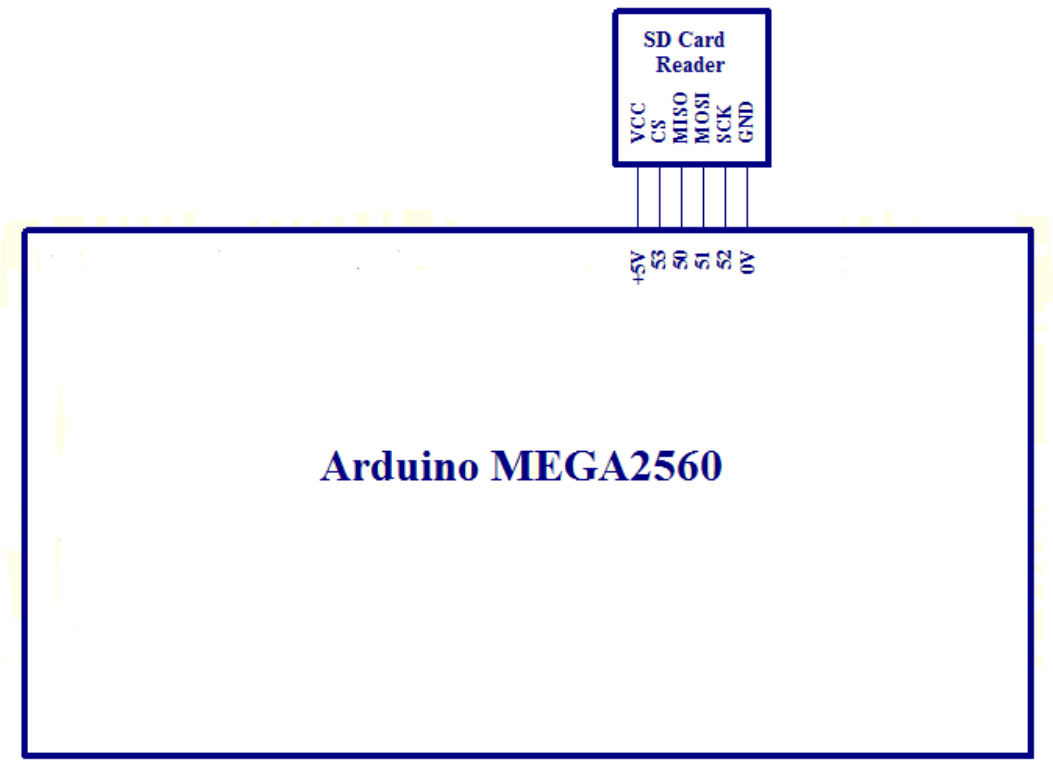

Figure 22: Interfacing SD card reader to Arduino

In figure 22 SD card reader has interfaced to Arduino board. In this figure MOSI, MISO, CS and SCK are connected to digital I/O pins of Arduino, GND to ground pin and VCC to +5V.

3.6. Interfacing and Implementing GSM/GPRS Module

The GSM represents a mediator between the mobile phone and Arduino board microcontroller it is used to provide a communications between them. There are set of commands called AT commands that utilized in GSM interfacing operation. Each AT command is responsible for a specific function.

When GSM holds the SIM card, the second one must be activated to register the operator of GSM network. SIM card can be activated by using AT command which is AT+COPS.

In this project the internal clock of GSM has been used to get the date and time instead of using an external clock. The AT+CCLK command has used to active the clock of GSM. Another AT command (AT+CSQ) was used to determine the strength of signal that related to the operator of GSM network. The AT commands are inserted within programming statements that have written in C++ language.

Table 7: GSM pins description

Pins	**Descriptions**
VCC	Power supply pin to provide GSM with +5V
P_ON	Represents an output pin
RX	Used for receiving information from Arduino
TX	Used for transmitting information to Arduino
GND	Ground pin (0V)

