CHAPTER 1

INTRODUCTION

1.1 Background Of Study

This paper discusses the research done on the cases of gas leakage around the world even including that occurs in our country. Recently, there have been few cases that involved the ammonium gas leakage in Malaysia. The newest one happened in Johor Baharu on 14th August 2009, where it involved 2 factory workers inhale ammonia gas due to leakage from the factory itself. Both of them are now in weak condition and having trouble to breathe [1]. Another case happened on 11th August 2009 at Tanjung Karang and here is some part of the news:-

> "Six men, comprising four locals and two Bangladeshis, died after inhaling ammonia gas leaked from a refrigerator at Kampung Bagan Pasir here this morning. Selangor Fire and Rescue Department director Soiman Jahid said the department received information on the case at 8.59am. A team of fire and rescue personnel arrived at the scene 10 minutes later and found that five others were experiencing breathing difficulties, he said, adding that the personnel took immediate steps to contain the leakage. He said that the six victims were rushed to the Tanjung Karang Hospital where they were pronounced dead on arrival." [2]

There are also cases involved at the international. The author has done some research on the internet and found a website [3] shows that gas leakage is fatal to human being. The website showed that around 200 people fell ill after an ammonia gas leak at a pharmaceutical plant in north China's Inner Mongolia Autonomous Region [2].

Hence, the author chose to do topic on gas leakage detector as it can help people to know the leakage before an accident can happen.

1.2 Problem Statement

Since gas leakage is fatal to human beings, it is therefore necessary to build a portable device to detect gas using catalytic sensor.

1.3 Objective

The objective is to design and construct a portable sensor based gas leakage detector. The device will be efficient; cost effective and user friendly.

1.4 Scope Of The Study

The device is only limited to detection of flammable gas specifically propane gas also known as liquefied petroleum gas (LPG) and can be used at home and factory**.** The devices used the catalytic type of sensor.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory

In order to fully understand the project, the author read some studies on type of gases that could be fatal for human. These are some information regarding the type of gases that were found in the website.

Liquefied petroleum gas (also called LPG) is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, and increasingly replacing chlorofluorocarbons as an aerosol propellant and a refrigerant to reduce damage to the ozone layer [4].

Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and the more common, mixes including both propane C_3H_8 (60%) and butane C_4H_{10} (40%), depending on the season — in winter more propane, in summer more butane. Propylene and butylenes are usually also present in small concentration. A powerful odorant, ethanethiol, is added so that leaks can be detected easily.

LPG is a low carbon emitting hydrocarbon fuel available in rural areas, emitting 19 percent less CO_2 per kWh than oil, 30 percent less than coal and more than 50 percent less than coal-generated electricity distributed via the grid. Being a mix of propane and butane, LPG emits less carbon per joule than butane but more carbon per joule than propane. As a low carbon, low polluting fossil fuel, LPG is recognized by governments around the world for the contribution it can make towards improved indoor and outdoor air quality and reduced greenhouse gas emissions. LPG is widely available and can be used for hundreds of commercial and domestic applications. Moreover, LPG is now being used alongside renewable technologies, as well as with decentralized electricity generation (Combined heat and power systems — See Uses - Rural heating) to help reduce carbon emissions on a local level.

The gases mentioned above show how hazardous they can be if not prevented.

2.1.1 What Is Gas?

According to [8], the name gas comes from the word “chaos”. Basically, the molecules of gases move randomly and constantly colliding with each other and anything else around it. They move at a very high speed and due to this matter, they will mix rapidly into any atmosphere in which they are released. There are three main types of gas hazard which is **flammable**, **toxic** and **asphyxiated**. The objective of this report is to explain more on hazardous gas type of toxic.

2.1.2 Toxic Gas Hazards

Some gases are poisonous and can be dangerous to life at very low concentrations and some toxic gases have strong smells like the distinctive ‘rotten eggs’ smell of H2S. The measurements most often used for the concentration of toxic gases are parts per million (ppm) and parts per billion (ppb).

More people die from toxic gas exposure than from explosions caused by the ignition of flammable gas. It should be noted that there is a large group of gases which are both combustible and toxic, so that even detectors of toxic gases sometimes have to carry hazardous area approval. The main reason for treating flammable and toxic gases separately is that the hazards and regulations involved and the types of sensor required are different.

As mentioned in [8], it tells us that the effect on workers of exposure to the low concentration of hazardous gas that which being inhaled, ingested or absorbed through skin is the main concern. It is important not only to measure the concentration of gas, but also the total time of exposure. There are even some known cases of synergism, where substances can interact and produce a far worse effect when together than the separate effect of each on its own.

Concern about concentrations of toxic substances in the workplace and houses focus on both organic and inorganic compounds, including the effects they could have on the health and safety of human life's and also the subsequent disruption of normal daily activities.

2.1.3 Toxic Exposure Limits

There are several type of toxic exposure limits according to the national authorities, which some of them are the **European Occupational Exposure limits, US Occupational Exposure Limits** and **Malaysia Occupational Exposure Limits**. Below are some explanations on both types of toxic exposure limits [13][APPENDIX H].

- European Occupational Exposure Limits:

Occupational Exposure Limit values (OELs) are set by competent national authorities or other relevant national institutions as limits for concentrations of hazardous compounds in workplace air. OELs for hazardous substances represent an important tool for risk assessment and management and valuable information for occupational safety and health activities concerning hazardous substances.

