GAS LEAKAGE MONITORING AND ALERTING SYSTEMS FOR INDUSTRIES USING IOT

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ABSTRACT

Gas leakage is a major problem with industrial sector, residential premises and gas powered vehicles like CNG(compressed natural gas) buses and cars. Homes and Industrial fires have taken a growing toll on lives and property in recent years. Most gases used for industrial activities are highly inflammable and can burn even at some distance from the source of leakage. Most fire accidents are caused because of a poor-quality rubber tube or when the regulator is not turning off. The supply of gas from the regulator to the burner is on even after the regulator is switched off. By accident, if the knob is turned on, it results in gas leaks. Safety plays a major role in today's world, and it is necessary that good safety systems are implemented in places of education and work. This project modifies the existing safety model installed in industries and this system also can be used in homes and offices. The main objective of this project is to design a microcontroller-based gas leakage detecting system. Some hazardous gases like Liquefied petroleum gas (LPG) and propane can be sensed using this device. One of the preventive methods to stop accidents associated with gas leakage is to install gas leakage detection kit at vulnerable places. The aim of this project is to present such a design that can automatically detect gas leakages in vulnerable premises. In particular gas sensors have been used which have high sensitivity. This project was based on liquefied petroleum gas. If these gases exceed the normal level, then an alarm is generated immediately. The advantage of this detection and alerting system over the manual method is that it offers quick

response time and accurate detection of an emergency and in turn leading faster diffusion of the critical situation.

CHAPTER 1

INTRODUCTION

1.1 Background Of Study

With the increase in the development of technology and the human race, we failed to care about the surroundings in which we live in. Thus, we polluted the environment and thereby reducing the quality of the place we live in. Even though there are several aspects of pollution such as soil, air and water pollution, out of these air pollution acts as the serious aspect as the other can detect visually and by taste, but the polluted air cannot be detected as it can be odorless, tasteless and colorless. Hence there is a growing demand for the environmental pollution monitoring and control systems. In view of the ever-increasing pollution sources with toxic chemicals, these systems should have the facilities to detect and quantify the sources rapidly.

Toxic gases are one that causes serious health impacts but are also used in industries in large quantities. These gases have to be monitored; such that an increase in their normal level of them could be known and proper precaution measures can be taken. But the current systems available are not so portable and are costly and difficult to implement. So, an embedded system is designed using ATmega-328 Microcontroller, for the purpose of detecting hazardous gas leakage, which in turn avoids the endangering of human lives. Hazardous gases like liquefied petroleum gas (LPG) were considered here. If these hazardous gas levels exceed normal levels, that is LPG>1000ppm then an alarm is generated immediately which leads to faster diffusion of emergency situation. The system is affordable and can be easily implement in the chemical industries and in residential areas, which is surrounded by the chemical industries or plants, to avoid endangering human lives.

Liquefied petroleum gas (LPG) consists of a mixture of propane and butane which is a highly flammable chemical. It is odorless gas due to which Ethanethoil is added as powerful odorant, so that leakage can be easily detected. There are other international standards like EN589, amyl mercaptane and tetrahydrothiophene which are most commonly used as odorants. LPG is one of the alternate fuels used now days. Sometimes liquefied petroleum gas is also known as LPG, LP gas, Auto gas etc. This gas is commonly used for heating appliances, hot water, cooking, and various other purposes also. LPG is also used as an alternate fuel in vehicles due to soaring in the prices of petrol and diesel.

Some people have a low sense of smell, may or may not respond to low concentration of gas leakage. In such a case, gas leakage security systems become essential and help to protect from gas leakage accidents. A number of projects have worked on gas leakage security system (Hung *et al*, 2011 and Stepanovich*es al*, 2007). Embedded system for Hazardous gas detection and Alerting has been proposed in literature (Ramya and Palaniappan, 2012). Here the alarm is activated immediately, if the gas concentration exceeds normal level.

Bhopal gas tragedy was an example of gas leakage accident in India. This was the world’s worst gas leakage industrial accident.

Gas leakage detection is not only important but also alerting the people involved is equally essential. This project provides a cost effective and highly accurate system, which not only detect gas leakage but also alert (Beep) the necessary people.

1.2 Problem Statement

Gas leakage leads to various accidents resulting in both financial loss as well as human injuries. In human's daily life, the environment gives the most significant impact to their health issues. The risk of fires, explosions, suffocation, all are based

on their physical properties such flammability, toxicity etc. The number of deaths due to the explosion of gas cylinders has been increasing in recent years. The reason for such explosion is due to sub- standard cylinders, old valves, worn out regulators and lack of awareness using gas cylinders add to risks. Inspections by oil companies found that many LPG consumers are unaware of safety checks of gas cylinders.

In order to minimize or eliminate the hazard of gas leakage there is a need for a system to detect and alert such incidence leading to the development of this project.

1.3 Aims and Objectives

The aim of this project is to design and construct a gas leakage detector using ATmega328 microcontroller. The objective of this project is as follows:

The primary objects of this project is to provide a novel means for safely detecting any malfunction of a pressurized gas system in order to prevent accumulation of combustible gases so that damage or explosion due to such an accumulation of gases is prevented. Another object is to provide a novel safety means for detecting the leakage of gas into the area of an appliance when the appliance is in a shutdown condition and not in operation. Yet another object is to provide a novel gas detection and monitoring system which is economical to manufacture and which may be readily installed in conventional trailers, boats or the like which are normally dependent upon a stored supply of pressurized gas. Typical installation areas being gas yards (Bullets), gas banks with multi cylinders in manifold, user production departments / utility areas like kitchens.

1.4 Scope of Study

This work will go a long way to cover the past works on gas leakage detector system, how it can be achieved using a microcontroller (ATmega328) alongside MQ 7 gas sensor. It also explains the software approach of the project as the coding or program used is C programing language. It also tells its importance in both industrial activities and other applications and then gives a clear step by step design approach to achieve this project.

