College of Engineering

Electrical Engineering Department

Communication and Electronics Engineering

Bachelor Thesis

Graduation Project

Smart Security System Based on Wireless Sensor Network and Third Generation Technology

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كلمة شكر

أولاً الحمد لله العليّ القدير على إعانته وتوفيقه لنا على إتمام هذا المشروع.

ونتقدم بجزيل الشكر وخالص العرفان إلى الهيئة التدريسية في كلية الهندسة في جامعة البوليتكنك ، ونخص بالشكر الأستاذ أيمن وزوز

على إرشاده لنا في مشروعنا هذا، ومساهمته في رفع مستوانا بتوجيهاته الحكيمة .
كما نتقدم بجزيل الشكر إلى كل من ساهم بإنجاح هذا المشروع بإمداده العون والمساعدة بشكل مباشر أو غير مباشر..

إهداء

إلى أول المعلمين سيدنا محمد صلى الله عليه وسلم.

إلى من شاركونا أجمل الذكريات وكانوا معنا كل اللحظات فكانوا نعم الأخوة والأصدقاء.

إلى أسطورة الزمان شعب كنعان صانع حضارتنا.

إلى الشامخات الماجدات..... أمهات الشهداء.

إلى الطيور المرفرفة..... أطفالنا المشردون تحت الحصار و القمع.

إلى أنين الجرحى و عذاب المعتقلين في دروب النضال.

إلى شوارع المدينة العتيقة..... زهرة المدائن..... إلى القدس.

إلى وطننا فلسطين من زرقة البحر إلى خضرة النهر.

إلى معاناة أهلنا وذوينا من أجل أن نرى النور.

إلى أنفسنا إذا كنا نستحق ذلك.

Abstract

This project is developed and implemented as an integrated wireless sensor system; it is specialized in safety and security issues in buildings, in order to protect it from risks before they happen, or at least to minimize the impact of risks as much as possible.

The first phase of the project is the Wireless Sensor Network WSN; it contains fire and motion sensors, water pumps and doors connected to the network using Zig-Bee technology. The second phase is the central server, which let the users control and monitor buildings by Wi-Fi technology. Moreover, control an IP camera using the same technology .the final phase is the tele-controlling subsystem, which allows users to monitor and control the whole system using 3G network. At the end, we developed a robust, efficient and valuable system that helps to protect our stuff wherever we are.

الملخص

المشروع هو عبارة عن نظام حماية ذكي للمباني من الحرائق والسرقات، باستخدام شبكة من حساسات حركة الإنسان والحرائق وشبكات الجيل الثالث للهواتف اللاسلكية.

تقوم الحساسات بكشف إذا كان هناك حريق في المبنى او حركة صادرة من الإنسان، ومن خلال ربطها بمتحكم دقيق باستخدام تقنية لاسلكية (Zig-Bee) ترسل له إشارة بوجود حريق أو حركة، وبدوره يقوم المتحكم بتشغيل مضخة مياه لإطفاء الحريق ويقوم أيضا بفتح واغلاق أبواب النجاة في المبنى ليتمكن القاطنين في المبنى من الخروج منه بسهولة وبدون التعرض للأذى، أو إغلاق الأبواب إن كان هناك سارق بالداخل.

بالإضافة إلى كاميرا مراقبه تعمل على تقنية ال Wi-Fi ، وستعمل هذه الكاميرا بالاعتماد على إشارة من حساسات الحركة للإنسان، ففي حال كان هناك إنسان في المبنى، تصل إشارة لاسلكية إلى الكاميرا من خلال تقنية ا ل Wi-Fi حيث تبدأ الكاميرا بتسجيل الفيديو وارساله لجهاز الحاسوب من خلال التقنية نفسها .وبدوره يقوم جهاز الحاسوب بإرسال الفيديو إلى الهاتف الذكي من خلال شبكات الجيل الثالث للهواتف اللاسلكية.

المشروع تم تطبيقه على أحد الطوابق في (مبنى B)، جامعة بوليتكنيك فلسطين.

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List of Abbreviations

Abbreviation	Stands for
PC	Personal Computer
Wi-Fi	Wireless Fidelity
PIC	Programmable Integrated Circuit
3G	Third Generation
HSDPA	High-Speed Downlink Packet Access
GSM	Global System for Mobile Communication
WSN	Wireless Sensor Network
SMS	Short Message Service
A/D	Analog to Digital
LED	Light Emitting Diode
RF	Radio Frequency
IDE	integrated development environment
PAN ID	Personal Area Network identifier

Chapter 1: Introduction

1.1 Overview.

1.2 Project Objectives.

1.3 Motivation.

1.4 Requirements.

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1.10 Project Schedule.

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1.1: Overview

In this chapter, a brief description of the system will be shown .Starting with objectives, the goals that we are targeting to achieve will be shown by the end of this project. Then, the hardware and software requirements and challenges, that will we face. At the end, we will show the approach and scenario of the project.

1.2: Project Objectives

The main aim of our project is to provide the building's guard a valuable information and ability to control, in the case theft or fire. Thereby protect the residents of the building from the risk before it happens, or at least minimize the impact of the risk as much as possible.

We can divide objectives to the following:

- Design and Implement a robust and accurate security system that can detect motion by certain detection sensors and camera.
- Automatic fire alarm system to prevent fire from burn, damage the building, by detecting fire through smoke detectors, and automatically turn on a firefighter device (water pump).
- The whole system is battery power dependent, so it is independent on buildings electricity, which is an important matter in security issues.
- System with the lowest possible costs compared to other available systems in the market.

1.3: Motivation

The building's guard is responsible in monitoring the front and back yards and building's entries. Moreover, he is responsible in monitoring several floors and be ready for any emergency case .The idea behind the intelligent safe building comes from the huge need of an integrated safety system that helps the building's guard in his work, and the use of available technologies to make this job much easier and better.

1.4: Requirements

This system requires hardware and software requirements in order to achieve our goals in this project. We need sensors and security camera for detection, controllers, PC, smart phone for monitoring and controlling, and pumps and relays to carry out orders:

Hardware requirements:

- Motion, smoke sensors.
- Wi-Fi camera.
- X-Bee PRO S2 and X-Bee Regulator.
- 3G HSDPA Modem.
- Arduino microcontroller.
- Personal Computer (PC).
- Smart phone with android platform.
- Electronic firefighter (Pump).
- Electronic and Electrical components.

Software Requirements:

- Programming Languages such as Android, Arduino Programming Language (C), Zig-Bee configuration, and 3Gmodem configuration.

1.5: Challenges

Some challenges we **expect** to face in our project:

1) Designing an accurate, efficient and valuable system, with limited hardware and software resources.
2) Learning programming languages that we need in programming system devices.
3) Implementing a subsystem depends on 3G technology, which is not supported in our area.
4) Building live video streaming software with acceptable resolution and short delay.

1.6: Assumption

The project will be applied in Palestine Polytechnic University in one of the floorsin Building "B" as following:

- There will be Wi-Fi camera with human detection sensor to catch the theft when pass through it.
- Three nodes will control water pump, fire and motion sensors to sense existence of fire and motion, automatically control and notify the guard.

1.7: Approach

This system uses wireless sensor network to protect the building from fire, accidents, remotely control, and monitor using mobile. The following is the general block diagram. (Interfaces will discussed later)

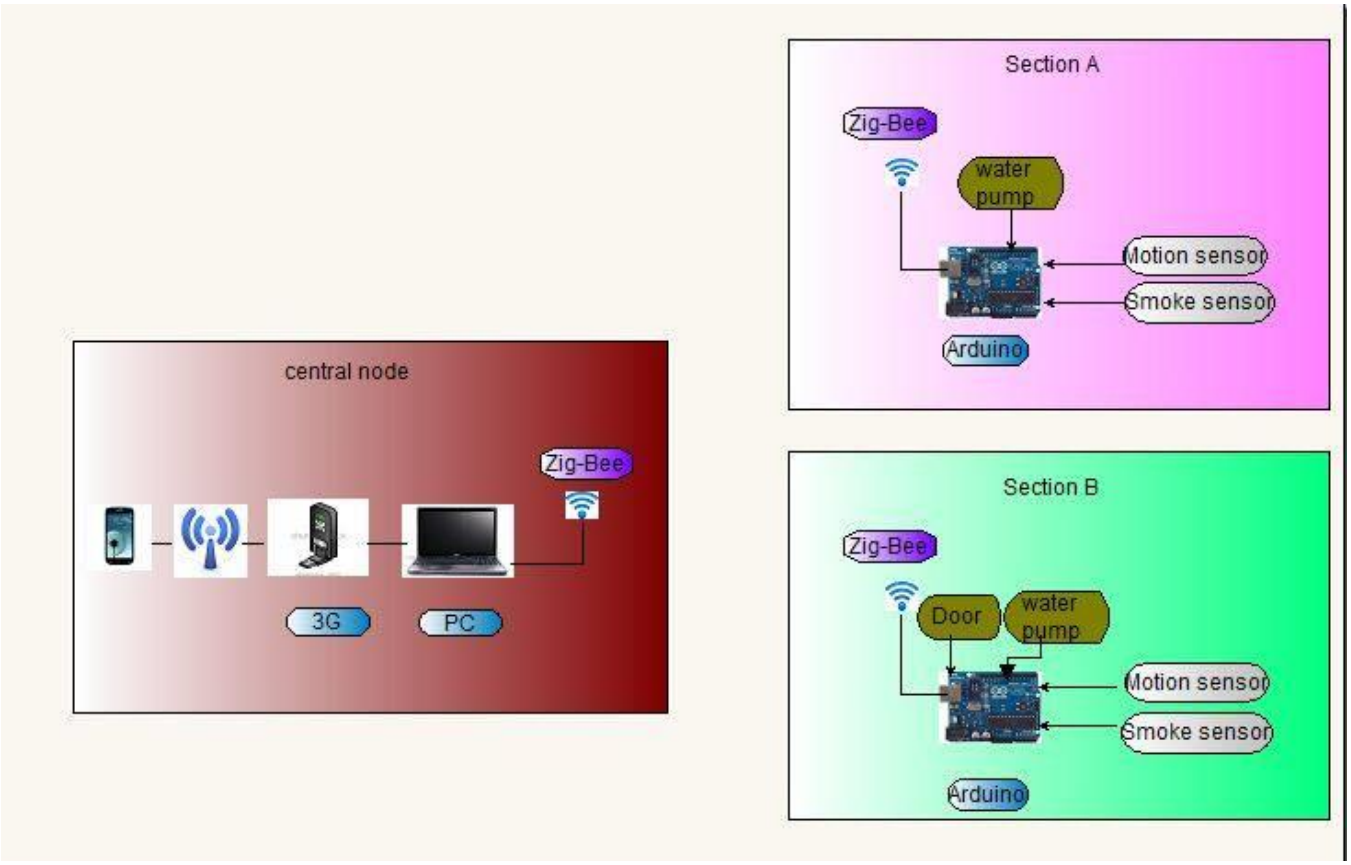

Figure 1.1 General System Block Diagram

Step by step description approach:

- WSN send signal about its status to the Zig-Bee, e.g. the fire detection sensor detect a fire accident and send this information to the nearest Zig-Bee node.
- The information travels from Zig-Bee nodes to another node until it reached the central node, which is directly connected to the PC.
- Wi-Fi camera detect the human motion using sensors and send the recoded videos to the PC device.
- PC device managed the received data from camera and microcontrollers, then send it to the 3G modem.
- 3G modem receives signal from the PC and send it to smart phone with high speed, high data rate.
- All monitoring data will reach the guard's phone, which makes him familiar with all details of the building (fire alarm, motion detection).
- Android application allows the guard to control and overcome the accident immediately, so he send control signal to 3G modem – PC – microcontroller.

1.8: Scenario

Location: Building B in Palestine Polytechnic University (PPU)

- **Security Systems**

A) Indoor System:

1) At night, the motion across the university corridors or classes will be absolutely from an unauthorized person. The human motion sensor triggers the security system by sending its alert signal to the Zig-Bee unit, which will communicate to the Zig-Bee coordinator .In its turn the Zig-Bee coordinator will send the signal to the PC.
2) The PC provides the gaud through the 3G modem about the sensor place.
3) The expected control step from the guard is to close the doors. The building guard can send the order through his android application to the 3G modem then to the PC, which will translate this signal to the microcontroller to close the doors.

B) Outdoor System:

1) In the case of any unexpected motion around the building within its surroundings, the Wi-Fi human detection camera will start record the motion. Then, through the Wi-Fi network, it will send the video to the receiver node, which is the PC in this case.
2) The PC will send the recorded video to the guard smart phone. Then, he will decide to close the doors as the process above or to call the police.

- **Safety System:**

At the emergency case of fire, the fire sensors will trigger the system by sending its alert signal to the microcontroller through the Zig-Bee coordinator. The microcontroller will open the water pump automatically, and then sends a notification to the guard. He will decide to open the emergency doors through his android application.

1.9: Literature Review (Related Works)

Smart Farm [1]

In the project, Alsharawi et al, described the design of "chicken Eggs Farm", that allows the system to collect the eggs automatically when its ready to be collected, without the need to get inside the farm, and allow the manager to get an measurement for the temperature and humidity status on the mobile, the sensors covers the farm connected via Wi-Fi network. The Microcontroller that use in this project is PIC 16f688, it processes the temperature and humidity in the farm, and this processed information send to the owner using GSM modem as a short message (SMS) at his request through Wi-Fi network.

We use in our project Zig-Bee network to connected the sensors the Zig-Bee is better than Wi-Fi because Zig-Bee is a low-cost, low power transceiver. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Other differences, in our project the mobile station is communicate with the system through the 3G modem, the 3G modem is consider too much faster and higher data rate than use GSM modem.

A Remote Home Security System Based on WSN and GSM Technology. [2]

In this paper, Huang et al, describe the remote home security alarm with low-power consumption system developed by applying WSN and GSM technology presented. It can detect the theft, leaking of raw gas and fire, and send alarm message remotely. The hardware of this system includes the single chip C5081F310, wireless receiving and sending chip CC1100 as well as the SIMENS TC35 GSM module. The system software developed in C51 language has the ability of collecting, wireless receiving and sending data, and can send a piece of alarm short message to the user.

We will design a remote security system mainly for large buildings like Universities, that needs a security guard, but it can be implemented for homes. Our system designed by using Zig-Bee based WSN configuration for motion and fire detection, 3G technology for sending alarm messages - including data packets - faster using 3G modem instead of GSM modem they used, and Wi-Fi technology for remote control security cameras. We used human recognition algorithm for detection any person who want to steal the building or damage it. Moreover, there will be an Android platform used for controlling the whole system. This research paper is clearly part of our widened, compact project.

Home Automation System [3]

In this project, S. Khan et al, mainly focused on the design and implementation of system that control various appliances at home. The system used A/D converter that connected to a temperature sensor .Moreover, a light monitoring and controlling subsystem implemented in this project. The 89C51 microcontroller is the brain of the whole system. A java software application, which downloaded on a fixed PC machine, presents the user interference part.

The Zig-Bee and Wi-Fi technologies with their huge benefits and challenges will be the main advanced step in our system. Furthermore, the remotely monitoring and controlling system will be a great change in the world of smart buildings.

Building Management System [4]

In this project, H. Abu Ajamia et al, design stand-alone system that utilize power consumption and other house application (lighting management, security by using electronic lock motion detector, water and electricity monitoring, control via voice recognition mechanism).The project use data base, C# programming language, sensors, GSM cellular module and PIC microcontroller (18F4550).

Our project will focus on safety and security system in building(fire and human motion detection) using wireless sensor network, cameras,3G modem, microcontroller, based on(Zig-Bee, Wi-Fi) technology. Android software configuration will be used to monitoring and control our system, which makes our project different from others .Moreover, our project not depends only on alarm notifications, but allows the guard to give orders to overcome accidents directly.

Alarm System Using Body Detector [5]

In this project, U. Noor Din, designed alarm system adopts advanced RF oscillators matched with reliable software technology and advanced hardware circuitry. It integrates capacitance detection, network search, and automatic voice alarm. This system mainly uses capacitance detector, body-intruding detection to transmit alarming signal to main unit. When signal received, it processes it immediately, and then main unit will automatically give an alarm by the designed code. In this project, a Microcontroller PIC16F877 will be used as an actuator of the system that will control the output system through a programming system. The system will be developed to control the system flow such as register data, delete data, and creating program flow to produce the output depends on the activation of body detector hardware circuitry. The PIC16F877 microcontroller will analyze and process the data and if the data has been registered in the system, the security application will work such as triggering the buzzer and LED.

In our project, we will use cameras for human detection instead of using capacity sensors, for tow advantages, traditional security monitoring and human detection. Although using capacity sensors is useful technique it probably less accurate than others.

1.10: Project Schedule

Table 1.1: Project timing schedule

Activity	Time	Activity
A	1st SEP 2013 – 20th SEP 2013	Ideas surveying, searching references, set a group and supervisor, and preparing proposal.
B	18th SEP 2013 – 26thOCT 2013	Draw the general block diagram and understanding the system's components and technologies
C	19th OCT 2013 – 30th OCT 2013	Collecting theory information
D	1stNOV 2013 – 30thNOV 2013	Understanding system block diagram (Hardware and Software Design)
E	25th NOV 2013 – 20thDEC 2013	Analyze System Design and interfacing between components and devices.
F	1stFEB 2014 – 28thFEB 2014	Learning software languages for microcontroller, modem, and recognition technique used. Buy all components and devices.
G	24th FEB 2014 – 15th APR 2014	Programming Hardware, setup the whole system and testing it.
H	16thAPR 2014 –5thMAY 2014	Finishing Documentation
I	6th MAY 2014 –25th MAY 2014	Deliver Documentation For Supervisor. Documentation For the Electrical Department.

Summery For Project Plan:

Table 1.2: Summery of project plan for the first semester

Week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A														
B														
C														
D														
E														

Table 1.3: Summery of project plan for the second semester

Week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14
F														
G														
H														
I														

1.11: Budget

Table 1.4: Budget

Price / Unit	Quantity	Equipment
163 $	2	Arduino Microcontroller
200 $	1	3G modem
400 $	1	Security Camera (Wi-Fi camera)
20 $	3	X-bee transceiver
131 $	1	Automatic Water Pump
60 $	2	Fire Sensors
46 $	2	Motion Sensors
50 $	-	Documentations
140 $	-	Others
1210 $	**13**	**Total**

Chapter 2: Theoretical Background

2.1 Wi-Fi Technology.

2.2 Zig-Bee Theory.

2.3 3G Technology.

2.4 Microcontroller.

2.5 Fire System.

2.6 Motion sensor.

2.7 Android.

2.1: Wi-Fi Technology

2.1.1 : Introduction

Short for "wireless fidelity", Wi-Fi is one of the most popular wireless communication standards on the market. Wi-Fi is technically a trademarked brand name for the wireless standard owned by the Wi-Fi Alliance, much like *Bluetooth* is trademarked by the Bluetooth Special Interest Group. In its fledgling stages, Wi-Fi technology was almost solely used to wirelessly connect laptop computers to the Internet via local area networks (LANs), but thanks to the immense flexibility the technology provides, that's no longer the case. Wi-Fi technology now found in a host of non-computer electronic devices as well, such as home theater receivers, video game consoles, Blu-ray player digital cameras, and even GPS devices.

Figure 1.1: Wi-Fi technology

2.1.2: Wireless Standards

The official name for the specification is IEEE 802.11, and it is comprised of more than 20 different standards, each of which denoted by a letter appended to the end of the name. The most familiar standards are 802.11b and 802.11g (Wireless B and G) which are used in the majority of commercial Wi-Fi devices. Both of these standards operate in the 2.4 GHz band, and the only major difference between the two is the transfer rate (see chart below).

Some consumer electronics, however, use a different standard — Wireless A. These devices operate within the 5 GHz range and have transfer rates equivalent to 802.11g. However, since they operate on different frequencies, devices using the 802.11a standard can't communicate with B and G-enabled devices.

The newest standard, dubbed 802.11n was designed to replace all three of the previous standards. It's up to five times faster than 802.11g, with a range almost twice as far. It also adds multiple-input multiple-output (MIMO) technology, which uses multiple antennas to increase data transfer rates. The 802.11n standard was drafted to allow up to four channel configurations with potential speeds up to 600 Mb/sec. It is becoming increasingly popular for its high speeds, which allow for smoother audio and video streaming among devices.

The table below provides a brief overview of the four most popular current 802.11 standards.

Table 2.1: Brief overview of the four most popular current 802.11 standards

Standard	Frequency	Data Transfer Rate Typical (Max)	Range (indoor)
802.11a	3.7/5 GHz	20 (54) Mb/sec	About 35 m (115 ft.)
802.11b	2.4 GHz	5.5 (11) Mb/sec	38 m (125 ft.)
802.11g	2.4 GHz	22 (54) Mb/sec	38 m (125 ft.)
802.11n	2.4/5 GHz	110+ (300+) Mb/sec	70m (230ft)

2.1.3: Advantages and Limitations

Advantages:
The Wi-Fi technology have many advantages some of them are:

1) Unparalleled mobility and flexibility
2) Quick, easy setup
3) Fast data transfer rates
4) Flexibility to connect Wi-Fi camera with PC and Arduino.
5) Quick, easy setup, do not need complex configuration to connect devices. Fast data transfer rates, that we need it specially to transfer lifetime video from Wi-Fi to PC camera immediately.

Limitations:

So far, we've covered some of the advantages offered by Wi-Fi wireless technology, but there are some limitations that must be addressed as well. Security and interference are the main issues with current Wi-Fi standards.

1) Security concerns
2) Interference from other devices.[6]

2.1.4: Wi-Fi Camera

A Wireless IP Camera lets you view real-time images over the Internet. In other words, you can monitor your home or office from a distant location using a PC, even a Multi-Function mobile telephone or PDA. Network cameras even feature a built-in Web server function, so the network camera does not have to be connected to a PC.

Wireless means that you can set up wireless IP cameras anywhere without cumbersome LAN cable connections. Most wireless IP cameras support the 802.11g 54-Mbps / IEEE 802.11b 11-Mbps wireless communication protocol and the latest Wireless-N 802.11n for fast transmission of recorded images to a distant PC. [7]

2.2: Zig-Bee Theory

2.2.1: Overview

Zig-Bee is a specification based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs). Zig-Bee operates in the ISM radio bands, and it defines a general-purpose, inexpensive, self-organizing, mesh network for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation and home automation.

2.2.2: Zig-Bee Types

There are three different types of Zig-Bee devices in a Zig-Bee network:

1) Coordinator (Master): Only one coordinator exists in each Zig-Bee network. Its function is to store information about the network and to determine the optimum transmission path between any two points of the network.

2) Full function device (Router, Repeater): Routers act as an intermediate repeater that passes data from other devices.

3) Reduced Function Device (End Device): This device contains a minimal amount of functionality to enable it to talk to its parent node (either the coordinator or a router); itcannot relay data directly from other devices.