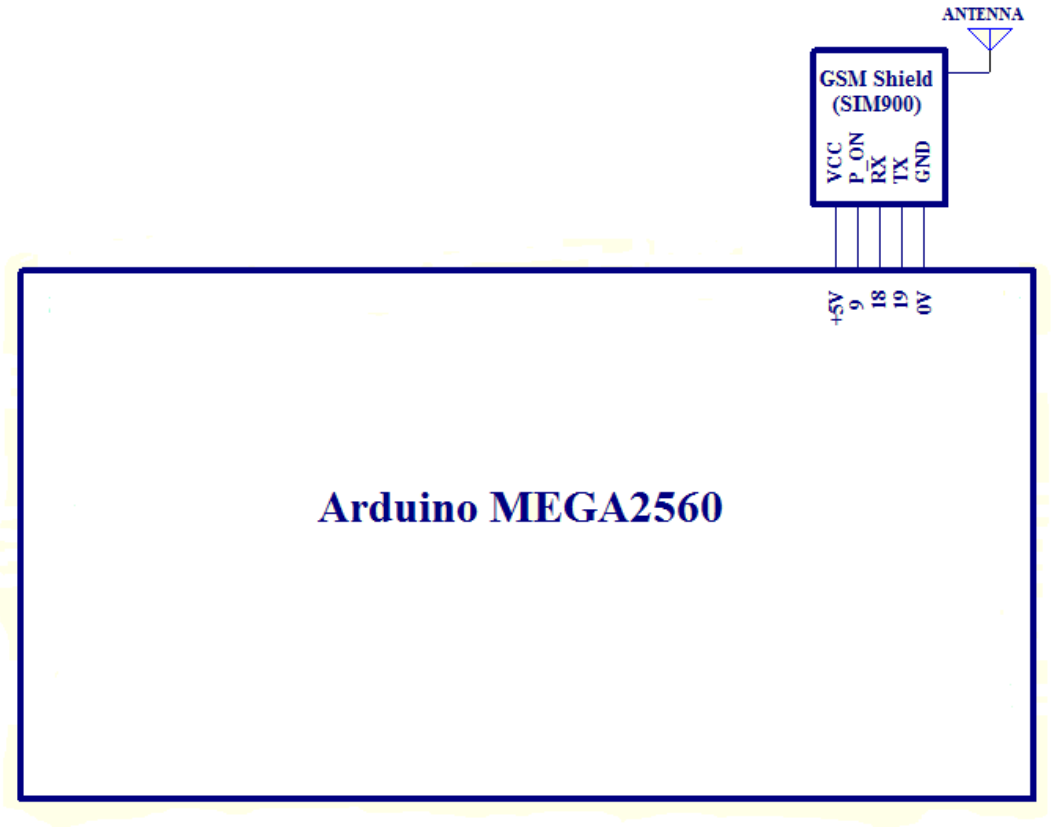

Figure 23: Interfacing GSM to Arduino

Figure 23 demonstrates the connecting operation of GSM to Arduino board. The RX pin of GSM is interfaced to TX pin of Arduino (Pin number 18) and GSM TX pin has wired to Arduino RX pin (Pin number 19), P_ON pin is connected to digital I/O pin. The GSM will send the information through the TX pin and the Arduino will receive the information through RX pin from the GSM. In the other hand the GSM gets data from Arduino by using RX pin and Arduino transmits data to GSM by using TX. For these two reasons RX pin that belonging to GSM is connected to TX in Arduino and TX of GSM is interfaced to RX of Arduino.

3.7. Development of Smart System

A smart system is developed in this thesis by implementing three sensors which are passive infrared sensor that used to detect motion in the environment, Temperature and humidity sensor for measuring temperature and humidity and flame sensor that detects the flame of fire. In addition eight devices has implemented in this smart

system which can be switched on/off remotely. The sensors and electronic devices will controlled remotely by sending a command as SMS from mobile phone to GSM modem which is connected to Arduino board in its turn controls the devices and sensors. The devices are connected to Arduino through the relays shield.