1.5 Significance of Study

The main Importance for designing a gas leakage detection system is the following:

- It is used in houses as liquefied petroleum gas (LPG) detector.
- It also detects alcohol, so it is used as a liquor tester.
- The sensor has excellent sensitivity combined with a quick response time.

1.6 Organization of Chapters

This work is made up of four Chapters; chapter 1 gives a clear introduction to the effect of hazardous gases, problems caused by gas leakages and the possible solution to checkmate them in industries. Chapter 2 explains review of literature, previous projects done on gas leakage detection system and their drawbacks. Chapter 3 gives a clear explanation of the materials and methods used to achieve this project. Chapter 4 explains the working principles of the project, the results obtained from it and Chapter 5 is the conclusion and recommendation of the study.

CHAPTER 2

LITERATURE REVIEW

2.1Review Of Related Works

(Xie and Tan, 2006) Developed a system to counter the problems of gas accidents in coal mines and family safety from gas usage through the use of a new infrared detection optics principle. The infrared optics gas detection was high in detection accuracy, long range service life. The system allowed the passage of infrared signals to the gas intended for measurement while its molecules will absorb the light energy. The absorption relationship followed Lamber-Beer law. In the year 2014, (Soundarya *al*, 2014) stated that an efficient and smooth working controller is needed to continuously sense both leakage and level of the gas.

Also, fast response is required when leakage is found, and the monitoring system must provide additional leakage information which can be used in further processin.

The detection system includes Arduino, microcontroller board compatible with ATmega328p coupled with the system is the weight sensor, LCD display, GSM and DC motor (Chen and Jiang, 2008). Designed and implemented a GSM-Based Remote Monitoring System. The paper focused on wireless monitoring because the wireless remote monitoring system has a wider application. The hardware and software architecture of the system was designed where the remote signal is transmitted through GSM network. The system has two parts: the monitoring center and the remote monitoring station. The monitoring center consists of a computer and a TC35 communication module for GSM. The computer and the TC35 are connected by RS232. The remote monitoring station consists of a TC35 communication module for GSM, an MSP430F149 MCU, a display unit, sensors and a data gathering and processing unit. The software for the monitoring center and the remote monitoring station were designed using VB. A review of gas leak detection techniques was done by (Prane*t al*, 2014) with a classification of leak detection methods in a gas pipeline to monitor the integrity of a pipeline.

In terms of mode of operation, (Soundarya *al*, 2014) settled for the use an Arduino board, which is quite expensive and bulky. (Ramya and Palaniappan, 2012) Used microcontroller (PIC16F877), which in turn is a soft real time system. It is said that "A hard real time system should always respond to an event within the deadline or else the system fails and endangers human lives but in soft real time system, failing to meet the deadline produces false output and does endanger the human lives."

2.2 Embedded and Real Time systems

Embedded system is a field in which the terminology is inconsistent. A real time system is one in which the correctness of the computations not only depends on the accuracy of the result, but International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.3, May 2012 289 also on the time when the result is produced. This implies that a late is a wrong answer. A hard real time system should always respond to an event within the deadline or else the system fails and endangers human lives but in soft real time system, failing to meet the deadline produces false output and does not endanger human lives.

All embedded systems are not real time systems and vice versa. And our designed embedded system is a soft real time system.

2.2.1 Features of Embedded Systems

• Multiple operations can be performed using single chip

• It is Fully automatic.

• Compact and Faster

2.2.2 Components of Embedded System

• Hardware specifically built for that application

• An embedded operating system

• User interface like push buttons, LCD, numeric displays

The major part of this project is the hardware model consisting of sufficient sensor with embedded system. Embedded systems are computers in the widest sense. Based on functionality and performance requirements, embedded systems can be categorized as, Stand-alone system, Real time system, Networked information appliances and Mobile devices. Every embedded system consists of custom-built hardware built around a central processing unit (CPU). This hardware also contains memory chips onto which the software is loaded. The software residing on the memory chip is also called as the firmware.

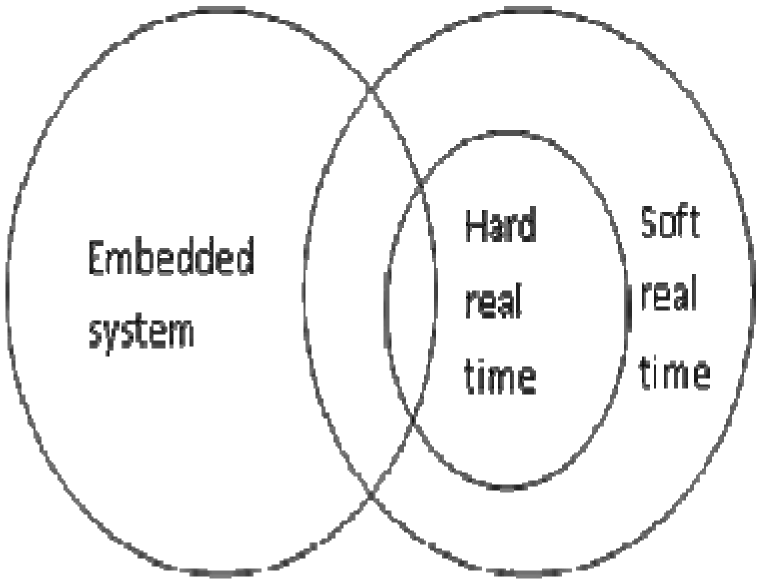

Fig 2.1: Real time operating system.

2.2.3 Types of Hazardous gas and their risks

Types	Gases	Representation
Flammable	Methane, butane LPG, propane	 RISK OF FIRE, EXPLOSION
Toxic	Hydrogen carbon monoxide	 RISK OF POISONING
Asphyxiate	Oxygen deficiency	 RISK OF SUFFOCATION

Table 1: Hazardous gas and their risks

Necessity for detection: The consumers have to upgrade their safety standards, act in accordance with statutory requirements Necessity for detection. The consumers have to upgrade their safety standards, act in accordance with statutory requirements on Environmental commitments and most importantly the Basic function being prevented by accidents and protect life and property from disasters.