2.2.3: Topologies

There are three types of Zig-Bee topologies:

- Mesh
- Star
- Cluster Tree

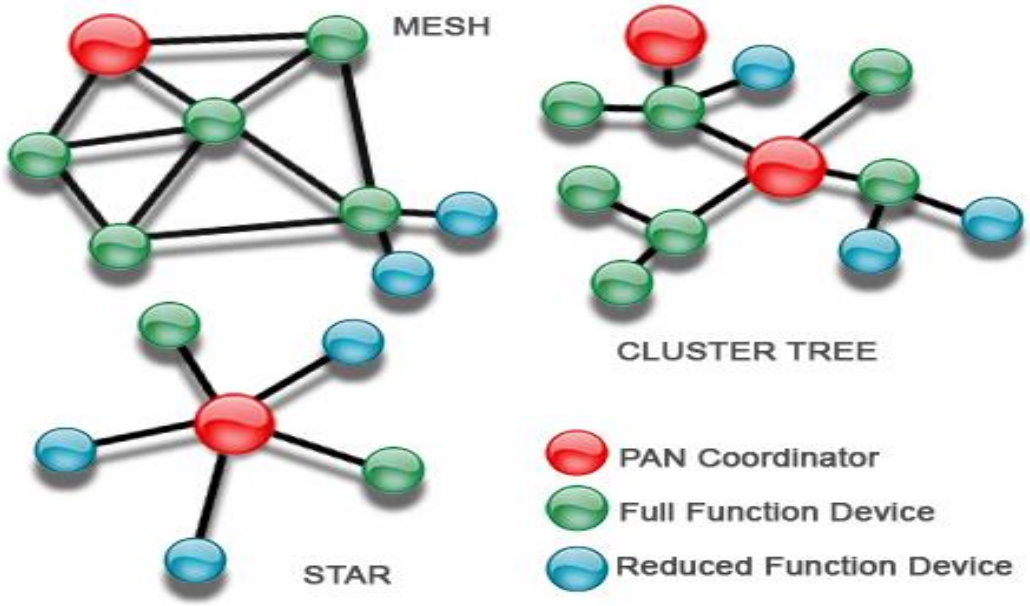

Figure 2.2 Zig-Bee topologies

We will implement the mesh topology, since it provides three enhanced capabilities to the wireless network as shown in figure 2.3.Extended range through multi-hop, ad-hoc formation of the network, and most importantly automatic route discovery and self-buildings. [8]

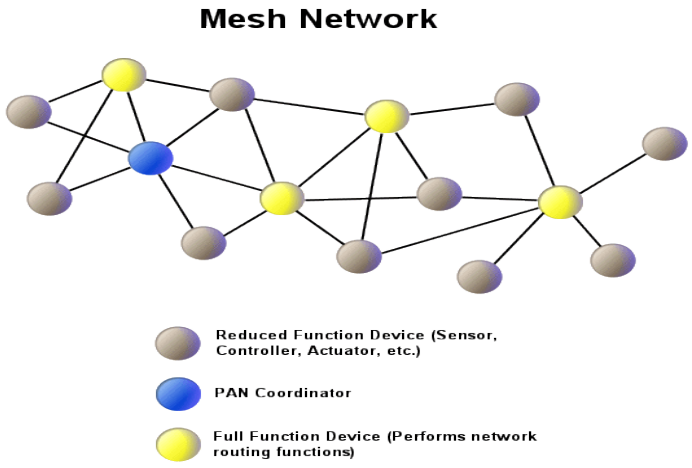

Figure 2.3 Zig-Bee Mesh topology

2.2.4: Zig-Bee properties

The following table summarizes the properties of the Zig-Bee technology:

Table 2.2: The Zig-Bee properties

Property Description	Prescribed Values	
	915 MHz	2.4 GHz
Raw data bit rate	40 kbps	250 kbps
Transmitter output power	1 mW = 0 dBm	
Receiver sensitivity (<1% packet error rate)	-92 dBm	-85 dBm
Transmission range	Indoors: up to 30 m; Outdoors: up to 100 m	
Latency	15 ms	
Channels	10 channels	16 channels
Channel numbering	1 to 10	11 to 26
Channel access	CSMA-CA and slotted CSMA-CA	
Modulation scheme	BPSK	O-QPSK

Zig-Bee vs. other technologies:

Table 2.3: Zig-Bee in comparison with Wi-Fi and Bluetooth

Feature(s)	IEEE 802.11b	Bluetooth	ZigBee
Power Profile	Hours	Days	Years
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	3 Seconds	10 seconds	30ms – 1s
Range	100 m	10m	70m-300m
Extendibility	Roaming Possible	No	YES
Data Rate	11Mbps	1 Mbps	250Kbps
Security	CCMP/TKIP 128bit/64bit	64 bit, 128 bit	128 bit AES and Application Layer

Based on the previous table (Table 2.3) the Zig-Bee technology will fit our needs to build a wireless sensor monitoring and control system, because it is:

1) Highly reliable :the Zig-Bee can achieve high reliability in a number of ways :
   - IEEE 802.15.4 with O-QPSK & DSSS.
   - CDMA-CA
   - 16 bit CRC's

2) Able to achieve very low power: devices in Zig-Bee network can operate for years on a pair of AA batteries.

3) Highly secured: it is an internationally recognized and trusted standard. It is free patent infringements.

4) An open global standard: Zig-Bee uses as its foundation of IEEE 802.15.4 specification for lower MAC and physical layers. The IEEE defines a reliable radio slandered in the 2.4GHz bandwidth, which used worldwide.

2.3: 3G Technology

2.3.1: Overview

Short for third generation is the third generation of mobile telecommunication technology. 3Gtelecommunication networks support services that provide an information transfer rate of at least 200 Kbit/s. However, many services advertised as 3G provide higher speed than the minimum technical requirements for a 3G service. Later 3G releases, often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to smart phones and mobile modems in laptop computers.3G finds application in wireless voice telephony, mobile Internet access, fixed wireless Internet access

2.3.2: Principle

3G works by parceling the data sent on the network into small packets. These packets are then assembled in the correct order at the receiver's end. This is very different from normal 2G (GSM) technology, in which a small portion of the network is 'reserved' or kept open for a call. Thanks to this parceling process, 3G networks are able to send more data efficiently in a shorter period of time, smart 3G technology also enables mobile service providers to know the location (to within a new meters) of the handsets using their service. This not only allows them to send information about offers in certain areas (say, if you are near a restaurant your service provider might send you a message about a special dish being served there on that particular day), but is also immense help in case of emergencies those who are lost can find their way out or the police

can be directed to them, based on information from the service provider about the location of the phone. [9]

2.3.3: Main Characteristics

• IP connectivity, which is packet based.

• Multimedia services with streaming audio and video.

• Email with full-fledged attachments such as Power Point files.

• Instant messaging with video / audio clips.

• Fast downloads of large files such as faxes and PowerPoint files.

• Access to corporate applications.

2.3.4: ADVANTAGES and DISADVANTAGES

ADVANTAGES

- High-speed network for communication.
- Customer can see video or satellite based programs like TV programs using this technology.
- The many in one services will be available at the same network. Due to use of the DTH & the 3G technology, everyone will use multi-purpose services to avoid time loss and keeping records for different service providers.

DISADVANTAGES

• High costs (the technology and the maintenance are more expensive than the ones in 2G networks, reflecting in higher end-consumer prices)

• Base stations need to be closer to each other (again more cost). [10]

2.3.5: 3G modem

A 3G modem is a device that allows a computer to connect to the internet via a high-speed mobile broadband connection. This means that the internet signal broadcast over the airwaves

rather than sent and received through a cable or telephone line. The technology is largely the same that used for delivering internet content to modern cell phones.

There are a variety of broadcasting standards covered by the 3G title, which is short for the "third generation" of mobile technologies. The most common standards in the United States are UMTS and CDMA. Because the various standards are not always compatible with one another, users must check carefully that a 3G modem is compatible with the cell phone network from which they intend to get 3G service.

In most cases, a 3G modem will come as a plug-in device, often referred to as a dongle. This is usually plugs into a USB slot on a computer and closely resembles a portable memory drive. The device houses the antennae that receive the signal, the SIM card that authenticates the user to communicate on the network, and the modem itself, which converts the wireless information into data the computer can understand. [11]

2.4: Microcontroller

2.4.1: Introduction

A microcontroller is a self-contained system with peripherals, memory and a processor that can be used as an embedded system. Most programmable microcontrollers that are used today are embedded in other consumer products or machinery including phones , peripherals,automobile and household appliances for computer systems. Due to that, another name for a microcontroller is "embedded controller." Some embedded systems are more sophisticated, while others have minimal requirements for memory and programming length and a low software complexity. Input and output devices include solenoids, LCD displays, relays, switches and sensors for data like human detection, fire system, amongst others.

2.4.2: Types of Microcontrollers

There are several different kinds of programmable microcontrollers at future electronics many of the most common types categorized by several parameters including Bits, Flash size, RAM size, number of input/output lines, packaging type, supply voltage and speed. Our parametric filters will allow you to refine your search results according to the required specifications.

Programmable microcontrollers contain general-purpose input/output pins. The number of these pins varies depending on the microcontroller. They can be configured to an input or an output state by software. When configured to an input state, these pins can be used to read

external signals or sensors. When they are configured to the output state, they can drive external devices like those that LED displays and motors.

Common type's microcontroller:

1) 1-PIC (PIC 18 family and PIC16 family)
2) 2-Arduino
3) 3-Intel (8048, 8051, and 8086). [12]

2.4.3: Arduino

Arduino is a single-board microcontroller to make using electronics in multidisciplinary projects more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.

Arduino boards can be purchased pre-assembled or as do-it-yourself kits. Hardware design information is available for those who would like to assemble an Arduino by hand. It estimated in mid-2011 that over 300,000 official Arduino had been commercially produced.

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2.4.4: Arduino Feature

Some of the features of the Arduino include:

- An open source design. The advantage of it being open source is that it has a large community of people using and troubleshooting it. This makes it easy to find someone to help you debug your projects.
- An easy USB interface. The chip on the board plugs straight into your USB port and registers on your computer as a virtual serial port
- Very convenient power management and built-in voltage regulation. You can connect an external power source of up to 12v and it will regulate it to both 5v and 3.3v. It also can be powered directly off of a USB port without any external power.[13]

2.5: Fire system

2.5.1: Smoke Detector

A smoke detector is a device that senses the presence of smoke in a building and warns the occupants, enabling them to escape a fire before succumbing to smoke inhalation or burns. Equipping a home with at least one smoke detector cuts in half the chances that the residents will die in a fire. In 1992, the readers of R&D Magazine selected home smoke alarms as one of the "30 Products that Changed Our Lives." Smoke detectors became widely available and affordable in the early 1970s. Prior to that date, fatalities from fires in the home averaged 10,000 per year, but by the early 1990s, the figure dropped to fewer than 6,000 per year.

2.5.2: Basic types of Smoke Detector

- The photoelectric smoke detector: uses an optical beam to search for smoke. When smoke particles cloud the beam, a photoelectric cell senses the decrease in light intensity and triggers an alarm. This type of detector reacts most quickly to smoldering fires that release relatively large amounts of smoke.

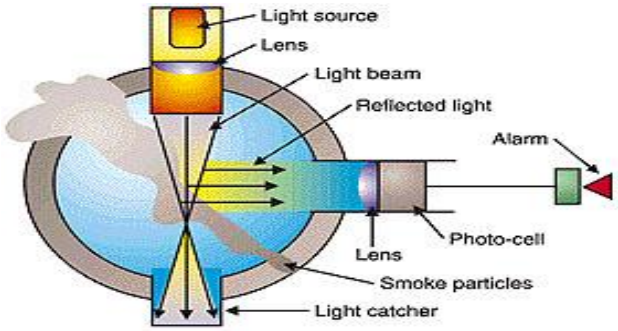


Figure 2.4 Photoelectric smoke detector

- The second type of smoke detector, known as an ionization chamber smoke detector (ICSD), is quicker at sensing flaming fires that produce little smoke. It employs a radioactive material to ionize the air in a sensing chamber; the presence of smoke affects the flow of the ions between a pair of electrodes, which triggers the alarm. Between 80 and 90% of the smoke detectors in (American homes) are of this type. Although most residential models are self-contained units that operate on a 9-volt battery. [14]

2.5.3: Water Pump

A pump is a device that raises or transfers fluids. Pumps selected processes to not only raise and transfer fluids, but also to meet some other criteria. This other criteria may be constant flow rate or constant pressure.

2.5.4: Water Pump Applications

Pumps used for variety applications. Here is a list of a few applications:

- Drainage - Used to control the level of water in a protected area.
- Sewage - Used in the collection and treatment of sewage.
- Irrigation - Used to make dry lands agriculturally productive.
- Chemical Industry - Used to transport fluids to and from various sites in the chemical plant.
- Petroleum Industry - Used in every phase of petroleum production, transportation, and refining.
- Medical Field - Used to pump fluids in and out of the body.
- Steel Mills - Used to transport cooling water.

2.6: Motion Sensor

2.6.1: Introduction

A motion detector is a device that monitors a field of view and performs a function if motion detected within that field. The function might be to trigger the opening of a door, as in the case of a grocery store; start a videotape machine for surveillance; turn on floodlights; or sound an alarm. A motion detector might detect motion with optics or acoustics and can be passive or active.

2.6.2: Kinds of motion detectors

- Active motion detectors:

An active motion detector emits optics or sound waves and measures feedback to detect motion. The simplest type of active motion detector commonly used in commercial doorways to trigger a doorbell. A device fixed to one side of the doorway, an optical sensor to the other. A beam of light passes from the device to the sensor. When someone enters the establishment, the beam is broken, triggering the doorbell.

Another kind of active motion detector used at grocery stores to automatically open the doors for customers. Other active motion detectors emit ultrasonic acoustic waves to detect motion. Any object moving across that plane will disturb the acoustic signature and change the picture. The human ear cannot detect ultrasonic waves, but certain animals are sensitive to ultrasonic signals. Some motion detectors can be set to be less sensitive to the movement of small animals.

They transmit energy and look for a frequency (Doppler) shift due to motion in the covered area. The microwave motion detector sends out high radio frequency waves and then detect the level of energy reflected back to the device. If the radio frequency wave hits a moving object, the frequency changes and the motion detector activated. [16]

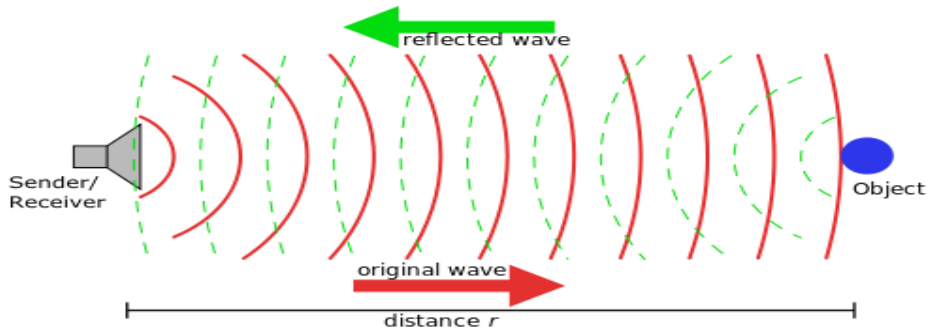


Figure 2.5: Active motion detector

- Passive infrared (PIR) motion detectors:

Commonly used inside homes, linked to security systems. PIR sensors allow you to sense motion, almost used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low power, easy to use and do not wear out. For that reason, they commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Piezoelectric", or "IR motion" sensors.

PIRs made of a pyro electric which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation emitted. The sensor in a motion detector actually split in two halves. For many basic projects or products that need to detect when a person has left or entered the area, or has approached.

To explain how a basic sensor works, see Figure2.6

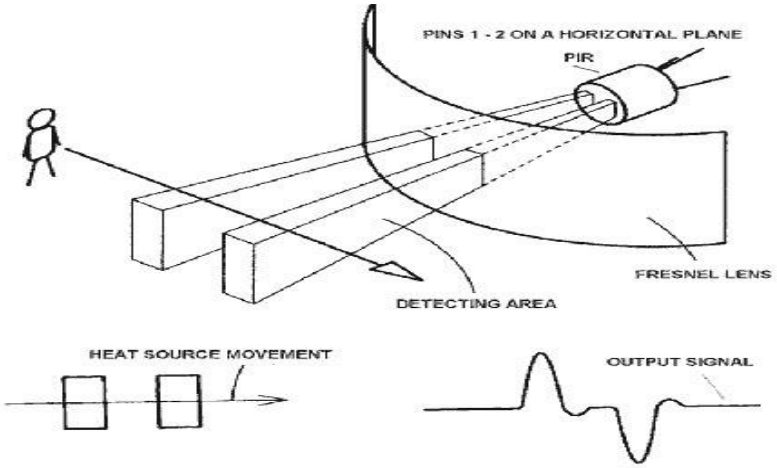


Figure 2.6: Explanation of basic sensor operation

The PIR sensor has two slots; each slot is made of a special material that is sensitive to IR. The lens used here is not really doing much and so we see that the two slots can see out past some distance (the sensitivity of the sensor). When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room, walls, or outdoors. When a warm body like a human or animal passes by, it first intercepts one-half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what detected. [17]

2.7: Android

2.7.1: Mobile

Mobile phone is one of the most sophisticated and modern techniques that spread dramatically in our societies, it transformed from a simple use to make call, to be used nowadays in many complex and useful applications.

The most common mobile operating systems are:

- Android is a Linux-based operating system (open source).
- IPhone OS FROM apple Inc. (closed source).
- Blackberry OS from RIM (closed source).
- Windows phone from Microsoft (closed source).

In our system Android is the operating system that we want to use in order to support our project objective requirements, like in Figure 2.7

Figure 2.7 Android Phone

2.7.2: Introduction

Android is one of the most versatile, powerful and elegant platforms coming out of Google in recent. It initially developed by Android Incorporation. Later purchased by Google and positioned in the Open Handset Alliance.

Android is an open source platform and it is released under open source license. The Android operating system software stack consists of Java applications running on a Java based object oriented application framework on top of Java core libraries running on a Dalvik virtual machine featuring JIT compilation. Libraries written in C include the surface manager, Open Core media framework, SQ Lite relational database management system, OpenGL ES 2.0 3D ,graphics API, Web Kit. Layout engine, SGL graphics engine, SSL, and Bionic.

Applications: Android will ship with a set of core applications including an email client, SMS program, calendar, maps, browser, contacts, and others. All applications written using the Java programming language.

2.7.3: Android Architecture

The following diagram shows the major components of the Android operating system. [18]

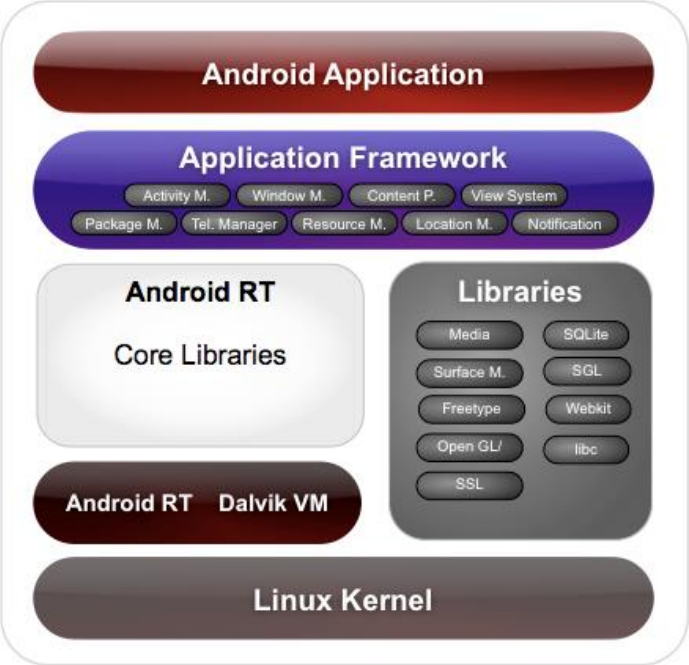


Figure 2.8 Android Architecture

Chapter 3: Conceptual Design

3.1 System Function and Block Diagram.

3.2 Block diagrams, Flow Charts, and Illustrations for each Subsystem.

3.3 System Components.

3.4 Microcontroller Interfaces with Xbee Unit, Water Pump

3.5 Data Flow.

3.1: System Function and Block Diagram

3.1.1: General Block Diagram

The project consists of four subsystems shown in Figure 3.1:

Wireless sensor network subsystem, Wi-Fi subsystem, monitoring and controlling subsystem and 3G subsystem.

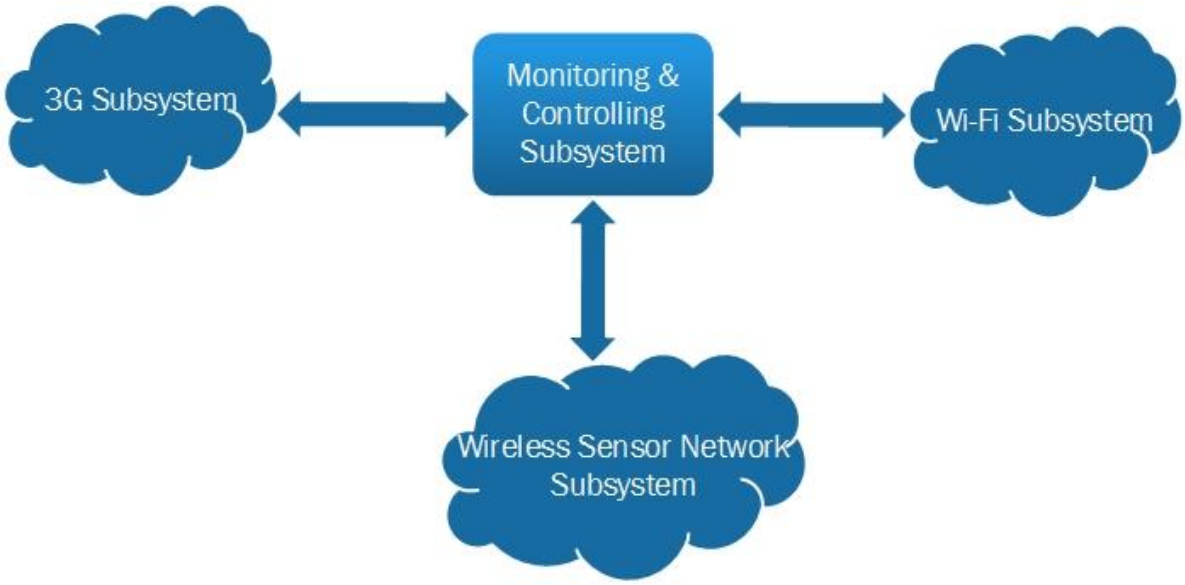


Figure 3.1: General Block Diagram

3.1.2: Detailed Block Diagram

All system components and interfaces shown in figure3.2. Four subsystems (wireless sensor network subsystem, Wi-Fi subsystem, monitoring and controlling subsystem and 3G subsystem) are connected to perform the smart security system.

