FEDERAL UNIVERSITY OYE EKITI (FUOYE)

FACULTY OF ENGINEERING
DEPARTMENT OF COMPUTER ENGINEERING

A PROJECT REPORT TITLED

MICROCONTROLLER GSM BASED LPG (LIQUFIED PETROLEUM GAS) LEAKAGE, MONITORING, DETECTION AND CONTROL SYSTEM

BY
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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING IN COMPUTER ENGINEERING

PROJECT SUPERVISOR

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CERTIFICATION

This project with the title

MICROCONTROLLER GSM BASED LPG (LIQUFIED PETROLEUM GAS) LEAKAGE, MONITORING, DETECTION AND CONTROL SYSTEM

Submitted by

OKUNLOLA SAHEED OPEYEMI

Has satisfied the regulations governing the award of degree of

BACHELOR OF ENGINEERING (B. Eng)

FEDERAL UNIVERSITY OYE-EKITI, NIGERIA.

.... 29/3/19..................

DR M.O. OLANIYAN **Date**

Signature of Supervisor

.... 29/3/19..................

DR M.O. OLANIYAN **Date**

Signature of (HOD) Head of Department

DECLARATION

I hereby declare that the project work titled "MICROCONTROLLER GSM BASED LPG MONITORING,DETECTION AND CONTROL SYSTEM" submitted to the department of Computer Engineering Federal University Oye Ekiti is a work done by me under the supervision of DR. Olaniyan O.M ,a senior lecturer in the department of computer Engineering Federal University Oye-Ekiti and DR Falohun,this project work is in partial fulfilment of the requirements for the award of Bachelor of Engineering in Computer Engineering .The result embodied in this thesis has not been submitted to any other institute or University for the award of any degree or diploma.

SIGNATURE OF STUDENT
(OKUNLOLA SAHEED OPEYEMI)

ABSTRACT

Liquefied Petroleum Gas (LPG) leakage poses great danger in this era where its use has become an important source of energy for industries, homes and vehicles alike. A means of avoiding dangers associated with LPG leakage is to install LPG leakage detectors at susceptible areas.

The objective of this proposed project therefore is to design and implement a microcontroller based LPG leakage monitoring, detection and control system. The system will be able to detect LPG leakage using MQ-5 gas sensor and alerts the user of the leakage through GSM-based SMS and a buzzer. Most importantly, the will be able system shuts off LPG supply to minimise wastage and prevent accidents.

This will be achieved using datasheets in selecting suitable components for the circuit design and using Proteus in simulating the proposed design in order to validate the feasibility of the design. At the end of this proposed project ;when LPG concentration in the air exceeds the set threshold, the system will immediately alerts the user by sending SMS to two specified mobile number programmed with the sim900 A6 GSM (Global system for mobile communication) module and activate the alarm buzzer simultaneously, displaying the information on an 16x2 LCD. A signal will also be sent to the solenoid valve to shut off LPG supply. This design will provide adequate safety and prevent gas wastage and accidents associated with LPG leakage, by providing notification of gas leakage and shutting off the gas supply.

DEDICATION

I dedicate this project to the Almighty God; my strong pillar, my source of inspiration he has been the source of my strength throughout the years of this program and on him I have relied. I also dedicate this work to my parents (Mr and Mrs Okunlola) for their unending support and words of encouragement during my stay in the university .To the entire staff of Computer Engineering, I can not thank you enough for your support and advice. Thank you; God bless you all.

ACKNOWLEDGEMENT

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TABLE OF CONTENTS

Contents **Page**

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 Preamble

Liquefied petroleum gas (LPG) is a commonly gas use in the world wide in different applications of home and industrial locations that because it is characterized by cheapness and availability. LPG is a simple asphyxiant gas (propane and butane) and flammable, LPG is heavier than air it stays in low levels and spread in the same level in case it leak in ground floor. For safety requirements, continuous monitoring to the gas leakage is an important measures and solutions in home or industrial locations. Many studies are focused on this side of health and safety requirements; in this project of "GSM BASED LPG LEAKAGE DETECTION, MONITORING AND CONTROL SYSTEM "Accuracy, simplicity, and safety" are the main characteristics of these systems. On the other hand, the different aims work of this design is introduced based on discrete components for sensing, monitoring, and controlling actions.

This project is an integrated system for continuous monitoring, buzzer alarming, gas valve shutting down, and GSM modem for wireless communication alerting to the security. The system is starting by stage of deployed gas sensors for gas leakage sensing and informing a certain microcontroller unit and an alarm system via continuous data monitoring of gas detectors. The type of sensor used is the MQ5 used for coal gas, natural gas and Liquefied Petroleum Gas (LPG) detection respectively. The monitoring system includes ATmega32 8-Bit AVR microcontroller unit, LEDs, buzzer,16X2 LCD module and SIM900 A6 GSM module.

LPG is the acronym for liquid petroleum gas. It is a mixture of aliphatic hydrocarbon gases such as propane and butane with smaller amount of ethane, propylene, butanes, and pentane. Mercaptan is a foul-smelling odorant added to LPG for odour detection as the LPG is an odourless gas. The physical and chemical properties of its components made it very dangerous especially with any failure and/ or negligence of safety requirements, it can create potential health hazard in case of leakage since it is heavier than air, so it move away from its source with the air movement but settles and accumulate along ground.

exposure to LPG can result in serious organ system dysfunction, irritation in the eyes and the respiratory tract tissues, drowsiness, hallucination and feeling of euphoria, inhalation high concentration of LPG inhibit central nervous system as it has narcotic effect ,unconsciousness , somnolence, light-headedness, cyanosis, cardiopulmonary arrest, and sudden death is the most feared complications Nevertheless LPG has no toxicologically important effect but, by consuming the atmospheric oxygen, carbon monoxide will produce which is toxic. It is highly flammable gas possibly can ignite this gas even when light is switched if any undetectable leakage from cylinder occur which result in dangerous burning which ends with death.

1.2 Problem Definition

Gas leakage poses great danger in this modern era where the use of gas has become an important source of energy for industries, homes and vehicles alike. The leakage of Liquefied Petroleum Gas (LPG) is known to cause serious accidents which have resulted in loss of lives and properties worth billions of dollars across the globe. LPG is one of the most commonly used fuels in Nigeria and as such precautions have to be taken in order to safe guard against accidents such as explosions and suffocation that are associated with its usage.

LPG is made up of mixtures of propane and butane which are inflammable chemicals. Due to the odourless nature of these chemicals, Ethyl Mercaptan is added as odorant in order to make the gas detectable by smell. However, some people have poor sense of smell especially at low concentrations and so a more effective and reliable means of detecting the gas has to be adopted in homes or industries that rely on the use of LPG. One of the preventive methods of stopping accident associated with LPG leakage is to install a Microcontroller GSM based gas leakage detection, monitoring and control device.

Even though there have been great strides in developing effective LPG leakages monitoring, detection and control systems over the past years, there are still improvements that can be made to previous designs. Most systems developed focus on the detection of the leakage and sounding of an alarm in response to the detection. Other systems detect the gas and use a microcontroller to activate an alarm and also send SMS to the appropriate personnel. A much more improved version has a power fan installed for circulating the gas. These designs even though prudent do not solve the leakage problem.

The primary aim of this project is to produce a system which is capable of detecting lpg leakage and alerting the user through GSM module SMS, LCD (liquid crystal display), a piezo electric buzzer and a solenoid valve to shut off the gas to control the gas leakage . This device would also send an SMS through a GSM module to the appropriate authority for investigations to be carried out on the leakage. The system consists of a sensor (MQ-5) that is highly sensitive to propane (C_3H_8) and butane (C_4H_{10}), an alarm, a microcontroller, a GSM module and a gas solenoid valve. This system does not only detect LPG leakage but shuts down supply to minimise wastage, accidents and cut down cost associated with the leakage.

Furthermore, the device is able to detect other gases which have traces of butane and propane.

1.3 Aim & Objectives

The aim of this project is to design and implement a microcontroller GSM based LPG monitoring, detection and control system.

The objectives of this project are:

- To design a microcontroller GSM based LPG detection, monitoring and control system.
- To implement the design of a microcontroller GSM based LPG monitoring and control system using a hardware prototype.
- To evaluate the developed system.

1.4 Scope of Work

This work is limited to the design of an efficient system for monitoring and detecting LPG leakage in a susceptible area (Home), alerting the user and shutting down the gas supply using a microcontroller based detection system.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Liquefied Petroleum Gas commonly known as LPG consists of a mixture of Commercial Propane and Commercial Butane having saturated as well as unsaturated hydrocarbons. It is an odourless gas due to which Ethyl Mercaptan is added as powerful odorant so that leakage can easily be detected. LPG is commonly used in homes for heating and cooking. This energy source is primarily composed of propane and butane which are highly flammable chemical compounds.

LPG was first produced in 1910 by Walter Snelling (Didpaye, 2015) and is classified as a hazardous material because of its flammable properties and explosive potential when stored under pressure. Before the development of electronic household gas detectors in the 1980s and 90s, gas presence was detected with a chemically infused paper that changed its colour when exposed to the gas (Didpaye, 2015). Since then, many technologies and devices have been developed to detect, monitor, and alert the leakage of a wide array of gases. Hence the requirement of an efficient system to detect leakage of LPG is inevitable, which may be used for domestic and commercial purposes.

2.2 Classification of Leak Detection Technologies

There are various classifications available for leakage detection. Several criteria are considered for classification, some of which are, the amount of human intervention needed, the physical quantity measured and the technical nature of the methods (Murvaya, 2011). If the degree of intervention needed from a human, by each detection method is used for classification, three categories are used to distinguish between them (Murvaya, 2011):

- Automated detection – complete monitoring systems that, can report the detection of a gas leak without the need of a human operator, once they are installed (e.g. fibre optic or cable sensors);
- Semi-automated detection – solutions that need a certain amount of input or help in performing some tasks (e.g. statistical or digital signal processing methods); and

- Manual detection – systems and devices that can only be directly operated by a person (e.g. thermal imagers or Light Detection and Ranging (LIDAR) devices).

Most detection techniques rely on the measurement of a certain physical quantity or the manifestation of certain physical phenomenon. This can be used as a rule for classification as there are several commonly used physical parameters and phenomena namely; acoustics, flow rate, pressure, gas sampling, optics and sometimes a mix of these. Because of the great variety of these detection solutions, leak finding technologies are sometimes classified into optical and non-optical methods (Batzias *et al.*, 2011).

Some authors see the technology as fitting into two great categories direct methods and indirect or inferential methods (Folga, 2007 and Liu *et al.*, 2008). The direct detection is made by patrolling along the pipelines using either visual inspection or handheld devices for measuring gas emanations. Thanks to technological advancements it is now common to use helicopter or airplane-mounted optical imaging devices especially for very long pipelines (Liu *et al.*, 2008). Indirect or inferential methods detect leaks by measuring the change of certain pipe parameters such as flow rate and pressure.

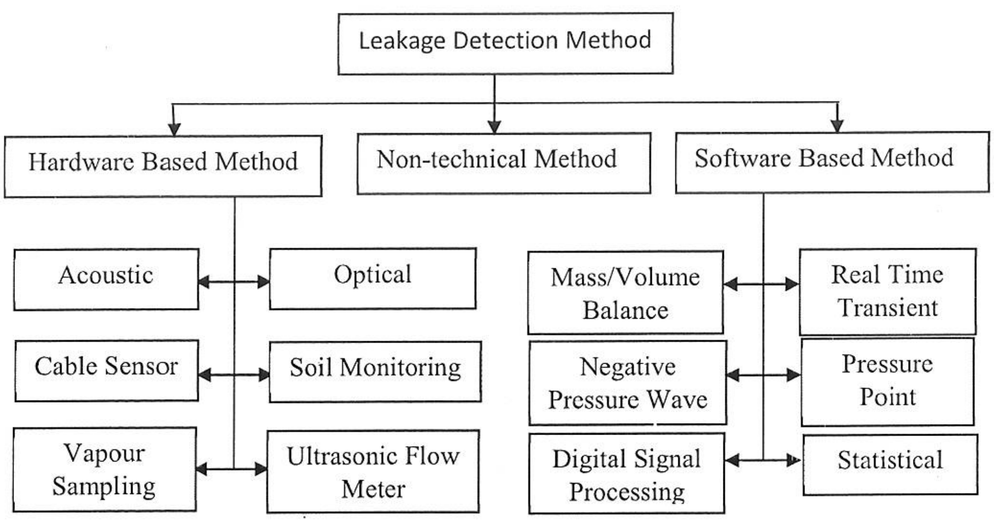


Fig. 2.1 Classification of Gas Leak Detection Techniques Based on Technical Nature (Source: Murvaya, 2011).

