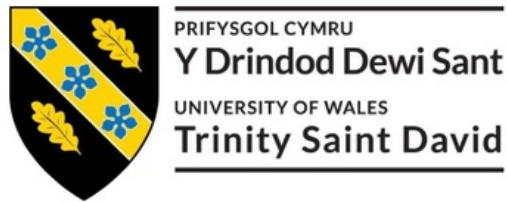


Angelo Amoruso Major Project

by Angelo Amoruso

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A Fire and Carbon Monoxide Alarm Device

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Project submitted as part of the requirements for the
award of BEng (Hons) Computer Systems and
Electronics

April 2016

DECLARATION

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Abstract

This project was to design and build a fully functional prototype of a Fire and Gas alarm. The reason for this project choosing this project was to create a safety device for the home that had both elements of a fire alarm and a Carbon Monoxide detector. This project is a personal interest as the safety device is a device that provides a service that can protect people, giving this project a goal of protecting life.

The overall aims of this project was to conduct a research to provide sensor types for the two different elements. Conduct a product research to see what is available and how it influenced the project for future enhancements. The aim to design the overall circuit on Proteus and a full circuit diagram and the overall aim or goal was to have a fully functional prototype of the Fire and Gas Alarm. The way in which this project was conducted was to read and learn about the different area that were involved, this process would involve researching about different topics about fire and gas then understand what it is these topics involved. The results that this project reviled were as expected. Results that were collect from testing the circuit was a positive set of results as it proved what the circuit simulation produced on Proteus was doing with very little variations in the outcomes. The overall conclusion of the project was that the project was a success, the design simulation worked as it was design and when the build and implementation of the code was completed there was a fully functional circuit prototype of the Fire and Gas alarm thus completing the overall aim to have a fully working circuit.

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1 CHAPTER I - INTRODUCTION

1.1 PROBLEM

The problem this reports aims to solve is the prevention of the deaths and injuries that occur in the home each year from house fires and gas leaks.

The problem can be broken down into two parts prevention of fire related home deaths and injuries and prevention of gas related home leaks and illnesses. The main problem in this topic is to design and create a fully functional prototype of a fire and gas alarm at an affordable cost.

There are a number of alarms on the market that offer the services of fire alarms and gas detectors but not many offer the service using both fire and gas as one unit. The product that offer both fire and gas alarm in one unit has a high cost value.

With the research into proper fire and gas safety regulations and laws, also the market research into available product and the marketability of the project. The aim of this project is to produce a working prototype that can be used to detect fires and gas leaks within the home.

1.2 MOTIVATION

The reason and motivation for the choosing of a fire and gas alarm device for the project was as a result of each year there are a many number of deaths, injuries and illnesses caused by fires and gas leaks that occur in the home. This can affect everyone in the UK and the rest of the world.

In these cases fires in the home occur more often than gas leaks but both are serious. With house fires and gas leaks children are the most vulnerable to these elements. As children are the future they need to be protected and feel safe in their own home. Also the parents of the children need the peace of mind that they and their children will be alerted to the presence of a fire (as most fires occur in the early hours when most families are asleep) quickly so that they can safely escape the house.

Furthermore the parents want to be alerted to the presence of Gas leaks as the most common gas that leaks in the home is Carbon Monoxide and it has no smell hence the nickname "Silent Killer." The result of this project can make the home a safer place giving the people the peace mind that their home is safe.

1.3 AIMS AND OBJECTIVES

1. Investigation into relevant Fire and Gas regulations.

- 1.1. Research the relevant fire laws, regulations and guides require for alarms and businesses, Schools.
- 1.2. Research the relevant Gas laws, regulations and guides require for alarms and businesses, Schools.

2. Investigation into fires that occurring in the home.

- 2.1. Research and evaluate the risks of fires in the home.
- 2.2. Analyse how and why most fires in the home are started.
- 2.3. Research and obtain the statistical number of deaths cause by house fires each year in the UK.

3. Investigation of Gas leaks and their dangers in the household.

- 3.1. Critically evaluate the risk of carbon monoxide leaks occur in the home each year.
- 3.2. Analyse the damages and effects of carbon monoxide poisoning.
- 3.3. Research and analyse the number of deaths caused by carbon monoxide.

4. Investigation into different sensors types

- 4.1. Research and identify the different sensor types for a fire alarm
- 4.2. Research and identify the different sensor types for a gas alarm
- 4.3. Identify the most suitable sensor for the fire alarm element.
- 4.4. Identify the most suitable sensor for the gas alarm element.

5. Investigation into similar products on the market.

- 5.1. Identify the different fire and gas alarms available for purchase.
- 5.2. Evaluate and compare the products, identifying key attributes.
- 5.3. Produce a comparison table to identify differences, similarities, advantages and disadvantages.

6. Investigation into Block diagrams and circuit designs for fire and gas alarms.

- 6.1. Identify and design a block diagram of a fire and gas alarms.
- 6.2. Examine circuit designs of both fire and gas alarms.
- 6.3. Establish a final circuit design that is suitable for a fire and gas alarm.

7. Investigation of components and costing for final circuit.

- 7.1. Establish the appropriate components that are required for the circuit.
 - 7.2. Identify how the sensor functions.
 - 7.3. Produce a costing table of the chosen
-

7.4. Assess the cost of the components and make a critical decision for the final circuit.

8. Building and implementation of the final fire and gas alarm circuit.

8.1. Analysis the design in preparation of the final build.

8.2. Construct final circuit prototype on a breadboard.

9. Assessment and testing of breadboard prototype.

9.1. Examine the breadboard to observe whether the circuit is achieving what it was designed to do.

9.2. Critically test the circuit to detect and eradicate any faults within the circuit.

9.3. Evaluate that the circuit is functioning as expected.

1.4 HOW PROBLEM WILL BE SOLVED

The way in which this project problem will be solved is by researching the relevant fire safety regulation that are required and the gas safety regulation that are also required. This gives an understanding of what will be best required for the fire and gas alarm.

The research into the available products on the market (i.e. fire alarms and gas alarms.) The research involves what type of sensor they uses, how they work, what they cost and the advantages and disadvantages they have.

Furthermore the research of the different sensor that could be used for this project will be carried out. This research involves how these sensors worked, what are the advantages and disadvantages of using these sensors and what they cost. After researching the different sensors the decision on which sensors are to be used giving the project direction.

Once that decision was complete the project design will now become the main focus how will the project come together. With the use of the software simulation program Proteus the design of the project will be created, after creating the design the use of coding will test the project. Providing an understanding how will the project work when the implementation stage is ready to be conducted.

Finally the implementation stage will include the build and testing of the fully functional Fire and Gas alarm. The build will be complete by using a breadboard to create the circuit and testing will involve the full circuit test, analysing to see if the circuit is acting as expected. Also the testing of the individual parts of the circuit to see what parts are working. This report will be finished with a evaluation of the project, a conclusion summing up the project, any recommendation and then a reflection on how the project went.

2 CHAPTER II RESEARCH AND LITERATURE REVIEW

This chapter of the report is the research and literature review it will outline a general explanation of how fire and gas alarms work, what are the relevant fire and gas safety regulations, statistics about fire and gas and their danger and the different sensors that can be used to detect these elements.

A fire and gas alarm is an alarm based device that is used to detect the presence of fires and gas leaks in a given area. These elements are detected by the use of heat detectors or smoke detectors for fire and gas sensors for the detection of gases.

2.1 FIRE SAFETY REGULATIONS

Fire is one of the biggest killers in the world, it does not discriminate, anyone or thing from people to animals to buildings, fire can effect and destroy lives in an instant. But this is preventable by the use of a device designed to detect fire and with the uses of some fire safety regulations.

Fire safety regulations are a set of regulations created to help people avoid fire and in the case of a fire how to not be injured or killed. But first a little bit of knowledge about what fire is will help also. Fire is a natural element that is used in everyday life as a result everyone is affected by it. Fire works by a chemical reaction that takes place between a fuel and oxygen.

Typically, fire comes from a chemical reaction between oxygen in the atmosphere and some sort of fuel (wood or gasoline for example). Of course, wood and gasoline don't spontaneously catch fire just because they're surrounded by oxygen. For the combustion reaction to happen, you have to heat the fuel to its ignition temperature.(1)

Fire only needs three things to start "A source of ignition (heat), a source of fuel (something that burns) and oxygen."(2) There are a number of things that can cause a fire to ignite. These can be everyday objects throughout the house, such as heaters, kitchen cooker and electrical equipment. Also most smokers carry around mini fire starters in their pockets called cigarettes and the things used to light the cigarettes matches and lighters.

In the UK the department for communities and local governments found that "Smokers material (e.g. cigarettes, cigars or pipe tobacco) caused the largest share of deaths in accidental dwelling fires (37%)."(3) Also in the US the National Fire Protection Association (NFPA) found that "Smoking was the leading cause of civilian home fire deaths."(4) This was 23% in the US.