1 minute	5 minute	15 minute	60 minute
3%	2.5%	2.0%	1%

Table 2: Typical Threshold value of LPG

Thus, it takes nearly 60 min to detect when 1% of gas leak occurs (Maralinga *et a, 2011l*). As a solution to the problem, a monitoring system of gas detectors by wireless system needs to be developed in order to solve the problem. By monitoring the system wirelessly, users can remotely view the condition of the home without them being themselves, but the system development has not gotten to that yet.

CHAPTER 3

MATERIALS AND METHODS USED

3.1 Materials Used

The major materials used are ATmega328 microcontroller, MQ 7 gas sensor, Pizo-electric buzzer, Analogue to digital converter, 16MHZ Crystal oscillator, LED's, 10k Resistors, 10microfarad Capacitors, D468 Transistor. Coding in embedded C is developed in Keil software, also using RTOS (real time operating system) to manage the entire task and to provide a result in real time.

To develop the overall system, different materials where used. Such as:

1. AT mega 328 microcontroller: The microcontroller used here is a common 8-bit Atmel microcontroller ATmega328. It is a low-power, high-performance CMOS 8-bit microcontroller with 12K bytes of In-System Programmable (ISP) Flash program memory and 2K bytes of EEPROM data memory. It has 32 programmable input output lines.

   FEATURES:

   • 12K Bytes of In-System Programmable (ISP) Flash Program Memory

   – SPI Serial Interface for Program Downloading

   – Endurance: 10,000 Write/Erase Cycles

   • 2K Bytes EEPROM Data Memory

   – Endurance: 100,000 Write/Erase Cycles

   • 2.7V to 5.5V Operating Range

   • Fully Static Operation: 0 Hz to 24 MHz (in x1 and x2 Modes)

   • Three-level Program Memory Lock

   • 256 x 8-bit Internal RAM

   • 32 Programmable I/O Lines

   • Three 16-bit Timer / Counters

   • Nine Interrupt Sources

   • Enhanced UART Serial Port with Framing Error Detection and

Automatic Address Recognition

• Enhanced SPI (Double Write/Read Buffered) Serial Interface

• Programmable Watchdog Timer

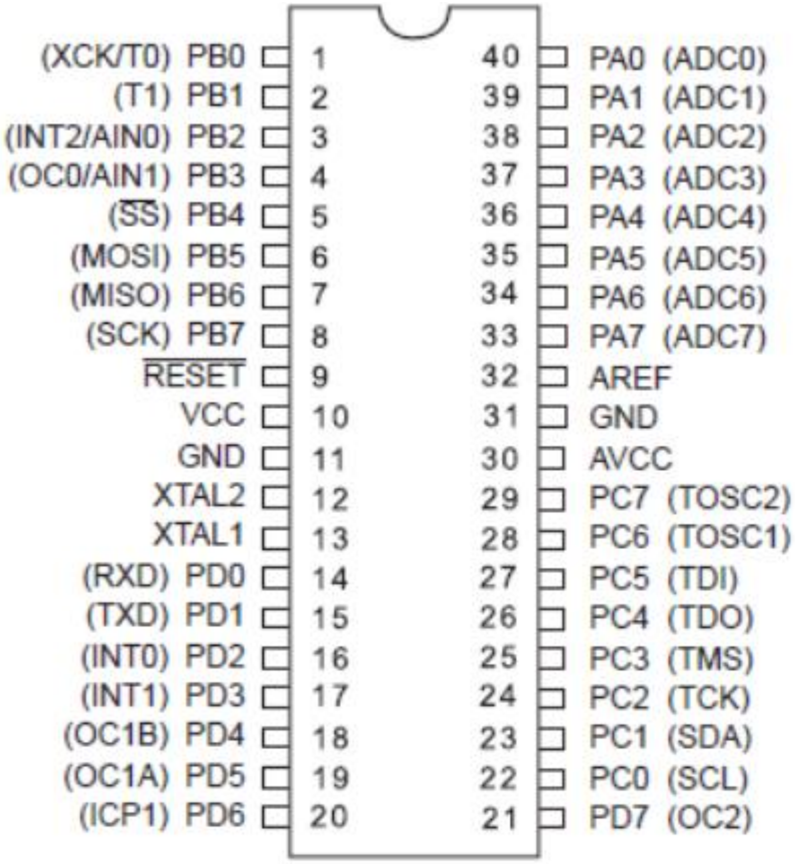

Fig 3.1: Pin outs of AT mega 328 microcontroller

2. Gas Sensor: Normally a gas sensor is the one which is made up of transducer that senses the gas molecules. It sends electrical signals as the output which is proportional to the gas concentration. The gas sensors do not sense a particular gas; thus, they must tend to employ analytical techniques to adopt to identify a particular gas. However, these analytical methods suffer from many disadvantages of skilled operator, specially designed PC's and slows response time etc., and the proposed system does not suffer such disadvantages. The proposed system is an automated one, but it requires resetting after every critical situation. The gas sensor used here is MQ 7 gas sensor.

MQ 6 GAS SENSOR: It is an ideal sensor to detect the presence of a dangerous LPG leak in our home or in a service station, storage tank environment and even in vehicles which use LPG gas as its fuel. This unit can be easily incorporated into an alarm circuit/unit, to sound an alarm or provide a visual indication of the LPG concentration. The sensor has excellent sensitivity combined with a quick response time. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising.

Fig 3.2: MQ 6 Gas Sensor

A simple electronic circuit is used to convert change of conductivity to its corresponding output signal of gas concentration. MQ-6S gas sensor shown in figure 3.2 is used to sense poisonous gas and has high sensitivity to LPG, and also response to Natural gas. It is a portable gas detector which has a long life at low cost. The specification of the LPG gas sensor is shown in table 3 shown below.