The most common way of classifying leak detection methods is based on their technical nature (Scottand, 2003). Thus, two main categories can be distinguish; hardware based methods and software based methods. These two categories are sometimes mentioned as externally or internally based leak detection systems. Fig. 2.1 above illustrates these main categories and the different methods associated with each of them. This classification is similar to the one presented in the previous paragraph with the remark that indirect or inferential methods overlap with the software based methods while the direct methods cover both hardware methods and non-technical methods.

Non-technical leak detection methods are the ones that do not make use of any device and rely only on the natural senses (i.e. hearing, smelling and seeing) of humans and/or animals.

Hardware based methods rely mainly on the usage of special sensing devices in the detection of gas leaks. Depending on the type of sensors and equipment used for detection, these hardware methods can be further classified as: acoustic, optical, cable sensor, soil monitoring, ultrasonic flow meters and vapour sampling.

Software based methods, as the name states, have software programs at their core. The implemented algorithms continuously monitor the state of pressure, temperature, flow rate or other pipeline parameters and can infer, based on the evolution of these quantities, if a leak has occurred. The software methods can use different approaches to detect leaks: mass/volume balance, real time transient modelling, and acoustic/negative pressure wave, pressure point analysis, statistics or digital signal processing.

2.2.1 **Non-Technical Method**

These methods involve personnel patrolling along the pipelines looking for visual effects of a gas leak, smelling substances that might be released through a leak or listening to specific sounds that can be made by gas as it leaks out. Sometimes trained dogs are used as they are more sensitive to the smell of certain gases (Kennedy, 2005). The sensitivity of dogs, depending on the target compound, has been found to be in the 10 parts-per-billion (ppb) – 500 parts-per-trillion (ppt.) range, in laboratory conditions (Johnston, 1999). However, using canines to detect leaks has the disadvantage that they cannot be effective for periods longer than 30 to 120 minutes of continuous searching (Garner *et al.*, 2001). Additionally, the accuracy of this approach can be affected by fatigue and the interpretation given by the handler to the canine response. These on-site inspections are required in some countries such as the USA as a regulation for hazardous substance pipelines operators (Anon., 2007).

Soap bubble screening, which is a low-cost method for locating smaller leaks (Liu *et al.*, 2008), can also be included in this category. It involves spraying a soap solution on different components of the pipeline or on suspicious surfaces on the pipe. Usually soap screening is mainly applied to valves and piping joints as these are gas leak prone places. This method is rapid and has a small cost, thus it would be helpful as a part of the routine inspection procedures.

The use of this type of method has the advantage that it requires no special equipment and that they result in the immediate localization of the leak upon detection. Unfortunately there are also some downsides for using it. For instance the detection time depends on the frequency of these inspections which is usually reduced (e.g. the USA regulation states that these inspections should be done at least once every three weeks). The detection of a leak greatly depends on the experience and meticulousness of the employed personnel. Another disadvantage is that this method can only be applied to pipelines that are accessible to personnel ruling out its application in the case of buried pipes (Murvaya, 2011).

2.2.2 **Hardware Based Methods**

Acoustic methods

Escaping gas generates an acoustic signal as it flows through a breach in the pipe. Thus, this signal could be used to determine that a leak has occurred. To record the internal pipeline noise, acoustic sensors have to be used. They can be integrated in handheld detection devices employed by personnel patrolling the pipeline or in intelligent pigs that travel through the pipeline inspecting it (Furness and van Reet, 2009). Continuous monitoring is also done by installing acoustic sensors outside the pipeline at certain distance from one another. The distance between two acoustical sensors has to be adapted based on the sensitivity of the acoustic sensor and allocated budget. Placing sensors too far from each other will increase the risk of undetected leaks while installing them too close will lead to an increased system cost. Several types of sensors were used to detect sounds produced by gas leaking out. They range from acoustic sensors and accelerometers to microphones and dynamic pressure transducers all of which are detailed in (Loth *et al.*, 2003).

Some methods involve the measurement of two acoustic signals on each end of a pipe segment. Based on these measurements, the leak can be detected using a time-frequency technique (Kim and Lee, 2009). A more recent experimental study focused on distinguishing between signals made by leaks and background noises using time-frequency analysis and adapted the leak location formula to increase accuracy (Meng *et al.*, 2011).

With regard to the advantages of using this technique, mention can be made of the fact that continuous mode operation is feasible and that the system can be automated. Acoustic methods can also help in determining the location of the leak and estimating its size. This technique could be used on new as well as on existing pipelines. When in continuous monitoring mode the system can respond in real-time. As a disadvantage high background or flow noise conditions may mask the actual leak signal (e.g. noise from vehicles passing by, valve or pump noise). As a financial downside, the cost of installing numerous sensors needed for long pipelines is high (Murvaya, 2011).

Optical methods

Optical methods used for leak detection can be divided in two categories namely, passive and active (Reichardt *et al.*, 2002). Some general benefits of using optical methods are their portability, remote detection and leak locating capabilities. A common approach is to survey the natural gas pipeline networks using aircraft-mounted optical devices for leak detection (Anon., 2009). The resulting map offers an overview of the entire network and reveals the locations of existing leaks faster than they would be found by a ground patrol with hand-held devices. The sole exception as regards portability comes from fibre optic sensing.

Active methods: The absorption or scattering of the emitted radiation caused by natural gas molecules is monitored and if significant absorption or scattering is detected above a pipeline, then a leak is presumed to exist. Several active methods for optical detection of natural gas leaks were studied such as LIDAR (Light Detection and Ranging) systems, Diode Laser Absorption, Millimetre Wave Radar Systems, Backscatter Imaging, Broad band Absorption and Optical Fibre.

Passive methods: This method of monitoring does not require a radiation source. This is an advantage as the lack of a source means some cost savings. However, this lack has to be compensated with more performance detectors and imagers which are expensive (Murvaya, 2011). There are several types of passive leak detection systems; Thermal Imaging, Multi-spectral Imaging and Gas Filter Correlation Radiometry.

Cable sensor

Electrical cable sensors are used for gas leak detection. The cables are built using materials that react when in contact with certain substances. This reaction changes cable properties such as resistance or capacitance which can be monitored to sense the appearance of a leak. Sandberg in 1989 used a sensing cable sensitive to hydrocarbons in a system that could detect and locate leaks with an accuracy of about 20 meters (Murvaya, 2011).

Some cables contain two circuit loops (Murvaya, 2011). One circuit will be connected to a power supply and the other one to an alarm. When the two circuits come into contact the alarm will be signalled. The short can be produced using several mechanisms, depending on the cable used. Direct wire contact can occur when the material separating the wires degrades, in the presence of leaked gas, allowing them to touch.

This leak detection technique gives a reasonably fast response and is more sensitive than some computational methods. However, the costs of implementing such a system are quite high. Other notable disadvantages are the difficulty of retrofitting this to existing pipelines and the inability of estimating the leak size (Murvaya, 2011).

Soil monitoring

Soil monitoring involves inoculating the gas pipeline with an amount of tracer compound (Lowry et al., 2005). This tracer chemical, a non-hazardous and highly volatile gas, will exit the pipe in the exact place of the leak (if this has occurred). To detect a leak, instrumentation has to be used to monitor the surface above the pipeline by dragging devices along or through probes installed in the soil near to the pipelines. The samples collected are then analysed using a gas chromatograph (Thompson and Golding, 2004).

The very low false alarm rate and high sensitivity are some of the advantages of using soil monitoring for leak detection. The method is quite expensive because trace chemicals have to be continuously added to the pipe during the detection process (Murvaya, 2011).

Vapour sampling

Leaks can be detected also by sampling hydrocarbon vapours in the vicinity of the pipeline. This can be done either through a vapour monitoring system which involves a sensor tube buried along the pipeline (Sperl, 2005), either by using mobile detectors carried by personnel or mounted on ROVs (remotely operated vehicles).

The remote monitoring system uses a sensor tube buried in parallel to the pipeline (Murvaya, 2011). The tube is permeable to the target gas so that in the event of a leak, some of the escaped gas will diffuse into the tube. In order to analyse the content of the tube, a pump is used to periodically push the content of the tube past a monitoring unit. The concentration profile will not be affected by the pumping action. Sensors in the detector unit will detect the gas concentration at a certain point in the examined air column, determining the size of the leak based on this concentration. To determine the location of the leak, a test gas is injected in the tube before the start of each pumping action. In this way, when the test gas is sensed by the detector unit it means that all the column was checked. The travel time of the gas from a leak spot on the pipeline, relative to the overall travel time is used. This method has a slower response time than other monitoring methods and it is typically used for short pipelines. The LEOS leak detection system (Bryce *et al.*, 2002) is supposed to work for methane gas pipelines up to 50 kilometres in length. According to the same source, this system has a detection threshold of 0.05% for gas leaks. This method is not applicable to above ground or high depth pipelines and the costs of employing it are extremely high.

Handheld or vehicle mounted gas sampling detectors are built using a great variety of sensors. The different types of gas sensors are covered in (Baratto *et al.*, 2009) and some recent advances in this field are presented in (Ren and Pearton, 2011). This approach can give better results than non-technical detection especially for very small leaks but its success greatly depends on the frequency of the patrols.

Ultrasonic flow meters

Systems based on ultrasonic flow meters can also be used for gas leak detection. Such systems were designed by Controlotron (Anon., 2005 and 2006) and then overtaken by Siemens Industry Automation division (Anon., 2011a). The system offered by this company works by considering that the pipeline is comprised of a series of segments. Each segment is bounded by two so-called Site Stations which consist of a clamp-on flow meter, a temperature sensor, and a processing unit. Each Site Station will measure or compute volumetric flow rates, gas and ambient air temperature, sonic propagation velocity and site diagnostic conditions. All data obtained on Site Stations are collected by a Master Station which computes the volume balance by comparing the difference in the gas volume entering and leaving each pipeline segment. Short integration periods show large leaks very quickly while longer integration periods detect smaller leaks (Bloom, 2004 and Anon., 2011).

This technology can locate the leak with an accuracy of 150 meters (Murvaya, 2011). Another advantage is offered by the non-intrusive character of the electronic devices utilized. On the downside, retrofitting to buried pipelines would be difficult.

2.2.3 **Software Based Methods**

The mass or volume balance leak detection technique is based on the principle of mass conservation. An imbalance between the input and output gas mass or volume can reveal the existence of a leak (Parry *et al.*, 2004). The volume of gas exiting a section of the pipeline is subtracted from the volume of gas entering this section and if the difference is above a certain threshold, a leak alarm is given. The mass or volume can be computed using the readings of some commonly used process variables; flow rate, pressure and temperature.

The mass balance approach is also used in conjunction with probabilistic methods for leak detection (Rougier, 2005). However, probabilistic methods need a considerable amount of computational power. The performance of this method mainly depends on the size of the leak, how frequently is the balance calculated and the accuracy of measuring instruments. It can be easily installed in existing pipelines as it relies on instrumentation that is available on all pipelines and it is easy to learn and use. The relatively low cost is another advantage of this method. Balancing techniques are however limited in what regards leak detection during transient or shut in and slack line conditions. If small leaks occur, it takes a long time to detect them. For example, a 1% leak needs approximately 60 minutes to be detected (Doorhy, 2011). This method cannot be used for locating the leak and it is prone to false alarms during transient states unless thresholds are adapted.