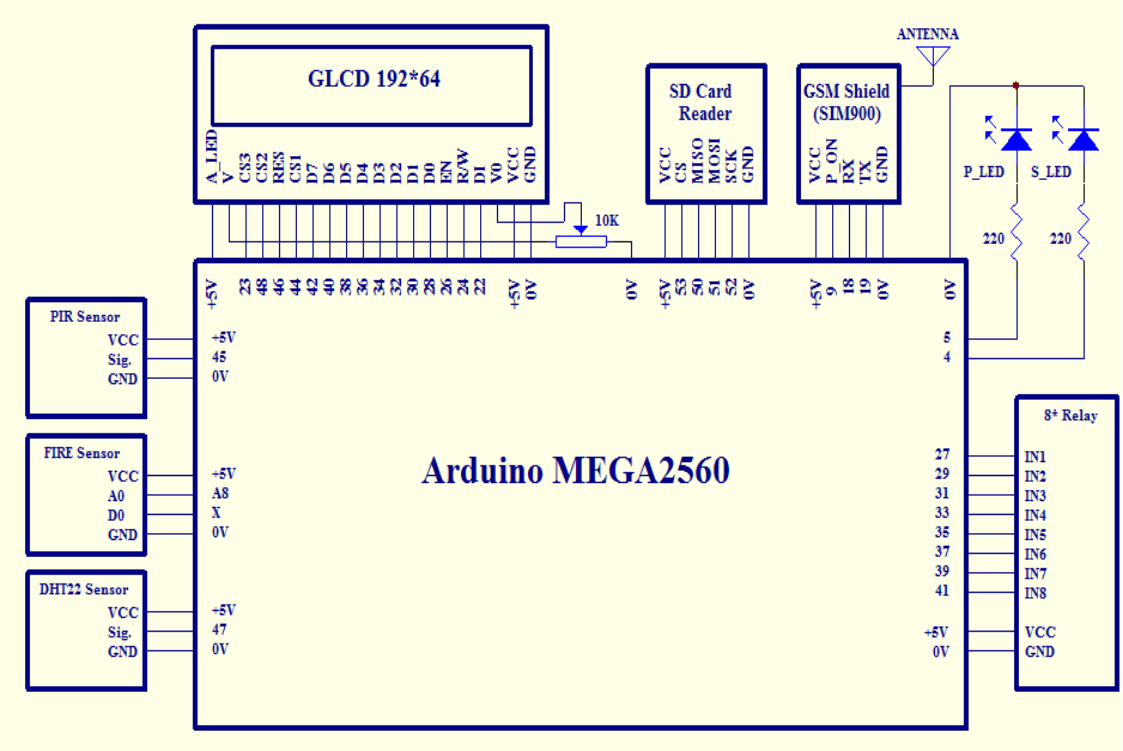

Figure 24: Block diagram of smart system after implementing

As illustrated in figure 24 there are two LEDs in the top right of the block diagram one of them will illuminate when the operation of saving information in the SD card started. Another LED will illuminate through reading SIM card by the GSM modem.

In case of sensors, when a motion or fire is detected, also when the values of temperature or humidity reaches the limited value an alert will be sent in a form of SMS from GSM modem to mobile phone of the user to inform him about what happened in the environment to take the suitable procedure. Furthermore, the user can know the value of each sensor by sending a command from mobile phone to GSM modem. In this smart system any alert will not be sent from GSM to mobile phone if abnormal situation detected by the sensors unless they are activated. To

active the sensors a particular command must be sent to GSM modem. Finally, a security will be provided in the environment by the smart system through the sensors.

In case of devices, the electronic devices switched on/off remotely. Moreover, the status of each device can be known if it was on or off by sending a specific command which used for this purpose from mobile phone to GSM.

The smart system can be controlled by more than one user but, not in the same time by sending an instruction to GSM that will change the current mobile phone number which controls the system to another mobile phone number which belonging to another person. In addition, there is a command that used to know which phone number controls the system. In this system there is a mobile phone number called master which it is the only number through it the controller of the system can be changed. After running each command in the system the mobile phone number will receive a response from GSM indicates to that command was performed. The following table includes the commands with their functions and responses that have used in controlling the smart system:

Table 8: List of commands that used for controlling the system

Command	Function	Response From GSM
Son	Enabling (active) the sensors	Sensors are enabled
Soff	Disabling (inactive) the sensors	Sensors are disabled
Sstatus	For knowingthe value and status of each sensor	……
Dxxxxxxxx	Turning devices on/off	Command executed is: Dxxxxxxxx
Dstatus	To know the status of each device	D_1:ON/OFF . . D_8: ON/OFF
Change :xxxxxxxxxxxxxx	Changing the controller of system (changing the mobile phone number)	Private_phone_number is replaced with: xxxxxxxxxxxxx
Controller	To know the controller of system	Current controller is:xxxxxxxxxxxxxx

The programming code for this smart system was written by using Arduino IDE (Integrated Development Environment) which is an open source environment that used to write the programming code and uploads it to the microcontroller of Arduino board. Arduino IDE is developed by using JAVA programming language and based on C++ programming language in writing the codes. Arduino IDE contains number of libraries some of them have used in this project for implementing sensors and other shields.