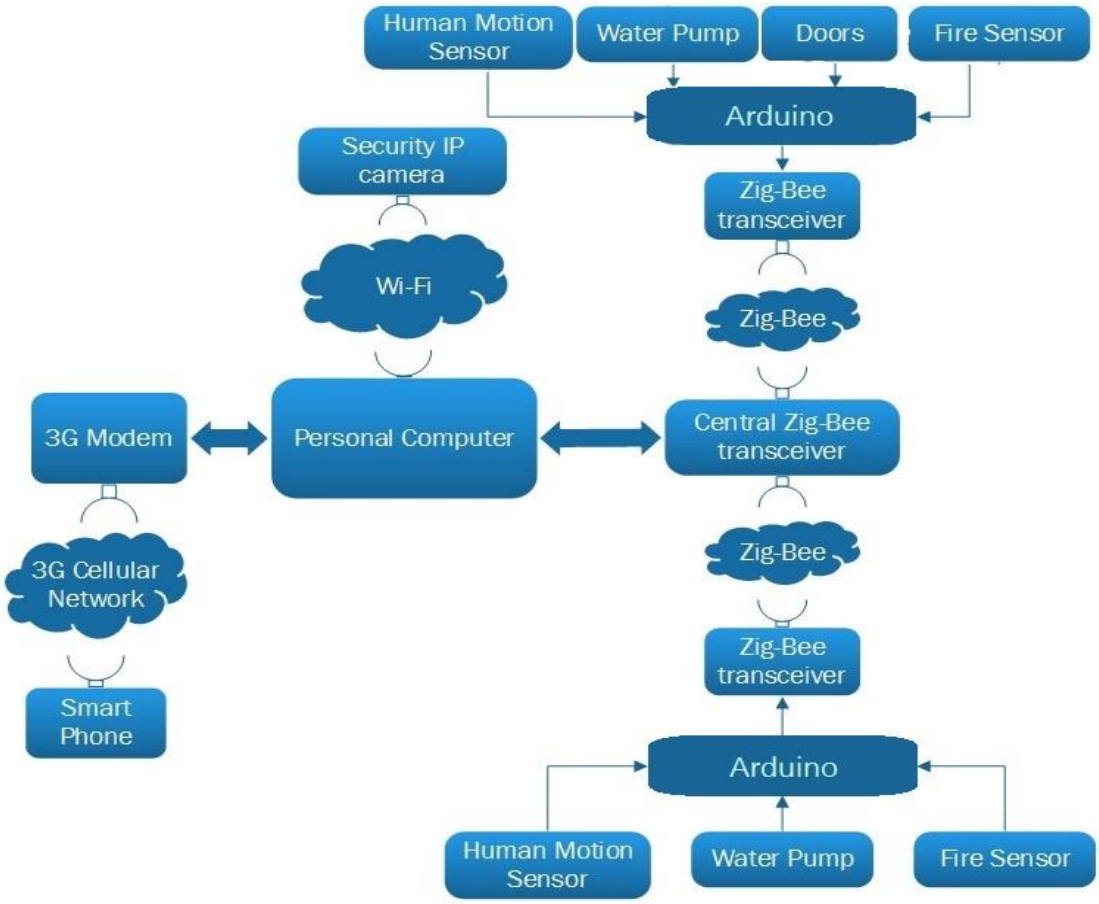


Figure 3.2: Detailed Block Diagram

3.1.3: System Environment

The wireless sensor network will be submitted in the seventh floor of building B.Th. network consists of three sections, two sections contains motion and fire sensor connected to a microcontroller, which will transmit its data to the central Zig-Bee node. In fire alarm system, two smoke sensors will be installed in the University. A water pump will be used to overcome the fire.

In monitoring system, we aim to detect human motion in four directions, a Wi-Fi camera and two human motion sensors with sensing range up to 12 meters will be installed in our university.

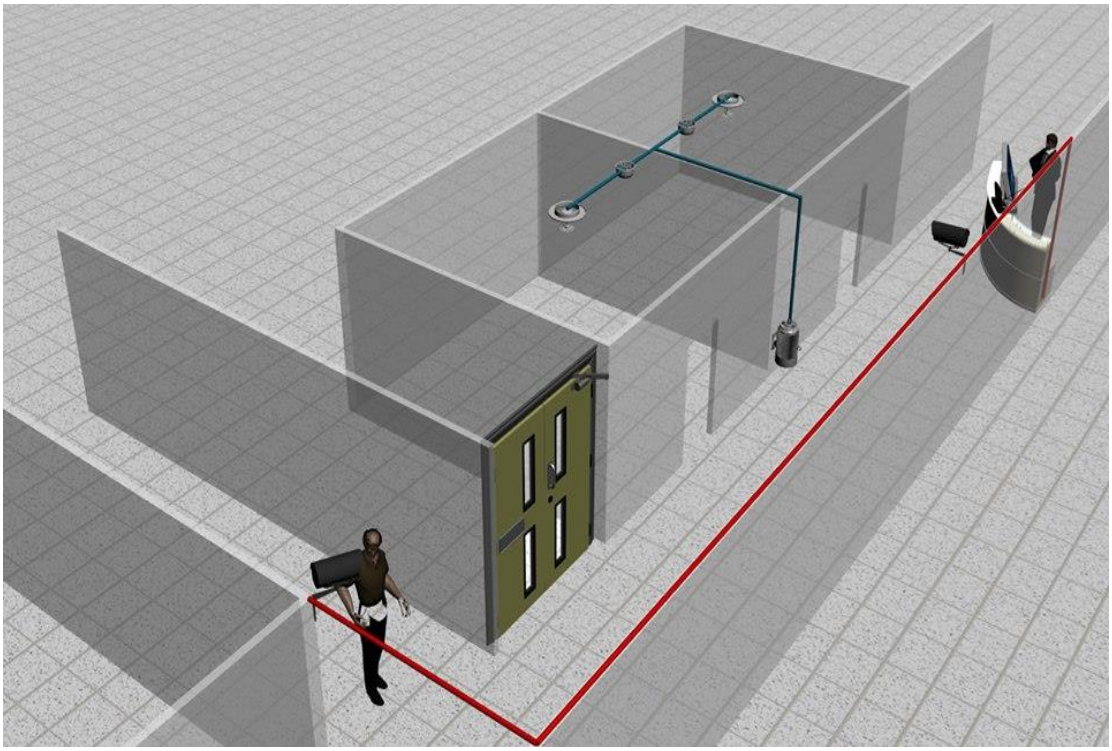


Figure 3.3: System Environment

3.2: Block Diagrams, Flow charts, Illustrations for each Subsystem

3.2.1: Zig-Bee Network

In our project, we are going to use three (X-bee Pro S1) units. One of them will be the network coordinator and the other two will be transceivers.

3.2.2: Zig-Bee Block Diagram

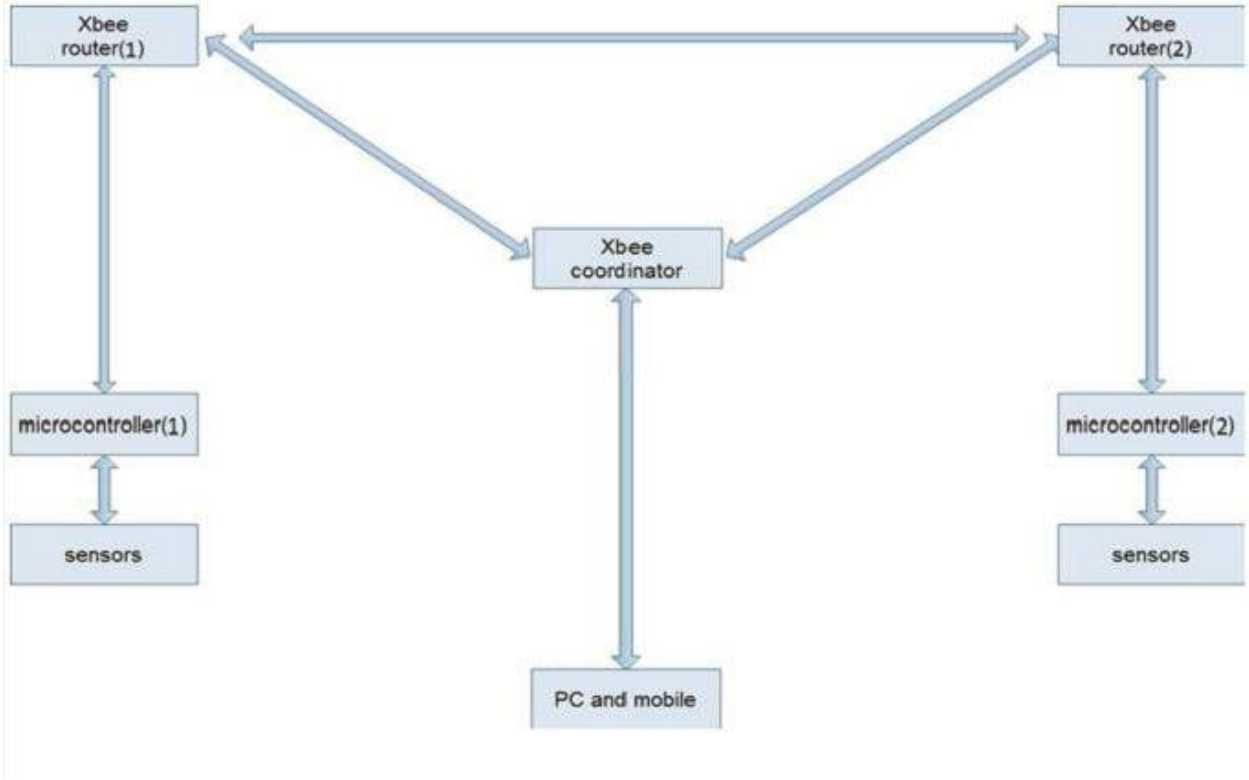


Figure 3.4: Zig-Bee block diagram

Figure3.4 shows the main Zig-Bee components in the system .The Zig-Bee network consists of X-bee coordinator and two X-bee routers. The X-bee coordinator connected to the PC, each X-bee router connected to a microcontroller that is responsible to connect the network to the sensors.

3.2.3: Zig-Bee Network Flow Charts:

- Figure3.5 shows the network establishing flow chart:
  It describes the delivering signals technique from PC to the Arduino microcontrollers to control the system.

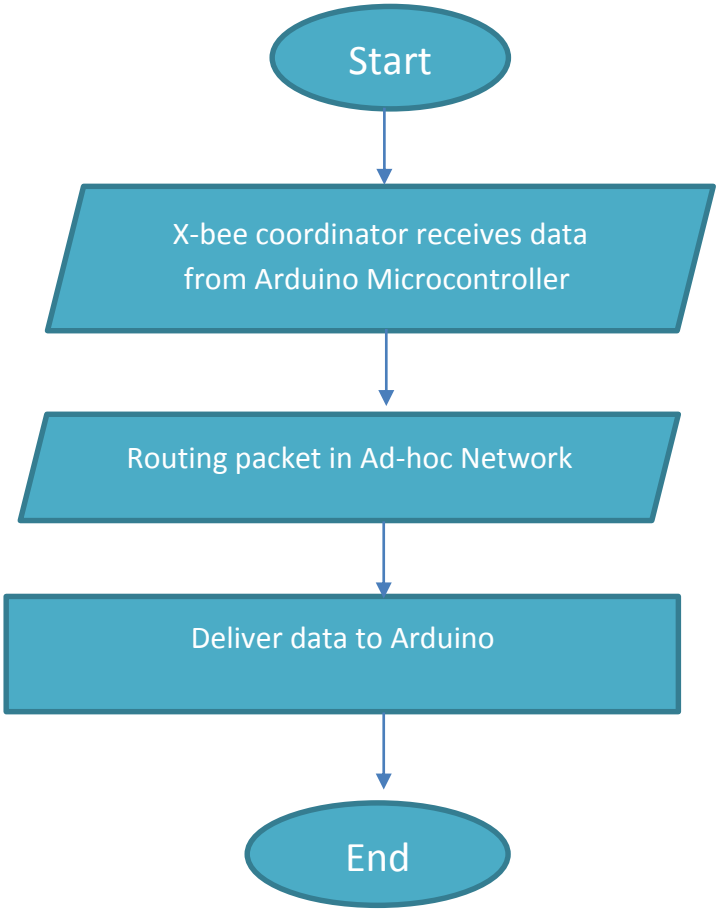


Figure 3.5: Network Establishing Flow Chart

- The following flow chart in Figure 3.6 shows that the coordinator responsible for starting the Zig-Bee network

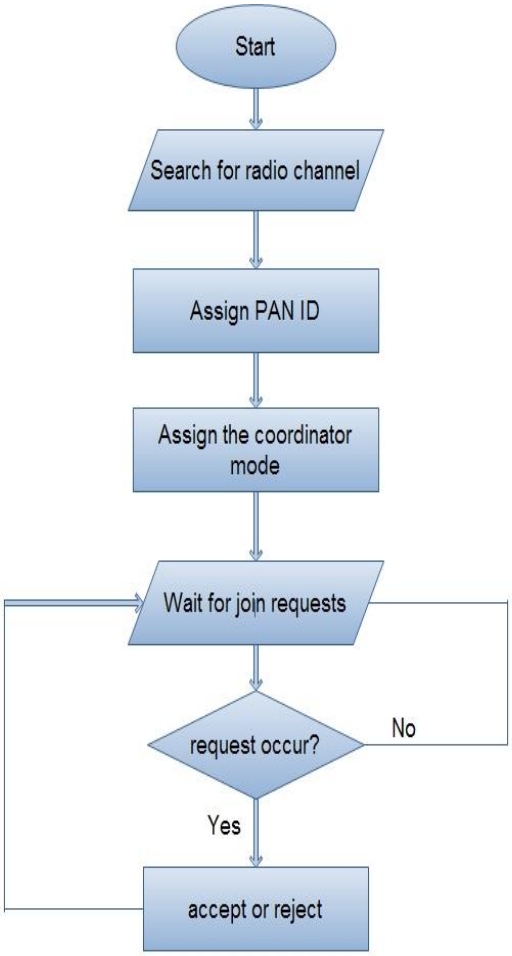


Figure 3.6: Starting the Zig-Bee network flow chart

❖ **Network initialization involves the following steps:**

1) Search for a Radio Channel

The coordinator first searches for a suitable radio channel (usually the one, which has least activity).

2) Assign PAN ID

The coordinator starts the network, assigning a PAN ID (Personal Area Network identifier) to the network.

3) Start the Network

The coordinator then finishes configuring itself and starts itself in coordinator mode. It is then ready to respond to queries from other devices that wish to join the network.

3.2.4: Arduino

In our project, we are going to use two Arduino Uno, to construct the wireless sensor network.

Arduino function: The functions of Arduino which is divided into two parts (Input, Output).

- The input functions are:
  - Read the incoming signal from sensors (motion, fire) through Zig-Bee
  - Receive control signal from the mobile through PC.
- The output functions are:
  - If there are a fire detection turn on the water pump and send control signal to close or open the doors.
  - Send control signal to turn the Wi-Fi camera through the PC ,if there is a human motion

3.2.5: Arduino Interface

Arduino interfaces in our project:

System with the presence of PC, that mean the PC will receive the signals from WSN, then send a control signal to the Wi-Fi camera and at the same time send the signals to the mobile through 3G modem.

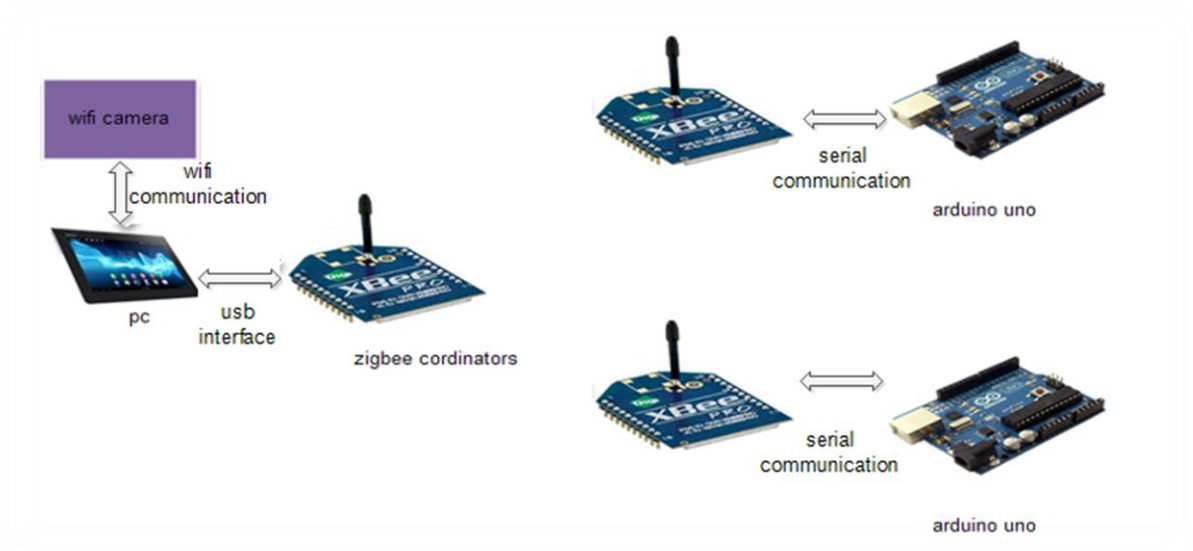


Figure 3.7: Arduino interface

3.2.6: Arduino Flow Chart

The decision points that the Arduino will take divided in two parts as Figure 3.8

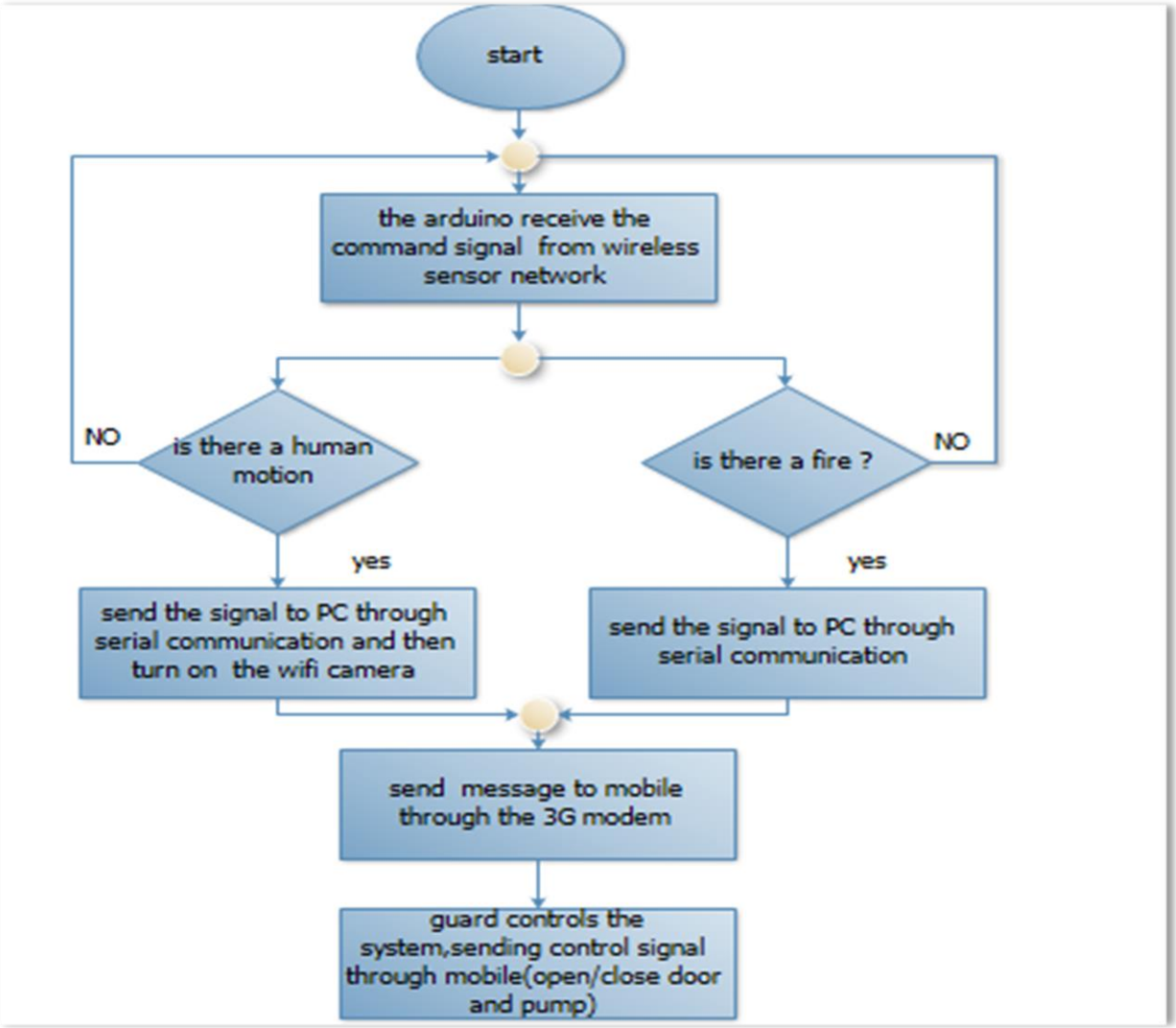


Figure 3.8: Arduino decision flow chart

Arduino processes the commands received from Zig-Bee and decisions as follows:

1) If this command is about fire, WSN sends the signal to pc. This signal contains information about the place of fire.
2) If this command is about human motion, WSN send control signal to get video from camera.

3.2.7: 3G and Wi-Fi subsystem

Interface Wi-Fi camera with smart phone:
For viewing an IP Camera video using smartphone, there are five components to the system:

1) IP camera, it needs to compress the video so that it uses as little data as possible to see the video without reducing the resolution.
2) Personal computer needed to transfer video captured from IP camera to 3G Modem connected to USB port of the PC.
3) The Data Rate available at our cellular modem is maximum 7.2 Mbps, which is enough to handle the data flow we need.
4) Phone company cellular system has 5 MHz bandwidth, which is very good to carry our data flow.
5) Smartphones has excellent performance to support the latest cellular services and to display the video.

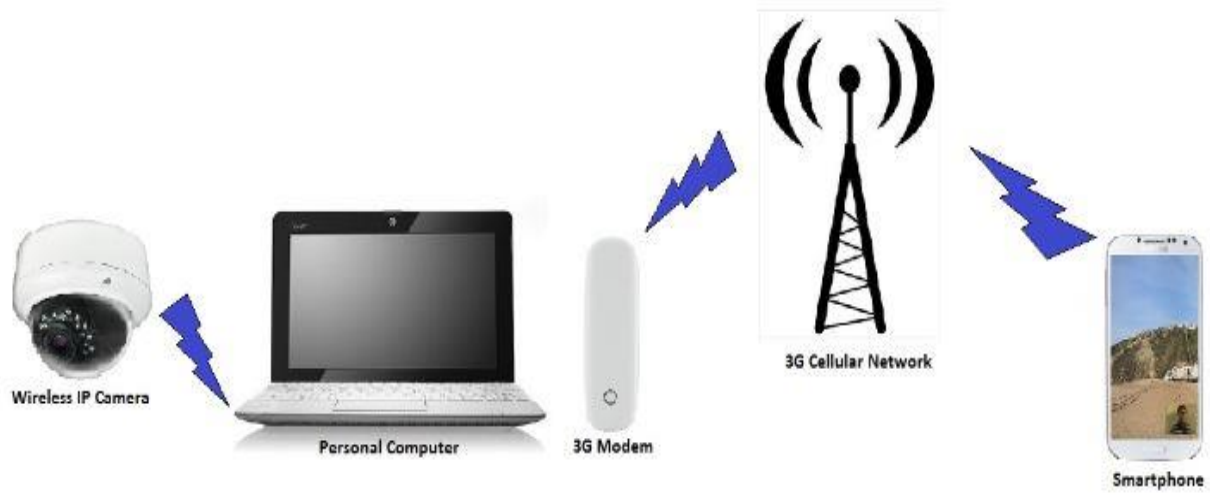


Figure 3.9: viewing an IP Camera video using Smartphone

3.2.8: Human Detection system

Wi-Fi camera will depends on human motion sensors to detect humans, so the camera will be in silent mode by default, and it starting capturing when it receives a control signal from Arduino due to WSN sensing.