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It is important that the home is a safe place as a number of people can be living in the home at a given time. With the use of fire safety regulation the home can become a much safer place, even though the government cannot enforce these regulation to people in their own home. But they can be used to help improve the safety in the home when involving fire. Furthermore these regulation are government enforce in the home when a tenant is subletting or renting their home out.

The fire safety regulations are divided into key points with several sub headings. The five sections are 1. General 2. Fire safety duties 3. Enforcement 4. Offences and Appeals 5. Miscellaneous. When in the home not all these sections are relevant (3.Enforcement and 4. Offences and Appeals) as there is no government enforced law that make residents use these regulations. Although these regulation are not enforced they can be very helpful guide that can prevent and save lives in the event of a fire occurring in the home.

The most important of the five sections that could be used in the home is 2. Fires safety duties – This section has the most sub heading with in it, 17 different sub headings. The most important of those sub headings is Risk Assessment. The Risk Assessment according to GOV.uk is set into five assessment areas “1. Identify fire hazards 2. Identify People at Risk 3. Evaluate, Remove or Reduce risk and protect against remaining risk 4. Record, Plan and inform or train. 5 Review.”(5) These areas each have a section of question that have to be answered to complete the risk assessment.

GOV.uk can provide a document from the Department of communities and local Government that can be used to help aid in the completion of a risk assessment. Regardless of this being created for a business the document can be used in the home with a few alterations.

The reason why the risk assessment is the most important section is because it is a simple task that when completed correctly can identify fire hazards in the home, thus giving the residents the means to reduce or eliminate the risk therefore preventing a fire and saving lives. Another reason why this is the most important section is that if it is completed correctly it is as effect as saving lives as the fire alarm itself by prevent the occurrence of a fire in the first place.

2.2 DANGERS OF FIRE IN THE HOME

Fire is a natural element that can do amazing thing but also it is a natural power that can destroy anything that crosses its path. Fires can occur anywhere at any time and can do a substantial amount of damage. The area this report focuses on is the occurrence of fire within a home and the prevention of that fire.

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When a fire occurs within a domestic premises the level of damage a fire can do is increase exponentially as there are many factor that will increase the rapid growth i.e. (accelerants.) Also the dangers of a fire that happen in the home have substantially more dangers for a number of reasons.

1. The number of occupants that live in the home with a range of ages. 2. The pets that are present within the home provided a danger as the owners will place themselves in harm's way to save their pets lives. 3. The possibility of fire hazardous possession that could accelerate the rate at which the fire grows. 4. Other resident's neighbours that live next door are at risk of the fire spreading into their home.

Fires have many dangers when they occur in the home but not all are directly a result of the fire itself, it is just exposed by the fire. An example is parents protecting their child's life. Another being a person's sentimental attachment to their pets, so as a result their risk their lives in order to save their pet.

Furthermore the dangers of fire is not just the fire on its own. The exposure to the harmful smoke which is inhaled by people in the event of a home fire. The NFPA National fire Protection Association says that "Most fire deaths are not caused by burns, but by smoke inhalation." (6) They also go on to say "Smoke incapacitates, people are overcome quickly and are unable to access an exit." (6) Another reason that fire has many dangers is because as the fire increases, it consumes the available oxygen. This slows the burning process which is known as "The incomplete combustion which results in toxic gases." (6)

2.3 FIRE STATISTICS

In the UK there are about 25 million homes. With that the potential for fires to occur in the home is high. Here are some statistics involving fires in the UK:

In the UK in the year 2013 to 2014 the fire and rescue service attended a total of 505,600 fires (which includes false alarms.) This is an increase of 2% when compared to last year (2012/2013.)

From the 505,600 fire and rescue call outs 212,500 were actual fires, this is an increase of 10% on the year (2012/2013.) Of the 212,505 one fifth or 19% were fire that occurred within the home. The one fifth or 19% accounted to 39,600 dwelling fires from 212,500. Around 88% of thoughts 39,600 were accidental.

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Year	Total fires & false alarms	Total Fires	Building fires			Outdoor Fires ¹	Chimney fires	False alarms
			Total	Dwellings ²	Other			
2000/01	895.0	444.8	107.3	67.4	39.9	323.9	13.6	450.2
2001/02	992.2	525.0	108.8	66.5	42.3	404.3	11.9	467.2
2002/03	949.3	502.8	97.8	59.7	38.1	395.0	10.0	446.5
2003/04	1,027.9	571.6	102.2	61.7	40.4	460.3	9.1	456.3
2004/05	845.0	412.5	92.9	57.1	35.8	311.2	8.5	432.5
2005/06	831.6	408.9	89.7	55.9	33.8	309.8	9.4	422.7
2006/07	837.7	411.3	85.5	53.8	31.7	318.2	7.6	426.4
2007/08	769.7	364.1	79.6	50.4	29.2	276.0	8.6	405.5
2008/09	694.2	309.3	73.5	47.5	26.1	225.1	10.7	384.9
2009/10	653.6	299.3	73.7	47.2	26.5	215.8	9.9	354.3
2010/11	626.9	288.0	74.1	46.0	28.1	203.9	10.0	338.9
2011/12	586.0	272.8	71.5	44.4	27.1	193.6	7.7	313.3
2012/13r	494.1	192.7	63.5	41.6	22.0	119.7	9.4	301.4
2013/14p	505.6	212.5	61.3	39.6	21.7	143.5	7.7	293.1

¹ Figures in thousands and figures are rounded and the components do not necessarily sum to the independently rounded totals.
² Includes caravans, houseboats, mobile homes and other non-permanent structures used solely as a permanent dwelling.
³ Primary and secondary fires. Excludes fires in derelict buildings (which are included in "Other Buildings" here, but are shown separately as "Outdoor Fires" in Annex table 1c).

Figure 1 - Total of fires and false alarms(3)

When an accidental fire occurred the main cause of the fires were misuse of equipment or appliances, this accumulated for 13,300 fires. On the other hand the main source of ignition (which accounted for more than half of all accidental dwelling fires) was cooking appliances (This was mostly cookers including ovens.)

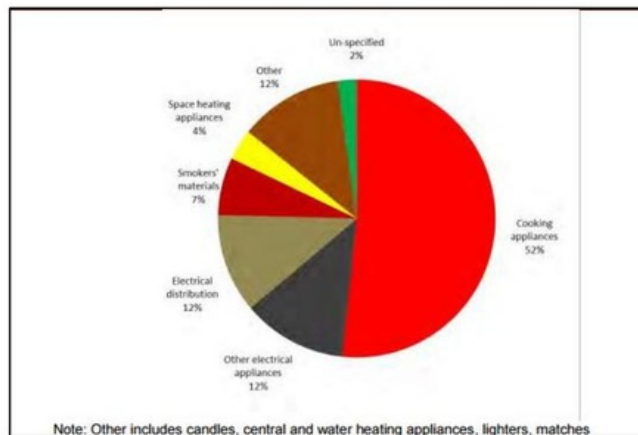


Figure 2 - Sources of Ignition(3)

As a result of the 505,600 fires that occurred in the UK between the years 2013/2014, there were a total 322 deaths. This is the lowest recorded number of deaths as a result of fires when compared to the highest recorded number of deaths 967 in 1985/1986 it is significantly lower.

The fatalities rate for fires that took place in the home accounted for more than three quarters or 80% of the 322 deaths in the year 2013/2014. That is 258 dwelling related fire deaths and 85% of the 258 fatalities, 219 were brought about due to accidental fires. The majority of these were down to

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careless handling of fire or hot substance. An example of this would be poor and careless disposal of cigarettes.

	Total accidental Fires		Fatal casualties		Non-fatal casualties			Total accidental Fires		Fatal casualties		Non-fatal casualties	
	Total	Per 1,000 fires	Total	Per 1,000 fires	Total	Per 1,000 fires		Total	Per 1,000 fires	Total	Per 1,000 fires	Total	Per 1,000 fires
Total accidental	35,024	219	6	6,872	196		Room of origin of fire	35,024	219	6	6,872	196	
Smokers' materials	2,360	80	34	673	285		Bedroom or bed-sitting room	3,039	63	21	1,031	339	
Cigarette lighters	217	5	23	93	429		Living room, dining room or lounge	3,170	94	30	890	281	
Matches	232	6	26	57	246		Kitchen	21,577	40	2	4,125	191	
Cooking appliances	18,092	30	2	3,642	201		Bathroom or lavatory	778	1	1	136	175	
Space heating appliances	1,256	20	16	313	249		Corridor, hall or stairs	930	5	5	130	140	
Central and water heating appliances	394	0	-	35	89		Laundry or airing cupboard	987	2	2	116	118	
Blowlamps, welding and cutting equipment	237	0	-	22	93		Store room or loft	1,284	2	2	111	86	
Electrical distribution	4,032	18	4	419	104		Other ²	3,140	11	4	320	102	
Other electrical appliances	4,277	13	3	682	159		Unspecified	119	1	8	13	109	
Candles	951	11	12	385	405								
Other	2,207	15	7	364	165								
Unspecified	789	21	27	187	243								

Figure 3 - Fatalities and Non Fatalities in the home(3)

Figure 4 - Room in the home where fire were started(3)

When an accidental fire related dwelling fatality occurred smoking materials were the main cause of deaths. In the event of a fire peoples popular belief is that burns are the main cause of death but it only equates to 20%. The main cause of deaths in a fire is the exposure and inhalation of gases, smoke and toxic fumes which are produced by fires. That's 41% of deaths which are caused by gases, smoke and toxic fumes.