Model No.	MQ-6
Sensor Type	Semiconductor
Standard	Bakelite (Black Bakelite)
Detection Gas	Isobutene, Butane ,LPG
Concentration	300-1000ppm (Butane, Propane, LPG)

Table 3: Specification of MQ 6 sensor

4. Piezo-electric Buzzer: Big word – piezein is Greek for "squeeze" Some crystals, when squeezed, make a spark, turns out the process goes the other way too Spark a quartz crystal, and it flexes. Piezo buzzers use this to make sound (flex something back and forth, it moves air) Piezo buzzers don't have quartz.
crystals, but instead a kind of ceramic that also exhibits piezoelectric properties. Piezo Buzzers have two wires, red & black. Polarity matters: black is connected to ground and apply an oscillating voltage to make a noise. The buzzer case supports the piezo element and has resonant cavity for sound Oscillating voltage alternately squeezes and releases the piezo element.

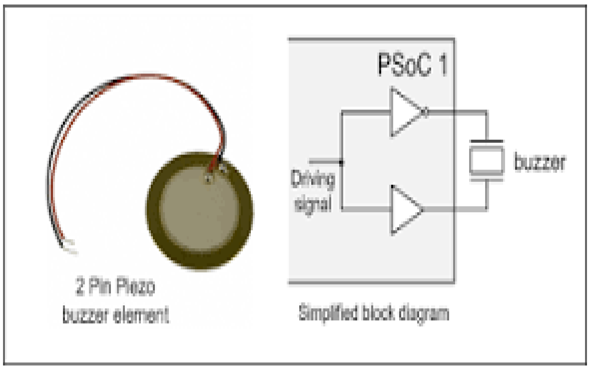

Fig 3.3: Piezo-electric buzzer

5. Analogue to Digital converter: An analog-to-digital converter (ADC, A/D, A–D, or A-to-D) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude. The conversion involves quantization of the input, so it necessarily introduces a small amount of error. Furthermore, instead of continuously performing the conversion, an ADC does the conversion periodically, sampling the input. The result is a sequence of digital values that have been converted from a continuous-time and continuous-amplitude analog signal to a discrete-time and discrete-amplitude digital signal.

An ADC is defined by its bandwidth (the range of frequencies it can measure) and its signal to noise ratio (how accurately it can measure a signal relative to the noise it introduces). The actual bandwidth of an ADC is characterized primarily by its sampling rate and to a lesser extent by how it handles errors such as aliasing. The dynamic range of an ADC is influenced by many factors, including the resolution (the number of output levels it can quantize a signal to), linearity and accuracy (how well the quantization levels match the true analog signal) and jitter (small timing errors that introduce additional noise). The dynamic range of an ADC is often summarized in terms of its effective number of bits (ENOB), the number of bits of each measure it returns that are on average not noise. An ideal ADC has an ENOB equal to its resolution. ADCs are chosen to match the bandwidth and require signal to noise ratio of the signal to be quantized. If an ADC operates at a sampling rate greater than twice the bandwidth of the signal, then perfect reconstruction is possible given an ideal ADC and neglecting quantization error. The presence of quantization error limits the dynamic range of even an ideal ADC, however, if the dynamic range of the ADC exceeds that of the input signal, its effects may be neglected resulting in an essentially perfect digital representation of the signal.

6. 16MHZ Crystal Oscillator: A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. This frequency is commonly used to keep track of time, as in quartz wristwatches, to provide a stable clock signal for digital integrated, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits. Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. More than two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cellphones. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes

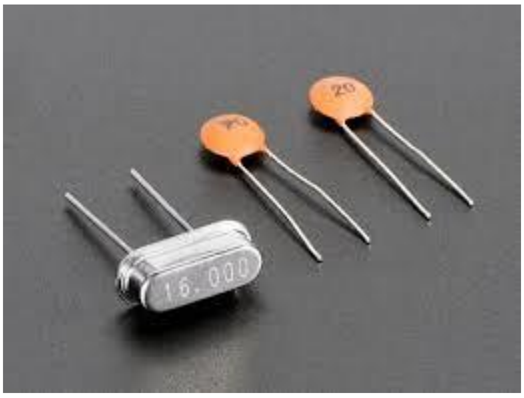

Fig 3.4: 16MHZ Crystal Oscillator

7. LED: A light-emitting diode (LED) is a two-lead semiconductor light. It is a junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm^2) and integrated optical components may be used to shape its radiation pattern.

It appeared as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared light. Infrared LEDs are still frequently used as transmitting elements in remote-control circuits, such as those in remote controls for a wide variety of consumer electronics. The first visible-light LEDs were also of low intensity, and limited to red. Modern LEDs are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness.

Fig 3.5: LED

8. 10k Resistor: A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors may be used to reduce current flow, and, at the same time, may act to lower voltage levels within circuits. In electronic circuits, resistors are used to limit current flow, to adjust signal levels, bias active elements, and terminate transmission lines among other uses. High-power resistors, that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to

adjust circuit elements (such as volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Fig 3.6: 10k Resistor

9. 10Microfarad Capacitor: A capacitor (originally known as a condenser) is a passive terminal electrical used to store electrical energy temporarily in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, air, vacuum, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge $+Q$ to collect on one plate and negative charge $-Q$ to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value, its capacitance. Capacitance is defined as the ratio of the electric charge *Q* on each conductor to the potential difference *V* between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{3} F).

Fig 3.7: 10 Microfarad Capacitor

10. D468 Transistor: A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits.

The transistor is the fundamental building block of modern electronic devices, and is ubiquitous in modern electronic systems. First conceived by Julius Lilienfeld in 1926 and practically implemented in 1947 by American physicists, John Bardeen, Walter Brattain, and William Shockley, the transistor revolutionized the field of electronics, and paved the way for smaller and cheaper radios, calculators, and computers, among other things. The transistor is on the list of IEEE milestones in electronics and Bardeen, Brattain, and Shockley shared the 1956 Nobel Prize in Physics for their achievement.