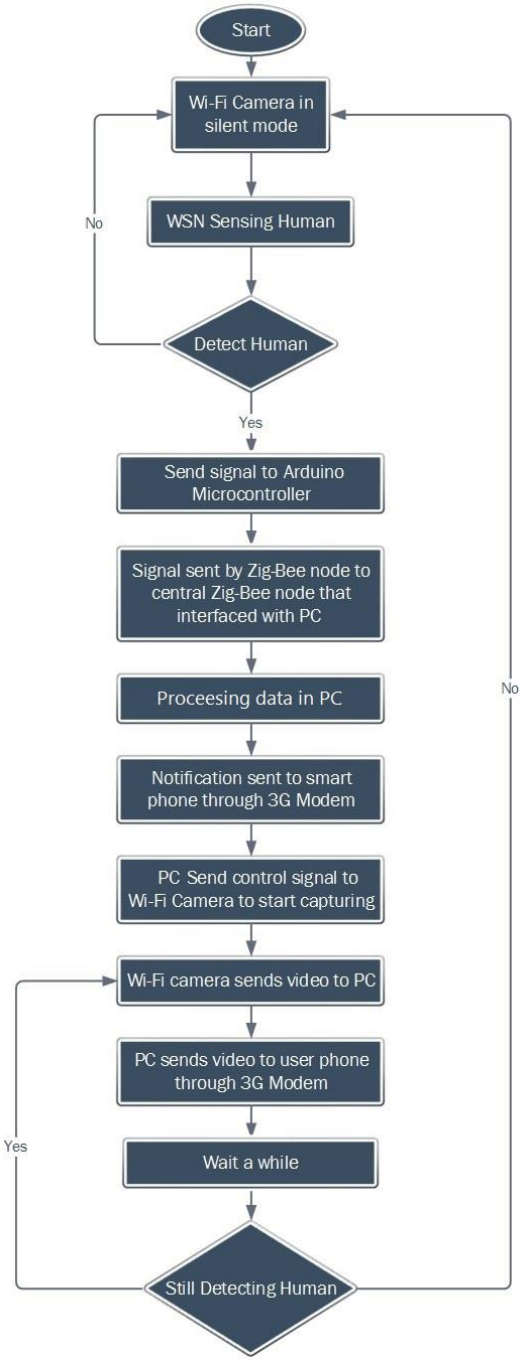


Figure 3.10: Human detection system flow chart

3.2.9: PC to (3G) Modem

3G modem programmed to send alarm messages and video to the smartphone, and to receive different control signal from smartphone as follows:

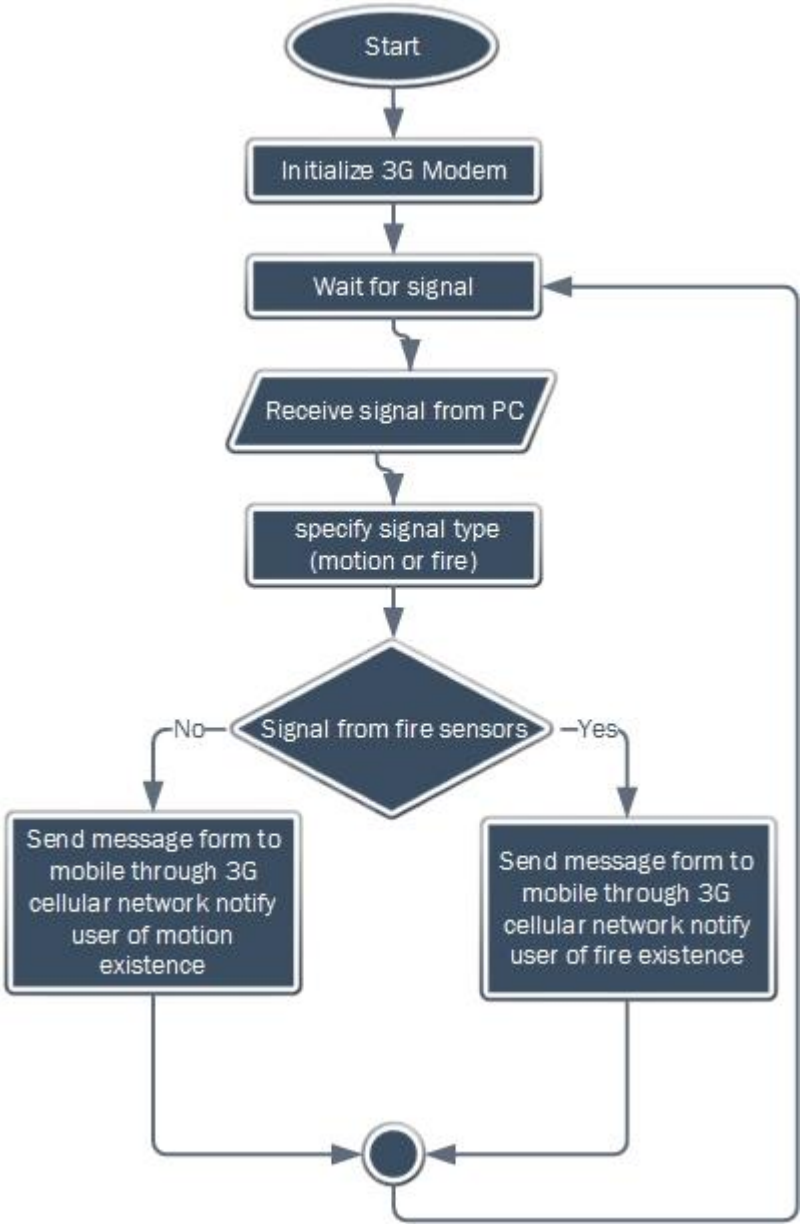


Figure 3.11: PC to 3G modem flow chart

3.2.10: Mobile application controlling system

The android based mobile application designed to receive alarm messages as notifications of fire or human detection. In addition, it designed to control doors and Wi-Fi camera through 3G network for sending and receiving.

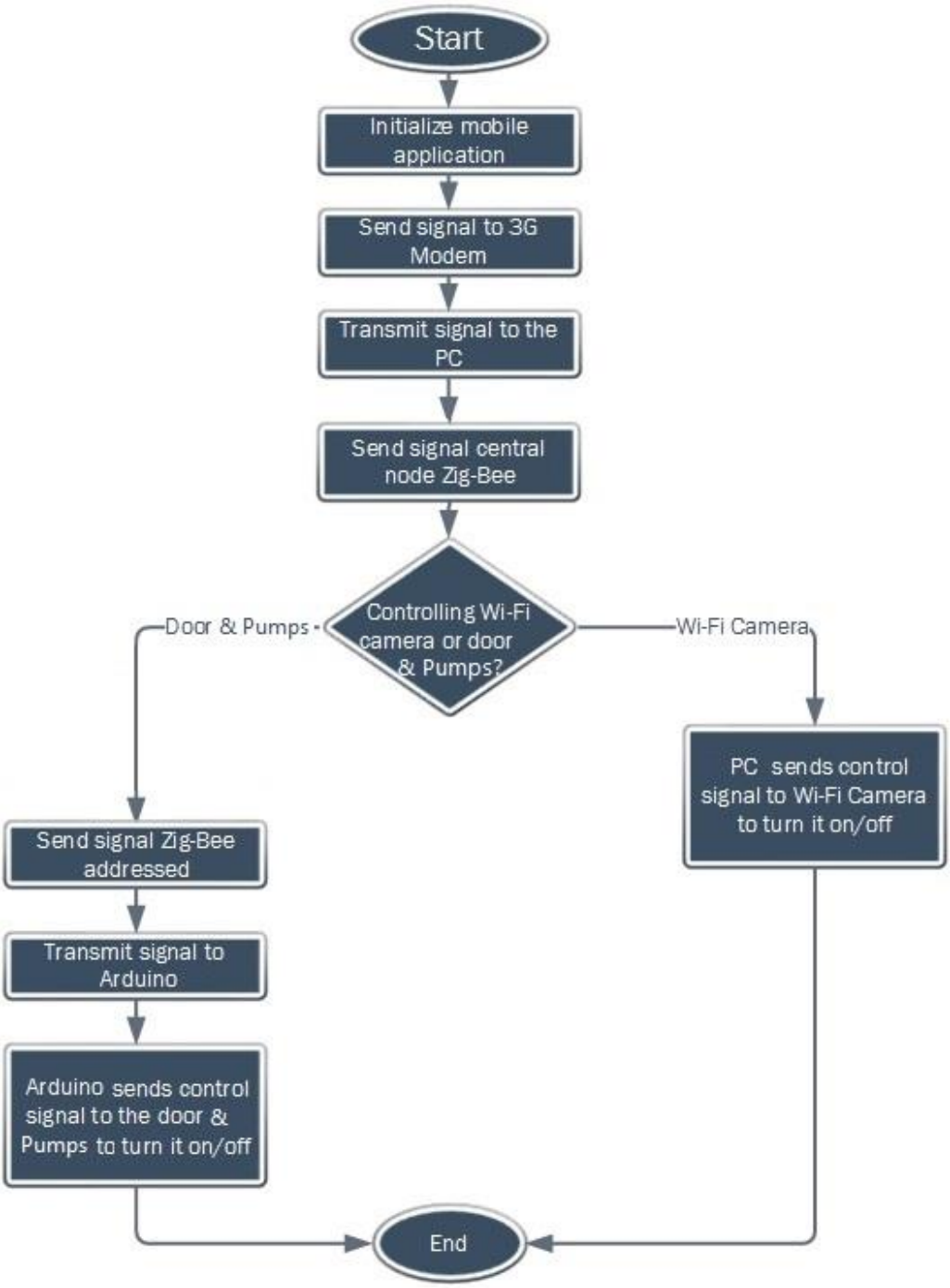


Figure 3.12: Mobile application controlling flow chart

3.3: System Components

3.3.1: Human motion detector

Figure 3.13 shows the human motion detector .We will use IS215T Honeywell Standard PIR, which is an entry-level passive infrared motion sensor.

Figure 3.13: Human motion detector

Technical Specification:

Table 3.1: Technical specification for human motion detector

Sensor	Honeywell Standard PIR
Operating Voltage	12V DC
Range	12 meters +/- 1m @ 20C, @ 2.4 m high, two steps walk at 1m/sec
Indicators	Red LED for alarm
Optical Filtering	White light protection, pigmented lens

3.3.2: Smoke Detector

We will use MQ2 smoke sensor, which has a potentiometer to adjust the sensitivity for accurate detection. It is with low cost and suitable for different application.

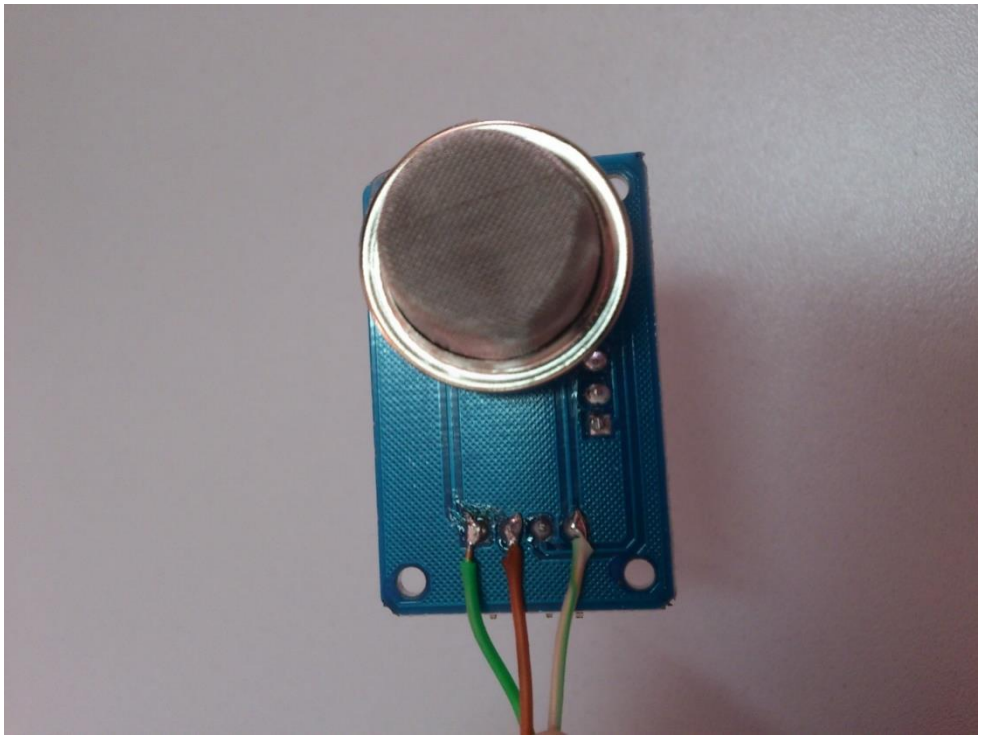


Figure 3.14: Smoke Sensor

3.3.3: X-Bee unit (Zig-Bee)

Physical specification:

Table 3.2: Physical specification for Zig -Bee unit

Operating frequency	ISM 2.4
Indoor range	90m
Outdoor range (LOS)	1600m
Transmit power output	63mw
RF data rate	250kbps
Receiver sensitivity	-100dBm
Number of channels	12 direct sequence channel

The above table explain some physical specifications about the (X-Bee Pro S1) component. In our project, we are going to use three (X-Bee Pro S1) units .one of them will be the network coordinator and the other two will be transceivers.

3.3.4: Arduino Microcontroller

The microcontroller is the brain of the automation management system that we are going to build; we should look for the flexibility in those processors is that they will give to the system. We have a limited time to develop the project, so we need the easiest and cheapest solution in order to satisfy the goals of the system, looking to that we will try to find a hardware that can be highly compatible with Zig-Bee and Wi-Fi communication. They should have low power consumption, and have enough I/O input to control of the system.

One of the most important features that we would like to add to the system is that it should be completely Open Hardware/Software, so we need a microcontroller, can be programmed using Open Source Software.

Filtering these criteria, we will compare Arduino Uno and Arduino Mega:

- **Arduino Uno**
  It is the standard Arduino, it uses 8-bit microcontroller, ATmega328, and it has 32 Kb flash memory, 2 Kb RAM, 16 MHz, 1 Serial port analog I/O ports, 13 digital ports.

- **Arduino Mega**
  It is the big one of the Arduino family, it based on ATmega1280. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator.

- **Arduino Uno vs. Arduino Mega:**
  These are some of the reasons of why we chose Arduino Uno to develop the system:
  - It is easily available than Arduino Mega
  - It is low cost; in our project, we will design system lower cost than other system will present in the market.

- **Arduino Uno:**

  The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset

button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.

Specification for Arduino:

Table 3.3: Specification for Arduino

Microcontroller	**ATmega328**
Operating Voltage	5V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by boot loader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

3.3.5: USB 3G Modem

A USB 3G modem (dongle) allows a computer to connect to the Internet via a high-speed mobile broadband connection. This means that the Internet signal broadcasted over the airwaves rather than sent and received through a cable or telephone line. The included SIM card authenticates the user to communicate on the network, and the modem itself, which converts the wireless information into data the computer can understand.

We need this device in our project to send alarm messages that includes data to the mobile application, sends video streaming captured from Wi-Fi camera, and receive control messages (signals) to control other system components. This 3G modem is better than GPRS one, cause it can transmit and receive data in a high speed and low delay. Controlling (programming) the 3G modem achieved by using AT commands. 3G Modem programming will be discussed later on chapter 4.

In our project, we will use ZTE MF190 HSUPA USB Modem.

Figure 3.15: ZTE 3G Modem Dongle

Technical Specifications:

Table 3.4: Technical Specification for 3G Modem

Power supply	5V
Maximum power consumption	2.5W
USB Version	USB 2.0 HIGH SPEED
Support	HSDPA up to 7.2Mbps, HSUPA up to 2Mbps
Frequency	►UMTS/HSDPA/WCDMA 2100MHz ►GSM/GPRS/EDGE 850/900/1800/1900MHz

- **Why we use this 3G Modem?**

The great user-friendly 3G Modem Manager interface not only manages connection, it displays all the messages receive on your mobile broadband number. It can even reply to text messages while logged in. In addition, the very best Internet speeds with 3G Reception Diversity, which improves the coverage in buildings and makes sure to stay on a Turbo Network.

3.3.6: Wi-Fi Camera

We need this camera to detect and track people who wants to steal or damage the building, and this camera will be connected to PC through Wi-Fi technology to send the real time streaming video using IP of its own. Wi-Fi camera better than wired one, because its connection flexibility with the microcontroller and PC.

In our project, we will use VisionNet 720p wireless IP camera. Model: (p.n. 571020)

Figure 3.16: VisionNet security IP camera

❖ **Technical Specifications:**

Table 3.6: Technical specification for Wi-Fi Camera

1.	Standard H.264 video compression algorithm that satisfy transmission of high definition video over narrow bandwidth network
2.	1.0 Mega Pixel
3.	Pan 300 degree, tilt 120 degree
4.	WEP,WPA and WPA2 encryption
5.	IR night vision (Range:8m)

6.	Wi-Fi compliant with wireless standards IEEE 802.11 b/g/n
7.	Supports image snapshot, dual stream, and IR-Cut.
8.	Supports HTTP/ TCP/ IP/ UDP/ FTP/ DHCP/ DDNS/ UPNP
9.	Motion detection alert via email or upload image to FTP
10.	Supports SD card to 32G

Human detection can be done by one of the following scenarios:

1) Wi-Fi Camera send video streaming to PC through Wi-Fi, then 3G Modem takes video from PC and send it to guard's smart phone.
2) Wi-Fi Camera send video streaming to the smart phone directly through Wi-Fi without need of 3G Modem.

To achieve the reliability, and perfect using of components in our system, we will use the first method for video streaming between camera and smart phone.

3.4: Microcontroller Interfaces with Xbee Unit, Water Pump

3.4.1: Microcontroller interface with Xbee unit:

Figure3.18 shows the general Universal Asynchronous Receiver/Transmitter (UART) interfaced environment.

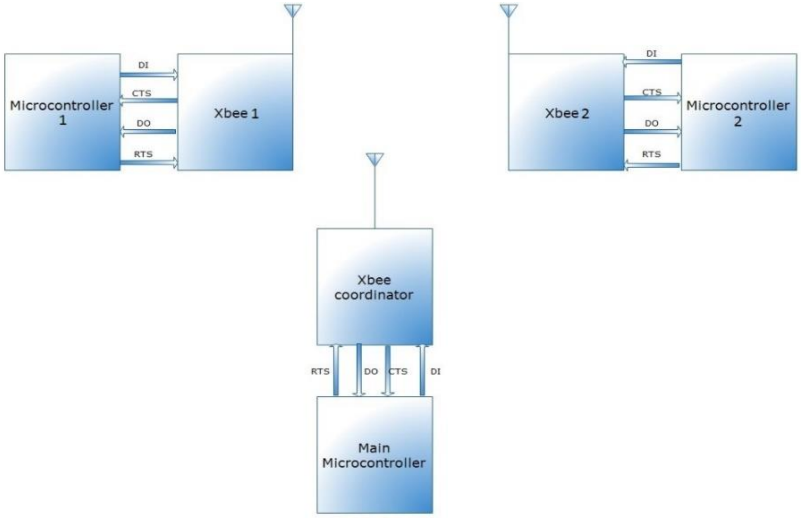


Figure 3.17: Zig-Bee Interference with the Microcontroller

The system triggered if any alert signal sent from sensors to the microcontroller. With serial data transmission the microcontroller, send the message to the main coordinator through Zig-Bee network to take the appropriate decision. The control signals sent from the user to the microcontrollers through the Zig-Bee network.

DI (Data Input): message from microcontroller to X-Bee.

DO (Data Out): message from X-Bee to microcontroller.

3.5: System Data Flow

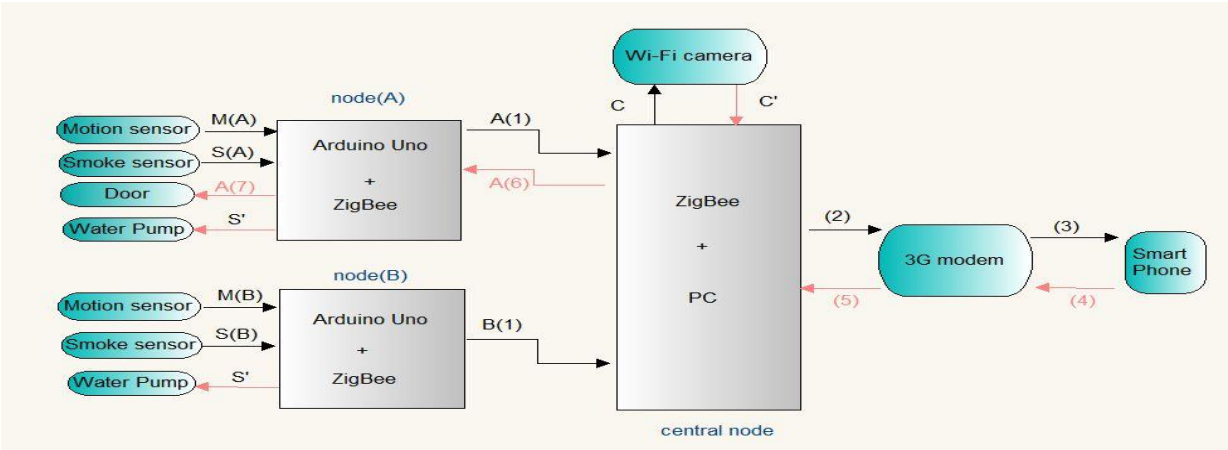


Figure 3.18: System data flow

WSN data flow for node A and node B

Node A:

M(A)The human motion sensor detects motion within room A, and then it send the sensing signal to the node connected to it.

The network node consist of Arduino microcontroller and Xbee transceiver.

S(A)The fire sensor detects fire within room A, and then it send the sensing signal to the node connected to it.

A(1) the node routs commands which consists information about the sensor location and states to the central node.

(S') the Arduino sends control signal to the water pump to switch it on in room A

Node B:

M(B)The human motion sensor detects motion within room B, then it send the sensing signal to the node connected to it .

the network node consist of Arduino microcontroller and Xbee transceiver.

S(B)The fire sensor detects fire within room B, it sends the sensing signal to the node connected to it.

B(1)the node routs commands which consists information about the sensor location and states to the central node .

(S') the Arduino sends control signal to the water pump to switch it on in room B

The central node receive the information commands process it and transmit it to the rest of the system.

(c)The PC switch on the Wi-Fi camera.

(c') The camera provides the PC with live video streaming.

(2) The PC in its turn transmit the data that contain video to the 3G modem.

(3) The 3G modem transmit sensor alert message and camera video to the mobile sequentially.

(4) (5) (red line) the user control message will flow in the reverse direction (3G modem, central node).connected to the doors to close them.

A(6) the PC transmit the control signals to node A, in order to open and close the door .

Chapter 4: Detailed System Design

4.1 Overview

4.2 Arduino Interfacing with Zig-Bee

4.3 Interfacing Zig-Bee with PC

4.4 WSN nodes circuit design

4.1: Overview

In this chapter, detailed circuits design and some software general description will be shown. Testing configurations will be discussed.

4.2: Arduino Interfacing with Zig-Bee

All system components with their physical specifications and interfaces will be shown in this section.