Occupational exposure limits in the UK function under the Control of Substances Hazardous to Health Regulations (COSHH). The COSHH regulations require the employer to ensure that the employee's exposure to substances hazardous to health is either prevented or if not practically possible, adequately controlled. As of 6 April 2005, the regulations introduced a new, simpler Occupational Exposure Limit system. The existing requirements to follow good practice were brought together by the introduction of eight principles in the Control of Substances Hazardous to Health (Amendment) Regulations 2004.

- US Occupational Exposure Limits:

The Occupational Safety systems in the United States vary from state to state. Here, Information is given on 3 major providers of the Occupational Exposure Limits in the USA - ACGIH, OSHA, and NIOSH. The American Conference of Governmental Industrial Hygienists (ACGIH) publishes Maximum Allowable Concentrations (MAC), which were later renamed to "Threshold Limit Values" (TLVs) [13].

- Malaysia Occupational Exposure Limits:

The Occupational Safety & Health Act 1994 (*Use and Standard of Exposure of Chemical Hazardous to Health, USECHH*) Regulations 2000 - Part VII, Section 25; prescribes that Chemical Safety Data Sheet (CSDS) shall be kept in a conspicuous place close to each location where that chemical is used, and shall be easily accessible to the employees [APPENDIX H].

2.1.4 *Typical Areas That Required Gas Detection*

As mentioned in [8], there are many different applications for flammable, toxic and oxygen gas detection. Industrial processes increasingly involve the use and manufacture of highly dangerous substances, particularly toxic and combustible gases. Inevitably, the gas leakages still occur, which create a potential hazard to the industrial plant, its employees and people living nearby. Worldwide incidents involving asphyxiation, explosions and loss of life, are a constant reminder of this problem. This is also important to the area such as the houses where liquefied petroleum gas (LPG) are in use that no one can detect the leakage rather than smell it and by the time people realize, it's always too late.

There is a case from California from the article [9], where gas leakage occurs at the Ventura oil field. There were 3 death reports from the tragedy, where two of them died during the incident and shows that the important of using the gas detector.

In most industries, one of the key parts of the safety plan for reducing the risks to personnel and plant is the use of early warning devices such as gas detectors. These can help to provide more time in which to take remedial or protective action and this will improve the safety system for an industrial plant.

2.1.5 *Principle of Detection*

Referring to the article [8], many people have probably seen a flame safety lamp at some time and know something about its use as an early form of 'firedamp' gas detector in underground coal mines and sewers. Although originally intended as a source of light, the device could also be used to estimate the level of combustible gases- to an accuracy of about 25-50%. Modern combustible gas detectors have to be much more accurate, reliable and repeatable than this and although various attempts were made to overcome the safety lamp's subjectiveness of measurement, it has now been almost entirely superseded by more modern, electronic devices.

Nevertheless, the most commonly used device, the catalytic detector, is in some respect a modern development of the early flame safety lamp, since it also relies for its operation on the combustion of a gas and its conversion to carbon dioxide and water.

Nearly all modern, low-cost, combustible gas detection sensors are of the electro-catalytic type. They are made of an electrically heated platinum wire coil (as in Figure 1), covered first with a ceramic base such as alumina and then with a final outer coating of palladium or rhodium catalyst dispersed in a substrate of Thorium Dioxide (formerly known as Thoria) [10].

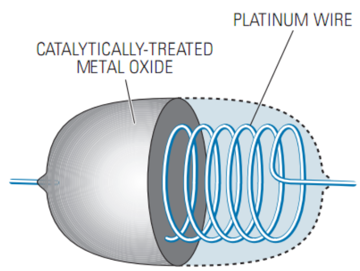

Figure 1: Catalytic Bead Sensor.

This type of sensor operates on the principle that when a combustible gas/air mixture passes over the hot catalyst surface, combustion occurs and the heat evolved increases the temperature of the 'bead'. This in turn alters the resistance of the platinum coil and can be measured by using the coil as a temperature thermometer in a standard electrical bridge circuit. The resistance change is then directly related to the gas concentration in the surrounding atmosphere and can be displayed on a meter or some similar indicating device.

To ensure temperature stability under varying ambient conditions, the best catalytic sensors use thermally matched beads. They are located in opposing arms of a Wheatstone bridge electrical circuit (as in Figure 2), in honor of English physicist and inventor Sir Charles Wheatstone (1802-75), where the 'sensitive' sensor (usually known as the 's' sensor) will react to any combustible gases present, whilst a balancing, 'inactive' or 'non-sensitive' (n-s) sensor will not. Inactive operation is achieved by either coating the bead with a film of glass or de-activating the catalyst so that it will act only as a compensator for any external temperature or humidity changes [10].

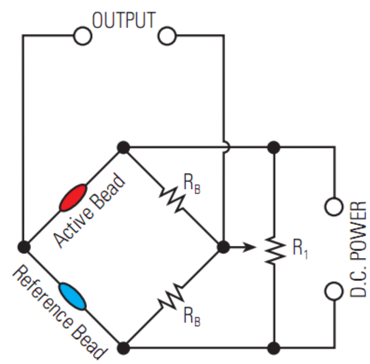

Figure 2: Wheatstone Bridge – a circuit for measuring unknown resistance by comparing it with known resistances.

A further improvement in stable operation can be achieved by the use of poison resistant sensors. It has better resistance to degradation by substances such as silicones, sulfur and lead compounds which can rapidly de-activate (or 'poison') other types of catalytic sensor.