Real Time Transient modelling

Some leak detection techniques work on pipe flow models built using equations like: conservation of mass, conservation of momentum, conservation of energy and the equation of state for the fluid (Murvaya, 2011). The difference between the measured value and the predicted value of the flow is used to determine the presence of leaks. Flow, pressure and temperature measurements are required by this technique. Noise levels and transient events are continuously monitored in order to minimize false alarms.

This method can detect small leaks (less than 1 percent of flow (Scott and Barrufet, 2003)) but has the disadvantage of being very expensive as it requires extensive instrumentation for collecting data in real-time. The models employed are complex and they require a trained user.

Negative pressure wave

A leak occurring in a pipeline is associated with a sudden pressure drop, at the location of the leak, which is propagated as a wave both upstream and downstream. This wave is called a rarefaction or negative pressure wave and can be recorded using pressure transducers installed at both ends of each pipe segment (Silva et al., 2007). The leak detection algorithm has to interpret the readings obtained from the pressure transducers and decide if a leak is present.

The location of the leak can be identified using the time difference between the moments at which the two pressure transducers from the pipe ends sense the negative pressure wave. If the leak is closer to one end of the pipe, then the transducer from this end will be the first to receive the pulse and the amount of time needed to receive the pulse at the other end can be used to detect the leak location with good precision. Negative pressure wave based leak detection systems, such as ATMOS Wave (Souza and Hoffman, 2011), can also estimate the size of the leak.

Another way of using pressure waves to detect leaks is to purposely generate transient pressure waves by closing and opening valves periodically (Mpesha *et al.*, 2006 and Elaoud *et al.*, 2010). If a leak is present, these pressure waves are partially reflected allowing for the detection and location of the leak. Still, using pressure waves to detect leaks was reported to be unpractical for long-range pipelines (Murvaya, 2011).

Statistical

A simpler way of detecting gas leaks, without the need of a mathematical model, is by using statistical analysis. This analysis is done on measured parameters like pressure and flow at multiple locations along the pipeline. The system generates a leak alarm only if it encounters certain patterns consisting of relative changes in pressure and flow (Zhang, 2006).

The leak thresholds are set after a tuning period during which the parameter variance is analysed under different operating states in the absence of a leak. This tuning process needs to be done over a long period of time and is required in order to reduce false alarms (Zhang, 2006). If a leak is present in the system during the tuning period, it will affect the initial data collected and the system behaviour will be considered as normal. This leak would not be detected unless it would grow in size enough to go beyond the threshold.

Detection of 0.5% leaks was reported (Zhang, 2006) but it is possible to detect even smaller leaks when using instruments with greater resolution. Statistical methods can also estimate the leak location. The technique is also easy to use, robust and easy to adapt to different pipeline configurations. Some of the main disadvantages of using this approach are the difficulty in estimating leak volume and high costs.

Digital signal processing

Another way to detect leaks by using measurements of the flow, pressure or other pipe parameters is to use digital signal processing (Anon., 2007). During the set-up phase, the response given by the system to a known change in flow is measured. This measurement is used together with digital signal processing to detect changes in the system response. Digital signal processing allows for the leak response to be recognized from noisy data. This kind of leak detection technique was first proposed for liquid pipelines (Golby, 2007) but its applicability to gas pipes was also considered. Solutions for both liquid and gas pipelines are currently available (e.g. the ClampOn DSP Leak Monitor (Anon., 2011).

This method does not need a mathematical model of the pipeline, its main purpose being that of extracting leak information from noisy data (Murvaya, 2011). Like the statistical approach, if during the set-up phase a leak is already present in the system it will never be detected unless its size would grow considerably. Furthermore, besides having a high cost, this leak detection technique is difficult to implement, retrofit and test.

2.3 Microcontroller Based LPG Leakage Detection

This method of LPG leakage detection is an automatic method of detecting leakages and involves the use of a microcontroller which serves as the brain of the system. The microcontroller responds to the leakage of LPG detected by LPG sensors by initiating a set of commands to mitigate or alert the authorities for prompt action to be taken.

2.3.1 Microcontroller

A microcontroller often serves as the "brain" of a mechatronic system. Like a mini, self-contained computer, it can be programmed to interact with both the hardware of the system and the user. Even the most basic microcontroller can perform simple math operations, control digital outputs, and monitor digital inputs.

Recent microcontrollers are much faster, have more memory, and have a host of input and output features that dwarf the ability of earlier models. Most modern controllers have analogue-to-digital converters, high-speed timers and counters, interrupt capabilities, outputs that can be pulse-width1 modulated, serial communication ports, etc.

Fig. 2.2 shows a block diagram of a microcontroller below.

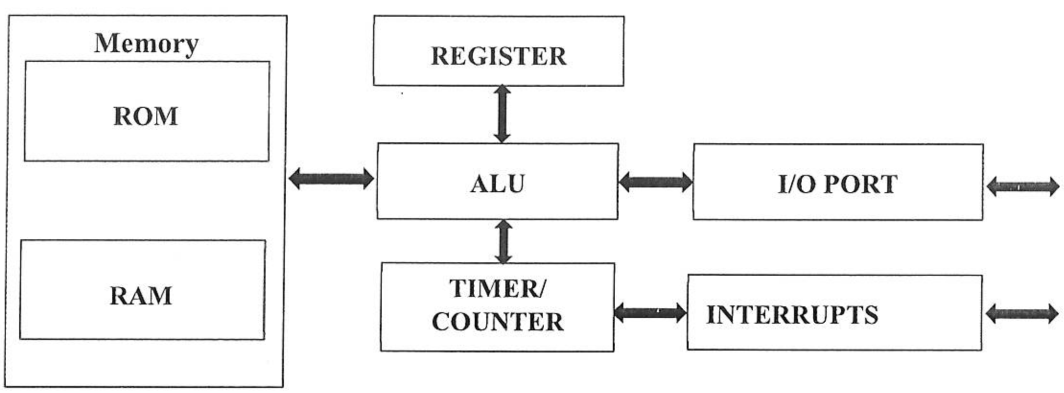


Fig. 2.2 Block Diagram of Microcontroller (Source: Parai *et al.*, 2013)

Classification of Microcontrollers

In 1993, the introduction of EEPROM allowed microcontrollers (beginning with the Microchip PIC16x840) to be electrically erased quickly (Parai *et al.*, 2013). It allows both rapid prototyping and In-System-Programming (ISP). The same year, the first microcontroller using Flash memory was introduced by Atmel. There are 4-bit to 32-bit microcontrollers available in the market. Based on the number of bits, it is broadly classified into four different categories i.e., 4-bit, 8-bit, 16-bit and 32-bit microcontrollers. The 4-bit microcontrollers are extensively used in electronic toys. The 8-bit microcontrollers are generally used in various control applications such as position control, speed control and any process control system. The 16-bit microcontroller are designed and developed for the purpose of high speed control application such as servo control system, robotics etc. (Parai *et al.*, 2013).

Programming of such microcontroller can be achieved either by high level programming language or by assembly language programming. For very high speed operations in robotics, image processing, automobiles, intelligent control system and telecommunications 32- bit microcontrollers are used. Typical examples of microcontroller are the Intel MCS48, 51 and 96 families, the Motorola MC68HC11 family and the Zilog Z8.

Most of these MCUs have an 8-bit word size (except the MCS-96 with a 16-bit word size), at least 64 bytes of R/W memory and 1 KB of ROM. The range of I/O line varies from 16 to 40 lines.

Fig. 2.3 shows the classifications of microcontrollers below.

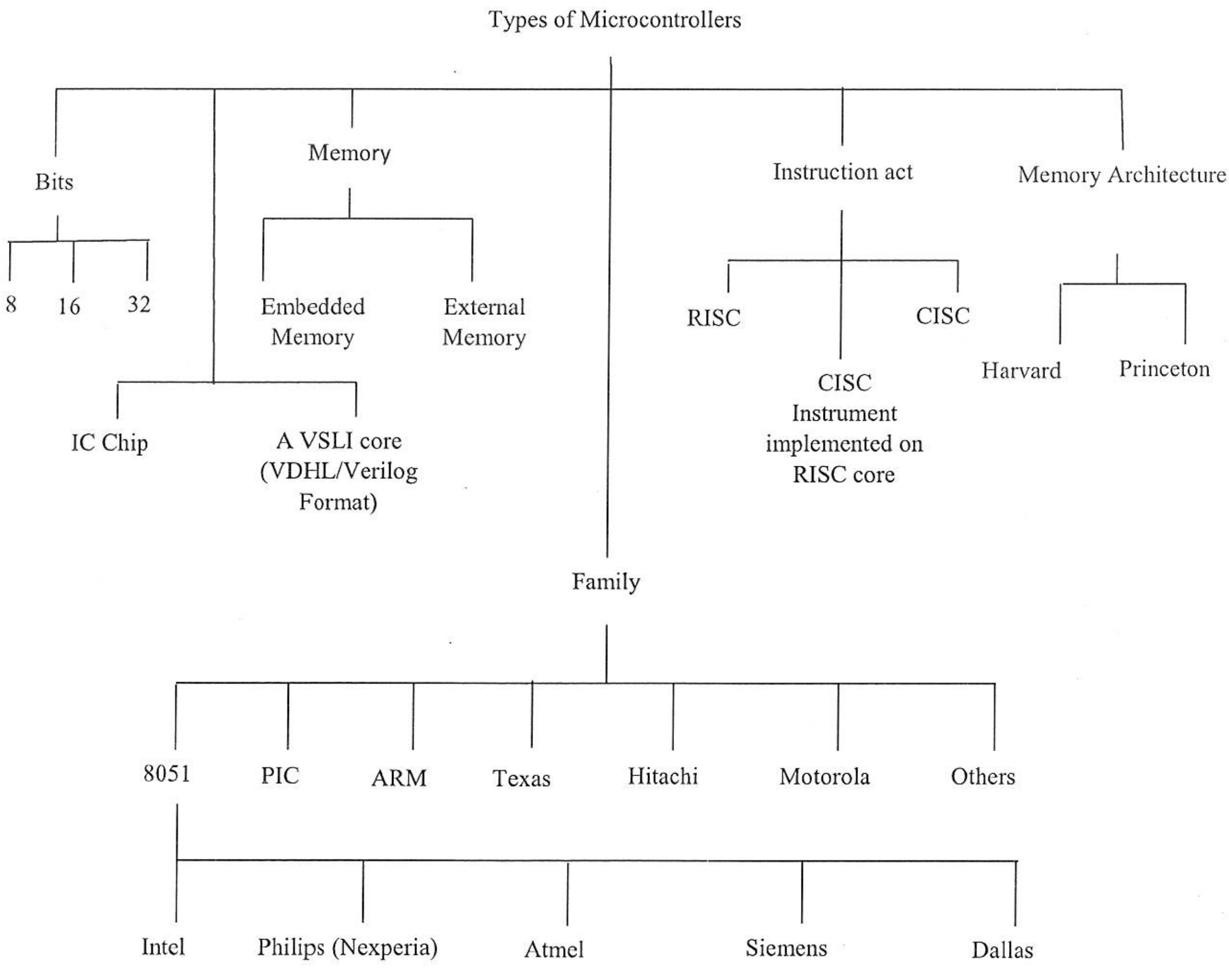


Fig. 2.3 Classification of Microcontrollers (Source: Parai *et al.*, 2013)

2.4 MQ Series Semiconductor Gas Sensors

These are highly sensitive devices that are used for detecting the presence of a variety of gases in an area. They range from MQ-2 through to MQ-9, MQ303, MQ306, MQ307, MQ131 and MQ135 to MQ138 with sensitivity to different kind of gases. Table 2.1 shows the various types of MQ sensors and their specifications.