4.2.1: Circuits Design:

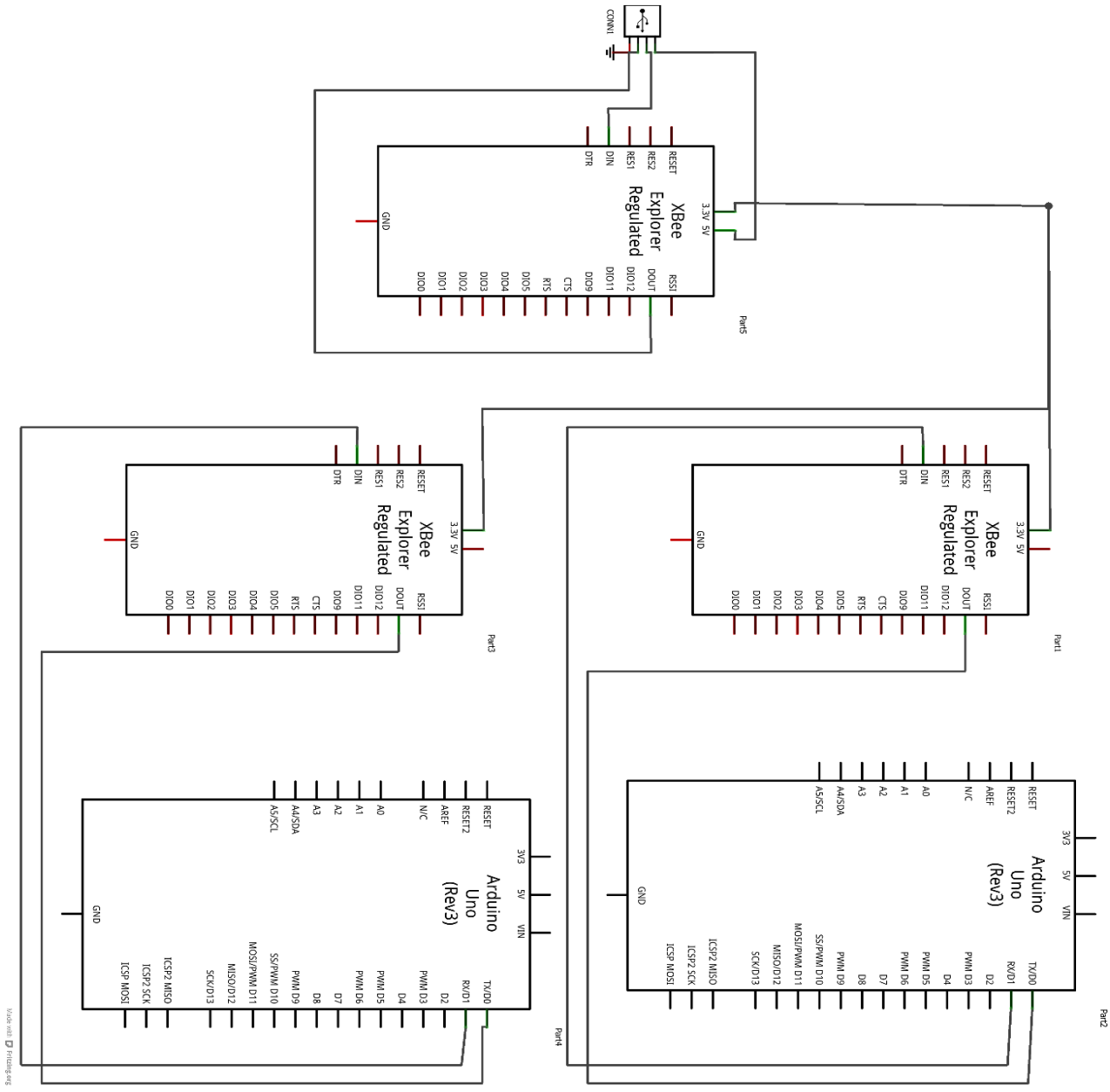


Figure 4.1: General Circuit Design.

4.2.2: Xbee Interface

The Xbee transceivers will be connected to two Arduino Uno microcontrollers. Figure4.2shows the connection between Xbee transceiver and Arduino Uno microcontroller.

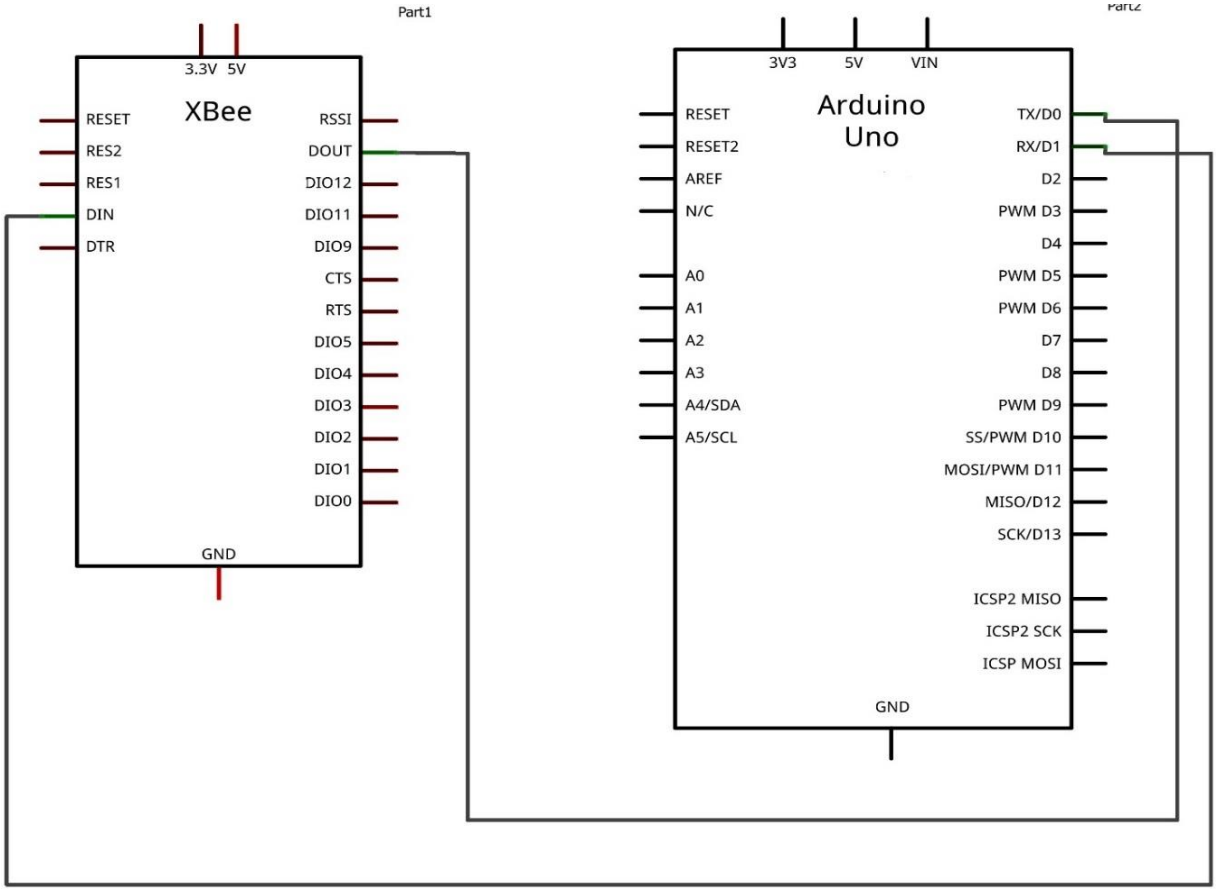


Figure 4.2: Xbee to Arduino Uno interface

Table 4.1: Pins connection for Figure 4.2

Xbee pin	Arduino Uno pin
DIN	TX
DOUT	RX

4.3: Interfacing Zig-Bee with PC

The Xbee coordinator connected to the PC to perform the central node in the WSN. The USB is TTL serial cable.

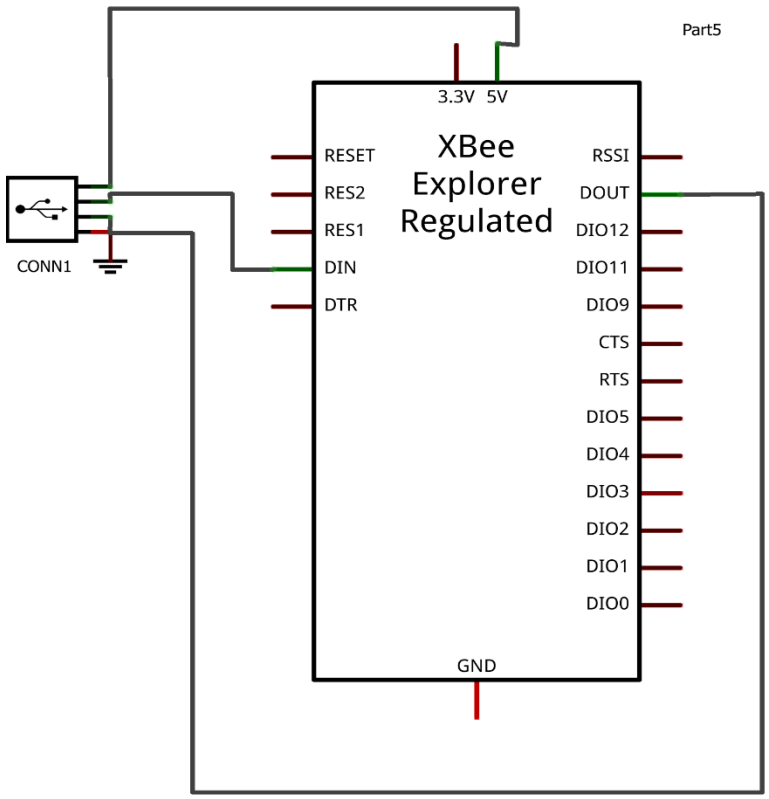


Figure 4.3: Zig-Bee interfacing with PC

Table 4.2: Pins connection for Figure 4.3

Xbee pin	TTL usb
DIN	TX
DOUT	RX
VCC	5V
GND	GND

4.4: WSN Nodes Circuit Design

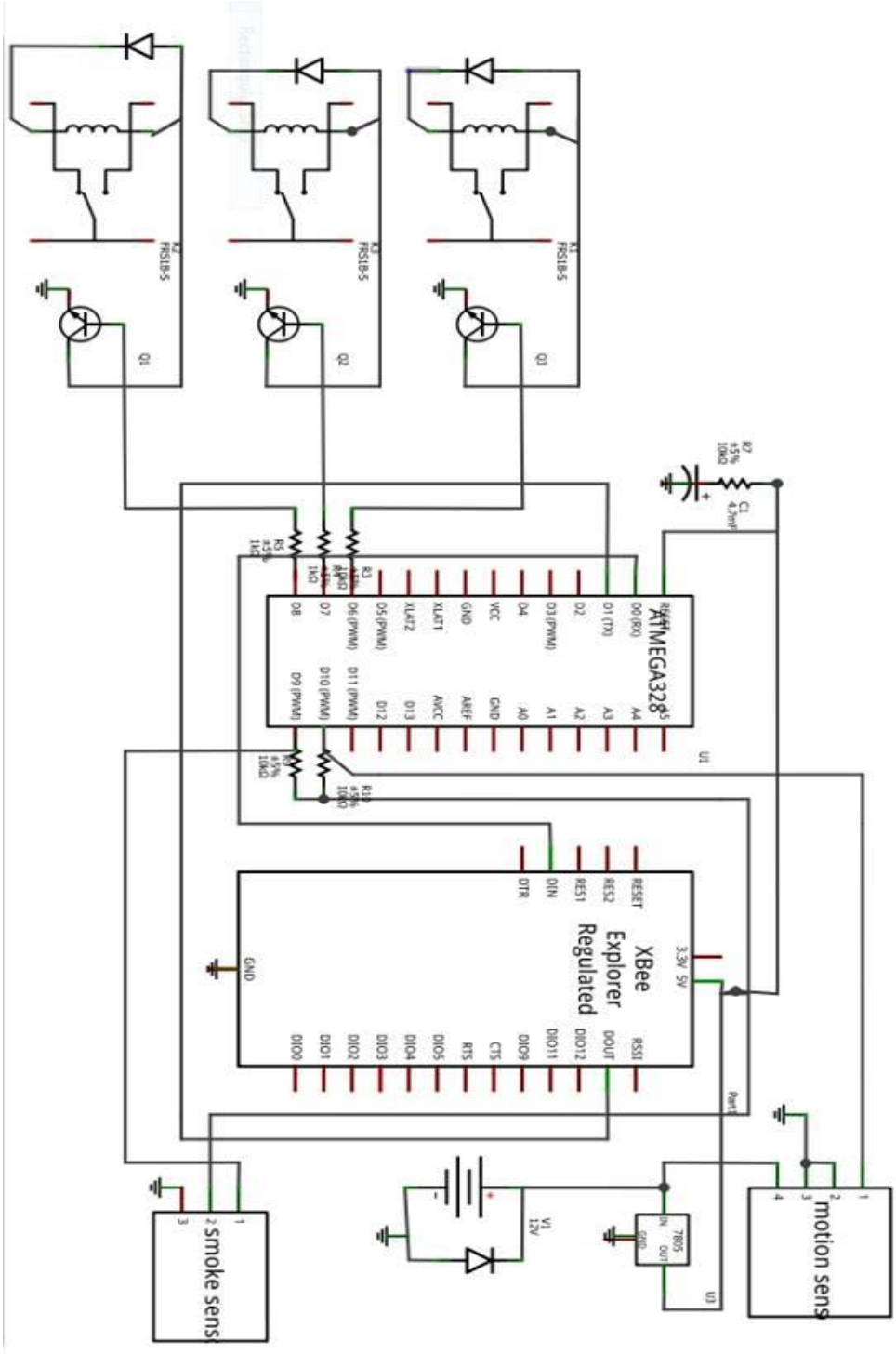


Figure 4.4: WSN node circuit design

The circuit above shows the detailed electronic circuit design for one node. Each node consists of AT mega microprocessor, Xbee transceiver, motion sensor, smoke detector, pump, regulators and relays.

Chapter 5: Software Design & Implementation

5.1 Overview

5.2 Arduino Software Programming

5.3 Android Mobile Application

5.4 C# Programming

5.5 Zig-Bee Network Implementation

5.1: Overview

In this chapter, we will show the implementation and programming of all system parts, from System WSN Nodes (Sensors, Arduino Microcontrollers, Zig-Bee Units, security door, and Pumps) to PC and mobile application.

5.2: Arduino Software Programming

The open source Arduino environment makes it easy to us to develop our system. Firstly, we define the parameters of the WSN (motion sensor, fire sensor, pumps and doors).
Then, each parameter is set at a specific pin number weather it is an input or an output.
Figure 5.1 explain definitions and pin connections.

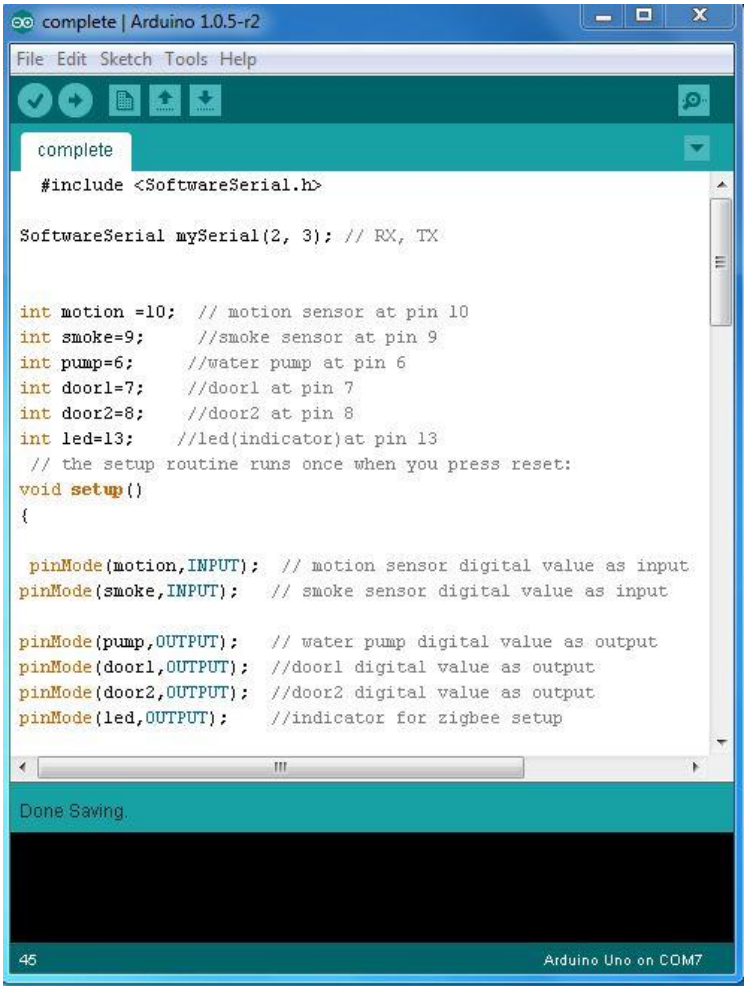


Figure 5.1: Definitions and Pin Connections

The WSN parameters are set as integers; the motion sensor is connected to pin 10, the smoke sensor is connected to pin 9. System outputs are set as integers connected to pin (6, 7, 8) for (pump, door1, door2) respectively. The LED connected to the board as an indicator of serial connection, it is connected to pin 13.

The door and pumps are defined as functions in the program; figure 5.2 describes the pump function. Figure 5.3 describes the door function.

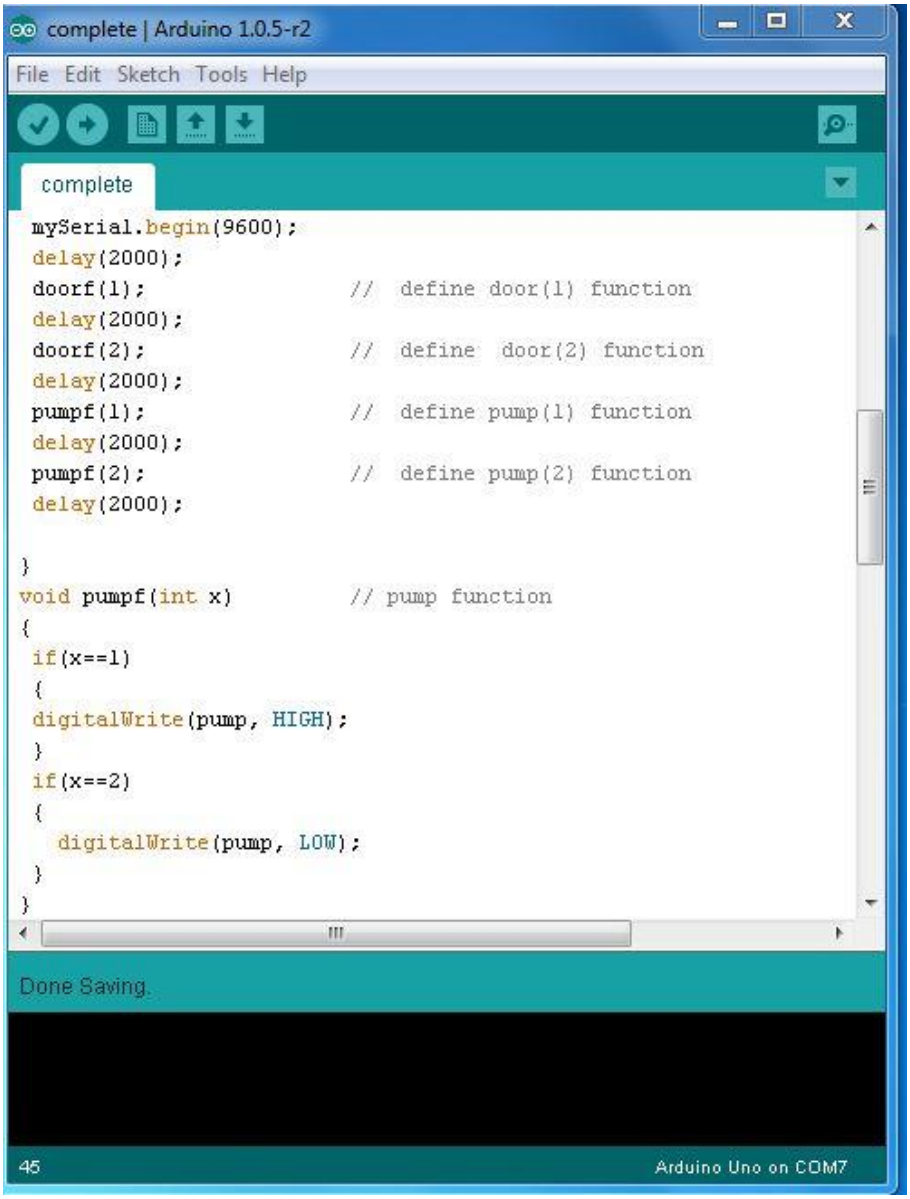


Figure 5.2: Pump Function

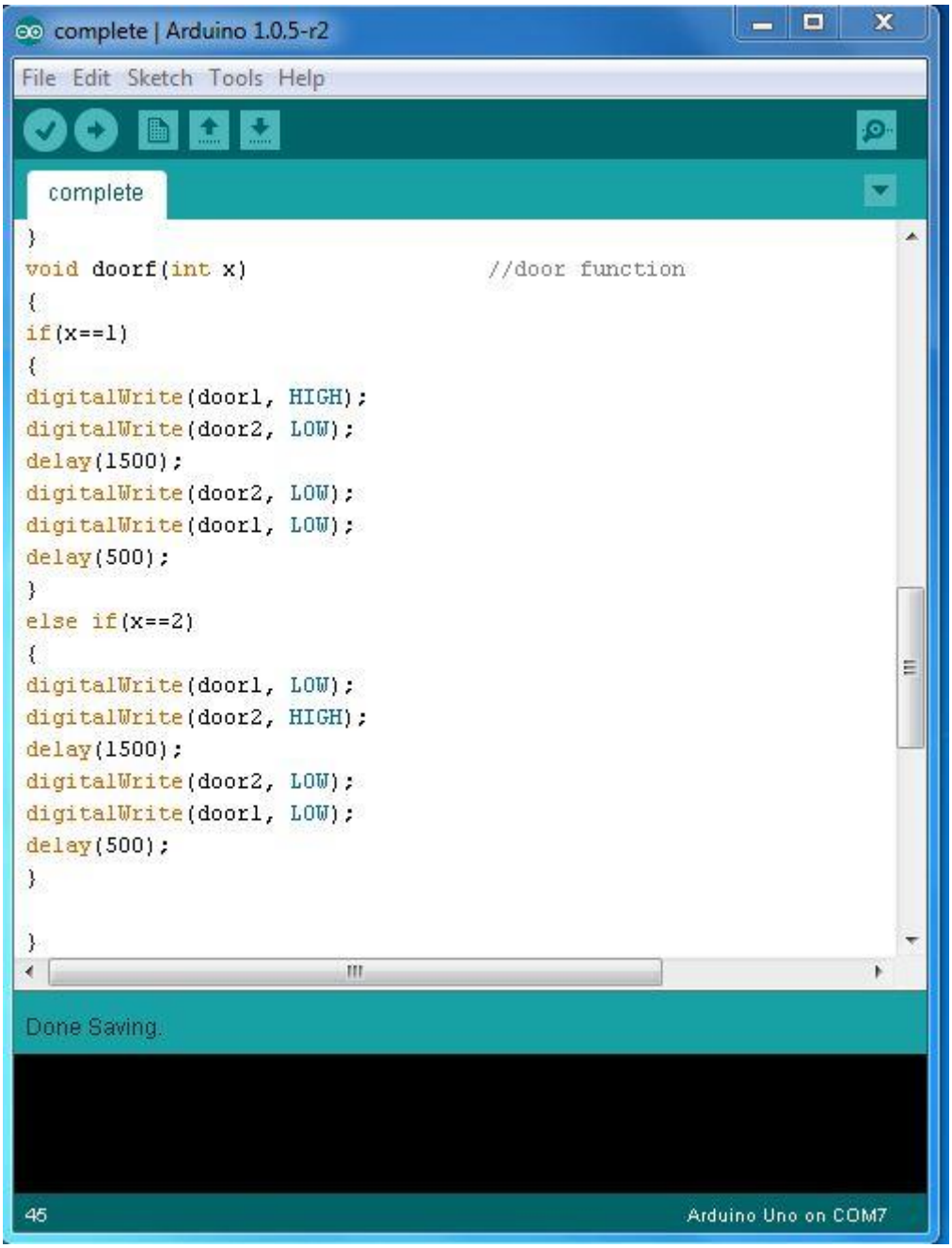


Figure 5.3: Door Function

The door function explains (x) as variable parameter; if it equals (1) then door1and door2 are activated ,but if it equals (2) then door1 and door2 are off .