To achieve the necessary requirements of design safety, the catalytic type of sensor has to be mounted in a strong metal housing behind a flame arrestor. This allows the gas/air mixture to diffuse into the housing and on to the hot sensor element (as in Figure 3), but will prevent the propagation of any flame to the outside atmosphere [10]. The flame arrestor slightly reduces the speed of response of the sensor but, in most cases the electrical output will give a reading in a matter of seconds after gas has been detected.

Figure 3: Hot Wire Sensor.

2.1.6 Location of Sensors

Questions that are commonly asked about the gas detection system; ‘How many detectors do I need?’ and ‘Where should I locate them?’ and probably two of the most difficult to answer. Unlike other types of safety related detectors, such as smoke detectors, the location and quantity of detectors required in different applications is not clearly defined. The placement of detectors should be determined following the advice of experts having specialist knowledge of gas dispersion, experts having knowledge of the process plant system and equipment use, safety and engineering personnel.

According to the article [8], the detectors should be mounted where the gas is most likely to be present and locations that required the most protection in an industrial plant such as around gas boilers, compressors, pressurized storage tanks, cylinders or pipelines. Areas where leaks are most likely to occur are valves, gauges, flanges, T-joints, filling or draining connections etc.

Listed below are a number of simple and quite often obvious considerations that can help to determine detector location:

- To detect gases that are lighter than air (e.g. Methane and Ammonia), detectors should be mounted at high level and preferably use a collecting cone.

- When locating detectors consider the possible damage caused by natural events e.g. rain or flooding. For detectors mounted outdoors it is preferable to use the weather protection assembly.
- Use a detector sunshade if locating a detector in a hot climate and in direct sun.
- Consider the process conditions. Butane and Ammonia, for instance are normally heavier than air, but if released from a process line that is at an elevated temperature and/or under pressure, the gas may rise rather than fall.
- Detectors should be positioned a little way back from high pressure parts to allow gas clouds to form. Otherwise any leak of gas is likely to pass by in a high speed jet and not be detected.
- Consider ease of access for functional testing and servicing.
- Detectors should be installed at the designated location with the detector pointing downwards. This ensures that dust or water will not collect on the front of the sensor and stop the gas entering the detector.

2.2 Hazardous Location

Hazardous locations mean the location of as those areas where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flying. Based on the article [7], it state that the location can be classified depending on the properties of the flammable gas, flammable liquid-produced vapor, combustible-liquid produced vapors, combustible dust or fiber that may be present.

There are 3 classes of hazardous location that can be defined [see Table 1].

Table 1: Class of hazardous locations

Class	*Explosive Danger*
Class I	**Flammable gases or vapors**
Class II	Combustible dusts
Class III	Combustible fibers or flying

Refer to the Table 1 above, Class 1 have been chosen as it involved with gas or vapors.

2.2.1 Division of Class 1

From Class 1 there can be more division of a location that defines the frequency that hazard may exist in a location.

A. Class I, Division 1 location:

Ignitable concentrations of flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, or combustible liquids above their flash points.

- Which can exist under normal operating conditions
- Which may exist frequently because of repair, maintenance operations, or leakage
- This might be released due to a breakdown or faulty operation of equipment or processes, and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition.

B. Class I, Division 2 location:

Volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors.

- Are handled, processed, or used, but they will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown
- Are normally prevented from becoming ignitable by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment
- (or combustible liquid-produced vapors above their flash points) Might occasionally be communicated by virtue of being adjacent to a Class I, Division 1 location, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

2.2.2 Protection Method

Nowadays, there are variety of method that are available for hazardous location including encapsulation, oil immersion, powder filling and hermetic sealing, but these are use mostly in Oil and Gas industry. However, most of the instrumentation needs to be accessible from time to time; the protection method can be used for fixed, continuous gas monitoring system (such as portable gas detection system) needs equipment that is explosion proof and intrinsically safe. Hence, the author chooses to do a portable detector that can easily be moved around by everybody so that when the leakage happens, people will be aware about it.

Information about the hazardous location helps the author in figuring out that gas detection installation in hazardous location can be complex.

2.3 Gas Detection System

In [11], the gas detection is an important element in an overall protection plan for life and property. Gas detection system is used in conjunction with other forms of fire detection such as smoke, heat or flame detectors.

Listed below are the typical applications for the gas detectors:

- Wherever highly combustible gases are involved;
- Where there is a need for instantaneous response to gas; and
- Where there is a large capital investment to be protected.

2.3.1 Types of Gas Detector Available

- *Catalytic Gas Detectors*

Catalytic sensor technology uses a pair of computer matched elements in a Wheatstone bridge circuit [15]. Combustible gases and vapours are detected as they oxidize on the active catalytic element. This reaction produces a differential voltage that is proportional to the gas concentration present up to its lower explosive limit (LEL).

Table 2: Advantages and Disadvantages of Catalytic Gas Detector

Advantages	**Disadvantages**
Comparative low cost	Routine calibration is required
Respond to virtually any flammable / combustible gas	Sensors wear out over a period of time
	Do not sense non combustible gases
	Sensors can be poisoned

- *Infrared Gas Detectors*

Infrared gas detection is used to detect combustible levels of hydrogen gases and vapours, based on the absorption of energy by hydrocarbons. There are two types of detection, **point** and **open path**. A point type detector is located as close to the risk as possible and samples around the risk e.g. a storage tank. In the detector a beam of IR energy is emitted between a source and detector, any attenuation caused by hydrocarbons in the short beam being electronically processed to give a reading in LEL. Commonly a reference beam is utilized to overcome any reduction in beam intensity due to of the optics being impaired e.g. fog, and temperature changes [15].