Table 2.1 below shows MQ Series Specifications

Semiconductor Sensor for Flammable Gas, Plastic or Metal Cover	
Model	**Target Gas**
MQ-2	General combustible gas
MQ-3	Alcohol
MQ-4	Natural gas, Methane
MQ-5	LPG, Natural gas, Coal gas
MQ-6	LPG, Propane
MQ-7	Carbon Monoxide
MQ-8	Hydrogen
MQ-9	CO and Combustible gas
MQ306	LPG, Propane
MQ307	Carbon Monoxide
MQ303	Alcohol
MQ131	Ozone
MQ135	Air Quality Control
Semiconductor Sensor for Toxic Gas	
MQ136	Sulphureted Hydrogen (H_2S)
MQ137	Ammonia (NH_3)
MQ138	Volatile Organic Compound (Mellow, Benzene, Aldehyde, Ketone, Ester)

2.5 RELATED WORKS

Table 2.2 below shows the related work which had be done over the years before this microcontroller GSM based LPG monitoring ,detection and control system .

NAME AND YEAR	WORK DONE	LIMITATIONS
Rocha, 1989	He used pressure sensors to record the appearance of acoustic pressure waves caused by leaks, while Brodetsky and Savic developed a system that requires permanent monitoring units along the pipeline.	It cannot control the leakage, therefore leaving the environment in great danger. It only makes sound as a signal for gas leakage occurrence. It is only applicable to pipelines. Cost of installing sensors into a long pipeline is very high.
Sunithaa and Sushmitha, 2012	They built a system that detects the leakage of the LPG and alerts the consumer about the leak through the GSM module and as an emergency measure, the system switches on an exhaust fan to circulate the gas.	It can not control the LPG leakage if the concentration is too high.
Ashish *et al.*, 2013	They designed a GSM based LPG detection system which consisted of a Philip microcontroller, MQ-6 sensor and a GSM module. The MQ-6 sensor is very sensitive to LPG and Propane and hence is capable of detecting the smallest leakage of the gas. The microcontroller response	It can not react in time and can not control the LPG leakage if the concentration is too high.

	to the leakage detected by the sensor by sending an SMS through the GSM module to the authority for appropriate response	
Mr. Akshay *et al* 2017	Development of a simple gas leak detector with Arduino ,GSM module and MQ6 gas sensor. Simple Gas leak Detector is a simple device which is used to detect the leakage of gas and if the gas leak occurs, an equivalent message is conveyed by the means of an LCD screen and a buzzer and with the help of the GSM module it is capable to broadcast messages to the stakeholders about the LPG leak.	It cannot control the leakage , therefore leaving the environment and properties to hazards which may arise from LPG leakage accident.
Okunlola ,2018	Design and the implementation of a Microcontroller GSM based LPG detection, monitoring and control system . The system detects LPG leakage using MQ-5 gas sensor and alerts the user of the leakage through GSM-based SMS and a buzzer with LCD display unit, the system shuts off LPG supply using a solenoid valve.	It can only be used for LPG leakage detection and control for its efficient capabilities, it has low smoke detecting ability and some other gases

CHAPTER THREE

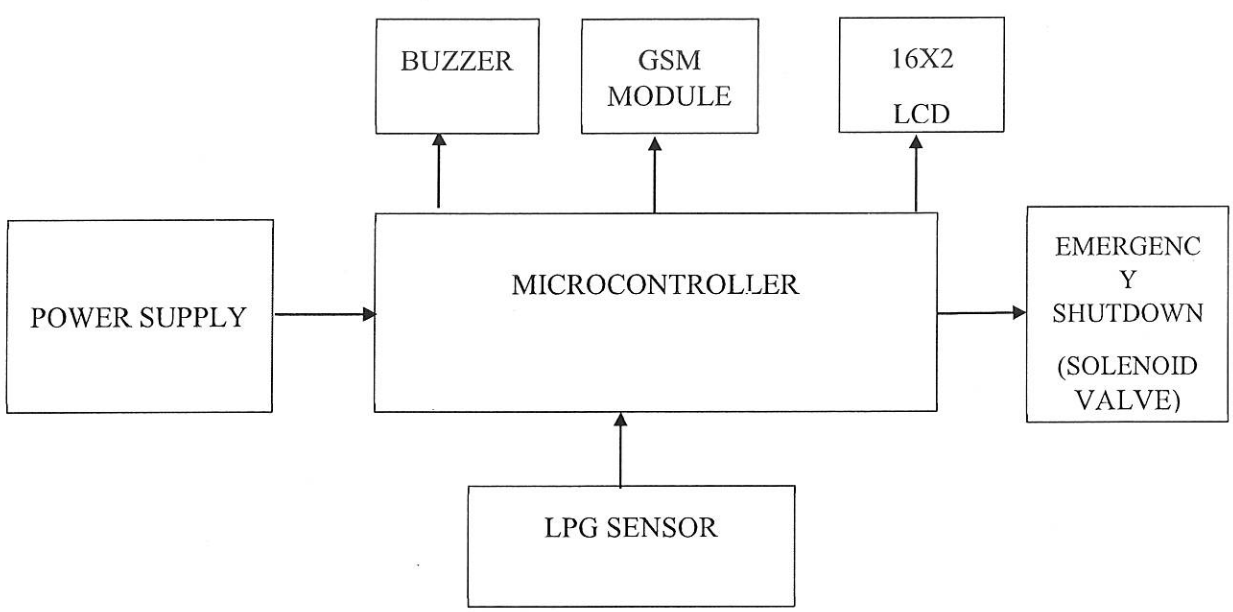
DESIGN AND COMPONENT SELECTION

3.1 Introduction

In this project,The main focus is designing an efficient system that is capable of detecting, displaying LPG leakage and shutting down supply of the gas in order to prevent wastage and accidents in Nigerian homes where the use of LPG is heavily depended upon. The system consists of a microcontroller Atmega328 with a MQ-5 gas sensor that is used to detect gas leakages. The system is integrated with an alarm unit, to sound an alarm and a LCD which gives a visual indication of the LPG leakage; If leakage is detected, a message will be automatically sent to the authorised person, using a GSM cellular module network. It also provides a feature that shuts down the main supply of the gas using an Emergency Shutdown System (ESDS) which is the solenoid valve.

The Fig 3.1 and 3.2 below show the block diagram of the proposed design and the architecture respectively.

Fig. 3.1 Block Diagram of the microcontroller GSM based LPG monitoring, detection and control system .



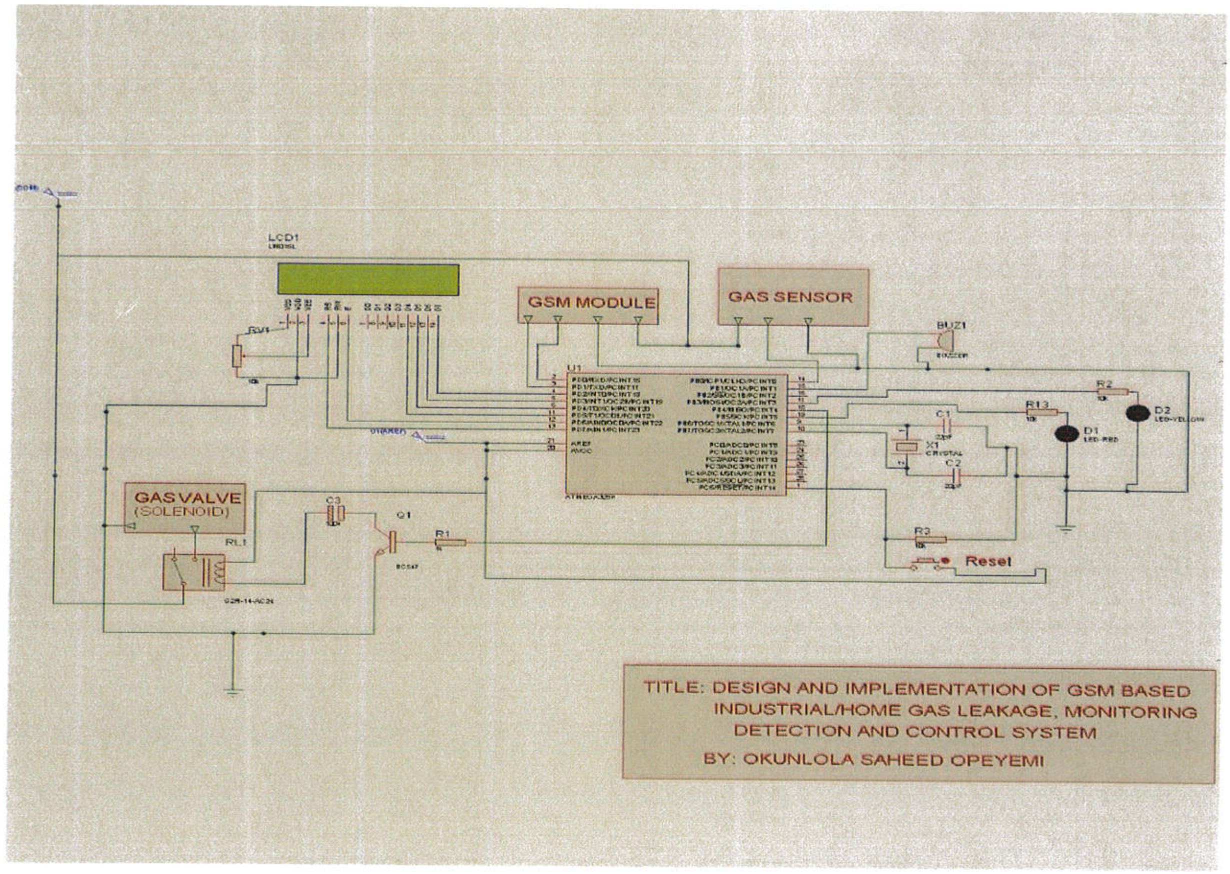


Fig 3.2 The architecture design of the project.

3.2 ATmega 328 Microcontroller

The ATmega32 8 bit AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega328 provides the following features: 32 kilobytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024 bytes EEPROM, 2 kilobyte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for boundary-scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes.

The Idle mode stops the CPU while allowing the USART, two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next external interrupt or hardware reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC noise reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. In extended standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega32 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications. The ATmega32 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits (Anon., 2003)

3.2.1 Features

The features of ATmega328 are listed below in Table 3.4.

Table 3.4 Features of ATmega328

Features	**Specifications**
High performance, low power AVR 8-bit microcontroller	Fast processing capability
Advance RISC architecture	1. 131 power instructions 2. 32×8 general purpose working registers 3. Up to 16 MIP throughput at 16 MHz 4. On-chip 2 cycle multiplier
Non-volatile program and data memory	

JTAG (IEEE std. 1149.1 Compliant) interface	1. Extensive on-chip debug support 2. Programming of flash, EEPROM, fuses, and lock bits through the JTAG interface
Peripheral Features	1. Two 8-bit timer/counters with separate prescalers and compare modes 2. One 16-bit timer/counter with separate prescaler, compare mode, and capture mode 3. Four PWM channels 4. 8-channel, 10-bit ADC
Special Microcontroller Features	1. Power-on reset and programmable brown-out detection 2. Internal calibrated RC oscillator 3. External and internal interrupt sources
I/O and Packages	1. 32 Programmable I/O lines 2. 40-pin PDIP, 44-lead TQFP, and 44-pad MLF
Speed Grades	1. 0 - 8 MHz for ATmega32L 2. 0 - 16 MHz for ATmega32
Power consumption at 1 MHz, 3V, 25°C for ATmega32	1. Active: 1.1 mA 2. Idle Mode: 0.35 mA 3. Power-down Mode: < 1 μA

3.2.2 **Pin Configuration**

Fig. 3.3 gives the pin configuration of ATmega328 while Fig: 3.4 shows a block diagram of ATmega328:

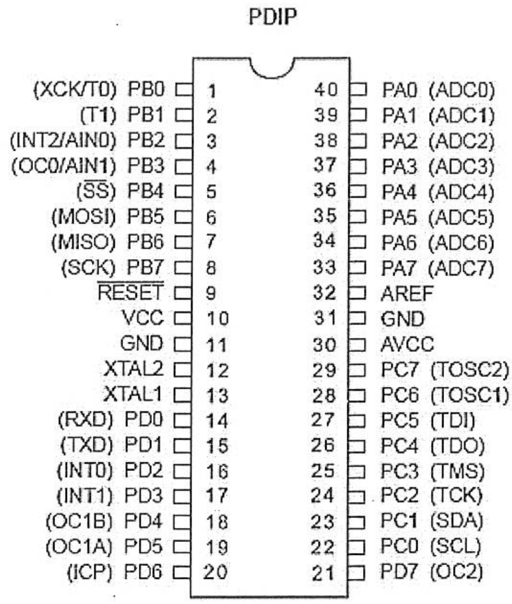


Fig. 3.3 ATmega328 Pinouts

3.2.3 Pin Description

VCC

Digital supply voltage.