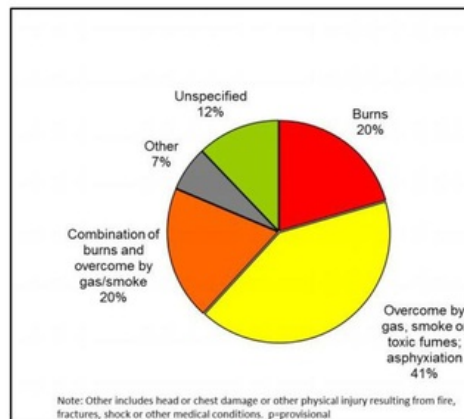


Figure 5 - Causes of deaths (3)

All statistical information cited from gov.uk(3)

2.4 FIRE SENSORS

Within this topic of the research the identifying of the possible sensors that could be used in order to detect the presence of a fire in the home will be completed. There are 2 main way which this topic will focus on: sensors for detecting heat and sensor for detecting smoke.

2.4.1 Heat detectors

Heat detectors are a temperature sensing detector. It uses the thermal energy given off by the fire to trigger the alarm device. There are two main type that heat detectors have rate of rise and fixed temperature. "Heat detectors are the oldest type of automatic fire detection device." (7) These detectors have and "element inside the unit that activates when it reaches a predetermined fixed temperature or when a specific increase in temperature has occurred." (7)

The rate of rise is used to detect the sudden change in temperature that takes place when a fire happens. The accelerated increase in temperature between 6.7° to 8.3° that is measured per minute. This rate of rise or change in temperature that occurs between 6.7° to 8.3° is used per minute to detect the increasing temperature of the home, if the temperature begins to climb at a rate between 6.7° to 8.3° every minute the device will alarm.

Also the start temperature of the room will not affect the rate of rise. The disadvantage of rate of rise detector is at slow developing fires the detection may not work as the low energy produced by the fire might not increase at the rate between 6.7° to 8.3°. By the time the fire starts to increase at the desired detection rate it could be too late for the persons in the house to be alerted. The fixed temperature detectors are more common than the rate of rise detectors.

The names of the detectors sums up what they do fixed temperature – when a fixed temperature is reached or exceeded it outputs a signal to an alarm buzzer. Rate of rise – when a set rate of rise temperature is increasing of a period of time then a signal will be send to an alarm buzzer.

2.4.2 Thermistor

The Thermistor is a sensing device that is used to detect heat. There are two types of Thermistor NTC and PTC. NTC stands for Negative Temperature Coefficient and PTC stands for Positive Temperature Coefficient.

The PTC is a resistor with a positive temperature coefficient that when temperature increases the resistance increases. "PTC Thermistor are resistors with a positive temperature coefficient, which means that the resistance increases with increasing temperature." (8)

The PTC Thermistor has two groups that based upon what materials they use, their structure and manufacturing process one group of Thermistor is comprised of silistors and this uses silicon as a semi conductive material. Their linear characteristics allow them to be used as PTC temperature sensors. Group 2 is a switching type PTC Thermistor. PTC heater and sensors use this type of Thermistor. Polymer PTC Thermistor, which are made of a special plastic, come into the second group, they are mostly used as resettable fuses. Switching type Thermistor have a highly nonlinear resistance temperature curve. When heated the PTC switching Thermistor type resistance initially decreases to begin with until a specific critical temperature is reached. Once the temperature increases higher than the critical temperature, this increases in resistance rise dramatically.



Figure 6 - PTC Thermistor(9)

NTC Thermistor are resistance with a negative temperature coefficient, this causes the resistance to decrease with the increasing temperature. The main use for a NTC Thermistor are resistive temperature sensors. They have a 5 times greater temperature sensitivity coefficient than silicon temperature sensors and much greater temperature sensitivity coefficient, ten times greater than resistance temperature detectors. The NTC Thermistor have a temperature range for -55°C to 200°C.



Figure 7 - NTC Thermistor(10)

"An NTC Thermistor is a thermally sensitive resistor whose resistance exhibits a large, precise and predictable decrease as the core temperature of the resistor increases over the operating temperature range." (11)

"NTC Thermistor are nonlinear resistors, which alter their resistance characteristics with the temperature. The resistance of NTC will decrease as the temperature increases. The manner in which the resistance decreases is related to the constant known in the electronics as beta or b beta is measured in 'K'." (12)

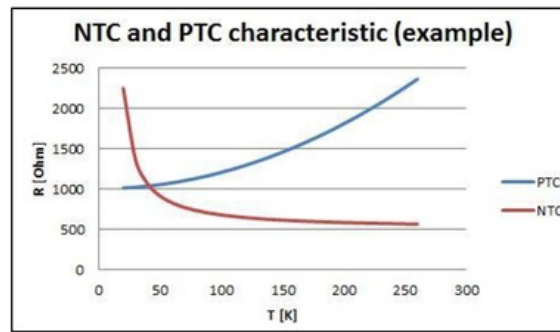


Figure 8 - Basic NTC PTC Resistance temperature graph(13)

2.4.3 Smoke Detectors

When detecting the presence of a fire the most common house hold alarms, use a smoke sensor based devices. Within the device is a smoke chamber that in the event of a fire, the smoke enters the chamber where the particles come into contact with an optical device or a radioactive isotope which then triggers the alarm. There are two type of smoke sensors 1. Photoelectric and 2. Ionization. Photoelectric makes use of the optical device and Ionization uses the radioactive isotope.

2.4.4 Photoelectric Sensors

The Photoelectric sensor or as it's also known as the Optical sensor is a more commonly used sensor type in household fire alarms. The basic setup of the photoelectric sensor is the use of a LED as a light source and a photoelectric receiver, which is a photodiode, phototransistor or photodarlington. This setup between the LED and photoreceiver can be defined as optoelectronics "The study of any device the produces an electrically induced optical (visible, Invisible light) output or an optically induced electrical output."(14)

The Photoelectric or optical sensor works by way of an infrared signal or beam from an infrared LED. Then that infrared signal is received by a photoelectric receiver, which is positioned at an angle to the infrared LED. In the occurrence of a fire the particles produced within the smoke enters the infrared LED, Photoreceiver chamber which then does one of two things dependent on the setup of the infrared LED and Photoreceiver.

1. If the setup is using a reflective object device then the smoke particles will disrupt the reflective process thus blocking the photoreceiver from receiving an infrared signal.
2. If the setup is at angle

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where the infrared light is angled out away from the photoreceiver, when smoke enters the chamber the particles cause the infrared light to reflect to the photoreceiver which would trigger the alarm.

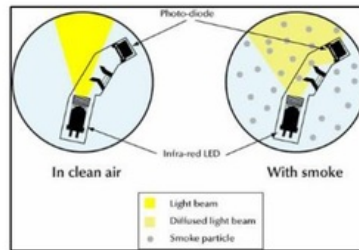


Figure 9 - Infrared Sensor(15)

These types of setup would be referred to as Optocouples. "A device containing an infrared LED and matching phototransistor mounted close together (optically coupled.)"(14)

This type of sensor (photoelectric) when used as fire alarms respond better to fires that start with a greater period of smouldering. These fires are known as smouldering fires. In comparison to fast spreading fires the photoelectric sensor is slower at detecting that type of fire, but this does not mean that it cannot detect the fire in a sufficient amount of time to alert people to the danger.

2.4.5 Ionization Sensor

The Ionization sensor is similar to the Optical sensor as it is used also to detect smoke. The two (Ionization and Optical) can be used as a pair optimising the performance of the fire alarm.

The Ionization sensor for smoke uses an Ionization chamber which has metal plates which are electrically charged with a supply of Ionizing radiation which detects the smoke.

Ionization type alarms have a small amount of radioactive material between two electrically charged plates, which ionizes the air and causes current flow between the plates. When smoke enters the chamber, it disrupts the flow of ions thus reducing the flow of current and activating the alarm.(16)

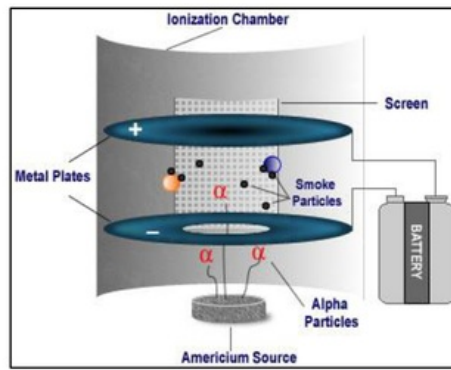


Figure 10 - Ionization Sensor(17)

Within the Ionization sensor chamber there is a radioactive isotope Americium 241 although it's in a small amount. The radioactive element has a good source of alpha particles and its half-life is 432 years. The Ionization sensor is although the same as the Optical in its ability to detect smoke it is different at sensing a kind of fire.