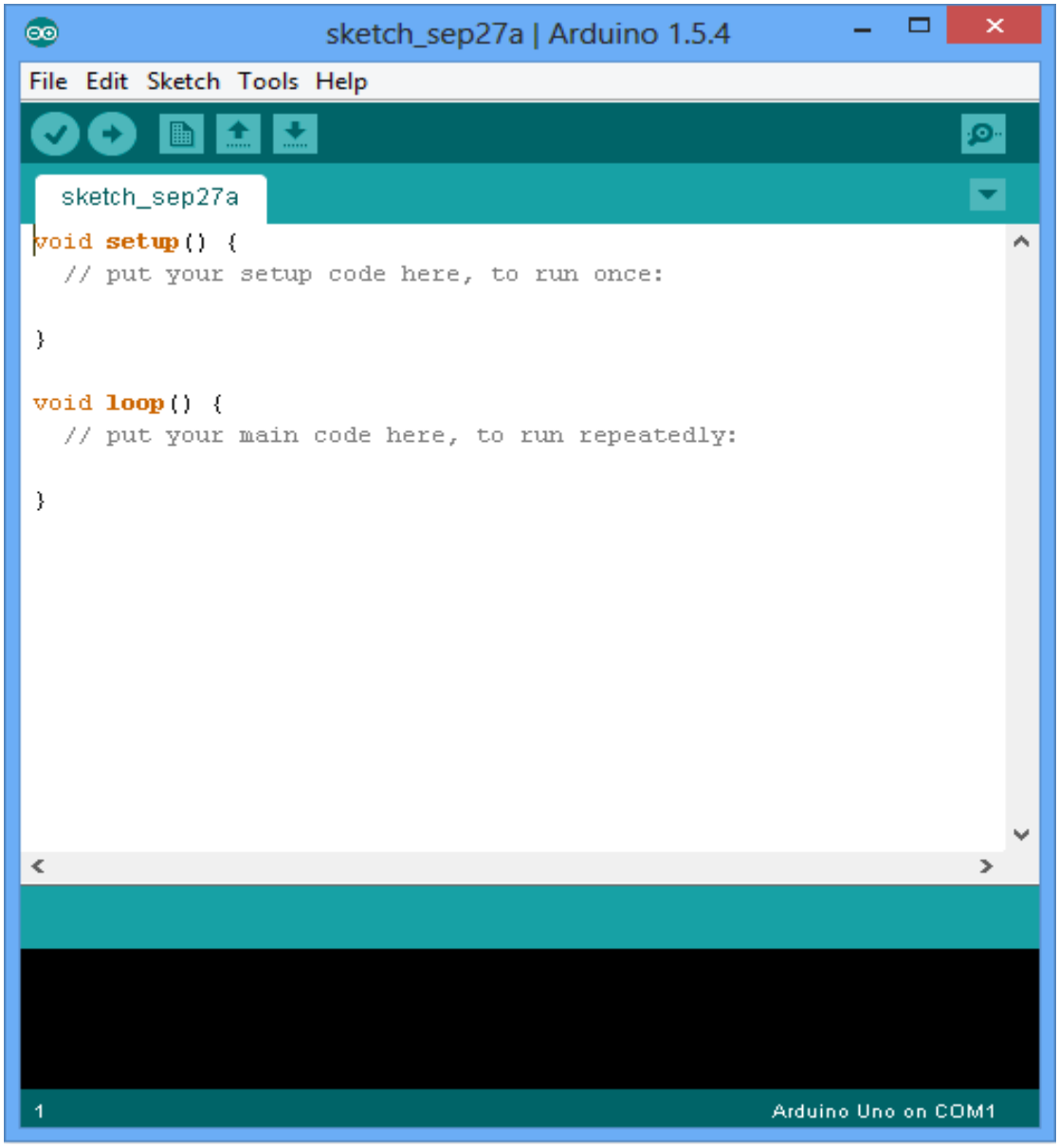

Figure 25: Screen shot of Arduino IDE

The smart system will start working after uploading the programming code to the microcontroller of Arduino. Also the system must be interfaced to power supply source that can provide +5V, an adapter with +5V power has used to operate the system.

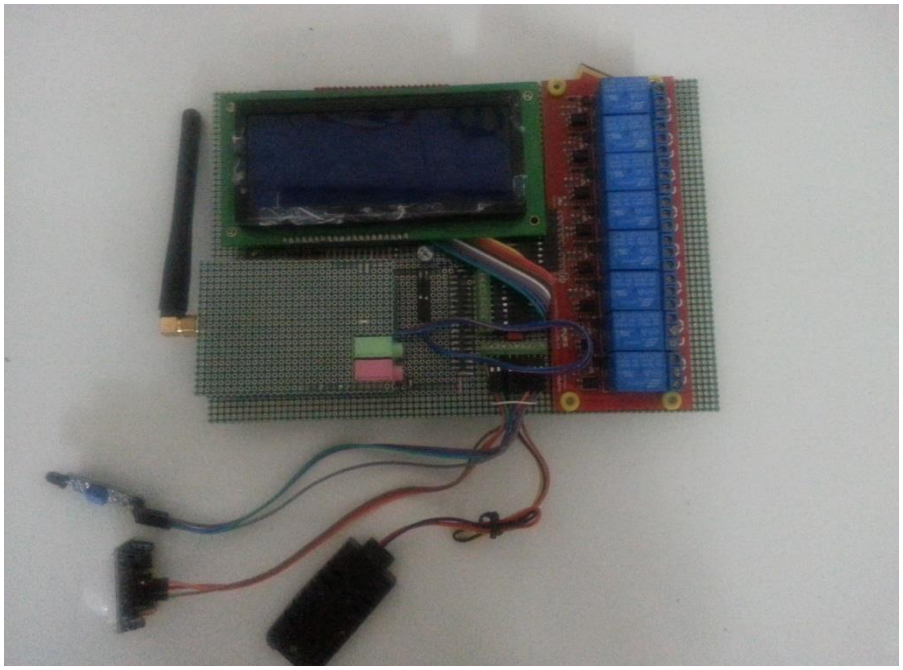

Figure 26: The first side of final smart system

Figure 26 explains the first side of smart system that has developed in this thesis. This side contains relays sheild, three sensors, GLCD screen and GSM.