Fig 3.8: D468 Transistor

3.2 Methods Used

The methods used to achieve this work are of two parts:

A. Hardware Design

B. Software Design

A. Hardware Design: The hardware design consists of Microcontroller AT mega 328, MQ 7 gas sensor, Analogue to Digital converter, Pizo-electric buzzer, Analogue to digital converter, 16MHZ Crystal oscillator, LED’s, 10k Resistors, 10microfarad Capacitors, D468 Transistor. All these hardware’s are interfaced with each other. A coding in embedded C is developed, also using RTOS (real time operating system) to manage the entire task and to provide a result in real time.

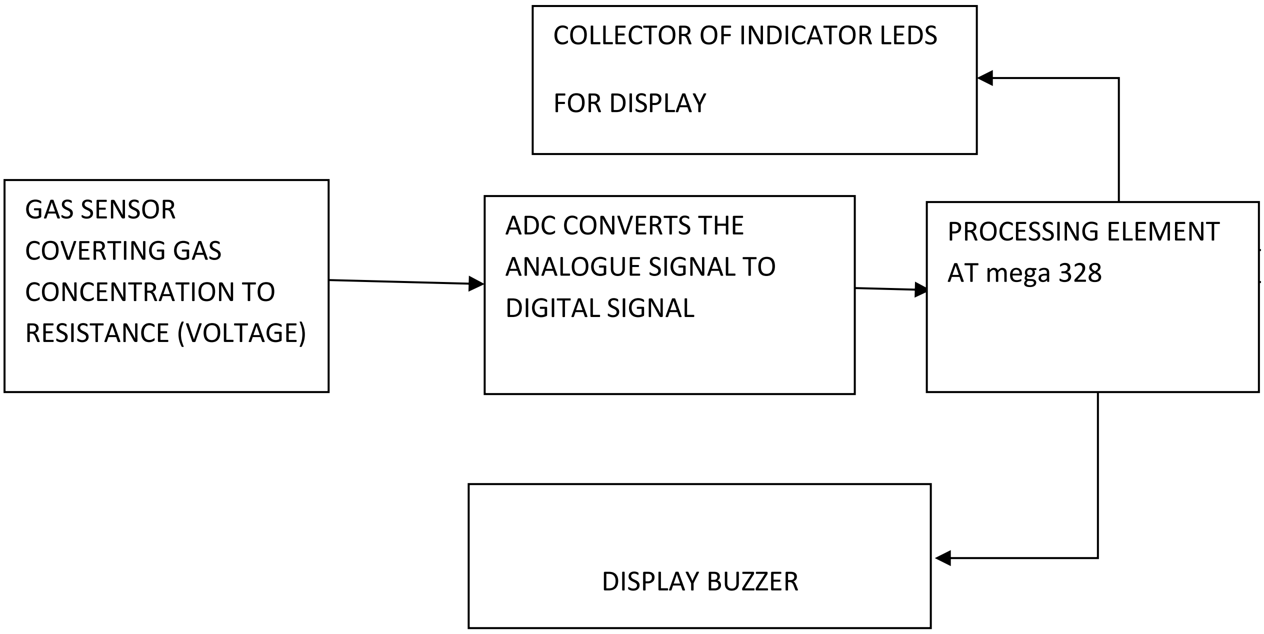

Fig 3.9: BLOCK DIAGRAM OF THE HARDWARD DESIGN

B. Software Design:

Application development on desktop computers is called native development as development and execution are done on the same hardware platform. Embedded software cannot be developed directly on the embedded system. Embedded software development is done in two stages. Initially, the software is developed on a desktop computer or a workstation. This is called the host system. Subsequently, the software is transferred to the actual embedded hardware called the target system. The host and the target system can be connected through a serial interface such as RS232 or through Ethernet. The processors of the host and the target system are generally different. Hence, this development is known as cross-platform
development. The embedded software can be transferred to the target system by programming an EEPROM or Flash memory using a programmer or downloading through a communication interface or JTAG port. There are several different ways of writing code for embedded systems depending on the complexity of the system and the amount of time and the money that can be spent. Many ready-built designs provide libraries and additional software support which dramatically cut the development time. Fig 3.10 shows the software cross-platform development.

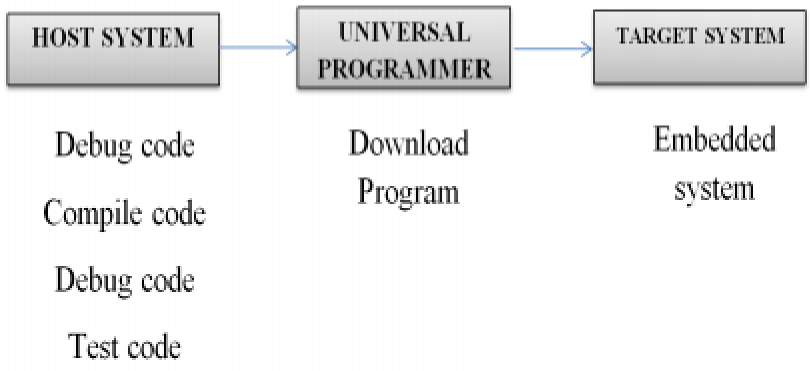

Fig 3.10: Software Developments

I. PROGRAMMING THE AT mega

Step 1: Click the Start Menu and select the MPLAB IDE from the program Menu and a window will be opened.

Step 2: Click Project new project (a window will be opened)

Step 3: Enter the PROJECT NAME, PROJECT DIRECTORY where the program to be stored in the corresponding fields and clicks ok.

Step 4: Click Configure Select device (a window will be opened)

Step 5: Select the device name as AT mega and click ok

Step 6: Click project set language tool locations

Step 7: Expend CCS C compiler for ATmega328 in line displayed window. Further expand the executable and select the CCS C compiler (CCSC.exe) and click ok.

Step 8: Click Project set language suits

Step 9: Select CCS C compiler for PIC12/14/16/18 in the active tool suite and click ok

Step 10: Click file new file. Now type the corresponding program and save it as <filename.c> in the corresponding location where the project name is denoted.