The Ionization is better at detecting a rapidly growing fire caused by most commonly cooking fires or flammable liquid fires.

2.5 FIRE ALARM GRADES

There is a grade system for fire alarms the grades go from A to F. The top grade being Grade A which is an intelligent system that is used in factories and big buildings. Then the bottom grade being Grade F which is the common household smoke or heat alarm powered by a battery. All new buildings must be equipped with a Grade D, this is a smoke and or heat alarm powered by mains and has a backup battery. This requirement is government legislated. See appendix 12.5 for fire grades.

There is also a combination of both the heat sensor devices and the smoke sensor devices, this is known as Thermoptek sensor technology.

2.6 GAS

This section of the report shows the research into the relevant gas sensors that could be used to sense the presence of gas within a home in conjunction with the fire sensor.

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A gas sensor is what it says it is, it is used to detect the presence of gas in an area. For the study of this report the gas sensor will be used to detect gases in the home. This sensors alarm will help prevent the deaths of people in their homes. The main focus of the gas is the gas known as Carbon Monoxide there is also the potential to detect other gases but ultimately Carbon Monoxide is what the target gas to detect is.

There are three sensor types that will be researched to see which is best for detecting gas in the fire and gas alarm. The three types of sensor for detecting gases to be research are Semi-conductors, Electrochemical and infrared.

2.6.1 Gas Regulations

The gas regulations are somewhat similar to that of fire regulations. There is no government law that states the home owner must have a gas detector but they recommend that one is used. On the other hand some domestic household by law must have a gas detector. These domestic home are properties that are rented out.

This means that the landlord of the property must follow government law. The main regulation that the government enforces is all gas appliances and/or flues must be regularly check at least every 12 months, this is to avoid blockage of flues or damage to appliances thus causing a gas leak or build up. All home must be fitted with a Carbon Monoxide detector. The home should be well ventilated to stop the build-up of gas.

When any form of gas appliance or piping is to be fitted the engineer must be a Corgi registered or gas safety registered otherwise the job will be up to government standard. This would then cause a safety risk put anyone within the house in danger.

2.6.2 Carbon Monoxide

There are many forms of gases that cause illness and harm to people in there every day life. The main focus for this project is Carbon Monoxide. Carbon Monoxide is a gas which is produced when fuel that contains Carbon (for example oil, coal, wood, etc) have an incomplete burning. Carbon Monoxide which is also known as CO that has the nickname 'Silent Killer' as a result of having no smell and it's colourless.

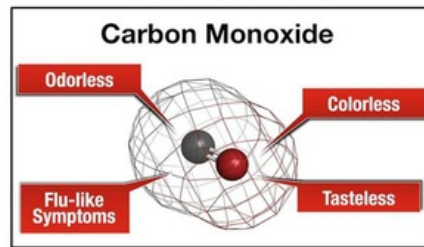


Figure 11 - Carbon Monoxide molecule(18)

Within the home there are a number of appliances that can cause a Carbon Monoxide leak to happen. The most common being boilers and fire places. The mistake made by people is the unclear determination between Carbon Monoxide and Carbon Dioxide which are commonly confused with one another. Carbon Dioxide CO_2 which has the one Carbon atom and two Oxygen atoms while on the other hand Carbon Monoxide CO has only one Carbon and One Oxygen atom. There isn't much difference between the two but the main difference is a critical one as it lies in the toxicity. Although Carbon Dioxide is a gas it can be tolerated as it is a by-product of the human and animal's respiratory system, as humans and animal exhale they emit Carbon Dioxide.

Then on the other hand Carbon Monoxide with its one less Oxygen atom can be very dangerous to humans. Carbon Monoxide has a number of symptoms but how it effects humans is "After breathing in Carbon Monoxide, it enters the blood stream and with haemoglobin (the part of the red blood cells that carry Oxygen around the body) to form carboxyhaemoglobin. When this happens the blood is no longer able to carry Oxygen and this lack of Oxygen causes the body cell and tissue to die." (19) The symptoms are very similar to the flu which make it hard to identify Carbon Monoxide poisoning. "Carbon Monoxide poisoning can be difficult to spot. The symptoms can be confused easily with flu or food poisoning." (19)

In a news article about Carbon Monoxide poisoning Professor Dame Sally Davies, Chief medical officer for England is quoted saying that "Carbon Monoxide is a Silent Killer which leads to 50 deaths every year." (20) She also goes onto say "The symptoms of Carbon Monoxide are very similar to those of flu and food poisoning." (20)

There are a many number of reasons to have a Carbon Monoxide detector the most prominent reason is for safety in the home but also the safety of the neighbours home also.

A daily mail article published January 6th 2014 about a ten year old boy who died in his sleep due to Carbon Monoxide poisoning that came from the next door neighbour's house. This prove the importance of a Carbon Monoxide Detector. There are many cases where people have died from this harmful gas which is very preventable with a small device that detects the gas.

2.6.3 Carbon Monoxide Statistics

In the UK each year there are as much as 50 accidental deaths each year which is caused from Carbon Monoxide poisoning. There are in excess of 1,100 recorded entries into hospitals where Carbon Monoxide poisoning was involved. This has frequently lead to neurological damage. Since recording started in September 1995 to August 2015 there have been a total of 699 deaths caused by Carbon Monoxide (CO) poisoning. The place that is highest on the list with Carbon Monoxide deaths is the home with 322 deaths. With the Flat and bungalow next highest on the list. This information show the importance of needing a Carbon Monoxide detector.

In the year 2014/2015 there were a total of 161 incidents involving gas of the 161 incidents 138 of those were a result of Carbon Monoxide poisoning. Furthermore there were 6 gas related deaths in 2014/2015 which were all due to Carbon Monoxide poisoning. There were a number of non-fatalities involved of the 161 incidents (an incident can cause more than one injury) 240 in total which 214 were directly involved with Carbon Monoxide poisoning.

The most common cause for Carbon Monoxide poisoning is the household boiler that provides heating for the house. The age group that is most at risk when it comes to Carbon Monoxide poisoning is children aged 14 and under, also the over 65's are at a high risk as well.

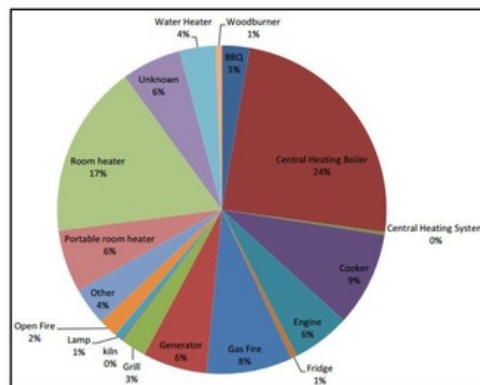


Figure 12 - Causes of Carbon Monoxide Leaks(21)

Statistically Wales experience the most Carbon Monoxide poisoning incidents but that is taking the consideration of the population of Wales which is smaller than England.

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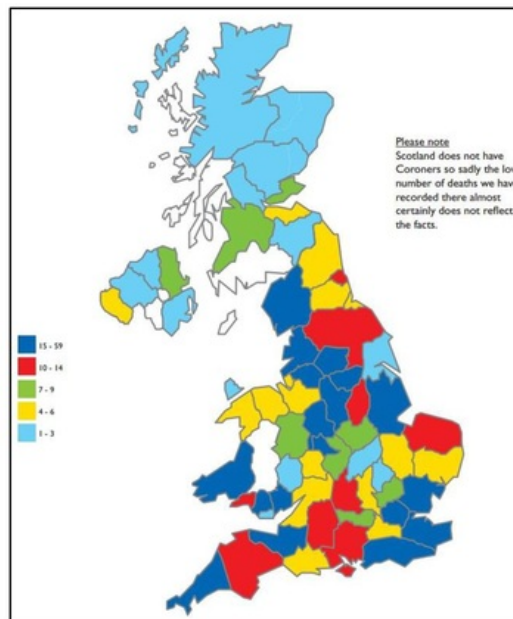


Figure 13 - Map of UK for Carbon Monoxide Leaks(22)

2.6.4 Semi-Conductor

The semi-conductor sensor also known as metal oxide sensor this gas sensor is electrically charged. When gas comes into contact with the sensor the resistance of the sensor changes. This change cause the polarity to change thus setting the alarm off. This type of gas sensor is acceptable for the vast amount of applications and the detection of reactive gases.