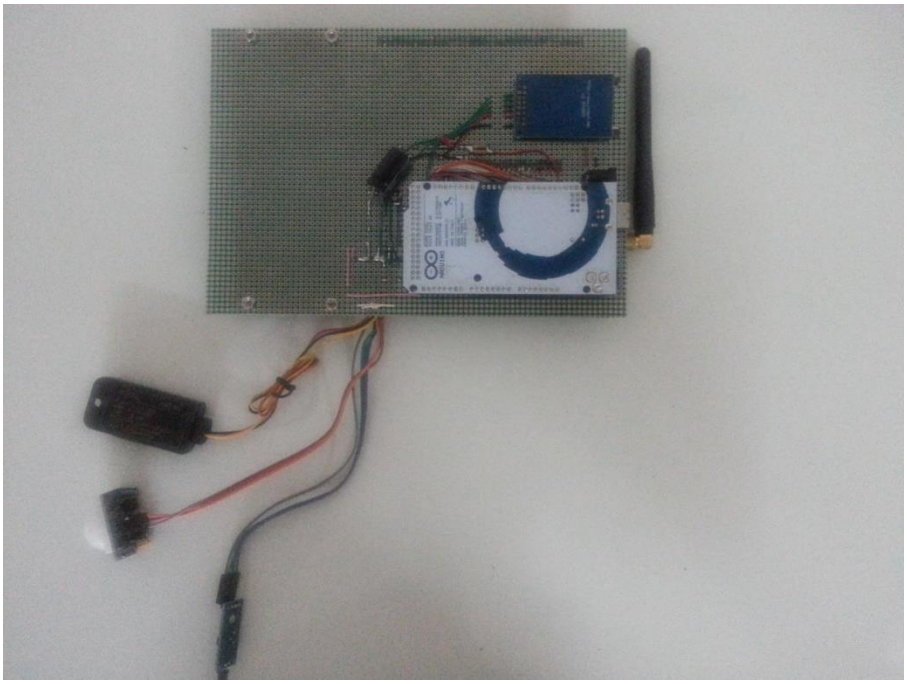

Figure 27: The second side of final smart system

Figure 27 illustrates the second side of smart system which consists of Arduino board, SD card and external power supply.

CHAPTER 4

RESULTS

When the operation of development finished the smart system has been tested to check if it works in aright form or not. The smart system has operated as expected after testing operation. The microcontroller of Arduino board can response to all commands that have sent by mobile phone and triggers alerts at abnormal situations. The results that have been gotten from testing the smart system will be explained in this chapter.

4.1. GLCD Details

Figure 28: The details of GLCD screen

As shown in figure 28 the GLCD screen displays some details such as date, time, day, the operator network of GSM (ASIACELL), the strength of signal and the status of SD card (SD OK!) this status has showed because the operation of reading SD card by SD card reader was successful otherwise the string “SD FAIL!” will appear on the GLCD screen. In addition, the sensors values, the command sent by mobile phone (Msg.) and the mobile phone number (P.N.) that sent the command have displayed by the GLCD screen. For POWER ON status that displayed on the top left of GLCD screen means that reading of SIM card by the GSM was successful.

4.2. The Results after Using Devices Commands

In the smart system which developed in this thesis eight electronic devices are controlled remotely. The command that used for switching ON/OFF devices is Dxxxxxxxx. When a command sent from mobile phone to the microcontroller each x symbol in Dxxxxxxxx will be replaced with 0 or 1 that depends on the user who controls the system. 0 for turning the device on while 1 to turn the device off. There are eight symbols of x after D character because eight devices will be controlled.

Figure 29 : The result after sending D11110000 to GSM

Figure 29 demonstrates the result after transmitting D11110000 command from mobile phone to the microcontroller. This command switched on four devices at the same time it switched off other four devices. As shown in this figure the red LED of four relays are illuminated that means four devices are ON, while the red LED of the other relays did not illuminate which means the rest four devices are OFF.

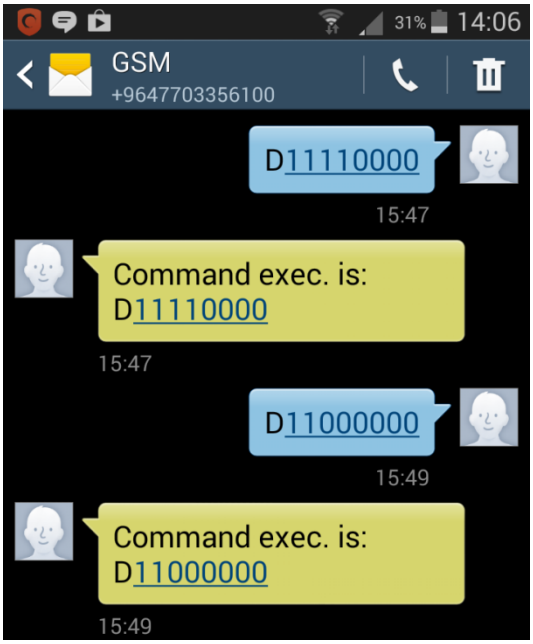

Figure 30: Screen shot of implementing Dxxxxxxxx command

In figure 30 the first command (D11110000) is sent from mobile phone to the Arduino microcontroller to turn on four devices and turn off four devices. When the microcontroller executed the command, it responded with SMS that says command exec. Is: D11110000, to inform the user that command has been executed. The second command (D11000000) is transmitted to microcontroller to switch on two devices at the same time to switch off six devices.