Table 3: Advantages and Disadvantages of Infrared Gas Detector (Point Detector)

Advantages	**Disadvantages**
Responds to many hydrocarbon gases	Cannot measure non hydrocarbons e.g. hydrogen
Highly resistant to poisoning and etching	
Limited maintenance required	
Long sensor life – some manufacturers offer a 5 year warranty	
Minimal drift	
Unaffected by oxygen depleted or enriched environments	

Table 4: Advantages and Disadvantages of Infrared Gas Detector (Open Path Detector)

Advantages	Disadvantages
Ideal for open areas without obstructions	Cannot measure non hydrocarbons e.g. hydrogen
Ideal for open areas without obstructions	
Limited maintenance required	
Fast response time	

- *Electrochemical Gas Detector*s

Electrochemical sensors are designed to be highly selective and are capable of detecting concentrations in the parts per million range (ppr). Gases detected include oxygen, hydrogen sulphide, carbon monoxide, nitrogen dioxide and sulfur dioxide. The sensors utilize multiple electrodes immersed in an electrolyte. As gas diffuses into the sensor an electrochemical reaction occurs, which produces a current that is proportional to the gas concentration.

Table 5: Advantages and Disadvantages of Electrochemical Gas Detector

Advantages	Disadvantages
Cost effective protection	Require a certain amount of humidity to correctly function
High sensitivity	Sensors ‘wear out’ over time
	Sensors can be poisoned by foreign material

Based on the readings made, the author decided to detect flammable gas, which is propane. The constructed gas leakage detector (GLD) device can be carried or simply handheld.

CHAPTER 3

METHODOLOGY

3.1 PROCEDURE IDENTIFICATION

This project begins with some research work about detector and its components. The project flow as below:

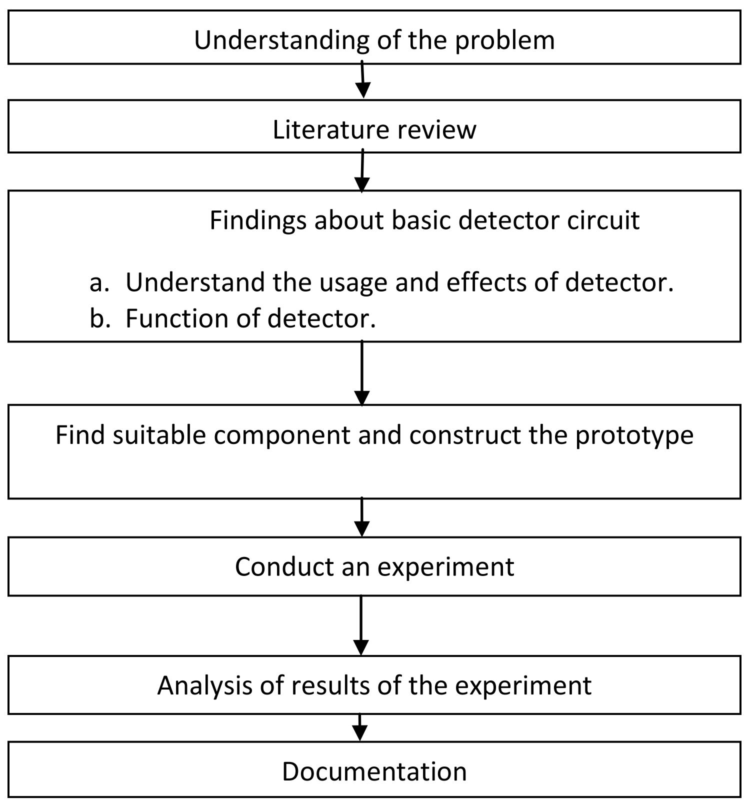

Figure 4: Project Work Flow diagram.

3.2 ANALYSIS TECHNIQUES

After knowing the whole idea of building a circuit for the detector system, the author revised some plans in order to build the circuit. The analysis technique can be done using:

- Experimental analysis by conducting circuit of detector system

3.3 TOOLS AND EQUIPMENT REQUIRED

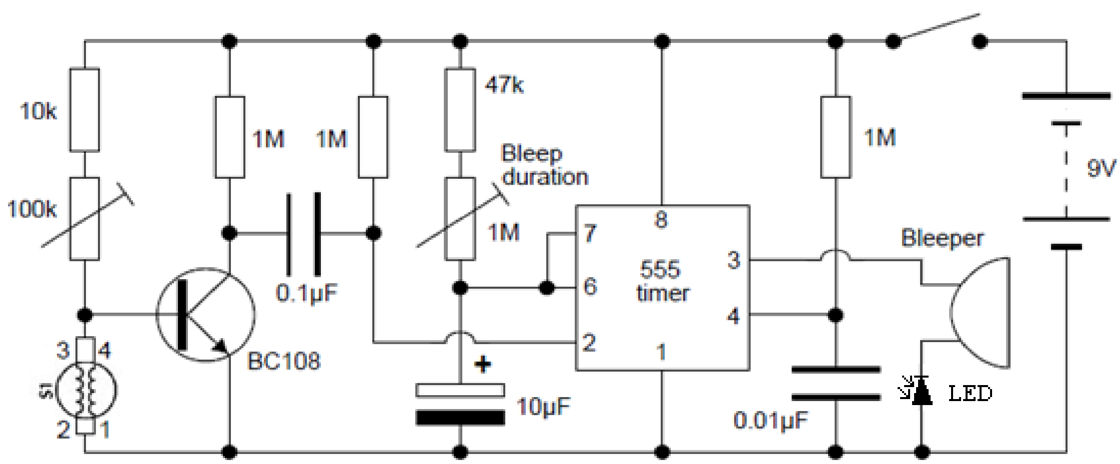

Figure 5: Basic circuit

3.3.1 Part Required

<u>Resistors</u>: 10kΩ, 47kΩ, 1MΩ ×3

A resistor is a two-terminal electronic component that produces a voltage across its terminals that is proportional to the electric current passing through it in accordance with Ohm's law:

$$V = IR \qquad (1)$$

Resistors are elements of electrical networks and electronic circuits and are ubiquitous in most electronic equipment. The primary characteristics of a resistor are the resistance, the tolerance, maximum working voltage and the power rating. Other characteristics include temperature coefficient, noise, and inductance [APPENDIX D].

7555 low-power timer IC

The 555 has three operating modes [APPENDIX F]:

Monostable mode	The 555 functions as a "one-shot". Applications include timers, missing pulse detection, bounce free switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) etc
Astable	The 555 can operate as an oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation, etc.
Bistable mode or Schmitt trigger	The 555 can operate as a flip-flop, if the DIS pin is not connected and no capacitor is used. Uses include bounce free latched switches, etc.

Presets: 100kΩ, 1MΩ

Preset is a three-terminal resistor with a sliding contact that forms an adjustable voltage divider. If only two terminals are used (one side and the wiper), it acts as a *variable resistor* or *rheostat*. Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment.

Capacitors: 0.01μF, 0.1μF, 10μF 25V radial

A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric (insulator). When a potential difference (voltage) exists across the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the conductors [APPENDIX D].

Buzzer 9V

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or electronic. Typical uses of buzzers and beepers include alarms, timers and confirmation of user input such as a mouse click or keystroke [APPENDIX G].

Transistor: BC108 (or equivalent)

A transistor is a semiconductor device used to amplify and switch electronic signals. It is made of a solid piece 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 flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal [APPENDIX E].

Sensor: TGS2610

Features	* High selectivity to LP gas * Low power consumption * Small size * Long life and low cost * Uses simple electrical circuit
Applications	* Residential LP gas leak detectors * Recreational vehicle LP gas leak detectors

This can refer in APPENDIX C.

3.3.2 Design for the Detector

The author decided to make enhancement on the basic circuit from Figure 5, where it will be installed with one type of sensor;

- Sensor 1: Detect the LPG Gas

The detector will also install one LED to show that the sensor is detecting the leakage so that the user will be aware that there is gas leaking.

In order to provide more protection to the user, the device will be installed with buzzer so that when it detects the leakage the user can react to take immediate action when there is buzzing sound.

3.3.3 How the Circuit Works

The toxic-gas alarm shown in Figure 5 uses a tin-oxide-semiconductor sensor. The sensor's resistance lowers as the sensor is exposed to toxic gases, which is propane as the dominant gas in LPG. When the threshold voltage on the gate is reached, an alarm buzzer is activated. Once triggered, the buzzer sounds and LED will turn on. The length of bleep can be varied from 0.5 to 10 seconds using the 1MΩ preset. Using the 7555 low-power timer ensures that the circuit draws very little current (about 0.5mA) except for the short times when the bleeper is sounding (this uses about 7mA). The sensitivity control 100kΩ preset (R_L) can be adjusted to the desired value prior to triggering the sensor.

3.3.4 Basic Measuring Circuit

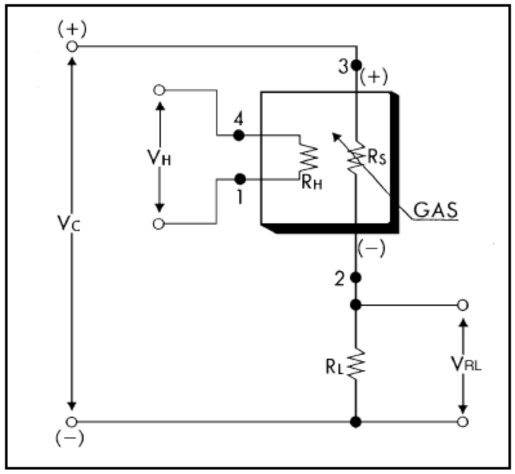

Figure 6: Basic measuring circuit

Figure 6 shows that the circuit voltage (Vc) is applied across the sensor element which has a resistance (Rs) between the sensor's two electrodes and the load resistor (R_L) connected in series. The Vc may be applied intermittently. The sensor signal (VR_L) is measured indirectly as a change in voltage across R_L. The Rs formula is:

$$Rs = \frac{Vc - \mathrm{VRL}}{VRL} \times RL \qquad (2)$$

3.4 CIRCUIT PROTOTYPE

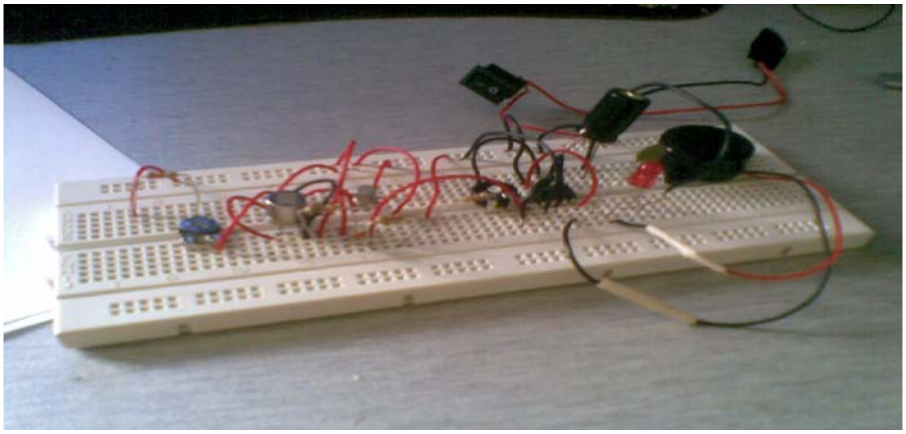

Figure 7: Circuit of Gas Detector on the Breadboard

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT

A series of experiment had been conducted in order to prove the sensitivity of the sensor by using the circuit in Figure 5. The author did an experiment using the circuit by using different set of values of R_L which in this circuit, it is the 100kΩ preset as it is used to control the sensitivity of the gas sensor. The experiment was conducted in the chemical lab using the LPG type of gas mainly iso-butane gas or also known as Propane.

Figure 8 and Figure 9 shows some characteristics from the datasheet of the gas sensor from APPENDIX C and the Ro, the sensor resistance when 1800ppm of gas acquired from the experiment is 8.53kΩ.

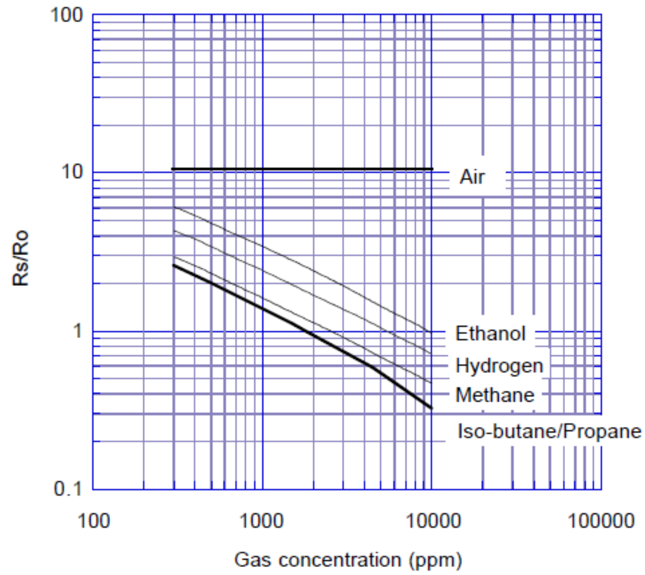

Figure 8: Sensitivity to various gas (Rs/Ro)

Figure 8 shows the relative of sensitivity of the sensor to various gases but in this project, I just focus on iso-butane/propane gas. On the Y-axis shows the ratio of the sensor resistance in various gases (Rs) to the sensor resistance in 1800ppm of iso-butane (Ro).

Using the basic measuring circuit illustrated in Figure 6 and with matched R_L value equivalent to the Rs value in 1800ppm of iso-butane/propane, will provide the sensor output voltage (VR_L) change as in Figure 9.

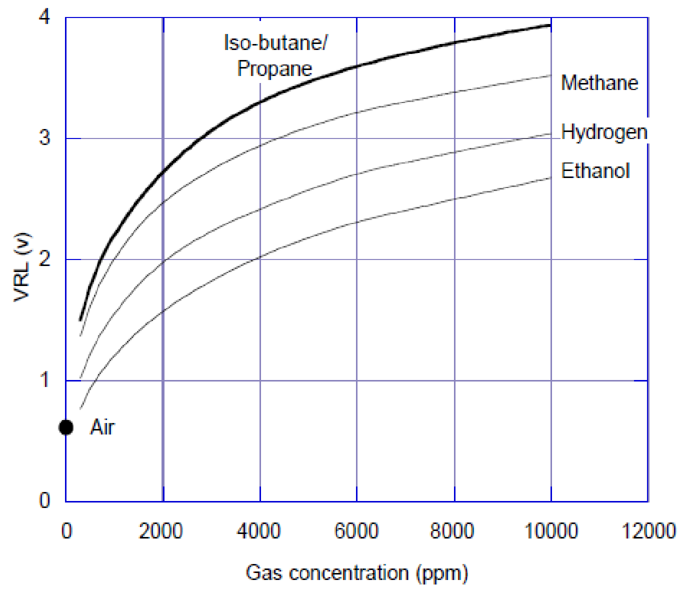

Figure 9: Sensitivity to various gases (VR_L)

Then, the author conducted an experiment by having different values of R_L to show that by having smaller value of R_L, we can have lower value of ppm of propane gas. This can be approved by the following Figure 10 and Figure 11, where the graph shows that increase in R_L and VR_L will increase the propane gas ppm.