The semi-conductor sensor works on the principles of operation of "A semi-conductor material is applied to non-conducting substance between two electrodes. The substance is heated to a temperature such as that the gases being monitored can cause a reversible change in the conductivity of the semi-conducting material. Under zero gas conditions, it is though that O₂ molecules tie up free electrons in the semi-conductor material by absorbing to its surface, there by inhibiting electrical flow. As H₂S or CHC gas or vapour molecules are introduced, they are replace O₂, releasing the free electrons and decreasing the resistance between the electrodes. This change in resistance is measured electrically and is proportional to the concentration of the gas being measured."(23)

There are many applications for semi-conductor gas sensors the main application it the safety device that detects harmful gases in the air. The range of measurement the sensor carries out is based on the gas being detected. The limit at which the gas can be detected is based on the gas sensitivity

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material present within the sensor. The number of gases that can be detected is large here are a few: Carbon Monoxide, Nitrogen Oxide, Ammoniac, sulphurous gases, hydrocarbon and also volatile organic compounds.

2.6.5 Electrochemical

The electrochemical is a sensor that detects a gas through the measuring of the amount that the specific gas "by oxidizing or reducing the gas at an electrode and then measuring the resulting current." (24) Electrochemical gas detectors with the use of a membrane allows gases to go through it and to electrode this is when it will chemically oxidized or reduce. Then the current produced is measured by the amount of gas that is oxidized.

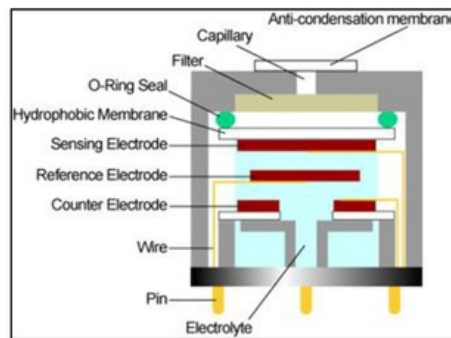


Figure 14 - Electrochemical Sensor(25)

"The electrochemical sensor target gas molecules that come into contact with the sensor first pass through an anti-condensation membrane which serves also as a protection against dust. Then the gas molecule diffuse through a capillary, potentially through a subsequent filter and then through a hydrophobic membrane to reach the surface structure of the sensing electrode. There the molecules are immediately oxidized or reduced on active catalytic sites, consequently producing or consuming electrons and thus generating an electric current." (25)

2.6.6 Infrared

The Infrared gas sensor make use of the absorption method of Infrared radiation at a precise wavelength as the volume of gas passes thought the infrared light. Within the infrared sensor there are usually two infrared light emitter and one infrared light detector. This measures the intensity of both the different wavelength, one within the absorption wavelength and one outside the absorption wavelength. When gas is present between the infrared light source and detector, the level at which the radiation falls on the detector will reduce. Gas concentration is decided by examining the relative values between the wavelengths produced. "Infrared gas detection is based upon the ability of some gases to absorb IR radiation." (26)

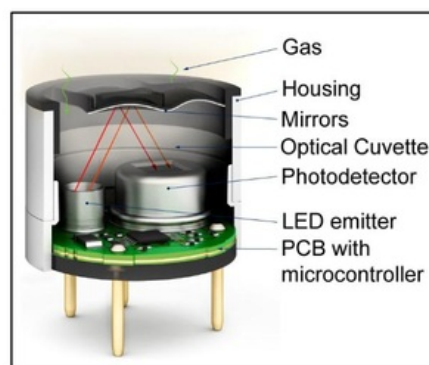


Figure 15 - Infrared Gas Sensor(27)

There are a number of hydrocarbons that absorb IR at approximately 3.4 micrometers, within this region H₂O and CO₂ moderately transparent. There are a numerous amounts of gases that general purpose IR cannot detect which is a problem. The gases that cannot be detected Hydrogen, Carbon Monoxide, Aromatics, Ammonia and Acetylene. In the absence of gas at the sensor the signal of reference, signal detector and measurement signal the detector is balanced. There a few benefits of having an IR detector, they have a very quick response time, resistant against contamination, operation is unaffected in oxygen rich and oxygen poor surroundings and they are practically maintenance free. There are some negative to the IR detector, they are not easily repaired, cost and they cannot detect gases that are unable to absorb infrared energy.

"Infrared gas detectors rely on two wavelengths in order to perform, one at the gas-absorbing wavelength and the other at a wavelength not absorbed by gas. If a gas intervenes between the source and the detector, the level of radiation falling on the detector is reduced and can be

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continuously monitored. Gas concentration is determined by comparing the relative values between the two wavelengths.”(28)

3 CHAPTER III - MARKET RESEARCH

3.1 FIRE ALARMS

There are many home in the UK and the rest of the world that have and need Fire and Carbon Monoxide alarms as there is a threat that they will be subject to a fire or gas leak. The market for the fire and gas alarm is a wide market with many different types of alarms with a range of different features.

The fire alarms that are available on the market have different sensor as stated in the research chapter of the report. The different alarm types that are available are heat alarms, optical and ionization smoke alarms. The price range of these types of alarms can vary for low in price to very high in price.

Also there are specific companies that provide a service which will supply a system an intelligent system that can communicate with one another, in the event of a fire if one alarm goes off then all alarms will go off. This is all run by the uses of a central command hub that is in control of the whole system.

3.1.1 Product 1 - 9v Optical smoke alarm with test and hush button.

This fire alarm is made by Fire Angel. Fire Angel is a safety company that specialise in providing fire and carbon monoxide alarms. The Fire Angel S0-601 is an optical smoke alarm with toast proof sensing technology, making it less prone to false alarms when cooking.

Figure 16 - Optical Fire Alarm(29)



Key Features:

- Battery Powered 9v
 - Large test button
 - Optical sensor – less prone to false alarms
 - Sound output 85dB at 3 meters
 - Grade F
-

- Cost - £9.47

3.1.2 Product 2 - 9v Ionization smoke alarm with test and hush switch.

This smoke alarm is made by First Alert. The Ionization sensor uses a radioactive isotope called Americium 241. This style of sensor is less commonly used but still work just as affectively as optical smoke alarm.

The first alert ionization sensor features a test/hush button for safety checks. When the alarm is activated a loud 85dB sound is outputted. Also there is a low battery warning chirp which indicates when to change the batteries.

Figure 17 - Ionization Fire Alarm(29)



Key Features:

- Battery Powered
- Test and hush button
- Low battery warning chirp
- Loud 85dB alarm sounder
- Price - £8.39

3.1.3 Product 3 - 10 year heat alarm

This fire alarm uses heat detection to detect fire instead of the more popular smoke detection used by the optical and ionization alarms. This fire alarm is made by Fire Angel and the product code is HT-630.

This product has an aesthetic low profile design. It uses heat detection which makes it ideal for kitchens and garages, this where smoke alarms are prone to false alarms.

The heat detection sensor provides a quick reaction to a significant rate of in temperature.

Figure 18 - Heat Fire Alarm(29)



Key Features:

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- 10 year long battery life.
- Tamper proof battery.
- Single easy to use test button
- Quick reaction to rate of rise in temperature.
- Ideal for kitchens, laundry and garages.
- Price - £22.79

TABLE 1

Product	9v Optical smoke alarm with test and hush button.	9v Ionization smoke alarm with test and hush switch.	10 year heat alarm
Image:(29)	 <i>Figure 19 - Optical Fire Alarm</i>	 <i>Figure 20 - Ionization Fire Alarm</i>	 <i>Figure 21 - Heat Fire Alarm</i>
Type:	smoke	Smoke	Heat
Power:	Battery	Battery	Battery
Alarm Sounder	85dB	85dB	85dB
Grade*:	F	F	F
Price:	£9.47	£8.39	£22.79

*- Read the grade system. Appendixes 12.5

The table 1 shows the very basic, bottom range fire alarms. These very basic alarms don't have many difference in fact the only differences is are the type of sensor that is being used and the price.

The advantages of owning one of these are:

- Relatively cheap

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- Reliable
- Has easy installation
- Designed to last

The Disadvantages of owning one of these are:

- Battery life can be low (except the heat detector)
- Not as reliable as the more expensive models

3.1.4 **Product 4 - The Kidde Main powered radio-interlined smoke alarms with alkaline backup battery**

This is available in 3 fire alarm (each sold separately) two smoke types ionization and optical. The other is a heat detector. They are all powered via mains power (230v) which is equipped with a backup alkaline battery. The alarms can all be interconnected by using radio frequency which allows them to talk to one another. All the units are fitted with RF transmitters and receivers, this enables the alarms to all active when only one of the 3 are activated.



Figure 22 - All 3 sensor Alarms with RF(29)

Key Features:

- Mains Powered with backup battery
 - Up to 15 units can be interconnected
 - RF communication
 - Unique id coding eliminates RF interference with other applications
 - Test Button
 - Low battery warning chirp
 - Grade D, E and F
 - Price – Ionization - £63.83 Optical - £69.95 Heat - £78.47
-

3.1.5 Product 5 - 9V Radio-interlinked smoke and heat starter kit.

This starter kit contain 3 fire alarms for the optimum fire detection system. The 3 different sensor type are on display as it contain ionization, optical and heat detectors. This allows the use to have an alarm in the hallway, bedroom and kitchen create the house a much safer place. The alarms are battery powered (9V.) The 3 can communicate with one another with the use of RF. With the use of RF if one alarm is activated then the others will also be activated.