Note: door2 is not implemented in our system; the code can be developed for number of sensors, doors and pumps.

Finally, the program verified, and then uploaded to the Arduino board. Figure5.4 shows the steps of compiling.

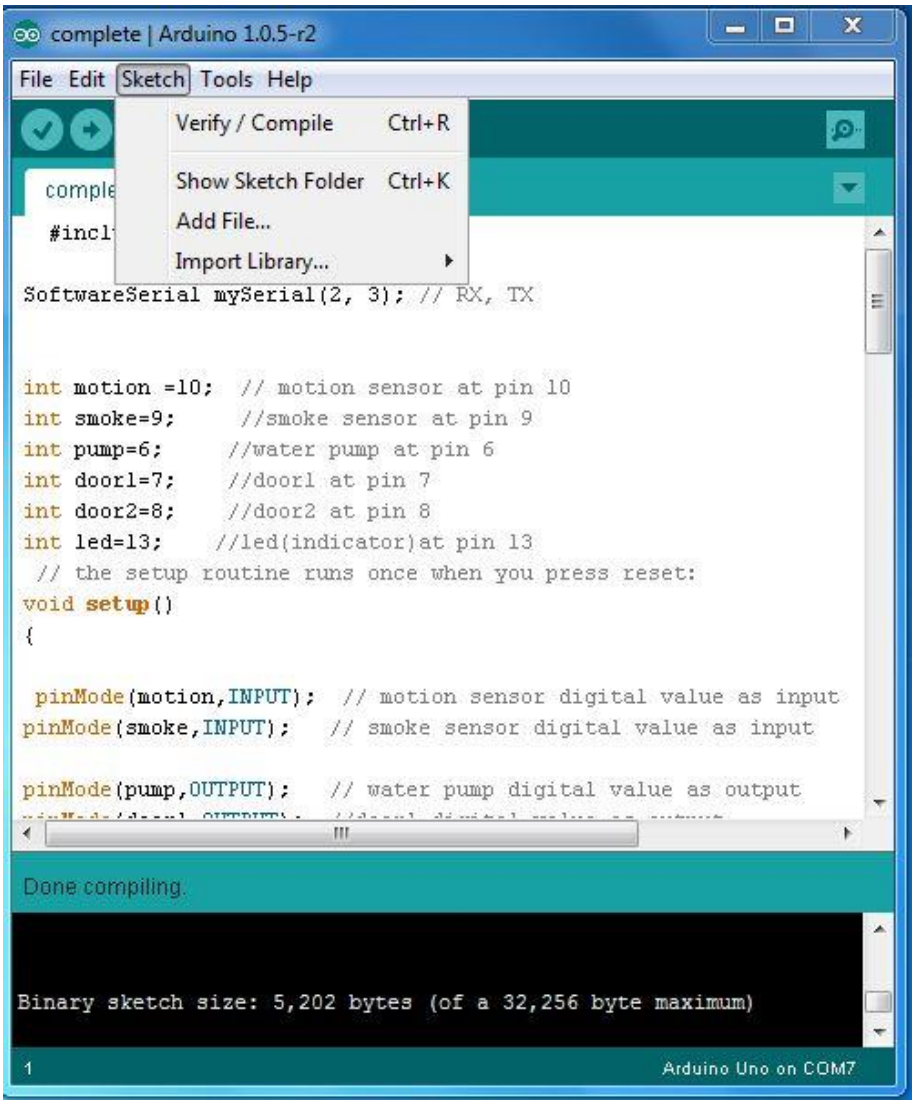


Figure 5.4: System Compiling

5.3: Android Mobile Application

We have designed Android application to control and monitor our system by using eclipse program. Through this program, we can design interfaces capable of receiving and sending data. Figure 5.5 shows the initial application interface, which includes specific information (such as username and password) to increase the protection and prevent unauthorized people to use this application

Figure 5.5: Initial Interface

The options interface in Figure 5.6 shows that t the user can choose the monitor or control button, also it contain back button to move to initial interface.

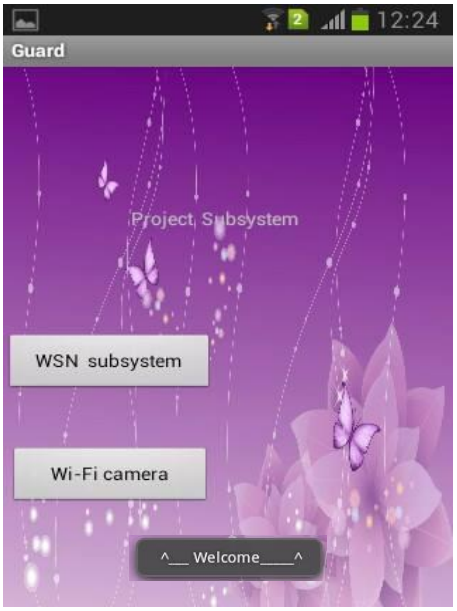


Figure 5.6: Options Interface

We also tested the IP camera, and stream live video through the Wi-Fi network on PC and on Smartphone using an Android application. By getting the static IP and port from camera, putting it in those devices, then start streaming, as shown in the following figures:

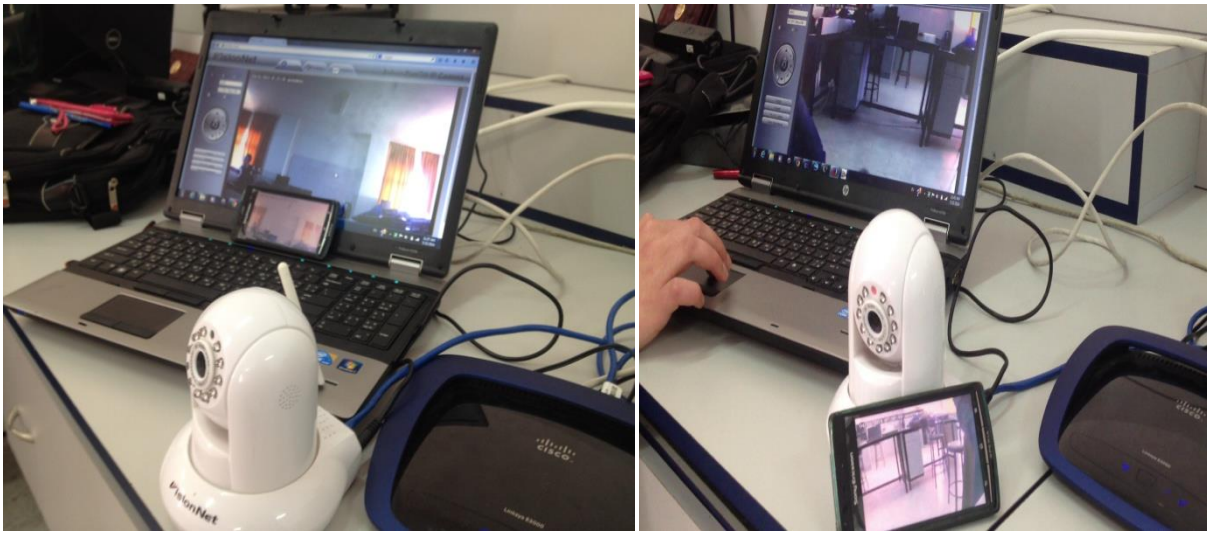


Figure 5.7: Live Video Streaming

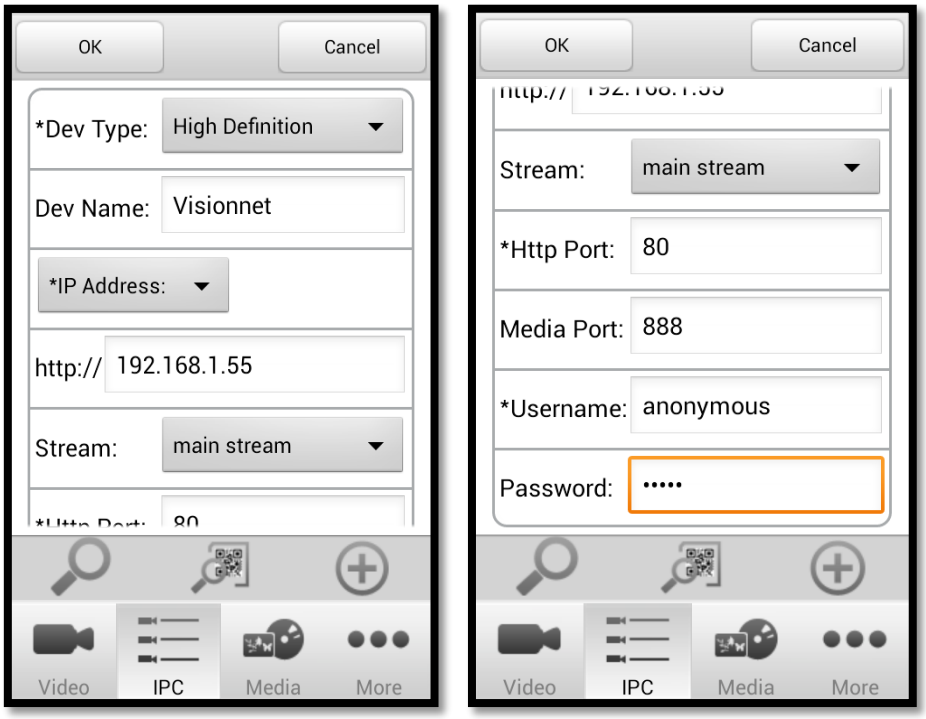


Figure 5.8: Inserting Settings on the Android Application

5.4: C# Programming

A C# program has the functionalities of controlling Security Door, Pumps, and the ability of automatically sending notification messages to 3G modem depending on specific conditions of Motion or Fire.

Here is the application graphical user interface:

Figure 5.9: C# program graphical user interface

The Connect button above opens the connection with WSN Nodes and 3G modem that interfaced with PC COM ports, and that TextBox necessary to show information about each process. We will show more about these buttons in chapter 6

Underneath this User Interface, there are codes for every button and label as follows:

1) This code opens ports with WSN Nodes and 3G modem

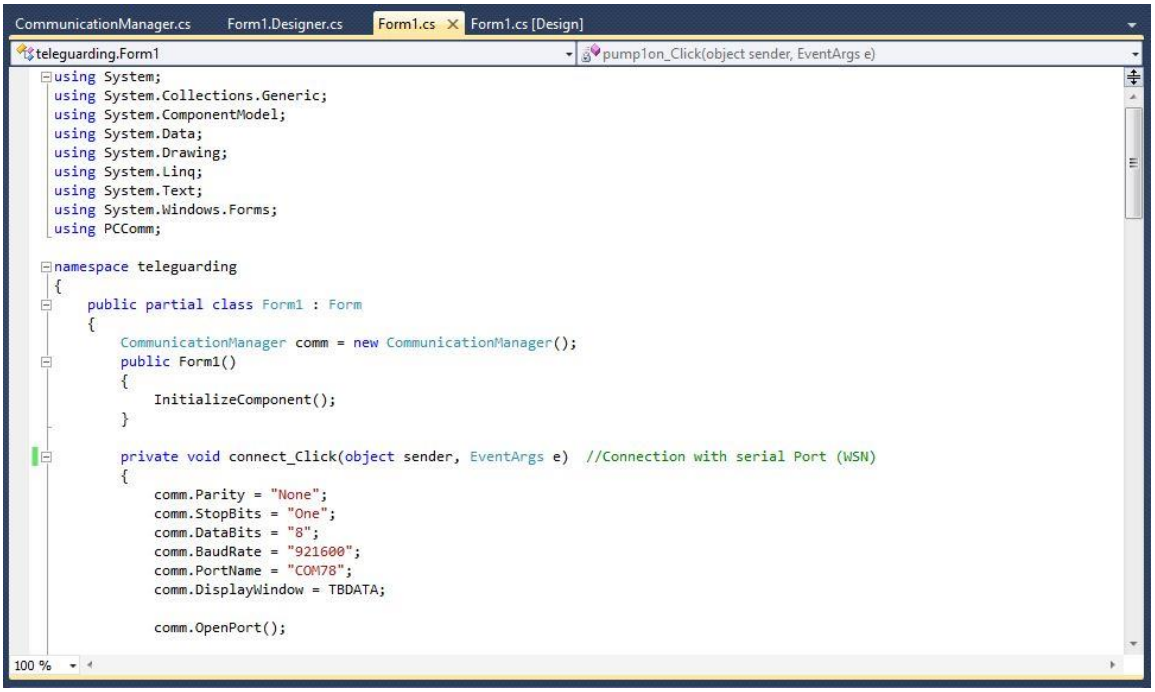


Figure 5.10: Open connection with 3G Modem

2) The following code has functionality of sending control signal to Security door.

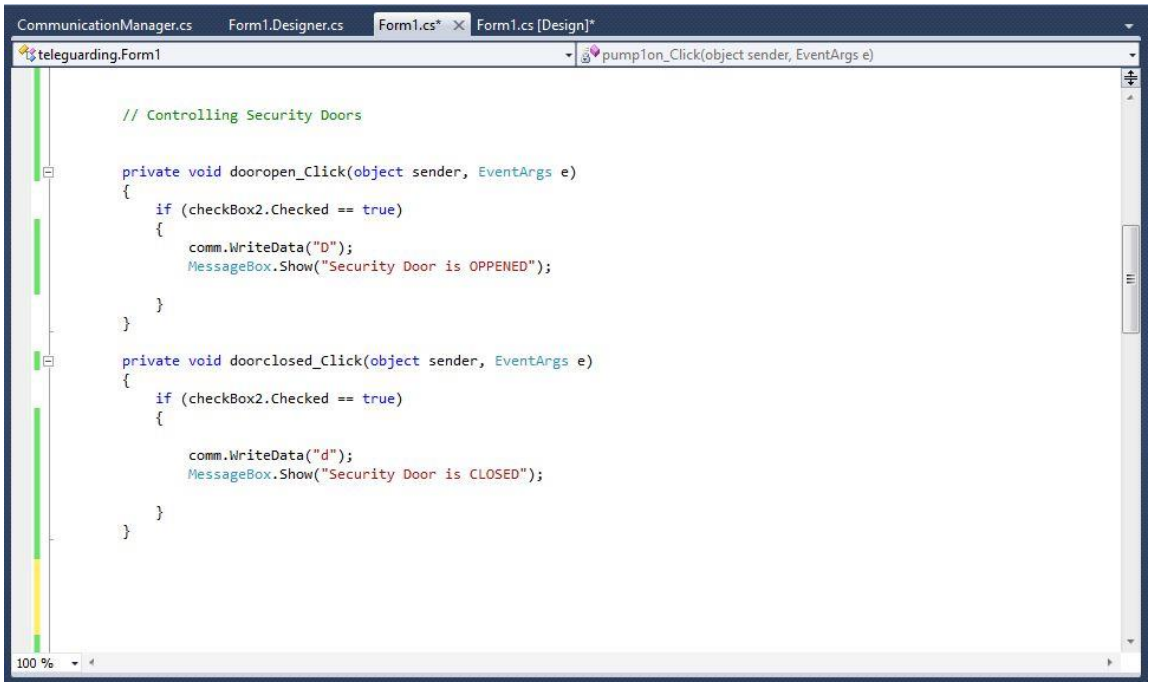


Figure 5.11: Security Doors Controlling Code

3) The following code has functionality of sending control signals to the two Water Pumps in the system.

```
        // Controlling Water Pumps

        private void pump1on_Click(object sender, EventArgs e)
        {
            if (checkBox1.Checked == true)
            {
                comm.WriteData("U");
                MessageBox.Show("Pump 1 is Turned ON");
            }



        }

        private void pump1off_Click(object sender, EventArgs e)
        {
            if (checkBox1.Checked == true)
            {
                comm.WriteData("u");
                MessageBox.Show("Pump 1 is Turned OFF");

            }
        }
```

100 %

CommunicationManager.cs | Form1.Designer.cs | Form1.cs | Form1.cs [Design]

teleguarding.Form1 | pump1on_Click(object sender, EventArgs e)

```
        private void pump2on_Click(object sender, EventArgs e)
        {

            if (checkBox3.Checked == true)
            {

                comm.WriteData("P");
                MessageBox.Show("Pump 2 is Turned ON");

            }
        }

        private void pump2off_Click(object sender, EventArgs e)
        {

            if (checkBox3.Checked == true)
            {

                comm.WriteData("p");
                MessageBox.Show("Pump 2 is Turned OFF");

            }
        }

    }


}
```

100 %

Figure 5.12: Water Pumps Controlling Code

5.5: Zig-Bee Network Implementation

The zig-bee network testing done by X-CTU software, which is a configuration and test utility software. Through a USB serial port, each Xbee unit will be connected to PC in order to set each unit parameters

PC settings:

It allows selecting the desired COM port, and configuring that port. Figure 5.10 shows the specific settings for each Xbee unit (baud rate, flow control, data bit, parity, stop bit).

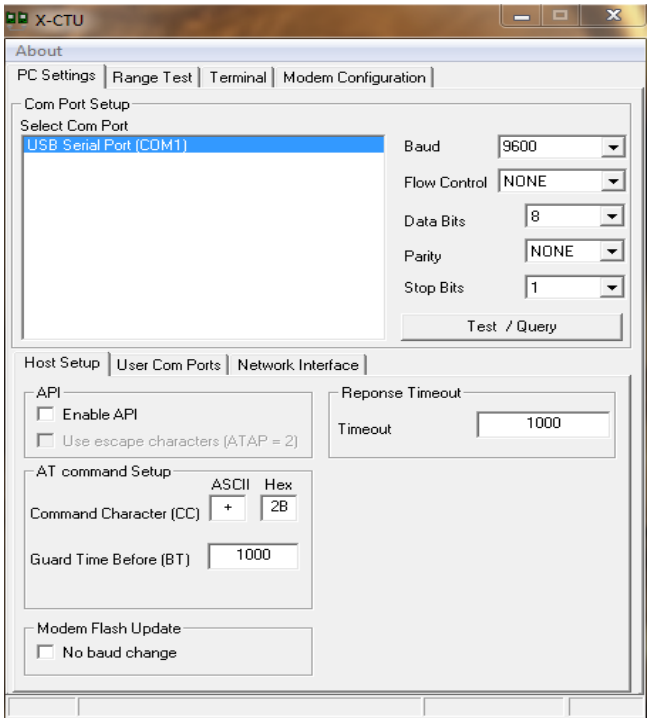


Figure 5.13: Specific settings for each Xbee unit

In order to establish the testing configurations we use two Xbee units and two PC's. We set each one as the destination of the other.

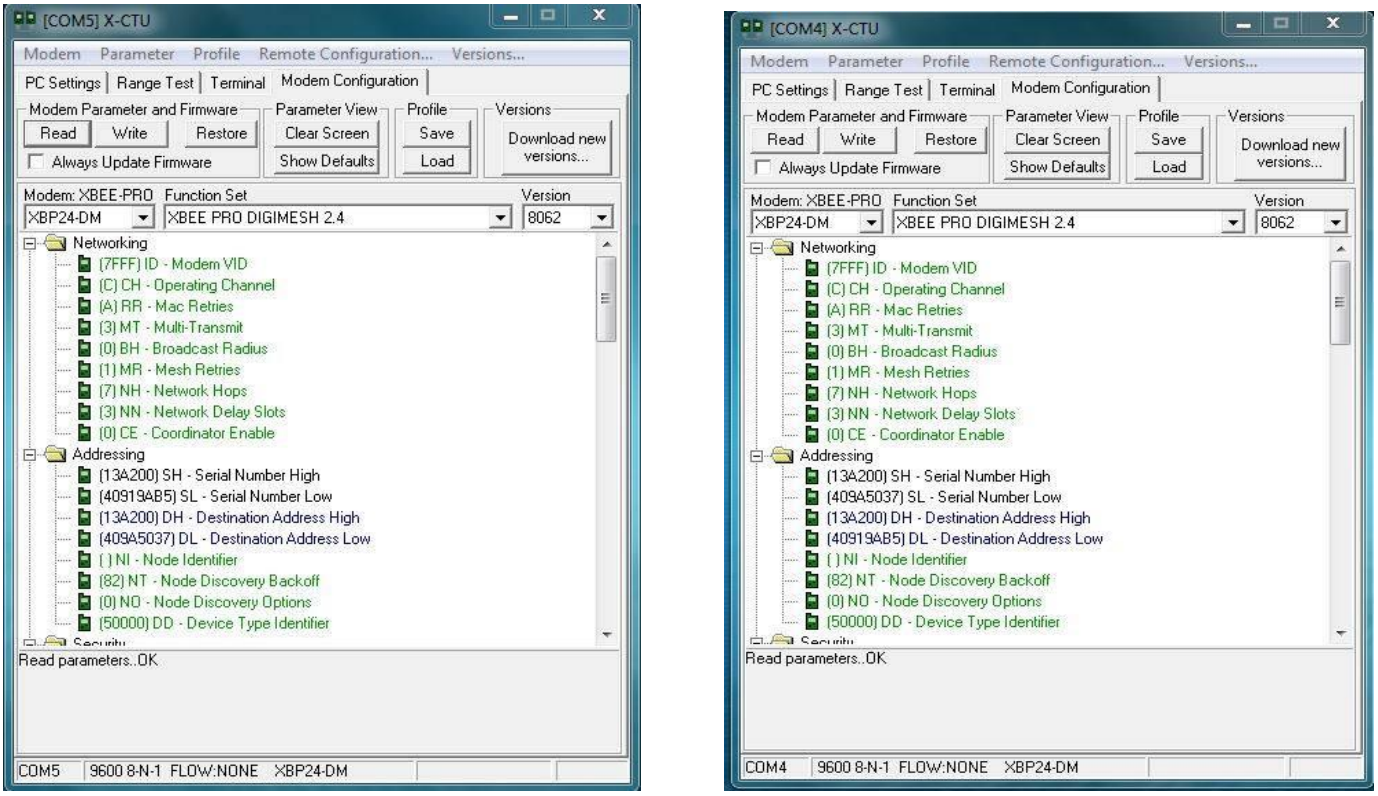


Figure 5.14: Xbee unit with MAC address

After setting the Xbee units, we have tried to send message from each on to the other .Figure 5.12 shows the text message (blue line: Transmit, red line: Receive)

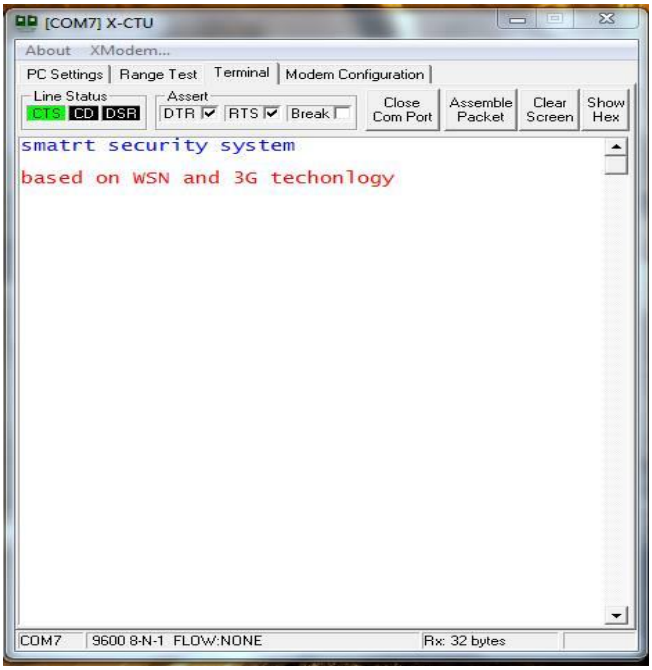


Figure 5.15: Message between Zig-Bee Units

Chapter 6: Testing and Results

6.1 Overview

6.2 WSN Nodes

6.3 Door Prototype

6.4 Controlling with C#

6.1: Overview

In this chapter, we will show the testing and results of the system. The test of WSN and the video streaming technique, also the door controlling using C# programming will be shown.