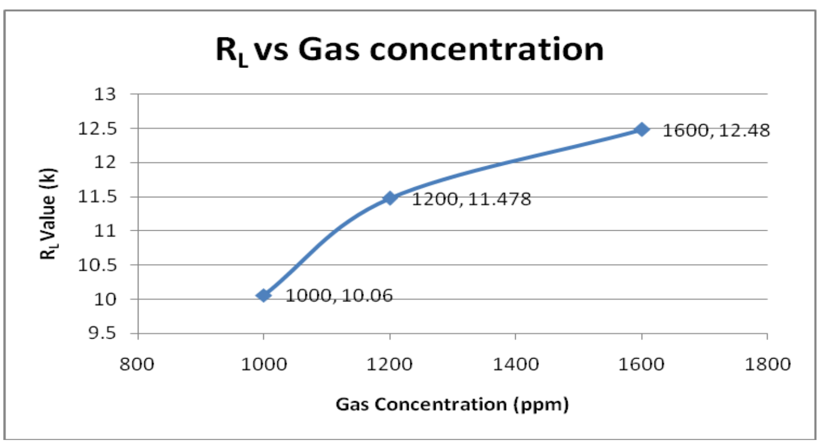

Figure 10: Graph of R_L versus gas concentration

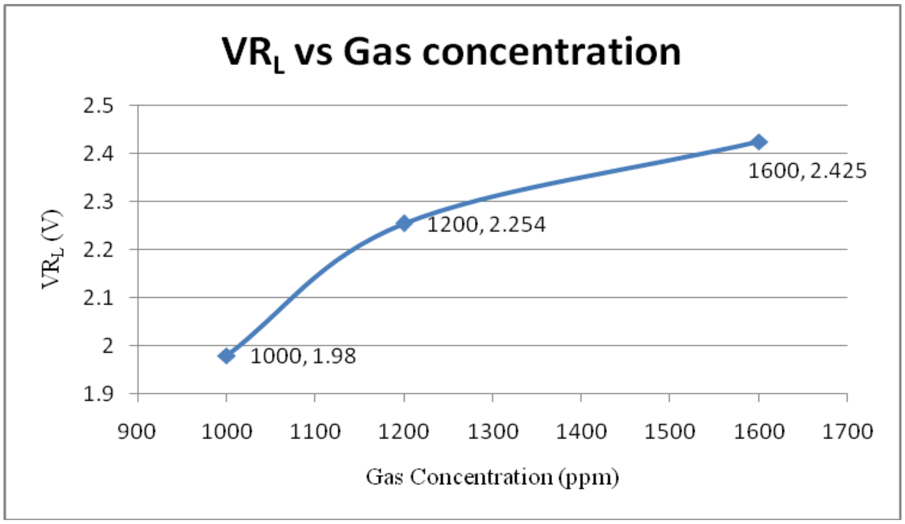

Figure 11: Graph of VR_L versus gas concentration

This can be proven by comparing with the sensitivity characteristic as of in Figure 8 and Figure 9 from the LPG sensor datasheet in APPENDIX C.

4.2 DISCUSSION

From Figure 10 and Figure 11 above, the author computed the value of R_L and gets the value of i_L using ammeter, see Table 6 below.

Table 6: Value of R_L and i_L at certain ppm of iso-butane gas

R_L (kΩ)	i_L (mA)	ppm
10.06	0.197	1000
11.478	0.196	1200
12.48	0.194	1600

From the table above, the value during the experiment which was conducted in the lab showed that the larger the value of R_L the higher the gas concentration (ppm) and the author have done three trials with three different values of R_L. The R_L

was set at 10.06 kΩ and the alarm detects at 1000ppm, at 11.478 kΩ and the alarm detects at 1200ppm and at 12.48 kΩ, it detect at 1600ppm.

It was decided to set the detector in order to detect at 1000ppm as in [16], it stated that the current standard permissible exposure limit (PEL) by Occupational, Safety and Health Administration (OSHA) is been set at 1000ppm averaged on eight-hour shift.

If compared with the result from datasheet, the VR_L value for the detector is 1.98 V. If refer to the Figure 11, at 1000ppm the value of VR_L is about 2.1 V and for this project the VR_L is 1.98 V. It is proven that both values do not differ very much. From Figure 8, Rs/Ro need to be known as Ro is already known for 8.53kΩ. Now, the value of Rs can be calculated by using formula stated below [APPENDIX C].

$$Rs = \frac{Vc - V\mathrm{RL}}{VRL} \times RL \tag{2}$$

$$Rs = \frac{4.98\,V - 1.98\,V}{1.98\,V} \times 10.06\,k\Omega = 15.24\,k\Omega$$

$$\frac{Rs}{Ro} = \frac{15.24}{8.53} = 1.79$$

From equation above, Rs/Ro = 1.79 for 1000ppm of iso-butane/ propane gas and from Figure 8, the result is almost the same as in the datasheet for the sensor where the Rs/Ro for the sensor at 1000ppm is about 1.5 so there is only a slight different of value for the experiment and the characteristic of the sensor.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a result of the experiment conducted using the sensor based gas leakage detector, the constructed prototype can trigger the alarm and red LED is on when it is detects the leaked gas (propane). The device can detect as desired for the project. The constructed device made use of a catalytic sensor and for this project, the ppm set is at 1000ppm with RL at 10.06kΩ and the alarm time was set for duration of 10 seconds.

By knowing the value of the ppm of the gas leakage, the sensitivity of the sensor can be determined. Thereby, the objective and scope of study for this project has been achieved.

5.2 RECOMMENDATION

Although this project has achieved its objective, it can still be enhanced, so it is recommended that the alarm time should be increased from 10 seconds to 30 seconds.

Further test the circuit design to determine its efficiency before final construction of the prototype.