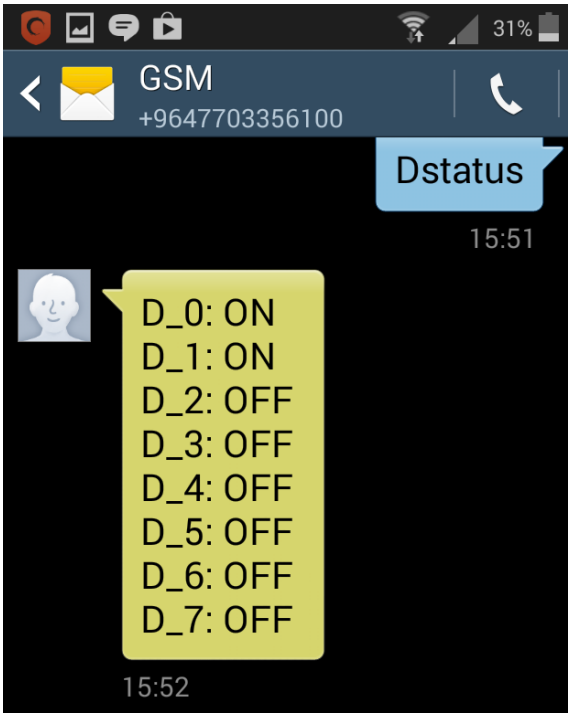

Figure 31: Screen shot of implementing Dstatus command

Figure 31 demonstrates the function of Dstatus command that used to check the status of devices for knowing which electronic device is ON and which one is OFF. As explained in the screen shot the SMS that contains the instruction Dstatus has sent from the mobile phone, after receiving the SMS by the microcontroller, it replayed with SMS to mobile phone includes the status of each device.

4.3. The Results after Using Sensors Commands

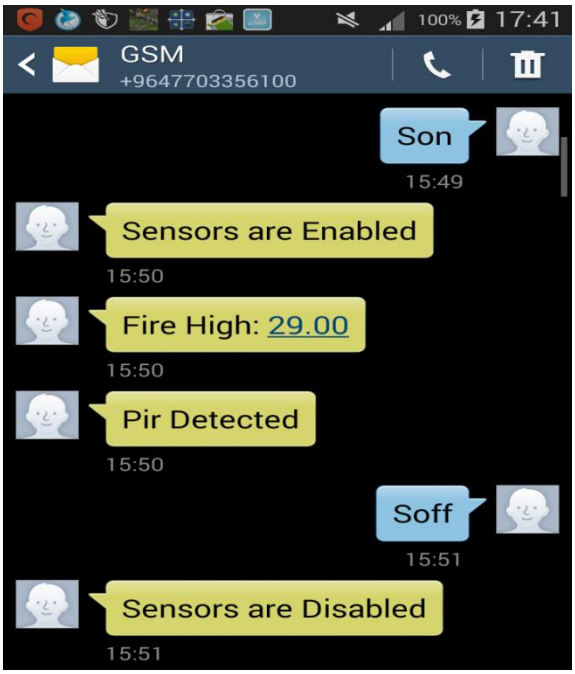

Figure 32: Screen shot of enabling and disabling the sensors

As mentioned previously the sensors will trigger alerts only when they are enabled but, when the sensors are disabled they will not trigger any alert even if there are abnormal activities in the environment. In this system the Son command has used to enable the sensors while Soff command to disable the sensors. The screen shot that belonging to figure 32 showed how the sensors are triggered alerts when they were activated.

Figure 33: Screen shot of implementing Sstatus command

As shown in figure 33 the purpose of using Sstatus command is to know the status of each sensor in the smart system.