Step 11: Click project add file to the project (Select the saved file and click open)

Step 12: Click project build option project (a window will be opened)

Step 13: Select CCS C compiler in the window, click none in the debug option, tick the use alternate settings and enter +p in the space provided and click ok.
Step 14: Click Project build all the CCS compiler will denote the result if any errors indicated, go to step 10 else continue.
Step 15: Click Start menu and select the AT mega ISP from the program menu and a window will be opened.

II. **Cross Compilation**: A compiler is mainly to translate programs written in some human readable language into an equivalent set of opcodes for a particular processor. Each processor has its own unique machine language, and then we need to choose a compiler that is capable of producing programs for the specific target processor. In the embedded system, this compiler almost always runs on the host
computer. It simply does not make sense to execute the compiler on the embedded system itself. A compiler that runs on one computer platform and produces code for another is called as cross compiler. The use of a cross compiler is one of the defining features of embedded software development, and these tools support an impressive set of host-target combinations. Toll chain for building the embedded software is shown in fig 3.11.

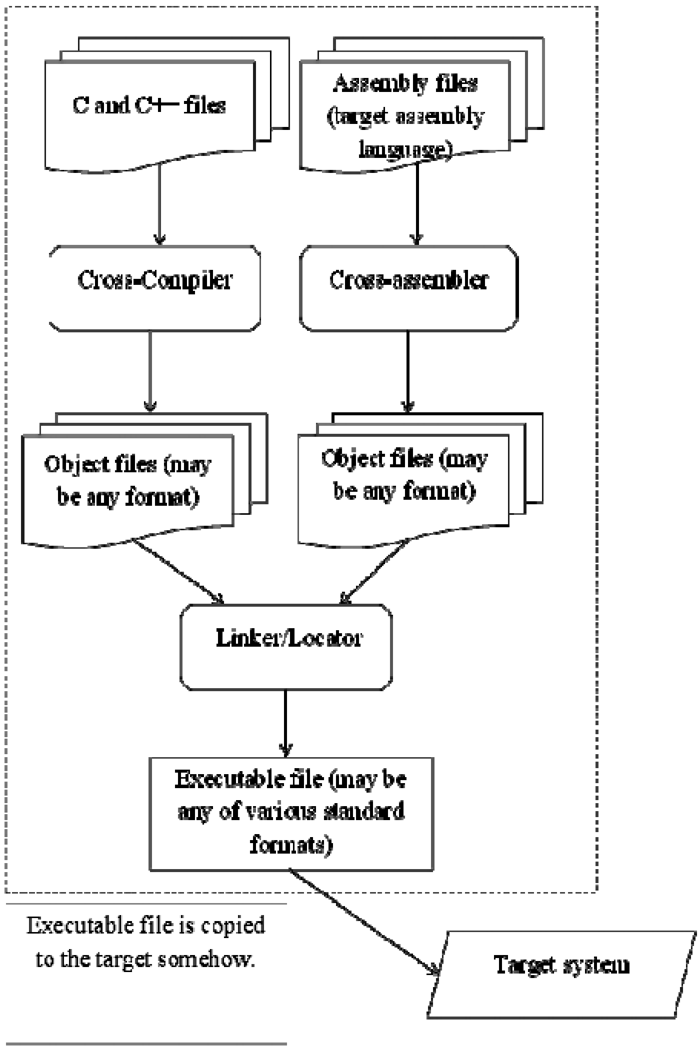

Fig 3.11: Tool chain for Building Embedded Software

III. Embedded C

One of the few constants across all these systems is the use of the C programming language. More than any other, C has become the language of embedded programmers. The C language has become so popular, because successful development is so frequently about selecting the best language for a given project; it is the one language that has proven appropriate for both 8-bit and 64-bit processors. In addition, C has the benefit of processor independence, which allows programmers to concentrate on algorithms and applications, rather than on the details of a particular architecture. C gives embedded programmers an extraordinary degree of direct hardware control without sacrificing the benefits of high-level languages. Embedded C is a set of language extensions for the C programming language by the C standards committee. It introduces a number of features not available in normal C and basic I/O hardware addressing. It is having the declaration of microcontroller registers and special function as header files; we can include these files to make easy implementation. Embedded C has the same flow and programming methodology as C. It has an unlimited number of source files, mixed C and assembler programming. Its Compatibility integrates into the MPLAB IDE, MPLAB ICD and most third-party development tools and runs on multiple platforms: Windows, Linux, UNIX, Mac OS X, Solaris EX: - Kiel C.

CODE:

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(6, 7, 8, 9, 10, 11);
float gasPin = A0;
float gasLevel;
int ledPin = 2;
int buttonPin = 3;
int buzzPin = 4;
int buttonState;
int fan = 5;
void setup(){
 pinMode(ledPin, OUTPUT);
 pinMode(buttonPin, INPUT);
 pinMode(gasPin,INPUT);
 pinMode(fan,OUTPUT);
 Serial.begin(9600);
```

```
 lcd.begin(16, 2);
 lcd.setCursor(0,0);
 lcd.print(" Welcome");
 lcd.setCursor(0,2);
 lcd.print("GAS LEAKAGE SYSTEM");
 delay(500);
 lcd.clear();
}
void loop(){
 // Read the value from gas sensor and button
 gasLevel = analogRead(gasPin);
 buttonState = digitalRead(buttonPin);
 // call the function for gas detection and button work
 gasDetected(gasLevel);
 buzzer(gasLevel);
 exhaustFanOn(buttonState);
}
// Gas Leakage Detection & Automatic Alarm and Fan ON
void gasDetected(float gasLevel){
 if(gasLevel >= 300){
 digitalWrite(buzzPin,HIGH);
 digitalWrite(ledPin,HIGH);
 digitalWrite(fan,HIGH);
 lcd.setCursor(0,0);
 lcd.print("GAS:");
 lcd.print(gasLevel);
 lcd.setCursor(0,2);
 lcd.print("FAN ON");
 delay(1000);
```