GND

Ground.

Port A (PA0 – PA7)

Port A serves as the analogue inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB0 – PB7)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C (PC0 – PC7)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs.

Port D (PD0 – PD7)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

$\overline{RESET}$

Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset.

XTAL1

Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2

Output from the inverting Oscillator amplifier.

AVCC

AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF

AREF is the analogue reference pin for the A/D Converter.

3.3 MQ-5 Gas Sensor

MQ-5 is a semiconductor type gas sensor which detects the gas leakage. The sensitive material of MQ-5 is tin dioxide (SnO_2). It has very low conductivity in clean air (Ashish, *et al.*, 2013). This Gas sensor not only has sensitivity to propane and butane but also to other natural gases, low sensitivity to cigarette smoke and alcohol.

The concentration range of MQ-5 gas sensor is 200-1000 ppm. This sensor is available in 6 pins package, out of which 4 pins are used for fetching the signals and other 2 pins are used for providing heating current. This sensor has fast response time. The power required by the sensor is 5 V. The sensor has different resistance value in different concentration.

3.3.1 Features of MQ-5 Gas Sensor

The features of an MQ-5 gas sensors are:

- High sensitivity to LPG, iso-butane, propane;
- Small sensitivity to alcohol, smoke;
- Fast response;
- Stable and long life; and
- Simple drive circuit.

Fig. 3.1 shows a diagram and the schematic connection of MQ-5 gas sensor.

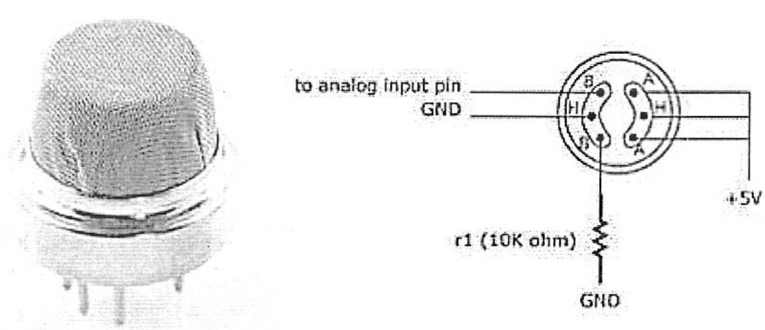


Fig. 3.4 MQ-5 Gas Sensor

3.2.2 Applications

They are used in gas leakage detecting equipment for homes and industries. They are suitable for detecting of LPG, iso-butane, propane, Liquefied Natural Gas (LNG), very high concentrations of alcohol, cooking fumes and cigarette smoke.

3.2.3 Specifications

Table 3.2 Standard Work Condition

Symbol	Parameter Name	Technical Condition	Remarks
V_C	Circuit Voltage	5 V ± 0.1	AC OR DC
V_H	Heating Voltage	5 V ± 0.1	AC OR DC
P_L	Load Resistance	20 kΩ	
R_H	Heater Resistance	33 Ω ± 5%	Room Temperature
P_H	Heating Consumption	Less than 750 MW	

Table 3.3 Environment Condition

Symbol	Parameter Name	Technical Condition	Remarks
T_{ao}	Using Temperature	-10 ^{O}C – 50 ^{O}C	
T_{as}	Storage Temperature	-20 ^{O}C – 70 ^{O}C	
R_H	Related Humidity	Less than 95 % R_H	
O_2	Oxygen Concentration	21 %(standard condition) Oxygen concentration can affect sensitivity	Minimum value is over 2%

Table 3.4 Sensitivity Characteristics

Symbol	Parameter Name	Technical Parameter	Remarks
RS	Sensing Resistance	10 kΩ – 60 kΩ (1000 ppm LPG)	Detecting concentration scope: 200 – 10000 ppm
1000 ppm/4000 ppm LPG	Concentration Slope rate	≤ 0.6	

Standard detecting condition	Temp: 20 °C ± 2 °C V_c: 5 V ± 0.1 Humidity: 65 % ± 5 % V_h: 5 V ± 0.1	LPG , iso-butane, propane, LNG
Preheat time	Over 24 hours	

Table 3.2 above provides the standard working conditions of MQ-5, Table 3.3 shows its environment conditions, while Table 3.4 shows the sensitivity characteristics of the device.

3.4 Power Supply Unit

The Power Supply Unit consists of a 240 V, 50 Hz alternating current source that is stepped down to approximately 9.5 V by a step-down transformer. The 9.5 V AC is rectified using a full wave bridge rectifier and smoothened by shunt capacitor filter to 12 V DC. The 12 V is regulated to 5 V, which is fed to the microcontroller, buzzer and gas sensor.

Fig. 3.5 Step-down Transformer

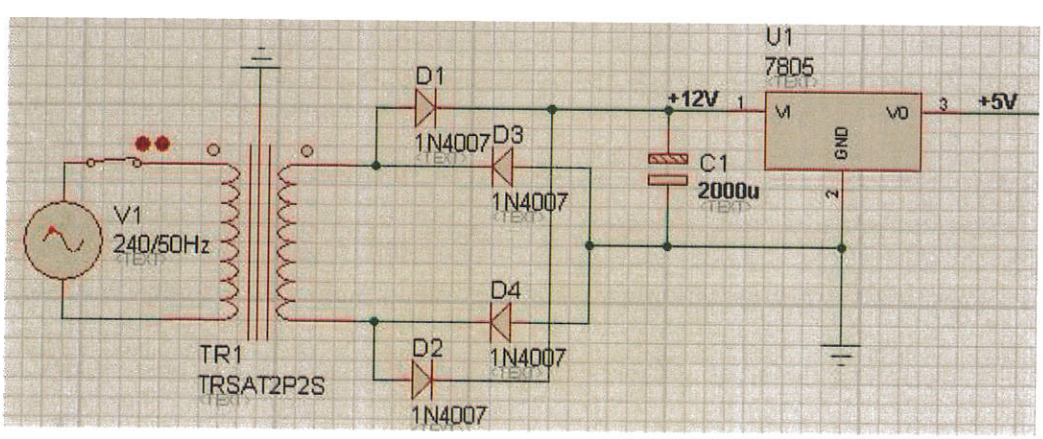


Fig. 3.6 Circuit Diagram of Power Supply Unit

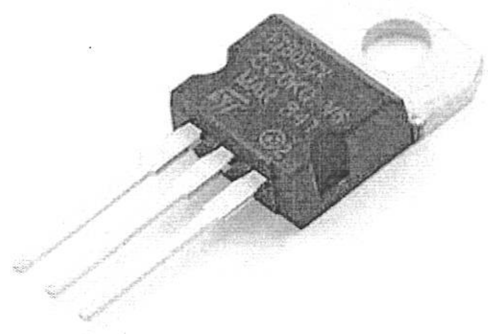


Fig. 3.7 LM7805 Voltage Regulator

Fig. 3.5, Fig. 3.6 and Fig 3.7 show a typical example of a step-down transformer, circuit diagram of the power supply and an LM7805 voltage regulator respectively.

3.4.1 Sizing of Power Supply

The turns ratio and the desired output voltage are determined according to the following calculations (Theraja and Theraja, 2005):

$$\gamma = \frac{1}{4\sqrt{3}fCR_L} \tag{3.1}$$

$$C = \frac{1}{4\sqrt{3}f\gamma R_L}$$

Since a very smooth dc is required, a ripple factor of 0.01 was used.

$$R_L = \frac{Load\ Voltage}{Load\ Current}$$

$$R_L = 52.60\ \Omega$$

$$C = \frac{1}{4\sqrt{3} \times 50 \times 0.03 \times 52.60}$$

$$C = 1.88\ mF \cong 2\ mF$$

$$V_{dc} = \frac{V_{IP}}{1+\frac{1}{4fCR_L}} \tag{3.2}$$

$$V_{IP} = 12\left(1 + \frac{1}{4 \times 50 \times 52.60 \times 2 \times 10^{-3}}\right)$$

$$V_{IP} = 12.60\ V$$

$$Peak\ secondary\ voltage = 12.60 + (2 \times 0.7)$$

$$= 14\ V$$

$$Peak\ primary\ voltage = 339.40\ V$$

$$Turns\ ratio = \frac{E_1}{E_2} = \sqrt{\frac{L_1}{L_2}} = \frac{339.40}{14} = \frac{24}{1}$$

Where; γ = ripple factor of the rectified voltage

f = line frequency

C = shunt capacitance

R_L = load resistance

V_{dc} = dc voltage

V_{IP} = peak full-wave rectified voltage at filter input

E_1 = peak primary voltage

E_2 = peak secondary voltage

L_1 = primary transformer inductance

L_2 = secondary transformer inductance

Table 3.5 below shows the obtained values of the calculated parameters.

Table 3.5 Calculated Values

Parameters	**Values**
Peak primary voltage	339.41 V
Peak secondary voltage	14.00 V
Transformer turns ratio	24:1
Voltage drop across each diode (Silicon)	0.70 V
Peak full-wave rectified voltage at filter input	12.60 V
Shunt capacitance	2000 μF

Ripple factor	0.03
Unregulated output voltage	12.00 V
Regulated output voltage	5.00 V
Load resistance	52.60 Ω

3.5 Normally Open Electromagnetic Solenoid Valve

The Emergency Shutdown System is designed to provide the ultimate safety when using toxic or reactive gases. It consists of a direct acting solenoid valve system in which a weak spring connected to a plunger in the gas system is activated in reaction to an electromagnetic field. When not energised, fluid flows through it without any restrictions. However, when the microcontroller sends a signal to it in response to leakage, it energises producing a magnetic field that repels the spring pushing the plunger to cut off gas flow. Its reaction time is between 5 – 10 ms. Fig. 3.8 below shows an example of a 9.5 mm gas solenoid valve.

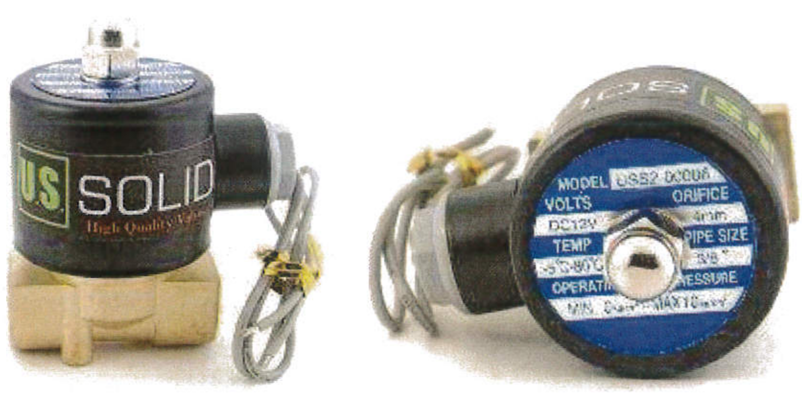


Fig. 3.8 Image of 9.5 mm Electromagnetic Gas Solenoid Valve

As stated earlier, the system is designed to electrically operate a solenoid valve, which in turn operates a spring-loaded valve. The safety valve with spring-loaded valve disc closes when energised and opens when de-energised. The system is typically installed at the outlet of the process manifold to which the cylinder pigtail is connected. Shutdown is automatically initiated based on the status of sensors.