The detector can also be upgraded to multi gas sensor so that it will not just be limited to iso-butane/propane gas.

REFERENCES

[1] Austin Camoens *"Another Ammonia Leak, 2 Hurt This Time"* The Star *http://thestar.com.my/news/story.asp?file=/2009/8/14/nation/20090814145850&sec=nation* modified on August, 14th 2009.

[2] Shaun Ho and Joshua Foong *"6 Die of Ammonia Poisoning"* *http://thestar.com.my/news/story.asp?file=/2009/8/12/nation/4502212&sec=nation* modified on 12th August 2009.

[3] Xinhua *"202 People Ill after Ammonia Leak in Inner Mongolia"* *http://en.kunming.cn/index/content/2009-08/05/content_1937740.htm* modified on August, 5th 2009.

[4] Wikipedia "*Liquefied Petroleum Gas*" *http://en.wikipedia.org/wiki/Liquefied_petroleum_gas* modified on June, 8th 2010.

[5] ATSDR "*ToxFAQs™ for Ammonia*" *http://www.atsdr.cdc.gov/tfacts126.html* modified on February, 18th 2010.

[6] Florin "*Gas Detector Circuit*" *http://www.youritronics.com/gas-detector-circuit/* modified on March, 27th 2008.

[7] Interscan Corporation *"Gas Detection Knowledge Base"* *http://www.gasdetection.com/kb/index.php?article=47* modified on February, 20th 2008.

[8] JJS Technical Services "*Gas Detection Principle*" *http://www.jjstech.com/gasdepr.html* accessed on September, 6th 2009.

[9] Tim Herdt "*Spill Off State's Coast May Create Bigger Problems*" *http://www.vcstar.com/news/2010/apr/29/oil-spill-off-california-could-create-bigger-say/* accessed on September, 9th 2009.

[10] Jack Chou "*Hazardous Gas Monitors: A Practical Guide to Selection, Operation and Applications*" pg. 37-45 2000 *http://www.intlsensor.com/pdf/catalyticbead.pdf* accessed on August, 25th 2009.

[11] Ampac Industries "*Flame and Gas Detection Handbook*" *http://www.iceweb.com.au/Technical/flame_and_gas.htm#GAS%20DETECTION* accessed on August, 20th 2009.

[12] Explore Circuits "*Toxic Gas Sensor*" *http://www.explorecircuits.com/circuit/cir_toxic_gas_sensor.htm* accessed on September, 6th 2009.

[13] European Agency for Safety and Health at Work "*Occupational Exposure Limits*" *http://osha.europa.eu/en/topics/ds/oel* accessed on August, 20th 2009.

[14] Thomas Petruzzellis "*The Alarm, Sensor & Security Cookbook*" TAB Books Imprint by McGraw Hill pg. 40-42 1994.

[15] Alexander G Kozlov "*Optimization of Structure and Power Supply Conditions of Catalytic Gas Sensor*" Sensors and Actuator B82 Pg. 24-33 2002

[16] U.S Department of Health and Human Services "*Occupational Health Guideline for LPG*" Pg. 1 September 1978 accessed on April, 28 2010.

APPENDICES

APPENDIX A: GANTT CHART – FYP 1 SCHEDULE

	PROJECT ACTIVITIES	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	• Project/Topic Selection														
2	• Data Gathering • Research and discussion on topic • Preparation for preliminary report														
3	• Research on Gas and Toxic Gas Hazard. • Define objective and scope of study. • Research on typical area require for detection. • Research on principles of detection.														
4	• Research on locations of sensors. • Research on hazardous location.														
5	• Research on the gas detection system.														
6	• Submission of preliminary report.														
7	• Seminar 1.														
8	• Research on circuit for the project.														
9	• Read books regarding project. • Update literature review. • Preparation and data gathering for final report and interim report.														
10	• Submission of Final Draft Report	21st October 2009													
11	• Submission of Interim Report	30th October 2009													
12	• Oral Presentation	30th November - 4th December 2009													

APPENDIX B: GANTT CHART – FYP 2 SCHEDULE

<table>
<tr><th rowspan="2"></th><th rowspan="2">PROJECT ACTIVITIES</th><th colspan="14">WEEK</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th></tr>
<tr><td>1</td><td>• Preparing report for Progress Report 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>• Ordering the gas sensor</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>• Preparing report for Progress Report 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>• Construct the circuit</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>• Research on the minimum level of ppm of propane leakage.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>• Experimenting the circuit in the chemical lab</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>• Preparing report for Draft and Final Report (Soft Cover)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>• Submission of Technical Report</td><td colspan="14">5th May 2010</td></tr>
<tr><td>9</td><td>• Submission of Final Report (Soft Cover)</td><td colspan="14">5th May 2010</td></tr>
<tr><td>10</td><td>• Submission of Final Report (Hard Cover)</td><td colspan="14">25th June 2010</td></tr>
<tr><td>11</td><td>• Oral Presentation</td><td colspan="14">7th June - 11th June 2010</td></tr>
</table>

APPENDIX C:
DATASHEET – TGS2610 SENSOR

APPENDIX D:
DATASHEET – RESISTOR AND CAPACITOR

APPENDIX E:
DATASHEET – TRANSISTOR

APPENDIX F:
DATASHEET - NE555 TIMER

APPENDIX G:
DATASHEET – BUZZER

APPENDIX H:
DATASHEET - CHEMICAL SAFETY