```
 lcd.clear();
 }else{
 digitalWrite(ledPin,LOW);
 digitalWrite(buzzPin,LOW);
 digitalWrite(fan,LOW);
 lcd.setCursor(0,0);
 lcd.print("GAS:");
 lcd.print(gasLevel);
 lcd.setCursor(0,2);
 lcd.print("FAN OFF");
 delay(1000);
 lcd.clear();
 }
}
//BUZZER
void buzzer(float gasLevel){
if(gasLevel>=300)
 {
 for(int i=0; i<=30; i=i+10)
 {
 tone(4,i);
 delay(400);
 noTone(4);
 delay(400);
 }
 }
}
// Manually Exhaust FAN ON
void exhaustFanOn(int buttonState){
```

```
 if(buttonState == HIGH){
 digitalWrite(fan,HIGH);
 lcd.setCursor(0,0);
 lcd.print("Button State:");
 lcd.print(buttonState);
 lcd.setCursor(0,2);
 lcd.print("FAN ON");
 delay(10000);
 lcd.clear();
 }
}
```

TINKERCAD LINK:

https://www.tinkercad.com/things/fGvVek7Ol3p-ibm-final-project/editel?sharecode=iGapHQfMmO_xV402duIgs56cyEezHI88xpORIGxviqc

LINK:-

https://drive.google.com/file/d/1iQ351A_5vi5RaYbCFBmZhbWGPaFNdfRO/view?usp=drivesdk

IV. IMPLIMENTATION

Gases like LPG and combustible gas are sensed by the MQ-7 sensors and are monitored by the ATmega328 microcontroller and the level of the gas determines the LED level indicator. In critical situations, which is when the LPG exceeds from normal level above 1000ppm then an alarm is generated which helps in faster diffusion of the critical situation.

CHAPTER 4

RESULTS AND DISCUSION

4.1 Test

Testing was carried out by releasing LPG into the atmosphere around the sensor. Fig 4.1 shows the gas detector and response unit with gas lighter used for the test and test setup respectively.

4.2 RESULTS

The results of test carried out on the device at different time and day for concentration of gas in the air around the sensor is shown in Table 4.1. The last four values are the case of an endless loop due to high gas concentration and were carried out on 17/05/2016.

The device was tested placing the LPG device at different distances from the gas source.

Set Point voltage	Sensed Voltage	Gas Leakage Detected?	Time
111	97	No	4.19p.m
111	111	Yes	4.20p.m
110	78	No	11.41.29a.m
110	78	No	11.41.35a.m
110	78	No	5.53p.m
110	78	No	5.53.37p.m
110	79	No	5.54.03p.m
110	90	No	5.54.48 p.m
110	84	No	5.55.02 p.m
111	82	No	5.55.59 p.m
110	81	No	5.56.18 p.m
110	81	No	5.56.26 p.m

Table 4: Test Results

4.2 DISCUSSION

It was observed that when the LPG device was tested by placing it at different distances from the gas source, the response time of the LPG system decreased as the distance from the gas source increased and vice versa. Also, it was

observed that the sensitivity of the gas sensor was very high in clean air. The gas sensor' sensitivity varied with temperature/Humidity while the reference voltage
remained constant over time with error of +1v. At constant gas concentration, the sensed voltage will always be constant. The gas sensor has a very fast response to gas since the time difference between test results with same concentration is very small while the difference between the sensed voltages is very high.

4.1 Circuit Diagram

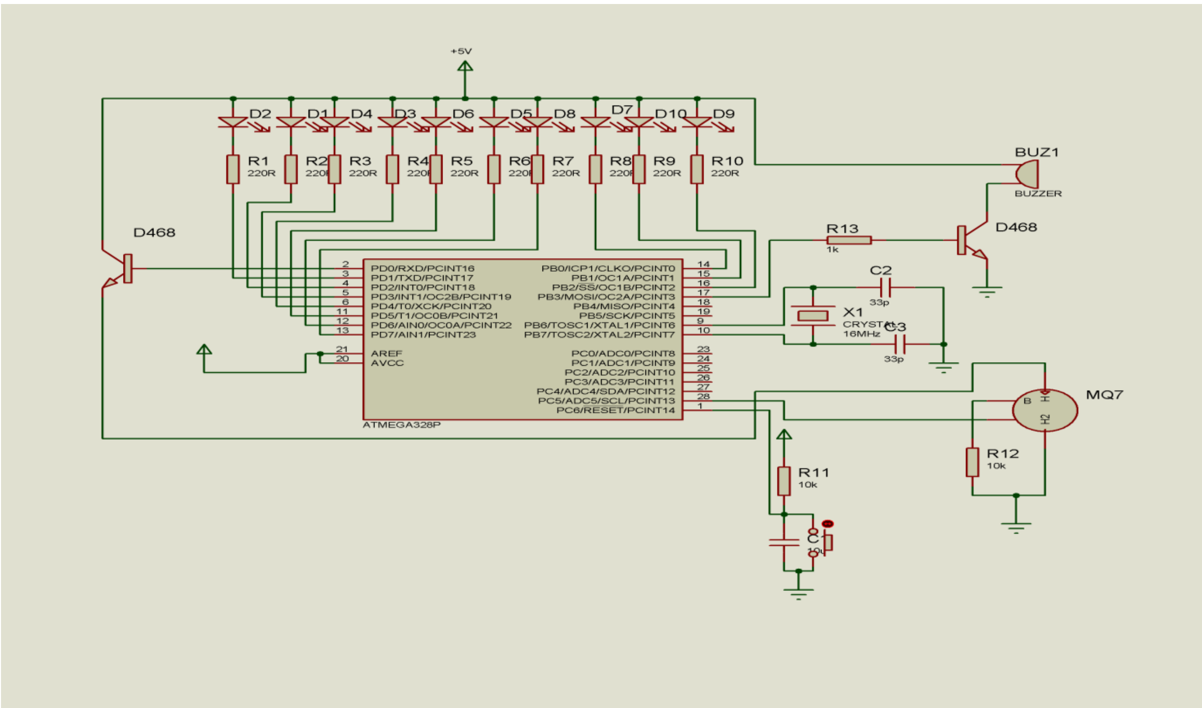

Fig 4.1: Circuit Diagram

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A cost-effective gas leakage detection system was proposed, designed and successfully implemented as a laboratory prototype, which was presented in this project. The practical testing of the system was done using butane based lighter, which forms an ingredient of LPG. The test results confirm the efficient operation of the prototype by detecting low and high gas leakage levels and alerts the users by issuing appropriate audio-visual warning signals. The proposed system is designed to meet Nigeria occupational health and safety standards with respect to gas leakage detection in residential and commercial premises. The cost involved in developing the system is significantly low and is much less than the cost of gas detectors commercially available in the market.

5.2 Recommendation

I recommend that this system is implemented for detecting various gases in domestic areas such as places of educational institutions, residential and industrial areas which avoids endangering human lives. This system provides quick response rates, and the diffusion of the critical situation can be made faster than the manual methods.