Figure 23 - All 3 sensor alarms RF battery(29)

Key Features:

- Battery Powered (9V)
 - Up to 12 Units can be interconnected
 - Uses RF
 - Wireless
 - Digitally coded to avoid interference
 - Grade F
 - Price - £126.98
-

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TABLE 2		
Product	The Kidde Main powered radio-interlined smoke alarms with alkaline backup battery SFWRF series	9V Radio-interlinked smoke and heat starter kit
Image:(29)	 Figure 24 - All 3 sensor Alarms with RF	 Figure 25 - All 3 sensor alarms RF Battery
Type:	Optical, Ionization (Smoke) and Heat	Optical, Ionization (Smoke) and Heat
Power:	Mains with battery Backup	Battery 9V
*NOU:	15	12
Wireless Comms:	Radio Frequency 868.499MHz	Radio Frequency 868.499MHz
Grade:	D, E and F	F
Price:	Ionization-£63.83 Optical-£69.95 Heat-£78.47	£126.98

*Number of units see Appendixes 12.5 for fire grades

The table 2 show two fire alarms that both have the same function but have some slight difference between on another. The differences being one is powered by main and has a battery backup and the other is powered with just a battery and has no backup. Also the mains powered alarms had the capability to have more units interlinked.

The advantages of the Mains powered alarm:

- Can have 3 different sensor types
- Mains powered
- Backup battery
- Radio Frequency communication

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- Up to 15 units can be interlinked
- Reliable
- When one alarm sounds they all sound
- No RF interference

The disadvantages of mains powered Alarm:

- Expensive
- Sensor have to bought separately
- Has to wired to the mains power

3.1.6 Product 6 - Fike Twinflex pro 2 zone Alarm kit

This is an alarm intelligent alarm system that is made up of many smoke and heat detector that is control by a central hub called the control panel. This allows the alarms to be tested randomly and indicates which alarm has been sounded. This system also allows for manual call points that enable people to press a fire alarm switch that then sets all the alarms off. The system is all wired together using only one pair of wires per zone. Price - £359.00



Figure 26 - FIKE Twinflex Pro 2(30)

Key Features:

- Two wire installation
 - LCD display
 - Call points
 - Up to 32 device per zone
 - Detects smoke and Heat
 - Warning of head contamination, before going into false alarm
-

The advantages:

- Intelligent system
- Sensors for smoke and heat
- Warning of head contamination, before going into false alarm
- Call point
- Up to 32 device per zone
- Output module for door release, power shutdown, etc.

The Disadvantages:

- Very expensive
- Call point can be activated accidentally

all product information cited form(29)

3.2 CARBON MONOXIDE DETECTORS

3.2.1 Product 1 – LED Carbon Monoxide Detector

This Carbon Monoxide detector is made by FireAngel. The detector is idea for the home, it can be free standing or wall mounted. The life span of this detector is 7 years, only needs two AA batteries to power it. There are LED that show when the detector is powered, when the alarm is switch and when there is a fault. It also has a test function so that the user can test the detector at any time to check that it's working.



Figure 27 - LED Carbon Monoxide Detector(29)

Key Features:

- Battery Powered (AA Batteries)
 - 7 Year life span
-

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- 85dB audible alarm and LED indicators
- Test feature
- Automatic diagnostic function – checks the sensor and batteries
- Price - £17.99

3.2.2 **Product 2 – Mains Powered CO detector with 10 year lithium backup battery**

This product is a Carbon Monoxide detector which is powered by mains 230V with a 10 rechargeable backup battery. The sensor within has a life span of 5 years. It is equipped with a test/hush button, there is a self-diagnosis to identify faults. The alarm detects from 30PPM (Parts per Million.)



Figure 28 - Mains Powered CO Detector(29)

Key Features:

- Mains Powered hard-wired 230V
 - Replaceable sensor (5 year life span)
 - 10 year backup rechargeable battery
 - Test/hush Button
 - Detects from 30PPM
 - Automatic Diagnosis of faults within the alarm.
 - Pre-alarm warning LED flashes at 50PPM CO
 - Price - £59.99
-

3.2.3 Product 3 – Carbon Monoxide detector with optional display

This product is for home use and it's portable. The detector has a life span of 6 years, its power comes from AAA batteries. The alarm is equipped with test/hush function, it check the concentration of CO every 50 seconds. End of life indicator tells user when to replace the alarm.



Figure 29 - CO Detector(29)

Key Features:

- 6 year life span
- Battery powered (AAA batteries)
- Test/hush function
- Detects from 30ppm
- Check CO concentration every 50 seconds
- End of life function
- Memory feature records the last CO alarm level.
- Price - £25.19

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TABLE 3

Product:	LED Carbon Monoxide Detector	Mains Powered CO detector	Carbon Monoxide detector
Image:	 Figure 30 - LED Carbon Monoxide (29)	 Figure 31 - Mains Powered CO (29)	 Figure 32 - CO Detector (29)
Power:	Battery (AA)	Mains 230V	Battery (AAA)
Backup Power:	Does not have one	10 rechargeable Battery	Does not have one
Life Span:	7 Years	5 Years	6 Years
PPM Active:	50ppm	30ppm	30ppm
Connectable with other device:	Not Able	Can connect to smoke alarm	Not able
Price:	£17.99	£59.99	£25.19

All product information and images cited from(29)

4 CHAPTER IV - RESEARCH METHODOLOGY

This chapter of the report details the methodology that was used to research the required topic suitable to aid the selection of project, the design and the implementation. The research method used for this project was 'The Research Onion'.

4.1 RESEARCH ONION

The Research Onion is a process that is used by researcher when looking into a specific field or topic, in this case it is for a Final year Major Project. This Research Onion provides a stage process which researcher can use to effectively understand the methodology. This means the researcher knows what to research, why they should research, how the research will be used, the length of time it will take and the final collection of the data.

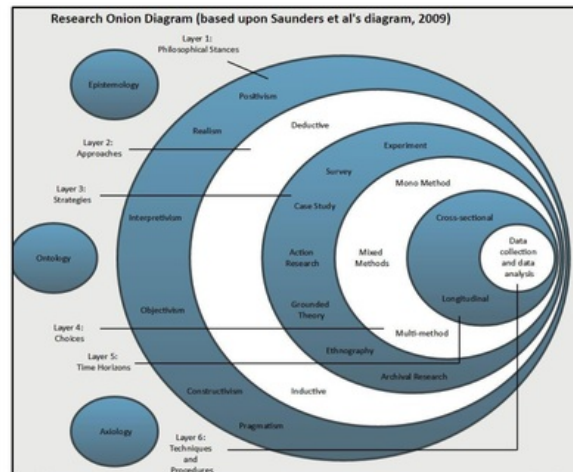


Figure 33 - Research Onion Model

There are a number of stages that the Research Onion uses. These stages/Layer are:

- 1 – The Philosophy
- 2 – The Approach
- 3 – The Strategy
- 4 - Choices
- 5 – The Time horizon
- 6 – The Data Collection Method

4.2 LAYER 1 – PHILOSOPHY

First when starting the Philosophy layer before entering the Research Onion a philosophy must be chosen. There are three options Epistemology, Ontology and Axiology.

Epistemology – This is the study of knowledge and the fact. This is a commonly used scientific approach. “Epistemology is concerned with addressing the facts by asking what the acceptable knowledge is.”(31)

Ontology – This is the study of reality, what is real and what isn’t. “Ontological Philosophy is concerned with the nature of reality.”(31)

Axiology – This philosophy is the study of how people think. Also how the researchers value and belief will influence their research. “Axiology allows the researcher to understand and recognise the role their values and opinion play in the collection and analysis of the research as opposed to eliminating or trying to balance the influence of it.”(31)

The philosophy that this project uses is the Epistemology. The reason of it study factual knowledge and it is used for scientific research which is similar to what this project does by looking for scientific factual answer to explain the project.

Within the Philosophy layer of the research Onion there are a few main research philosophies .

The research philosophy used for this project report was the Positivism. Positivism is the producing of research questions or hypotheses which verified and accept explanations that are determined against recognised knowledge. This research philosophy builds a body of research that other researchers can reproduce to accomplish the same outcome.

4.3 LAYER 2 – APPROACH

This layer contains two research approaches Deductive and Inductive. The strategy used for this project report was deductive. The Deductive approach is used at the start of research, the researcher begins with a statement or question which the research sets out to justify it. The overall aim would be to obtain an answer to the question or statement which was determined as yes or no.

The researcher question or statement about a specific topic must be one that they believe can be answered. With the deduction approach the thought process transitions from theory to research question, then on to data collection and finally on to the results of the research question.

This deductive approach was used because this project had a research aim, which needed to be answered in order to create the finished overall project aim.

4.4 LAYER 3 – STRATEGY

Within the strategy layer there are several different strategies that could be used, the strategies implemented for this project report were Case Study and Experiment.