6.2: WSN nodes

The WSN in our project is an ad hoc network consists of three nodes:

Node A: Arduino, Xbee transceiver, motion sensor (1), smoke detector, water pump, and two normally open relays connected to the door and other electronic components. As shown in figure 6.1

Node B: Arduino, Xbee transceiver, motion sensor (2), smoke detector, water pump and other electronic components. As shown in figure 6.2

Central node: Xbee transceiver and Xbee USB dongle. Figure 6.3 shows the WSN that we designed.

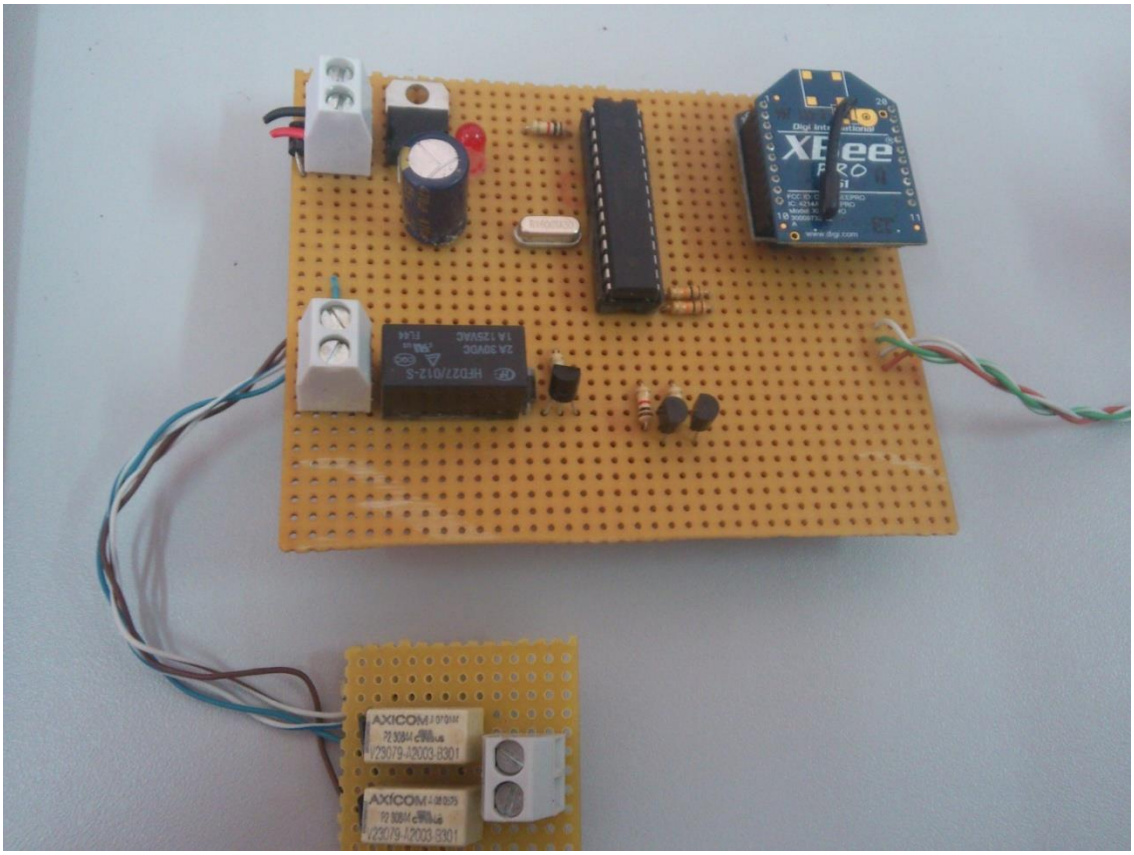


Figure 6.1: WSN Node A

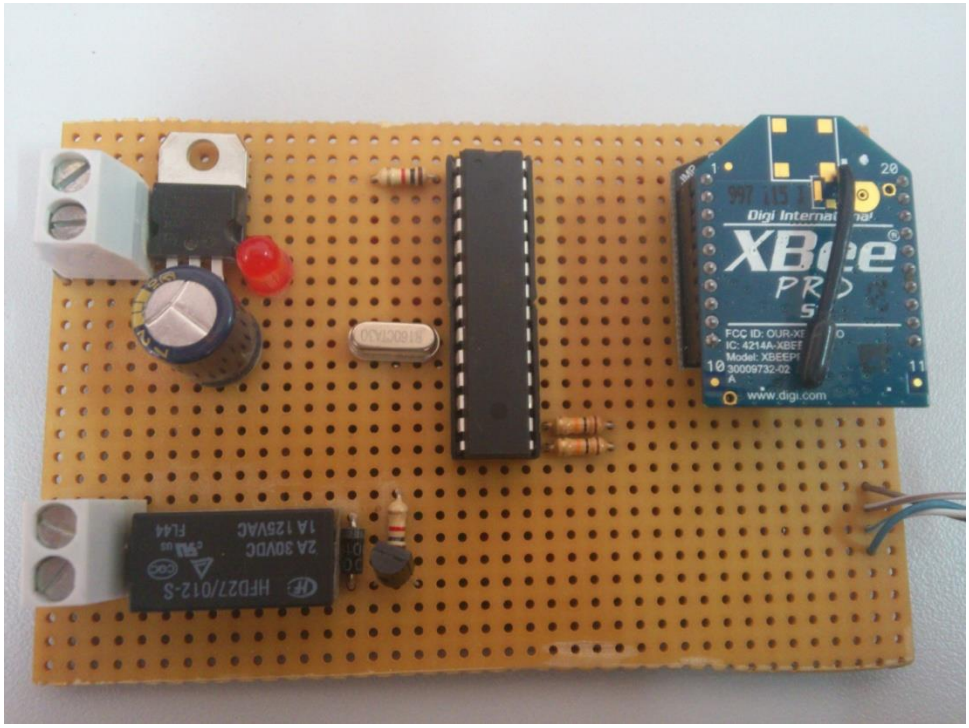


Figure 6.2: WSN node B

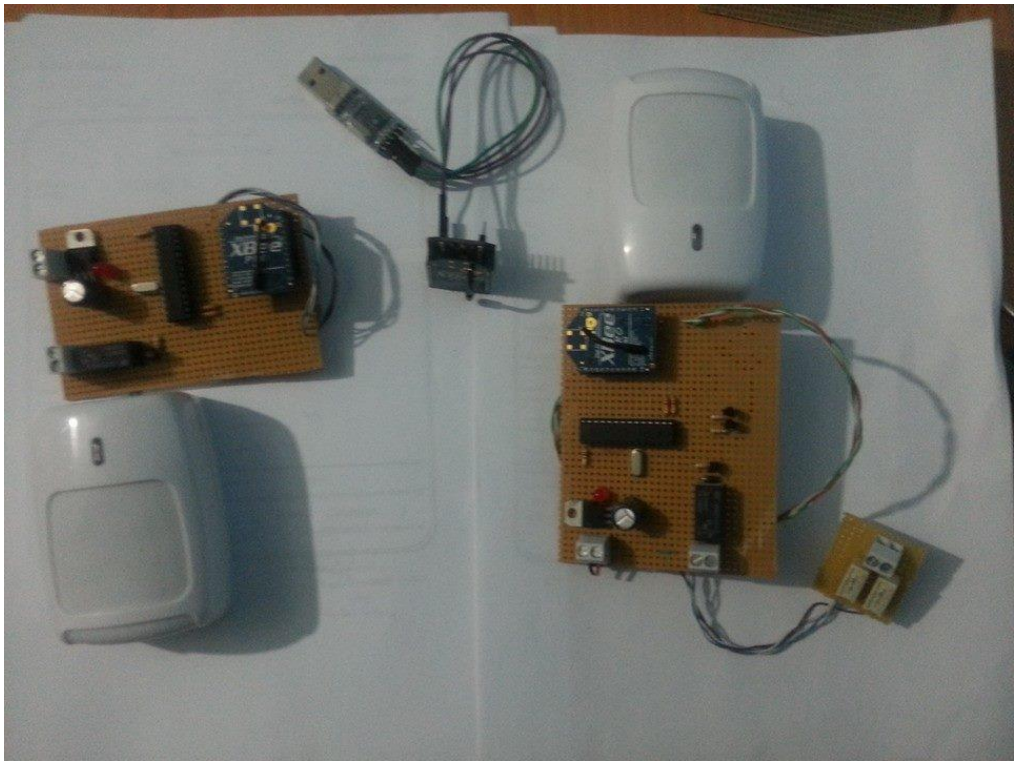


Figure 6.3: All WSN nodes

Motion Sensor:

We use Honeywell Standard PIR IS215T motion sensor. Figure 6.4 shows the sensor connected to the node. The range of this sensor is (8_12 meters).

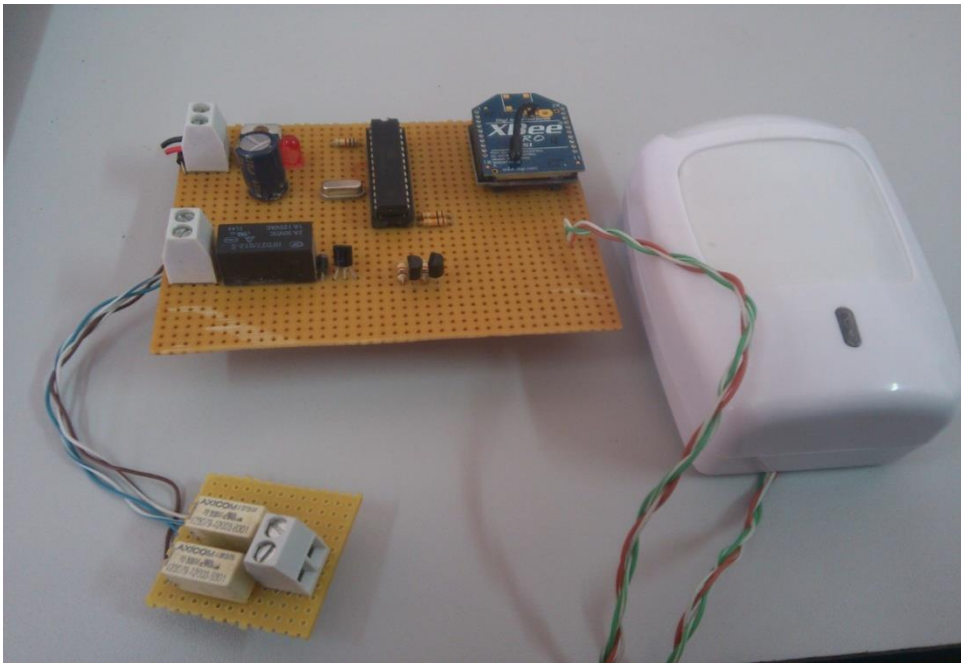


Figure 6.4: Motion sensor connection with WSN node

Figure 6.5 shows the water pump connected to the node. This water pump usually used for car, but we use it in our project as reuse of resources with least possible cost.

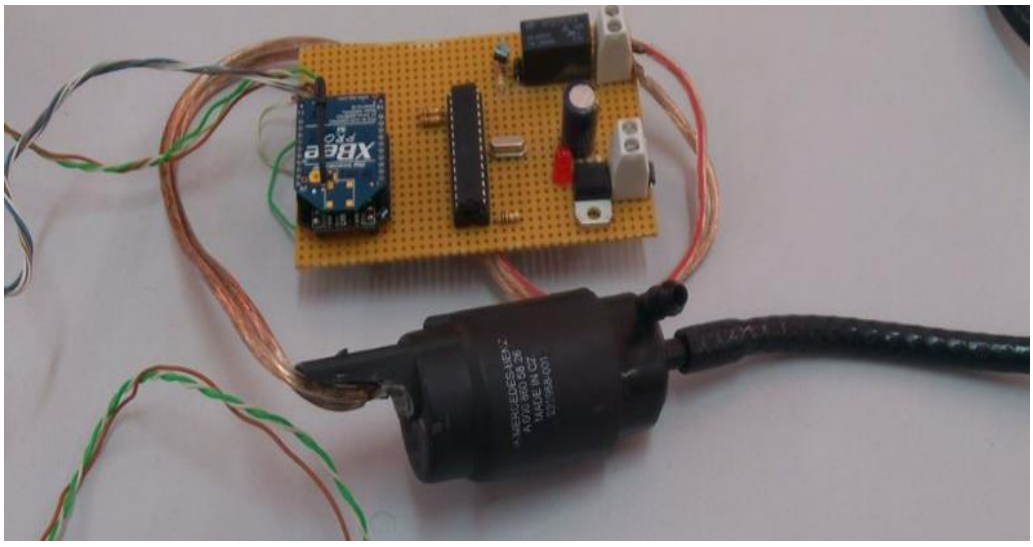


Figure 6.5: Water Pump connected to WSN node

Smoke sensor:

We use MQ2 smoke sensor. Figure 6.6 shows the sensor connected to the node.it has a good sensitivity to combustible gas in wide range.

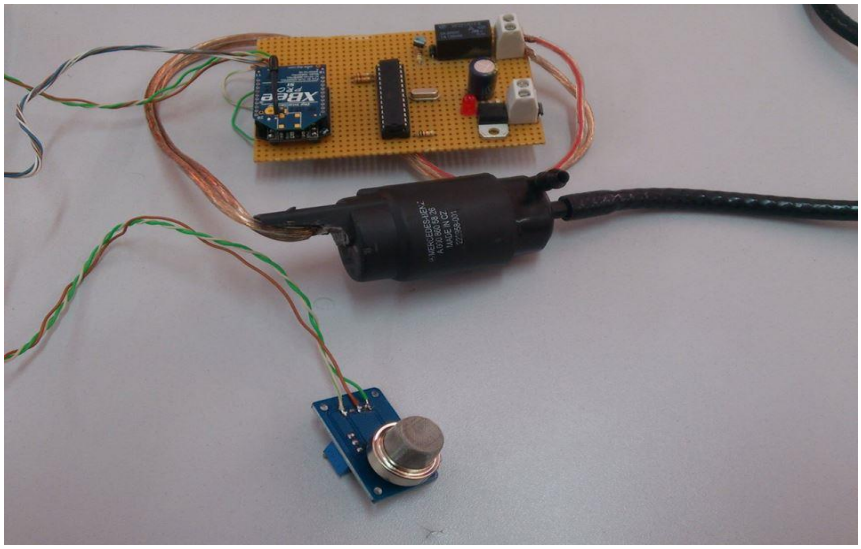


Figure 6.6: Smoke Sensor connection with WSN node

6.3: Door Prototype:

We design this door prototype by using CD–ROM in order to open and close it. Figure 6.7 shows the inside and outside view of it.

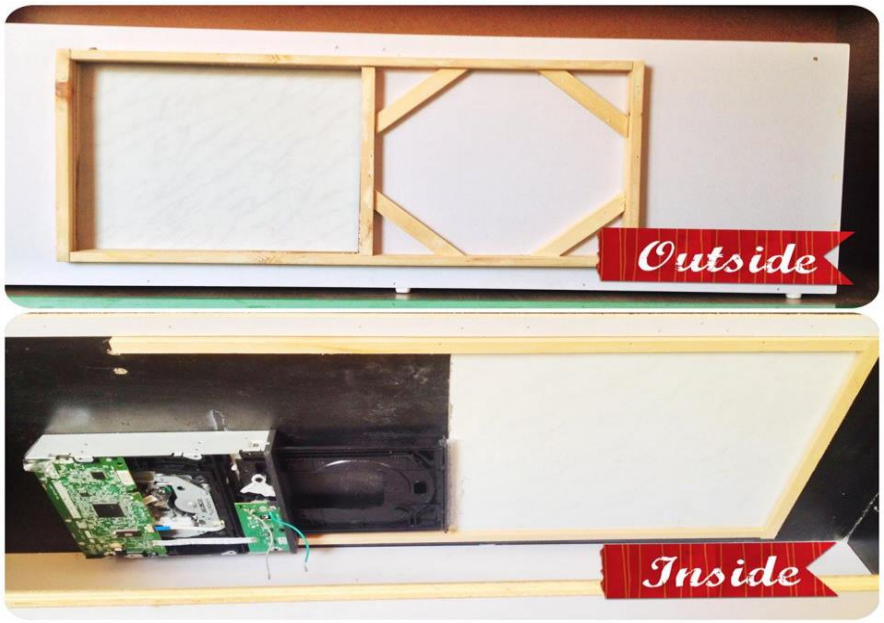


Figure 6.7: Door Prototype

We connected the door with the node A, to open or close it, as shown in Figure 6.8

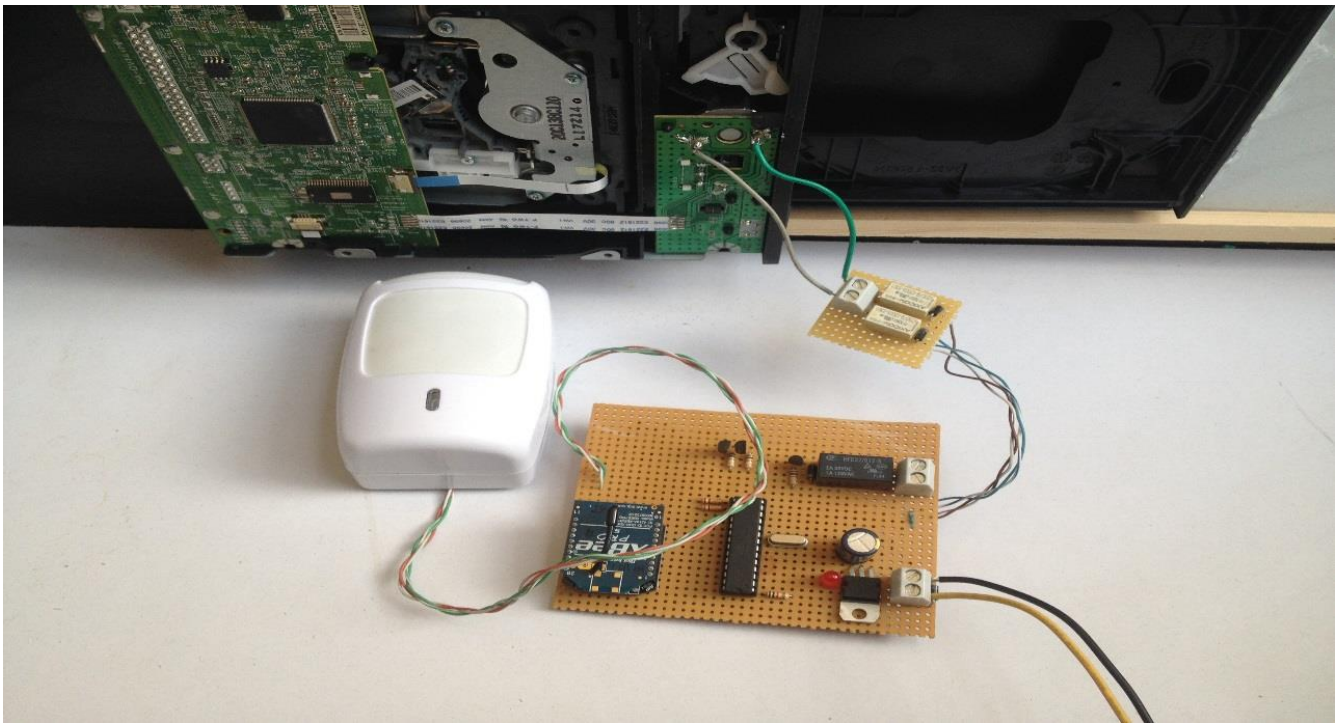


Figure 6.8: Door Model connected to WSN node A

6.4: Controlling with C#

Control feature is one of the major parts of PC program, using our C# program we can control security door as well as water pumps. In order to send controlling signals to these devices, we need to set connection with WSN then enabling control buttons to send these signals.

The following steps shows the process:

1) Connecting to WSN central node through pre-set COM port, so that word (+ZPSTM:) means that the connection was successful.

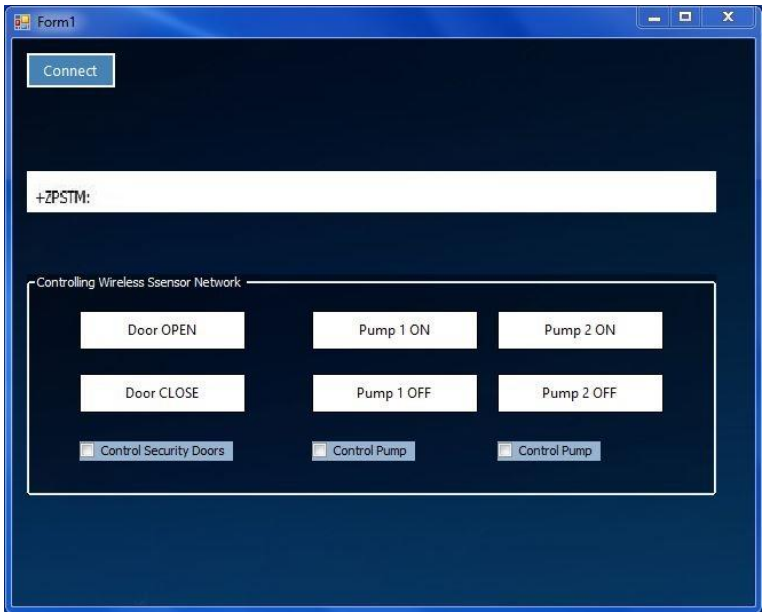


Figure 6.9: Server Connection with WSN

2) Controlling water pumps and security door, each with specific button.

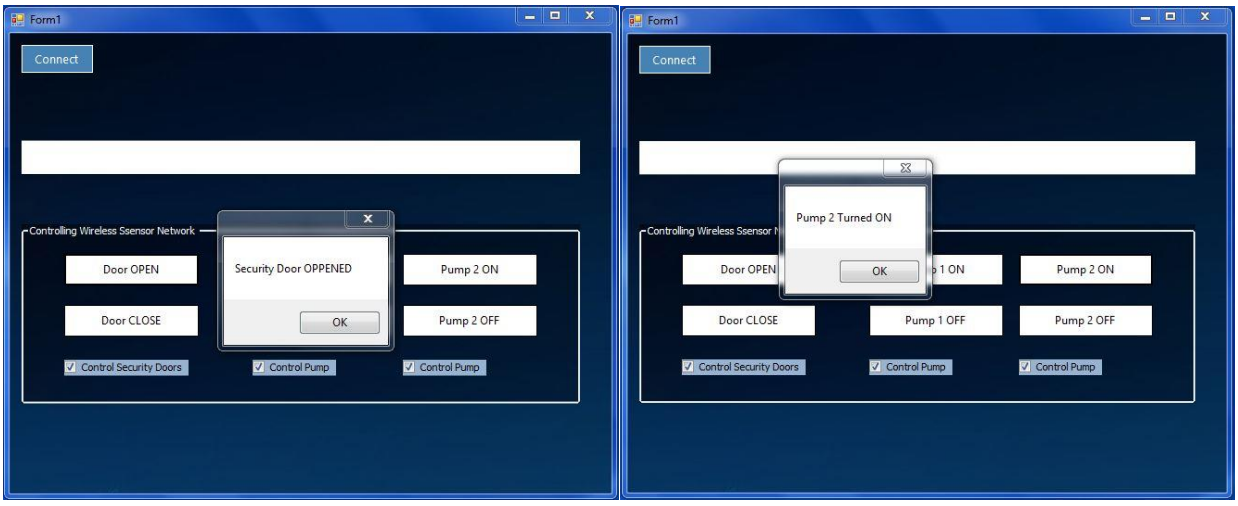


Figure 6.10: Controlling using Server

Chapter 7: Conclusion

7.1 Overview

7.2 Achievements

7.3 Conclusion

7.4 Future Work

7.1: Overview

In this chapter, we will discuss what we achieved in this project, overall conclusion, and future work suggestions and recommendations for even better implementation.