REFERENCES

Fraiwan, L.; Lweesy, K.; Bani-Salma, A.; Mani, N, “A wireless home safety gas leakage detection system”, Proc. of 1st Middle East Conference on Biomedical Engineering, pp. 11-14, 2011.

National Institute of Health. (2004). What you need to know about natural gas detectors. Available: http://www.nidcd.nih.gov/health/smelltaste/gasdtctr.asp. Last accessed 12th March 2011.

Johansson, A.; Birk, W.; Medvedev, A., “Model-based gas leakage detection and isolation in a pressurized system via Laguerre spectrum analysis”, Proc. of IEEE International Conference on Control Applications, pp. 212-216, 1998.

Lopes dos Santos, P.; Azevedo-Perdicoúlis, T.- P.; Ramos, J.A.; Jank, G.; Martins de Carvalho, J.L.; Milhinhos, J., “Gas pipelines LPV modelling and identification for leakage detection”, Proc. of American Control Conference, pp. 1211-1216, 2010.

Lopes dos Santos, P.; Azevedo-Perdicoúlis, T.-P.; Ramos, J.A.; Martins de Carvalho, J.L.; Jank, G.; Milhinhos, J., “An LPV modelling and identification approach to leakage detection in high pressure natural gas transportation networks”, IEEE Transactions on Control Systems Technology, vol. 19, no. 1, pp. 77-92, 2011.

Z. Zeng; L. Xuan; Y. Sun; L. Udpa; S. Udpa, “Probability of detection model for gas transmission pipeline inspection”, Research in Nondestructive Evaluation, vol. 15, no. 3, pp. 99-110, 2004.

ZhiweiZeng; LalitaUdpa; SatishUdpa, “Robust design of a natural gas transmission pipeline inspection tool using the Taguchi method”, Research in Nondestructive Evaluation, vol. 17, no. 1, pp. 17-28, 2006.

Ding Chengjun; Liu Ximao; Duan Ping, “Development on gas leak detection and location system based on wireless sensor networks”, Proc. of 3rd International Conf. on Measuring Technology and Mechatronics Automation, pp. 1067-1070, 2011.

Nasaruddin, N.M.B.; Elamvazuthi, I.; Hanif, N.H.H.B.M, “Overcoming gas detector fault alarm due to moisture”, Proc. of IEEE Student Conference on Research and Development, pp. 426-429, 2009.

Nakano, S.; Goto, Y.; Yokosawa, K.; Tsukada, K, “Hydrogen gas detection system prototype with wireless sensor networks”, Proc. of IEEE Conference on Sensors, pp. 1-4, 2005.

Shibata, A.; Konishi, M.; Abe, Y.; Hasegawa, R.; Watanabe, M.; Kamijo, H, “Neuro based classification of gas leakage sounds in pipeline”.

Ashish S., Ratnesh P., Rajeev K. and Rahul V. “GSM Based Gas Leakage Detection System”. International Journal of Technical Research and Applications eISSN: 2320-8163, Volume 1, Issue 2, PP. 42- 45(2013). Accessible at www.ijtra.com

Massachusetts Department of Fire Services “Liquefied Petroleum Gas (LPG)

Awareness.pdf", Massachusetts Department of Fire Services, Massachusetts Firefighting Academy, PP. 1-35.

Padmapriya K, Surekha M. Preethi R. "Automatic Refill Booking Using Embedded System". International Journal of Key Scientific Research for Industrial Engineering & Technology.Vol.1, Issue 1. PP. 01-05(2014)

Shinde S.,Patil S.B, Patil A.J." Development of Movable Gas Tanker Leakage Detection Using Wireless Sensor Network Based on Embedded System". International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 6, pp.1180-1183(2012). Accessible at www.ijera.com.

Soundarya T., Anchita Alagammai J.V., Deepa P. G., Sheela K. S. "Efficient Energy (LPG) Gas Leakage Detection and Prevention System for Home Safety". Artificial intelligence systems and machine learning. Vol 6, No 1. (2014) Accessible at http://ciitresearch.org

Theraja B.L. and TherajaA.K.. "A textbook of Electrical Technology". S. Chand& Co. Ltd, 23rd Edition, pp 1029-1118(2002).

Vipin J. V., Paul A., Nisha S. & Kevin J. "Experimental Investigation To Control Alcoholic Driving". International Journal of Research in Engineering & Technology. Impact Journals. ISSN (E): 2321-8843; ISSN (P): 2347-4599. Vol. 2, Issue 4, Pp. 123-128 (2014)

ZhijieT., Wang S., Luojun A "Remote Alarm Monitor System Based on GSM and ARM". Advances in Control Engineering and Information Science. Elsevier Ltd. Procedia Engineering 15, PP. 65 -69(2011). Available online at www.sciencedirect.com.