4.4. The Results of Using other Commands

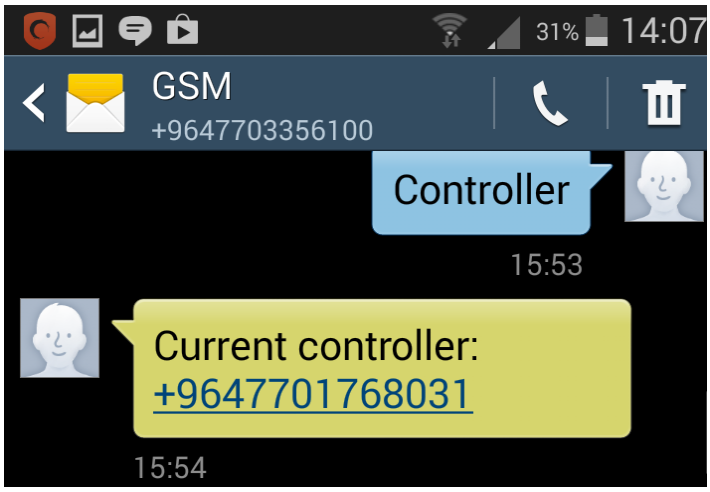

Figure 34: Screen shot of implementing controller command

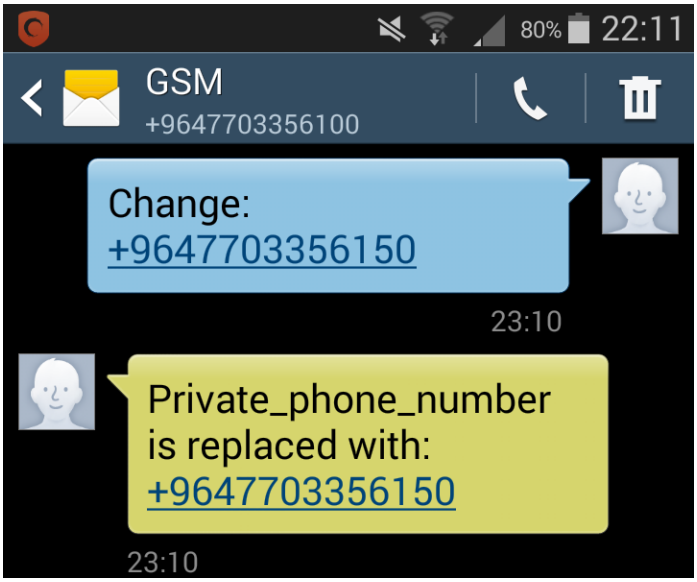

Figure 35: Screen shot of implementing Change command

As shown in figure 35 the form of change command is change word followed by the new mobile phone number that will be the controller of system. Change command has sent to microcontroller which in its turn will change the current controller of system to a new controller. After the operation of changing finished, the microcontroller sent a response to the mobile phone of the user to inform him that the changing is done and the new phone number can start controlling the system.

Finally, the microcontroller will response with error message if there is any fault in the form of any command or when unacceptable command that did not determined in the programming code has sent to it.

4.5. The Results Related to SD Card Reader

As mentioned in chapter 3 the SD card reader has used to save details that related to each SMS that sent to the microcontroller and each SMS received by mobile phone.