3.5.1 **Fig 3.9** shows the circuit diagram of solenoid Valve Unit

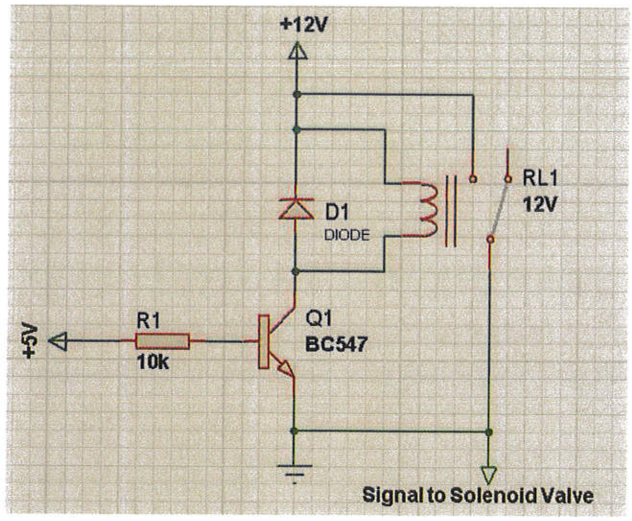


Fig. 3.9 Circuit Diagram of Solenoid Valve Unit

The signal from Port C0 is applied to the base of BJT transistors Q_1 (BC547). Resistor R_1 is the current limiting resistor which is used to bias the base current of transistor Q_1 indicated in the Fig. 3.9. At maximum rating of the BC547 from datasheet, I_C = 100mA, h_{fe} = 260, V_{BE} = 0.8 V and V_{CE} = 5 V. $R_{in} = R_1$ is determined according to equations (3.3) and (3.4) as (Theraja and Theraja, 2005):

$$R_1 = \frac{V_{BB} - V_{BE}}{I_B} \tag{3.3}$$

$$I_B = \frac{I_c}{h_{fe}} \tag{3.4}$$

$$I_B = \frac{100 \times 10^{-3}}{260} = 385\ \mu A$$

$$R_1 = \frac{5 - 0.8}{385 \times 10^{-6}} = 10.91\ k\Omega$$

A 10 kΩ resistor was chosen for this project.

Where; R_1 = current limitting resistor

V_{BB} = base voltage

V_{BE} = base – emitter voltage

I_B = base current

I_C = collector current

h_{fe} = common emitter d.c or flow transfer ratio

3.6 SIM900 A6 GSM Module

Fig. 3.10 is a diagram of a typical example of SIM900 A6 GSM module.

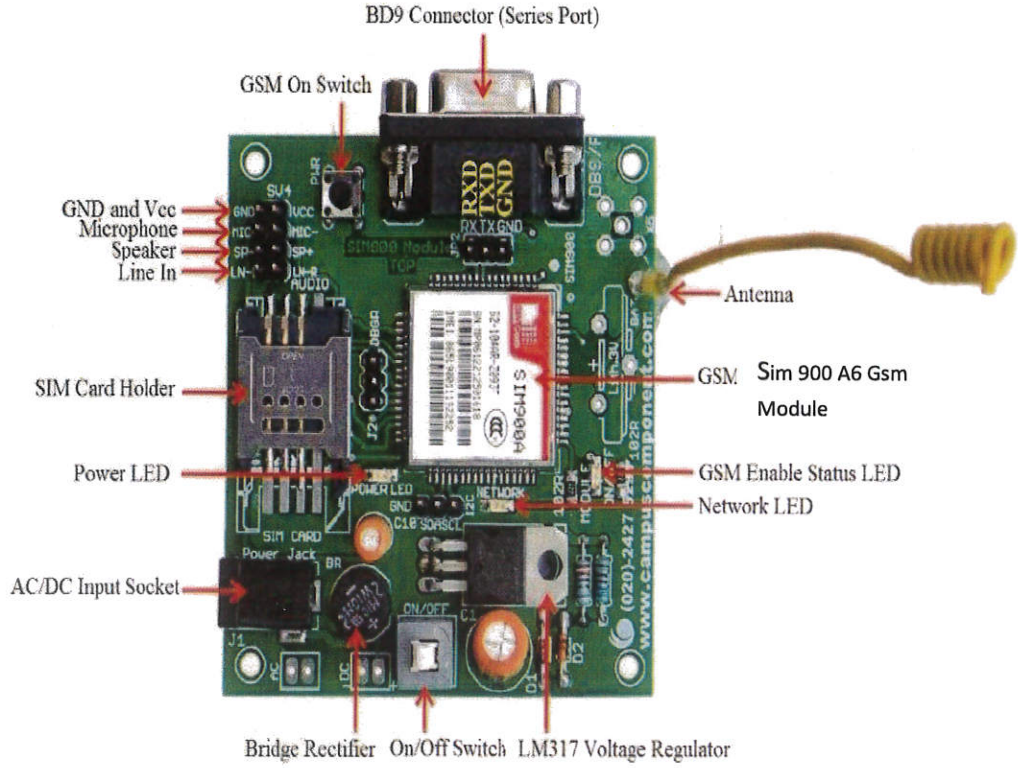


Fig. 3.10 SIM900 A6 GSM Module

GSM (Global System for Mobile) / GPRS (General Packet Radio Service) TTL –Modem is SIM900 A6 Quad-band GSM / GPRS device, works on frequencies 850 MHZ, 900 MHZ, 1800 MHZ and 1900 MHZ. It is very compact in size and easy to use as plug in GSM Modem. The Modem is designed with 3.3 and 5 V DC TTL interfacing circuitry, which allows User to directly interface with 5 V Microcontrollers (PIC, AVR, Arduino, 8051, etc.) as well as 3.3 V Microcontrollers such as ARM and ARM Cortex XX (Anon., 2011d).

The baud rate can be configurable from 9600 – 115200 bps through AT (Attention) commands. This GSM/GPRS TTL Modem has internal TCP/IP stack to enable User to connect with internet through GPRS feature. It is suitable for SMS as well as DATA transfer application in mobile phone to mobile phone interface. The modem can be interfaced with a Microcontroller using USART (Universal Synchronous Asynchronous Receiver and Transmitter) feature (serial communication).

3.6.1 **Features**

- Quad Band GSM/GPRS : 850 / 900 / 1800 / 1900 MHz;
- Built in RS232 to TTL or vice versa Logic Converter (MAX232);
- Configurable Baud Rate;
- SMA (SubMiniature version A) connector with GSM L Type Antenna;
- Built in SIM (Subscriber Identity Module) Card holder;
- Built in Network Status LED;
- Inbuilt Powerful TCP / IP (Transfer Control Protocol / Internet Protocol) stack for internet data transfer through GPRS (General Packet Radio Service);
- Audio Interface Connectors (Audio in and Audio out);
- Most Status and Controlling pins are available;
- Normal Operation Temperature : -20 °C to +55 °C;
- Input Voltage : 5 V to 12V DC; and
- DB9 connector (Serial Port) provided for easy interfacing.

3.7 SD1614TT-B3M Buzzer

This is a high reliability electromagnetic buzzer with pin type terminal construction for direct mounting on printed circuit board. It operate at a voltage between 3 V – 6 V and produces sound of about 90 decibels.

Fig. 3.11 **shows the circuit diagram of the buzzer.**

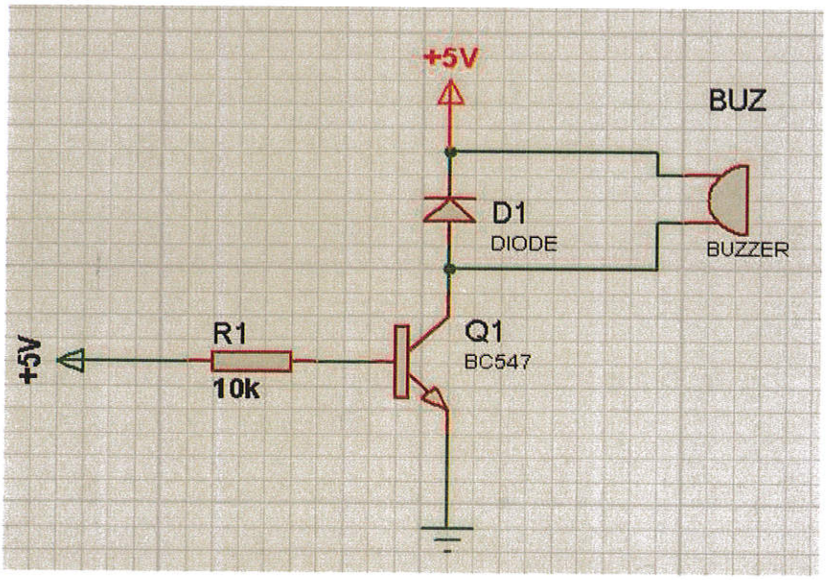


Fig. 3.11 Circuit Diagram of Buzzer

Table 3.6 shows the specifications of the buzzer used in this project.

Table 3.6 Buzzer Specifications

Part No.	**SD1614TT-B3M**
Rated voltage	12 V
Operating voltage	3 V – 6 V
Drive frequency	2048 Hz
Sound pressure	90 (dB(A)/10 cm)min
Current	80 mA
DC resistance	70 Ω
Operating temperature range	–40 °C to +85 °C

Fig. 3.12 below shows the flowchart of the microcontroller GSM based LPG monitoring,detection and control system.