Case Study strategy is comprised of the considerable study of one or more individual or cases in real life situation. It is recommended that the amount of case studies the researcher uses is restricted, in order to obtain clear conclusions about the data. The collection of data might contain record searching and or setting interview. This strategy was utilised in the project report one for looking a record that already existed for statistical reason. Also the finished project will be used by some individuals in order to test functionality.

The Experiment strategy has a rigid and scientific organisation this enables the research to be recreated. The Experiment strategy produces data can be analysed in a statistical way. This give the researcher information that can be used to complete the research question or aim.

Also survey was used to provide answer from people to see how they thought about this area.

4.5 LAYER 4 – CHOICE

The Choice layer of the Research Onion has three choices, these choices are Mono Method, Mixed Method and Multi Method. The choice that was used for this project report was the Mixed Method. The Mixed Method choice used the quantitative and qualitative research method.

The researcher uses the qualitative and quantitative research methods through the process of study, data collection and analysis. By combining the two quantitative and qualitative research the limitations of each method can be offset and the missing links can be completed and predicted.

The quantitative is used to generate numerical data or data that can be used to create statistic information. An example of this would be a questionnaire or survey.

The qualitative is used to obtain the understanding of fundamental reasons, opinions and motivations. An example of this would be interviews, observations and group discussions.

4.6 LAYER 5 – TIME HORIZONS

The Time Horizon layer has two from which to choose Cross-sectional and Longitudinal. Cross section uses both quantitative and qualitative research that calculate the aspects or behaviour of a number of groups or individuals and it's complete at a single point in time. Longitudinal also uses both quantitative and qualitative research, which study events and behaviours using focused samples over a long period of time.

The method used for this project was longitudinal as a longer period of time to collect results is needed.

4.7 LAYER 6 – DATA COLLECTION AND DATA ANALYSIS

The final layer of the Research Onion is the Data Collection and Data Analysis. This layer is where the researcher decides what data collection method they will use and the type of analysis to employ. The decisions this layer contains sample groups, questionnaire information and in an interview what question are to be asked.

5 CHAPTER V - DESIGN

This chapter of the report will detail and show the process that was used to create the design of this project. There will be many sub heading explaining the design process.

5.1 INITIAL DESIGN THOUGHTS

When design the Fire and Carbon Monoxide alarm device there are a many thing that have to be considered. The considerations are what are the inputs, outputs and the process. What factors come in within the inputs, outputs and process? In order to start and complete the design first a basic understanding of what component will be needed to complete the project.

5.1.1 Inputs

When thinking of what input were required first the understanding of what type of fire and Carbon Monoxide sensor would be required. For the fire element of the alarm as the research demonstrates there are three sensors that can be used Heat detection which is a Thermistor and Smoke which can be broken down into 2 sensor types Optical and Ionization.

For the Gas element of the alarm from the research it indicates that there are three sensor types Semi-conductor, Electrochemical and Infrared. There will also be the need for a test button for a safety check of the alarm device. Therefore the inputs that are essential to the alarm are the sensor for both Fire and Gas (Carbon Monoxide) and a button for safety testing.

5.1.2 Output

Following on from the inputs this alarm device will have the need outputs. The output provides an outcome a result to the project. The outputs for this alarm device does not need a massive though process compared to the inputs as the outputs that will be needed will be a device to make an alarm sound and some indicator to show that alarm is working.

5.1.3 Process

The process or control of the alarm device is the most important and critical part of the design as without the control the alarm device would not function and it would be just a bunch of

components. The controller device would need to be programmable thus making the choice of controller a PIC microcontroller as there is a wide selection from which to choose.

5.2 BLOCK DIAGRAMS

Before deciding on the specific components that will be used in for the project the fundamental understanding of how the circuit will work. This fundamental understanding will be illustrated in the form of a block diagrams these diagrams will start very basic then grow in detail.

5.2.1 Basic Block Process

The Figure34 shown below is illustrating the basic block diagram process for the Fire and Gas Alarm. This demonstrates the basic inputs and output required for the alarm to function.



Figure 34 - Basic Block Diagram

The following figure shows the block diagram design for the Fire and Gas alarm it shows a basic flow of how the project could work.

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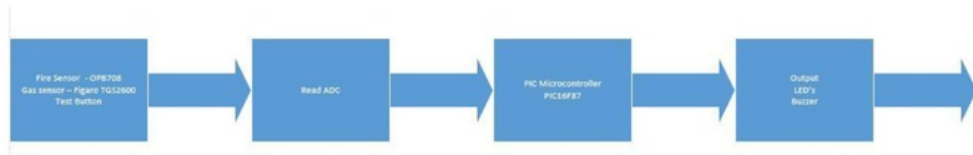


Figure 35 - Block diagram of project

5.3 SOFTWARE FLOW CHART

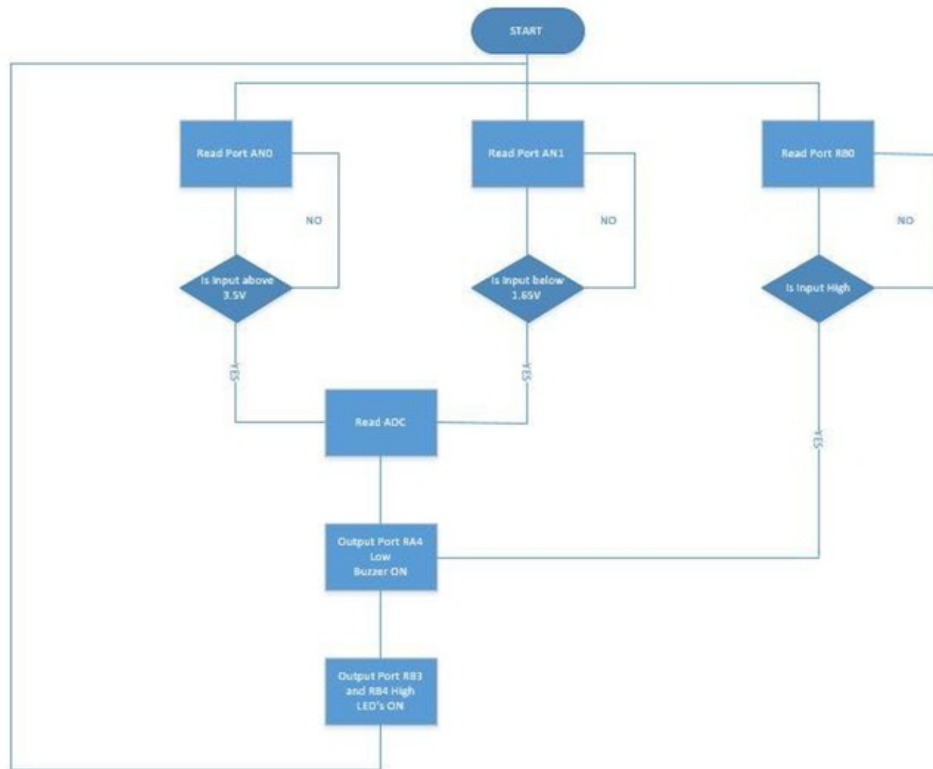


Figure 36 - Software Flow Chart

The figure36 demonstrates the software flow chart for the projects program code. The flow chart is used to explain the algorithm or how the code will work. The flow chart works in the following way:

- First the program starts and then reads ports AN0, AN1 and RB0. AN0 is the Fire sensor, AN1 is the Gas sensor and RB0 is the Test button.
- After this stage 1 of 3 things could happen.
- 1 – If there is an input of 3.5V or more at port AN0 then the program will read the ADC. If the is an input of 3.3V or less then return to read port AN0.

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- 2 – If there is an input of 1.65V or less at port AN1 then the program will read ADC. If there is an input of 1.7V or higher then return to read port AN1
- 3 – If the port RB0 has a high input then the test button has been pressed and an output low signal will output at port RA4 sounding the buzzer.
- When there is an input of 3.5V at port AN0 and the ADC has been read then a low signal is outputted at port RA4 sounding the buzzer and a high signal is send to port RB3 and RB4 switching on the LED's.
- When there is an input of 1.65V at port AN1 and the ADC has been read then a low signal is outputted at port RA4 sounding the buzzer and a high signal is send to port RB3 and RB4 switching on the LED's.
- This stays in a continuous loop repeat the process over and over.

5.4 COMPONENTS IDENTIFICATION AND SELECTION

This section of the report will detail the decision making process for the component that were required for this project. It will compare and justify the reasons for the selections.

5.4.1 Fire Sensor Selection

When deciding what sensor type to use for the fire part of the alarm, as the research pointed out there were three types from which to choose. The research confirms there are three types, Heat and smoke but there are two different sensor types for smoke Optical and Ionization.

From the research conducted three sensor types: heat detection was ruled out on the bases that it is designed mainly to be used in kitchen and garages and this Fire and Gas alarm is designed to be used throughout the house.