7.2: Achievements

Through past months, we achieve different points according to our project plan:

- Implementing a small sized electronic nodes
- Building an android mobile application for security notifications, accepted delay live video streaming viewing (monitoring), and controlling camera, pumps, and security door with a simple designed user interface.
- Building a specific PC program based on C# language with controlling functions for pumps and security door, and automatically sending alarm messages to mobile phone depending on motion or fire events. This program has simple and effective user interface as well.
- Implementing suitable door model for our project.

7.3: Conclusion

At the end of our project, we conclude some ideas as follows:

Working with a team is very important thing, and give a power and meaning to the project. The fact that four students in this project helped everyone in his/her project load, because of cooperation of different suggestions, and ideas and solutions that taken from everyone in our group, and this help us a lot especially when we faced some challenges. Because of that cooperation, our project succeed.

Video Streaming is one of the widely used techniques for many useful applications, in our project; we use video streaming to increase security protection for the building using IP camera that streams the live video to the Android mobile application using streaming protocol http, over TCP/IP. Video LAN VLC media player helped as a lot in this segment of the project, because it has streaming capability over many protocols.

An Open source android program is the more effective solution for developing mobile application for our project. We have learned many things about android programming while building the application, from dealing with Activities to designing the user interface.

Using C# to program the PC, because it fully featured and smooth on windows environment, so we build our monitoring and surveillance program using this programming language.

Arduino Microcontroller is very useful and simple than other microcontrollers, especially for controlling such devices, inputs, outputs, and the capability of interfacing with wide variety of transceivers such as Zig-Bee. We learned to program Arduino and connect it with different electronics and devices.

The high data rate and the wide coverage of the third generation cellular system is very important to achieve mobility in our project. Third generation modem stick interfaced with PC used in our project to send and receive data from mobile device over cellular network.

7.4: Future Work

We hope that our project will be a valuable and useful reference for other future projects related to smart security systems.

In our project, we focus on WSN that uses safety and security sensors to protect the building, other projects can use the same system topology for other purposes .For example: power efficient, lighting systems.

One of the most important goals of our project is to use the techniques of communications that we learned in our university study. Other future techniques might be useful for higher accuracy and efficiency.

Finally, the system can be implemented in companies and other Institutions by increasing the number of nodes fitting the building's shape.

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(2, 3); // RX, TX
int motion =10;  // motion sensor at pin 10
int smoke=9;     //smoke sensor at pin 9
int pump=6;     //water pump at pin 6
int door1=7;    //door1 at pin 7
int door2=8;    //door2 at pin 8
int led=13;    //led(indicator)at pin 13


 // the setup routine runs once when you press reset:
void setup()
{
 pinMode(motion,INPUT);  // motion sensor digital value as input
pinMode(smoke,INPUT);   // smoke sensor digital value as input
pinMode(pump,OUTPUT);   // water pump digital value as output
pinMode(door1,OUTPUT);  //door1 digital value as output
pinMode(door2,OUTPUT);  //door2 digital value as output
pinMode(led,OUTPUT);    //indicator for zigbee setup
 Serial.begin(9600);     // initialize serial communication at 9600 bits per second
 mySerial.begin(9600);
 delay(2000);
 doorf(1);               //  define door(1) function
 delay(2000);
 doorf(2);               //  define  door(2) function
 delay(2000);
 pumpf(1);                //  define pump(1) function
```

```
 delay(2000);
 pumpf(2);               //  define pump(2) function
 delay(2000);
}
void pumpf(int x)        // pump function
{
 if(x==1)
 {
 digitalWrite(pump, HIGH);
 }
 if(x==2)
 {
   digitalWrite(pump, LOW);
 }
}
void doorf(int x)                //door function
{
if(x==1)
{
digitalWrite(door1, HIGH);
digitalWrite(door2, LOW);
delay(1500);
digitalWrite(door2, LOW);
digitalWrite(door1, LOW);
delay(500);
}
else if(x==2)
```

```
{
digitalWrite(door1, LOW);
digitalWrite(door2, HIGH);
delay(1500);
digitalWrite(door2, LOW);
digitalWrite(door1, LOW);
delay(500);
}
 }


void loop()
{
int red;
  if (mySerial.available())              //verify the serial connection
 {
 red=mySerial.read();                    //read data from serial connection
 if(red=='R')doorf(1);
 if(red=='r')doorf(2);
 if(red=='U')pumpf(1);
 if(red=='u')pumpf(2);
 }
 if(digitalRead(motion)==HIGH)
 {
   mySerial.print("*A>M#");             //print at the serial port
   delay(5000);
 }
```

```
 if(digitalRead(smoke)==LOW)
 {
  mySerial.print("*A>S#");
  pumpf(1);
  delay(5000);
 }
}
```

Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 4/8/16/32K Bytes of In-System Self-Programmable Flash progam memory (ATmega48PA/88PA/168PA/328P)
  - 256/512/512/1K Bytes EEPROM (ATmega48PA/88PA/168PA/328P)
  - 512/1K/1K/2K Bytes Internal SRAM (ATmega48PA/88PA/168PA/328P)
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C(1)
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP PackageTemperature Measurement
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Byte-oriented 2-wire Serial Interface (Philips I^2C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V for ATmega48PA/88PA/168PA/328P
- Temperature Range:
  - -40˚C to 85˚C
- Speed Grade:
  - 0 - 20 MHz @ 1.8 - 5.5V
- Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega48PA/88PA/168PA/328P:
  - Active Mode: 0.2 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.75 µA (Including 32 kHz RTC)

8-bit AVR® Microcontroller with 4/8/16/32K Bytes In-System Programmable Flash

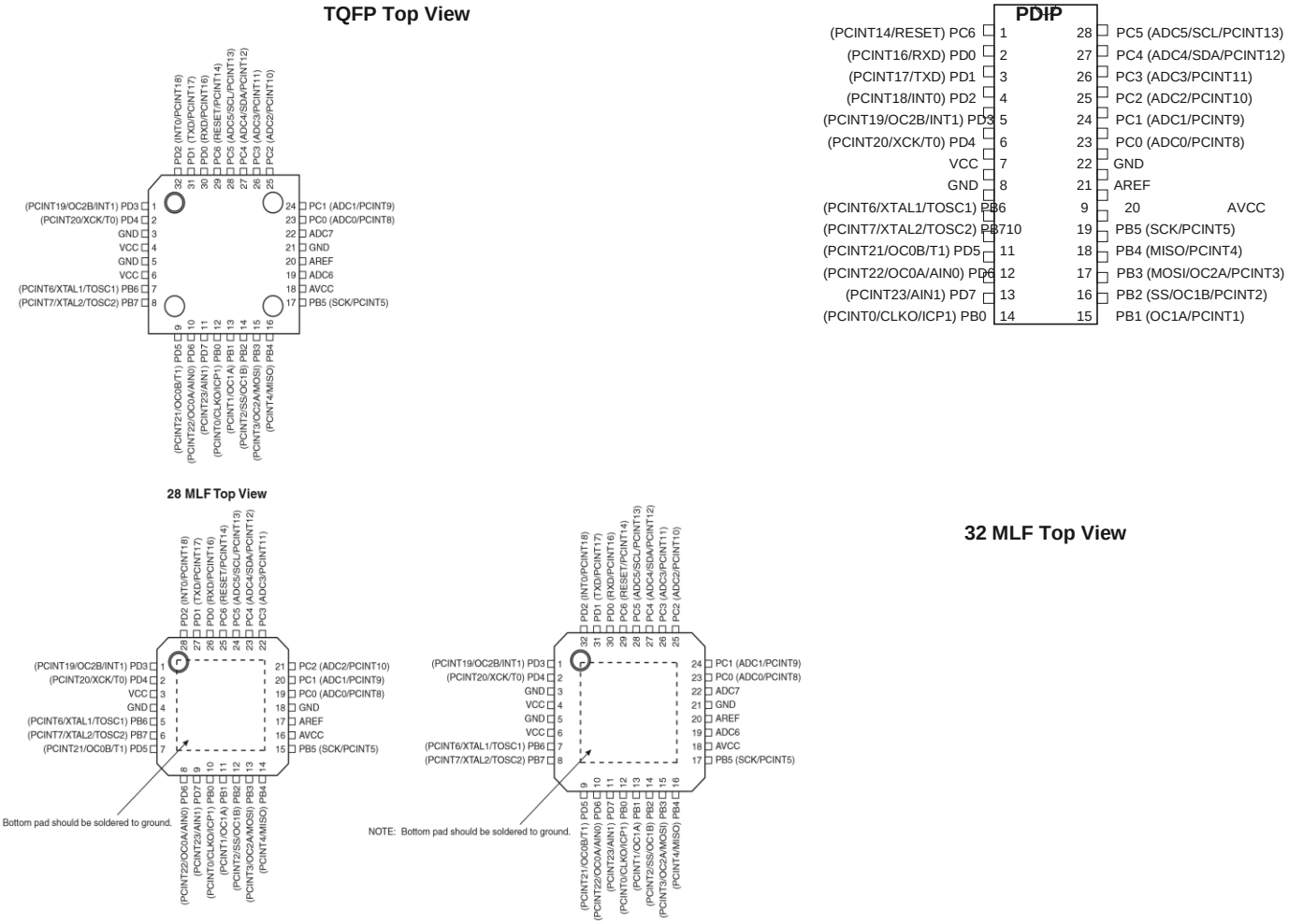
ATmega48PA
ATmega88PA
ATmega168PA
ATmega328P

Summary

Rev. 8161DS–AVR–10/09

1. Pin Configurations

Figure 1-1. Pinout ATmega48PA/88PA/168PA/328P



Appendix A

ATmega 328 Microcontroller

Data Sheet

Appendix B

Motion sensor

Honeywell Standard PIR

Data sheet

Appendix C

Smoke Sensor MQ-2

Data sheet

Appendix D

Arduino Uno Code

Honeywell

IS215T

PIR motion sensor

The IS215T is an entry level passive infrared motion sensor.
Dip switch setting, a large wiring channel and mounting flexibility make the IS215T easy to install.

Compromising the IS215T is inhibited by the look-down zones, tamper switch, sabotage-resistant lens design and the magnet-proof relay.
All these factors make the IS215T an ideal sensor for residential and light commercial applications.

Features:

- Cannot be compromised by a magnet
- Dip switches for easy setting of parameters
- Improved RF immunity
- Large wiring channel on back to allow surface wiring
- Patented look-down mirror provides optimum detection directly beneath the sensor
- Wall-mount and corner mount knockouts provides mounting flexibility
- Sabotage-resistant lens design
- Selectable sensitivity
- Tamper switch: activates before access to the circuitry is possible
- White Light Immunity of minimum 6500 Lux reduces the chance of false activiation
- Bug guard prevents insects access to the sensor optics which reduces the chance of false activation
- Designed for residential and light commercial applications
- Silent relay allows for use in quiet environments

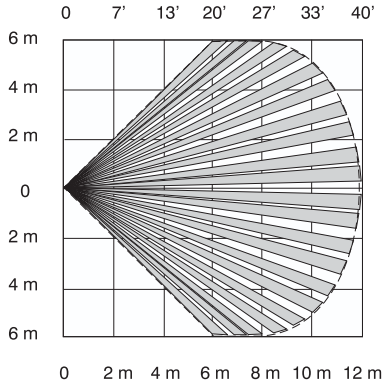
IS215T

PIR motion sensor

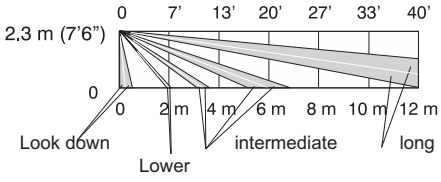
Specifications	
Detection method	Dual element passive infrared
Range	12 x 12 m
Detection zones	44 long range, 14 intermediate, 8 lower and 4 look-down
PIR sensitivity	Low (3-5 steps) and High (1-3 steps) by dipswitch
LED enable	By dipswitch
Mounting height	2.3 to 2.7 m
Power requirements	10 - 14 Vdc, 7 mA @ 12 Vdc
Alarm relay	Form A (NC) / 90 mA@16 Vdc, max. 40 Ohm protective resistor
Tamper switch	500 mA @ 30 Vdc
Operating temperature	-10ºC to +55ºC
Relative humidity	5% - 95% non condensing
RF Immunity	30 V/m from 10 to 1000 MHz
White Light Immunity	Better than 6500 Lux
Dimensions	86 x 60 x 38 mm. (HxWxD)
Weight	67g.

Detection Patterns:

- **Top View**



- **Side View**



Ordering:

IS215T	Passive infrared motion sensor
Accessories:	
SMB10	White swivel mount bracket (5 pack)
SMB10C	White ceiling mount bracket (5 pack)
SMB10T	Tampered white swivel mount bracket (5 pack)

Agency Listings:

- CE

Honeywell Security
Newhouse Industrial Estate
Motherwell
Lanarkshire
ML1 5SB
Scotland
Tel :+44 (0) 1698 738200
Fax : +44 (0) 1698 738300
www.honeywell.com/security/uk

HSC-IS215T-02-EN(1008)DS-Z
October 2008

Honeywell

MQ-2 Semiconductor Sensor for Combustible Gas

Sensitive material of MQ-2 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exist, The sensor's conductivity is more higher along with the gas concentration rising. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration.

MQ-2 gas sensor has high sensitity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

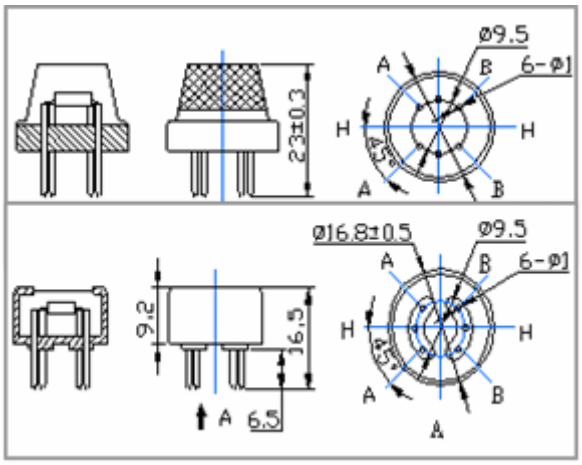
Character

*Good sensitivity to Combustible gas in wide range
* High sensitivity to LPG, Propane and Hydrogen
* Long life and low cost
* Simple drive circuit

Application

* Domestic gas leakage detector
* Industrial Combustible gas detector
* Portable gas detector

Configuration

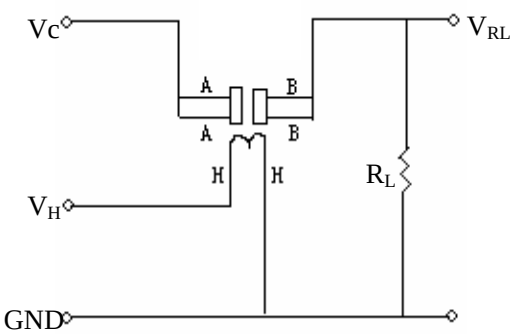


Technical Data

Model No.			MQ-2
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite (Black Bakelite)
Detection Gas			Combustible gas and smoke
Concentration			300-10000ppm (Combustible gas)
Circuit	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.2V ACorDC
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤900mW
	Sensing Resistance	R_s	2KΩ-20KΩ(in 2000ppm C_3H_8)
	Sensitivity	S	Rs(in air)/Rs(1000ppm isobutane)≥5
	Slope	α	≤0.6($R_{5000ppm}/R_{3000ppm}$ CH_4)
Condition	Tem. Humidity		20℃±2℃；65%±5%RH
	Standard test circuit		Vc:5.0V±0.1V； V_H: 5.0V±0.1V
	Preheat time		Over 48 hours

Basic test loop

T



The above is basic test circuit of the sensor. The sensor need to be put 2 voltage, heater voltage（VH） and test voltage（VC）. VH used to supply certified working temperature to the sensor, while VC used to detect voltage (VRL) on load resistance （RL） whom is in series with sensor. The sensor has light polarity, Vc need DC power. VC and VH could use same power circuit with precondition to assure performance of sensor. In order to make the sensor with better performance, suitable RL value is needed:

Power of Sensitivity body(Ps):

$Ps=Vc^2\times Rs/(Rs+RL)^2$

Resistance of sensor(Rs): Rs=(Vc/VRL-1)×RL

Sensitivity Characteristics

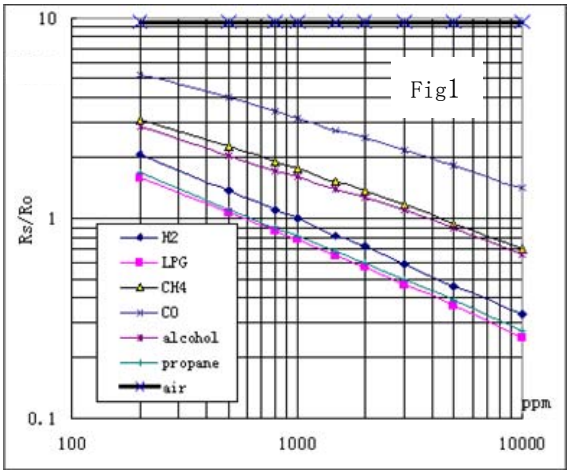


Fig.1 shows the typical sensitivity characteristics of the MQ-2, ordinate means resistance ratio of the sensor (Rs/Ro), abscissa is concentration of gases. Rs means resistance in different gases, Ro means resistance of sensor in 1000ppm Hyrogen. All test are under standard test conditions.

Influence of Temperature/Humidity

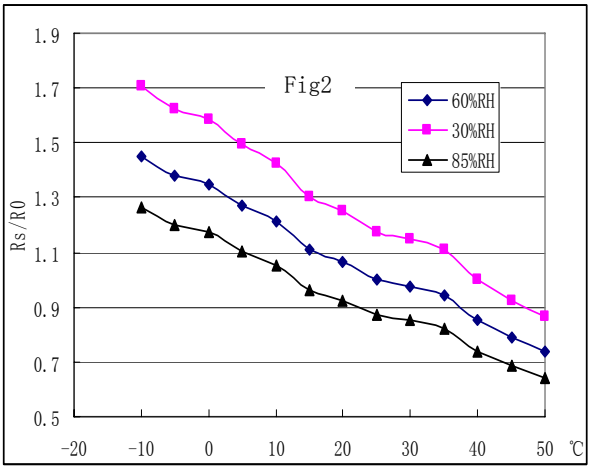


Fig.2 shows the typical temperature and humidity characteristics. Ordinate means resistance ratio of the sensor (Rs/Ro), Rs means resistance of sensor in 1000ppm Butane under different tem. and humidity. Ro means resistance of the sensor in environment of 1000ppm Methane, 20℃/65%RH

Structure and configuration

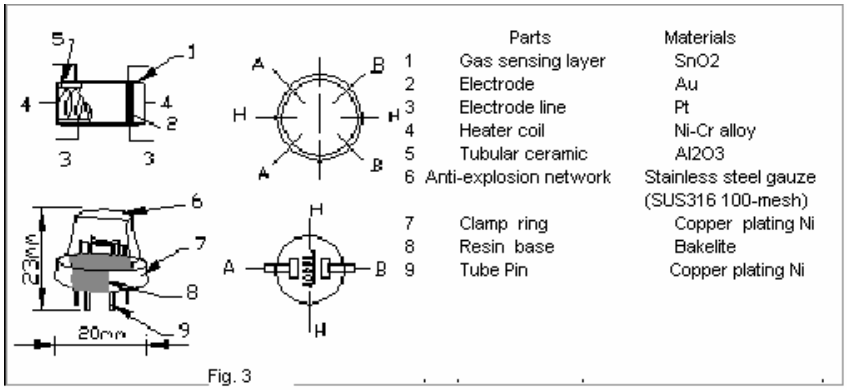


Fig. 3

Structure and configuration of MQ-2 gas sensor is shown as Fig. 3, sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

Notification

1 Following conditions must be prohibited

1.1 Exposed to organic silicon steam

Organic silicon steam cause sensors invalid, sensors must be avoid exposing to silicon bond, fixature, silicon latex, putty or plastic contain silicon environment

1.2 High Corrosive gas

If the sensors exposed to high concentration corrosive gas (such as H_2Sz, SO_X, Cl_2, HCl etc), it will not only result in corrosion of sensors structure, also it cause sincere sensitivity attenuation.

1.3 Alkali, Alkali metals salt, halogen pollution

The sensors performance will be changed badly if sensors be sprayed polluted by alkali metals salt especially brine, or be exposed to halogen such as fluorin.

1.4 Touch water

Sensitivity of the sensors will be reduced when spattered or dipped in water.

1.5 Freezing

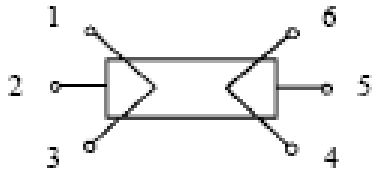
Do avoid icing on sensor'surface, otherwise sensor would lose sensitivity.

1.6 Applied voltage higher

Applied voltage on sensor should not be higher than stipulated value, otherwise it cause down-line or heater damaged, and bring on sensors' sensitivity characteristic changed badly.

1.7 Voltage on wrong pins

For 6 pins sensor, if apply voltage on 1、3 pins or 4、6 pins, it will make lead broken, and without signal when apply on 2、4 pins



2 Following conditions must be avoided

2.1 Water Condensation

Indoor conditions, slight water condensation will effect sensors performance lightly. However, if water condensation on sensors surface and keep a certain period, sensor' sensitivity will be decreased.

2.2 Used in high gas concentration

No matter the sensor is electrified or not, if long time placed in high gas concentration, if will affect sensors characteristic.

2.3 Long time storage

The sensors resistance produce reversible drift if it's stored for long time without electrify, this drift is related with storage conditions. Sensors should be stored in airproof without silicon gel bag with clean air. For the sensors with long time storage but no electrify, they need long aging time for stbility before using.

2.4 Long time exposed to adverse environment

No matter the sensors electrified or not, if exposed to adverse environment for long time, such as high humidity, high temperature, or high pollution etc, it will effect the sensors performance badly.

2.5 Vibration

Continual vibration will result in sensors down-lead response then repture. In transportation or assembling line, pneumatic screwdriver/ultrasonic welding machine can lead this vibration.

2.6 Concussion

If sensors meet strong concussion, it may lead its lead wire disconnected.

2.7 Usage

For sensor, handmade welding is optimal way. If use wave crest welding should meet the following conditions:

2.7.1 Soldering flux: Rosin soldering flux contains least chlorine

2.7.2 Speed: 1-2 Meter/ Minute

2.7.3 Warm-up temperature：100±20℃

2.7.4 Welding temperature：250±10℃

2.7.5 1 time pass wave crest welding machine

If disobey the above using terms, sensors sensitivity will be reduced.

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