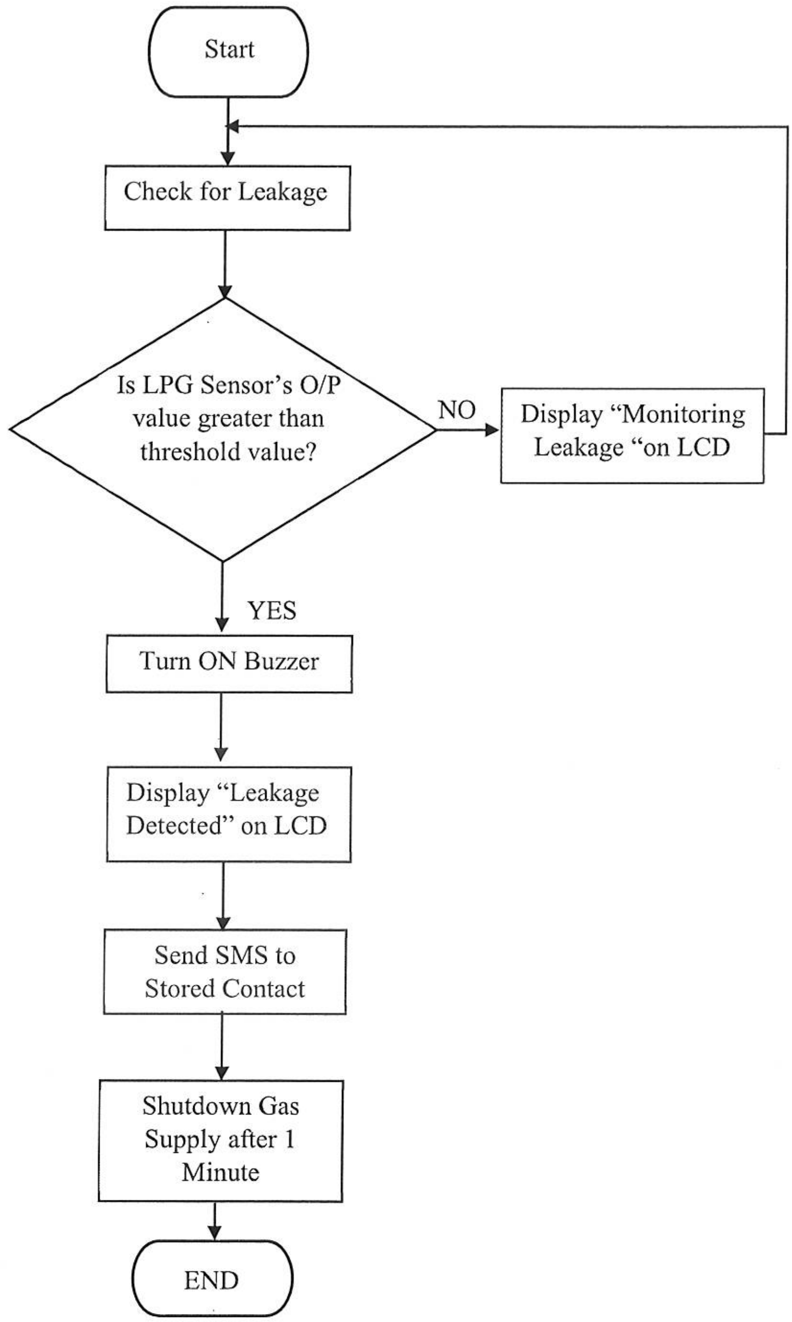


Fig. 3.12 Flowchart of the project's design

CHAPTER FOUR

RESULT, EVALUATION AND DISCUSSION

4.1 Introduction

Simulation is the imitation of the operation of a real-world process or system over time. A model is a representation of the system under study itself, whereas the simulation represents the operation of the system over time. A computer simulation is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables in the simulation, predictions may be made about the behaviour of the system. It is a tool to virtually investigate the behaviour of the system under study (Anon., 2016b).

The aim of the simulation performed in this project is to determine the feasibility and operation of the microcontroller based LPG monitoring detection and control system. This chapter gives a detailed result analysis and discussion of the simulation.

4.2 Circuit Simulator

The simulation software employed for testing the validity and performance of the design is Proteus 7.5 simulator. The software makes it possible for the design to be simulated by mimicking real life situations and also provides the possibility of generating a PCB layout. This makes it easier for the prototype of a design to be constructed devoid of errors.

4.3 Evaluation Analysis of Simulation

Fig. 4.1 and Fig. 4.2 below show the operation of the design under normal conditions and when leakage is detected by the MQ-5 sensor respectively. During normal operations the Microcontroller displays "Monitoring LPG leakage" on an LCD screen. When leakage is detected, signal is sent to the buzzer to blow an alarm. A message which reads "Leakage Detected" is sent to the user's phone through a GSM module. The same message is displaced on the LCD. Supply from the LPG mains is then shut off to stop further leakage

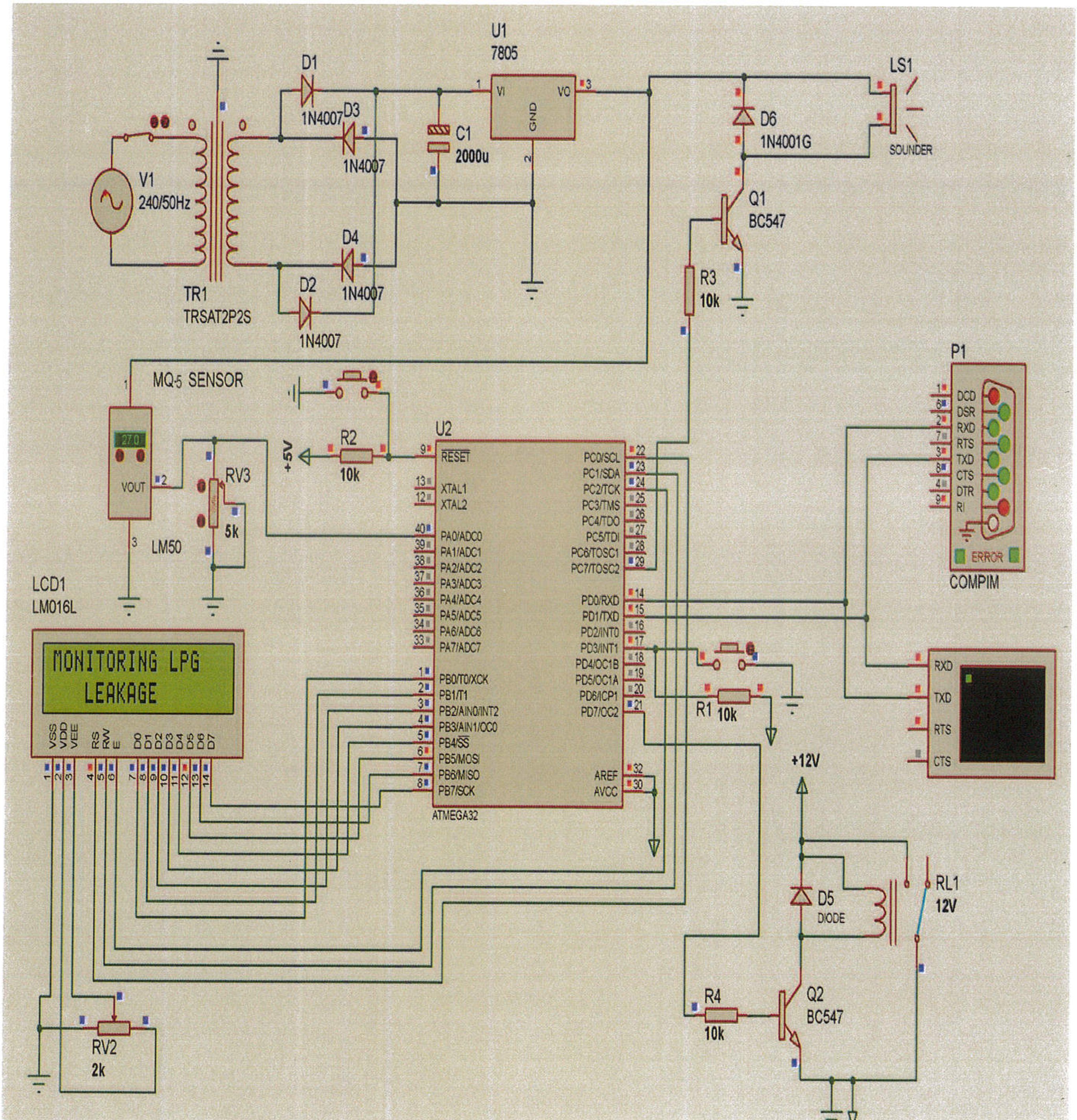


Fig. 4.1 Simulated Diagram of System when Leakage is Being monitored

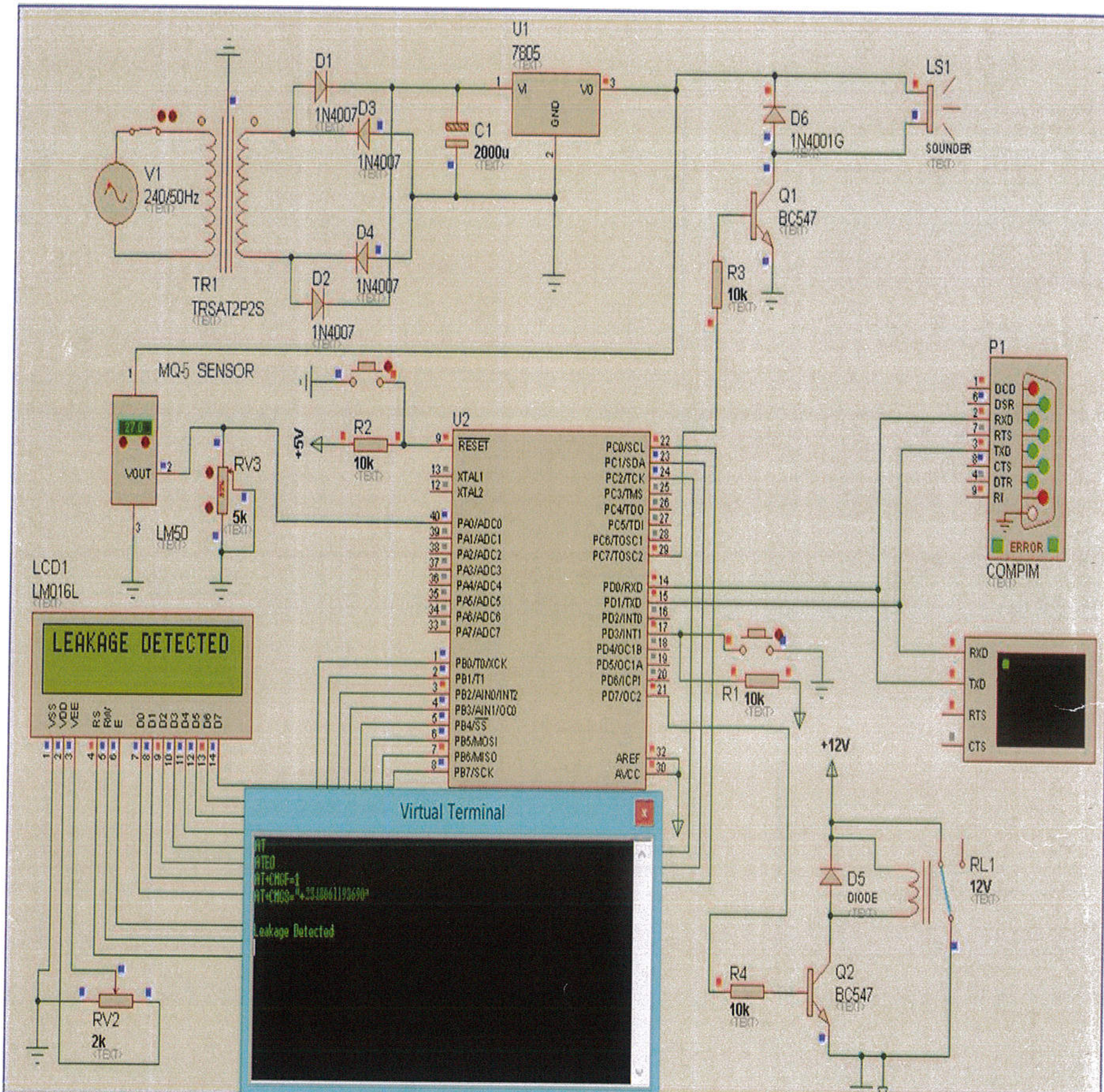


Fig. 4.2 Simulated Diagram of System when Leakage is Detected

The Digram in Fig. 4.2 above represents the SIM900A GSM module through which the leakage message is sent to the user phone. The Virtual Terminal beneath the Compim displays the programing codes and user phone number to which the "Leakage Detected" message is sent from the GSM module (Compim). The C language used in programming used in the microcontroller is used in appendix A.