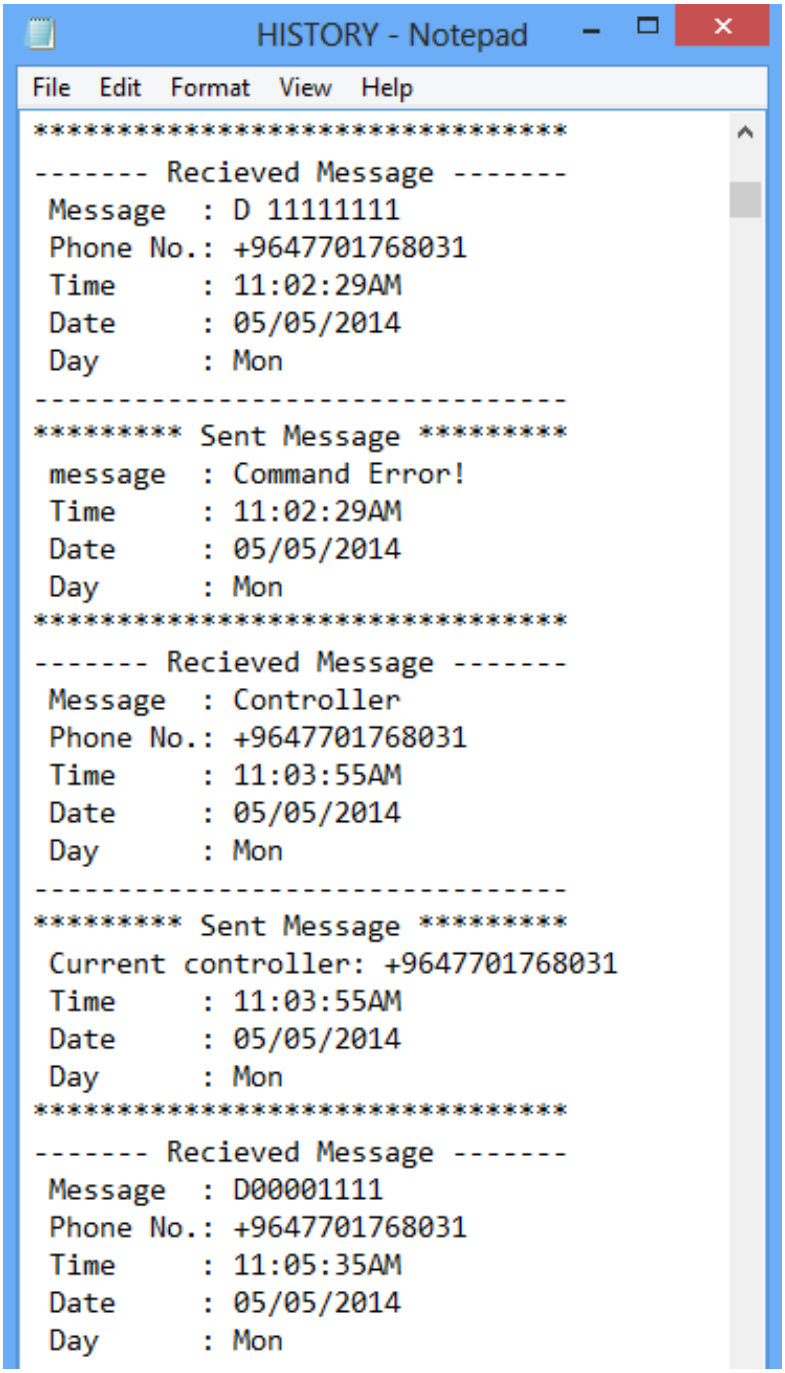

Figure 36: Screen shot of history file

As illustrated in figure 36 the details that belonging to each SMS exchanged between mobile phone and the microcontroller are saved in a text file called history.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. Conclusion

The aim of this thesis was designing a smart system that can control eight electronic devices remotely through switching them ON/OFF by using a mobile phone and receiving alerts as SMS from the system when critical situations are detected. The aim of this thesis is achieved. The eight electronic devices are controlled successfully and the system sends alerts to mobile phone when it detects abnormal activities. Arduino microcontroller has used in the developing operation of system and it considered as the heart because it responsible for most activities that occur in the smart system. GSM modem also is used and the main function of it is making an interface between the mobile phone and microcontroller to deliver the SMSs from mobile phone to microcontroller and vice versa.

The passive infrared sensor has used to detect the motion in the environment, the temperature and humidity sensor has utilized to measure the temperature and humidity and the flame sensor has used as flame detector. The relays shield is considered as interface through which the electronic devices connected to microcontroller and the red LED of each relay indicates to the status of device when the LED is illuminated that refer to switched on device while if the LED is not illuminated that means the device is switches off.

The GLCD screen also is one of components that have been utilized in system developing it displays different details such as date, time, etc. The details belonging to each SMS sent from mobile phone to the microcontroller and from the microcontroller to mobile phone such as command name, mobile phone number that

sent the command, etc are saved in the SD card by using SD card reader. The system has provided with external power supply to protect the voltage regulator of Arduino from damage, because the Arduino board can provide only +5V and the electronic devices need more than +5V to work. The system will not work unless programming code is uploaded from Arduino IDE to the microcontroller, and interfaced to +5V power supply source through the power port of Arduino.

There is no specific application or mobile model through which the system will be controlled. The system can be controlled from any model of mobile phone and without any application because the controlling of system depends on SMS.

5.2. Future Work

There are several points for the proposed smart system that considered as suggestions for the future work, including the following:

1. Instead of using SMSs to control the smart system or to receive alerts from it, a voice calls can be used for this purpose because GSM has the ability of receiving calls and making calls. In this case, the smart system will receive calls from the user to control devices and sensors. In the other hand, the smart system will call the user through the GSM when critical situations are detected.

2. In addition to three sensors, relays shield, SD card reader, GLCD screen which are implemented in the proposed smart system more sensors and parts can be interfaced and implemented by using more than one Arduino microcontroller because the pins of one Arduino will not be enough. In this situation the number of Arduino boards will be two at least. One of them will considered as master Arduino and other will be slaves which reads the data from sensors and other parts then sends them to the master Arduino for processing. More than one Arduino boards can be wired together by using I2C protocol.

3. In the proposed system when the user wants to control the smart system from another mobile phone number he has to use command called change as mentioned previously. There is another idea which can be used in the future. This idea is the user will send a command to the smart system from the new mobile phone number, the system will response with SMS that asks from user to enter a password, the user will send SMS contains the password to the smart system which in its turn will compare it with the password that must be determined in the programming code if it is true the user will be able to control the system by using the new mobile phone number.

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APPENDICES A

A. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: WAREED, Musaab Amer

Nationality: Iraqi

Date and Place of Birth: 21 January 1989, Mosul, Iraq

Material Status: Single

Phone: +90534380 4816, + 964 770 176 8031

Email: shinoda.maw7@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
B.Sc.	Mosul University College of Science. Computer Science Department	2012
High School	Al-Sharkia for Boys	2008

WORK EXPERIENCE

Year	Place	Enrollment
2014	Middle East Company for Engineering Equipments	Computer Maintenance

FOREIGN LANGUAGES

Arabic (mother language), English

HOBBIES

Reading, Travelling, Video Games