Fig. 4.3 Simulated Results of Output Power Supply

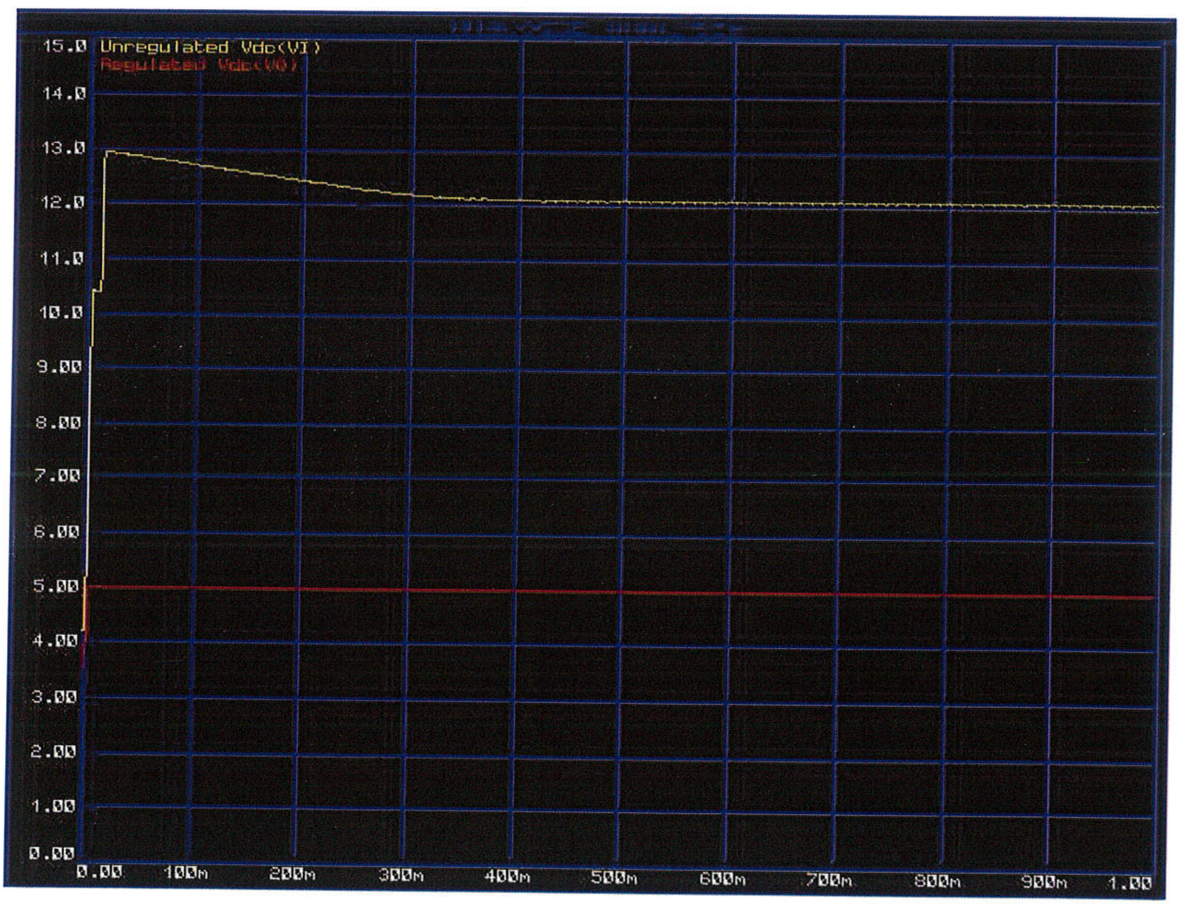


Fig. 4.3 above shows the analogue analysis of the output voltage of the power supply unit. The yellow line in the graph represent 12 V dc voltage which has been filtered by a shunt capacitor. The voltage is then regulated by a positive 5 V, 1A regulator to give an output of 5 V which is represented in the graph by the red line. The 12 V is fed to the gas solenoid valve while the 5 V is fed to the MQ-5, Microcontroller and the Buzzer

4.4 Cost Analysis

Table 4.1 below shows the cost analysis of the proposed Microcontroller Based LPG leakage detection and response System. The analysis is based on the lowest individual cost of each component used in the simulation while taking into consideration quality, in order to minimise the cost of building the system. This in turn makes the system economical and affordable for domestic use. This analysis is an estimate of the prices of components used in the simulation based on review of online prices.

Table 4.1 Cost Analysis

Items	**Quantity**	**Unit Price**		**Price total (Naira)**
		US($)	**Naira**	
Silicon Diode (1N4007)	6	0.03	150	900
Step down Transformer	1	11.95	5000	5000
Electrolytic Capacitor	1	0.42	200	200
LM7805 Voltage Regulator	1	0.45	150	150
MQ-5 Gas Sensor	1	1.50	580	580
Variable Resistor	2	1.55	600	1200
Microcontroller	1	3.10	1200	1200
Microcontroller Programmer	1	4.56	1800	1800
LCD Display (LM016L)	1	10.95	4250	4250
10 KΩ Resistor	4	0.39	150	600
BC547 Transistor	2	0.10	50	100
12 V Relay	1	4.50	1700	1700
SIM900A GSM Module	1	27.00	10550	10550
Buzzer	1	4.65	1800	1800
Switch	1	1.55	600	600
Push Button	2	0.45	500	1000
Gas Solenoid Valve	1	6.00	2500	2500
Total Price				**34,130**

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This work sets out the problem of LPG leakages that have resulted in numerous fatal casualties as well as damages to properties worth billions of dollars. As such a device that is capable of detecting such leakages and shutting off the gas supply was designed successfully.

The device is able to sense the leakage of LPG through a highly sensitive MQ-5 gas sensor and with the aid of a microcontroller activate a buzzer which buzzes to alert anyone nearby of leakage. An SMS with information "LPG Leakage Detected" is sent from the SIM900A GSM Module as a backup to alert the appropriate authority of leakage. Also, supply is shut down by the solenoid value unit under one minute to avoid wastage and possible accident.

5.2 Recommendations

Based on the design, the following are recommended:

- This design should be taken up, funded and implemented by any individual who has an interest in the project, as it has a great potential of mitigating against accidents associated LPG leakage; and
- A weighing scale be incorporated into the design to measure the amount of gas used or left in the gas tank or cylinder.

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APPENDIX A

ATMEGA32 PROGRAMMING CODES

```
/*
 * Gas_Leakage.c
 *
 * Created: 20-Feb-16 7:19:52 PM
 *  Author: clus
 */
#define F_CPU 16000000UL
#define BAUD_RATE 9600
#define PRESCALE (((F_CPU/(BAUD_RATE * 16UL)))-1)
#include <avr/io.h>
#include <util/delay.h>
#include <stdlib.h>
#include <string.h>
#include <avr/interrupt.h>

//***LCD***//
#define LCD_Data PORTB
#define rs PC0
#define rw PC1
#define en PC2
#define buzzer PC7
//***Sensor***//
#define sense PA0
#define button PA3

// GSM Stuff
void us_Init();
void us_wr_ch(unsigned char ch);
unsigned int us_rd_ch();
void us_wr_str(const char * msg);
```

- void us_wr_cmd(const char * msg);
-
- //	LCD stuff
- void LCD_cmd(unsigned char cmd); // Command function
- void init_LCD(void); // Initialize LCD
- void LCD_write(unsigned char data);	// Write data to LCD
- void LCD_string(char * str); // Write string to LCD
-
- //	ADC stuff
- void adc_init(void);
- int adc_read();
- int leak_det(int val);
-
- ISR(INT1_vect)
- {
- 	//	Display Leakage on LCD
- 	LCD_cmd(0x01);
- 	LCD_string("LEAKAGE DETECTED");
- 	//	Sound Buzzer
- 	PORTC |= (1<<buzzer);
- 	//	Shutdown
- 	PORTD |= (1<<PD7);
- 	//	Send A GSM
- 	us_wr_cmd("AT\r");
- 	_delay_ms(10);
- 	us_wr_cmd("ATE0\r");
- 	_delay_ms(10);
- 	us_wr_cmd("AT+CMGF=1\r");
- 	_delay_ms(10);
- 	us_wr_cmd("AT+CMGS=");
- 	us_wr_str("\"+2348061193690\"");
- 	us_wr_ch('\0');

```
•           us_wr_ch('\r');
•
•           us_wr_str("Leakage Detected");
•           us_wr_ch(26);
•
•           _delay_ms(500);
•   }
•
•   void Int_init()
•   {
•           GICR = (1<<INT1);
•           MCUCR = (1<<ISC01) | (1<<ISC11);
•           sei();
•   }
•   int main(void)
•   {
•           DDRB = 0xFF;
•           DDRC = (1<<rs) | (1<<rw) | (1<<en) | (1<<buzzer);
•           DDRA &= ~(1<<button);
•           DDRA &= ~(1<<sense);
•           DDRD |= (1<<PD7);
•
•           init_LCD();
•           LCD_cmd(0x0C);
•           _delay_ms(50);
•
•           LCD_string("   ");
•           _delay_ms(10);
•           LCD_cmd(0x0F);
•   LCD_string("WELCOME!!!");
•
•           LCD_cmd(0x0C);
```

- _delay_ms(50);
-
- LCD_cmd(0xC0);
- LCD_string(" ");
- _delay_ms(10);
- LCD_cmd(0x0F);
- LCD_string(">>By: Korbli<<");
- LCD_cmd(0x0C);
- _delay_ms(500);
-
- // USART>>GSM
- us_Init();
- // Interrupt
- Int_init();
-
- adc_init();
- LCD_cmd(0x01);
- LCD_cmd(0x80);
- LCD_string("MONITORING LPG");
- LCD_cmd(0xC2);
- LCD_string(" LEAKAGE ");
-
- while(1)
- {
- //TODO:: Please write your application code
- }
- }
- // Initialize the USART>>GSM
- void us_Init()
- {
- UCSRB |= (1<<RXEN) | (1<<TXEN); // Enabling character transmission and reception

- UCSRC |= (1<<URSEL) | (1<<USBS) | (1<<UCSZ0) | (1<<UCSZ1);
  // Using 8-bit char sizes
- // BAUD value
- UBRRL = PRESCALE;
- UBRRH = (PRESCALE >> 8);
- }
- // Write in Characters
- void us_wr_ch(unsigned char ch)
- {
- while ((UCSRA & (1 << UDRE)) == 0); // Wait till UDR is ready
- UDR = ch; // Write in/send data
- }
- // String of characters
- void us_wr_str(const char *msg)
- {
- while (*msg != '\0')
- {
- us_wr_ch(*msg);
- msg++;
- _delay_ms(10);
- }
- us_wr_ch(13);
- }
- void us_wr_cmd(const char *msg)
- {
- while (*msg != '\0')
- {
- us_wr_ch(*msg);
- msg++;
- _delay_ms(10);
- }

- }
-
-
- /*
- >   All LCD functions to display data
- >   on the LCD screen
- */
- /* Initialize the LCD */
- void init_LCD(void)
- {
-     LCD_cmd(0x38);
-     _delay_ms(1);
-     LCD_cmd(0x01);
-     _delay_ms(1);
-     LCD_cmd(0x02);
-     _delay_ms(1);
-     LCD_cmd(0x06);
-     _delay_ms(1);
-     LCD_cmd(0x80);
-     _delay_ms(1);
-
-     return;
- }
- void LCD_cmd(unsigned char cmd)
- {
-     LCD_Data = cmd;   //   Set data lines to send commands
-     PORTC &= ~(1<<rs);// Set RS to 0
-     PORTC &= ~(1<<rw);   // Set RW to 0
- PORTC |= (1<<en);
-     _delay_ms(100);

```
•           PORTC &= ~(1<<en);
•           return;
•   }
•   void LCD_write(unsigned char data)
•   {
•           LCD_Data = data;
•           PORTC |= (1<<rs);
•           PORTC &= ~(1<<rw);
•           PORTC |= (1<<en);
•           _delay_ms(100);
•           PORTC &= ~(1<<en);
•           return;
•   }
•   void LCD_string(char * str)
•   {
•           while(*str)
•           {
•                   LCD_write(*str);
•                   str ++;
•           }
•   }
•
•   void adc_init()
•   {
•           ADMUX = (1<<REFS0);
•
•           ADCSRA = (1<<ADEN) | (1<<ADATE) | (1<<ADPS0) | (1<<ADPS1) |
    (1<<ADPS2);
•   }
•   int adc_read()
•   {
•           ADMUX = 0b11110000;
```

- ADCSRA |= (1<<ADSC); // Start Conversation
- while(ADCSRA & (1<<ADSC)); // Wait till finish conversation
-
- return (ADC);
- }
- int leak_det(int val)
- {
- int temp = (((long)165 * (long)val)/(long)1023) + (-40);
- return temp;
- }
-