After eliminating the heat detection element for the fire sensor that left smoke detection which has the two options of Optical and Ionization. These sensor types are very similar as they both detect smoke but using different methods. Optical uses an infrared LED and Photoreceiver pairing and Ionization uses two metal plate charged with a radioactive isotope. Based on the research conducted the sensor type chosen for this project was the Optical sensor.

The reason for choosing Optical over Ionization was that Optical is better at detecting smouldering fires compared to Ionization and house fires are more often smouldering fires (this doesn't mean

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that Ionization doesn't work as well as Optical.) Also the most commonly used sensor type used in home fire alarm is Optical as it's the most effective sensor.

Once deciding what type of sensor was to be used for the fire sensing part, the decision on what Optical sensor would be suitable for the project. There are a many different Optical sensor option available to use but the two looked at for this project were Infrared emitter receiver pair and the OPB 708.

The Infrared emitter receiver pair is a basic Optical style sensor type, it uses an infrared emitter which sends out a beam of infrared light, it is then received by it receiver pair which would be position a couple of millimetre away with a direct line of sight. The disadvantage with using the emitter receiver pair would be that ambient light would affect how the emitter receiver pair would work as the light would interfere.

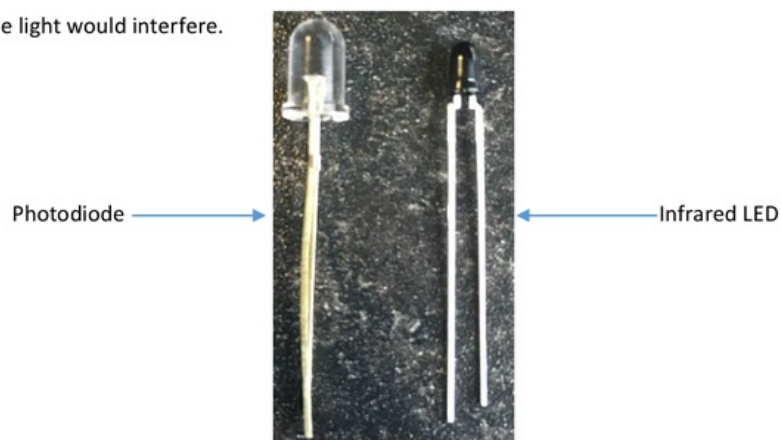


Figure 37 - IR Emitter Receiver Pair

The OPB 708 is a Reflective Optical sensor device which uses a similar style (to that of the infrared emitter receiver pair) of an infrared emitter and a phototransistor. The difference between the two being that the OPB 708 uses a phototransistor instead of a photodiode (receiver) the difference between the phototransistor and photodiode is a phototransistor make use of a "junction transistor which responds to incident light by generating and amplifying an electric current"(32) and the photodiode uses "Semiconductor which generates a potential difference or changes its electrical resistance when illuminated." (32)

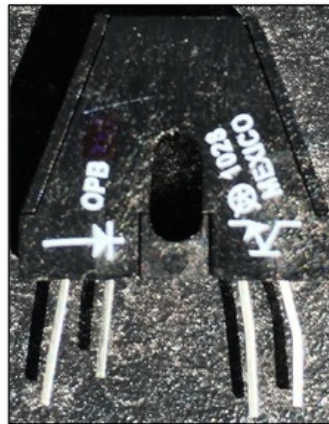


Figure 38 - OPB708

Also another difference between the OPB708 and the emitter receiver pair is that the OPB 708 uses a reflective surface to reflect the infrared beam to the phototransistor this means when the infrared beam is disrupted (i.e. broken) the sensor is active. After comparing the two different Optical sensors the chosen sensor for this project was the OPB708 the reasoning for choosing the OPB708 was that it housed both the infrared LED and phototransistor in one, there was less chance of interference when compared to the emitter receiver pair. Also it can be made into different circuit types (common-emitter circuit and common-collector circuit.)

5.4.2 Gas Sensor Selection

When selecting the gas sensor the referral to the research is required. Referring to the research illustrates that for the gas sensors there are three types that could be used. The three types that could be used are Electrochemical, Semiconductor and infrared.

The Electrochemical sensor uses a measuring technique of taking a certain gas then oxidize or reduce it at an electrode and measure its resulting current.

The Semiconductor sensor uses a semiconductor material with a non-conductive substrate which is between two electrodes. The substrate is then heated the gas that is present causes a reversible change in conductivity of the semiconductor material.

This causes the sensor to be active. The infrared sensor uses an absorption method of infrared radiation.

From the three researched gas sensor types the type that was selected for this project was the semiconductor sensor type. The reasoning for selecting the semiconductor sensor was for a number

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of reasons, first being that the semiconductor can be used to measure a wide range of gases, the sensor will be low cost, the life span of a semiconductor is about 5 years giving it a good life span.

There are some disadvantages but they are at extreme exposures to gas the sensor may take several hours to recover and irreversible changes may occur at the zero gas reading and sensitivity. Another reason for choosing semiconductor over infrared was that the gases which need to be measured must be infrared active, therefore gases that don't absorb IR energy are not detectable.

Furthermore the reason why the choosing of a Semiconductor gas sensor rather than Electrochemical gas sensor is for the reason that the when comparing the two sensors the Electrochemical has the disadvantages of the more exposure to the targeted gas the shorter the life span of the sensor.

After deciding on which gas sensor type to use and why, the decision on what Semiconductor sensor would be used. There are numerous amount of Semiconductor sensor that are available to use which all measurer different gases and multiple gases and in the range for 10 of pound to thousands of pounds.

For this project the two sensors that were looked at were the Figaro 2602 and the Figaro 2600. These sensors are both Semiconductor sensors that look for air contaminants in the surrounding area. There are also very small devices.

The Figaro TGS2602 is an air contaminants gas sensor that is a very small device which is used to monitor the level of contamination in the air. This sensor has a high sensitivity to air contaminants which are gaseous. The sensor has a long life and has a low power consumption.



Figure 39 - Figaro TGS2602(33)

The Figaro TGS2600 is very similar to the TGS2602, it a small device which monitors the air contaminants in the air that are gaseous. The sensor has a long life and uses low power consumption. Also it is low cost.



Figure 40 - Figaro TGS2600(34)

The sensor that was chosen for this project was the Figaro TGS2600. The reason for choosing this sensor was a simple reason (as both sensor are almost identical) the only difference between the two is what gases it can detect. The target gas for this project is Carbon Monoxide and the TGS2600 can detect Carbon Monoxide whereas the TGS2602 cannot detect Carbon Monoxide.

5.4.3 PIC Microcontroller Selection

The PIC Microcontroller is an essential and critical part of this project. The reason for this being a critical part of the project is for the reason that it is the control element. The control element is what make the other parts (Fire and Gas Sensor) work together.

When selecting a suitable PIC Microcontroller there are a many number of parameters that must be taking into consideration.

These parameters are:

- Minimum number of pins required
- Operating Voltage
- RAM
- Program Memory
- Max CPU Speed
- A/D Channels
- Max A/D Resolution
- Watch Dog Timer

These are just a few of the parameters that can be selected when selecting the PIC Microcontroller. Not all parameter need to be used.

When entering in the required parameters for this project PIC not all the option on the microchip website were necessary. The main parameters that were used for selecting the PIC Microcontroller were Program Memory, RAM, Pin Count, Operating Voltage, Max CPU Speed, Internal Oscillator, Max A/D resolution and Total A/D Channels.

After entering the parameters into the Microchip chip selector within the 8-bit Microcontroller range, it produced a list of PIC's that could be used. From that list the PIC's looked at for this project were the PIC16F883 and the PIC18F4321. For selection process see Appendixes 12.3



Figure 41 - PIC16F883(35)



Figure 42 - PIC18F4321(36)

5.4.3.1 PIC16F883

The PIC16F883 is a 28 Pin PIC that has a flash program memory type and the program memory is 7KB. The PIC features the RAM size of 256 bytes and an EEPROM of 256 bytes. This Microcontroller has a wide operating voltage within the range of 2V to 5.5V, there is a brown-out reset and it has a precision internal oscillator. Also this PIC has a 10 bit A/D resolution with a possible 11 channels available.

There are many features that this PIC Microcontroller has here are the key Features:

- 28 Pins
 - 24 I/O Pins
 - Possible 10 Analogue and a Possible 24 Digital Pins
- Flash Program Memory
 - 7KB
 - 4096 words
- Data Memory
 - SRAM – 256 bytes
 - EEPROM – 256 bytes
- 10-bit A/D
 - 11 channels
- Low Power
- Operating Voltage
 - 2V to 5.5V
- Timers
 - 2 x 8 bit
 - 1 x 16 bit
- CPU Speed
 - 5 (MIPS)

5.4.3.2 PIC18F4321

The second PIC that was looked at was the PIC18F4321, this PIC microcontroller has a CPU that can perform up to 10 MIPS, it contains an internal oscillator from 31KHZ to 8MHZ then up to 32MHz. It has a watchdog timer and the operating voltage has a range of 2V to 5.5V. The PIC18F4321 has a 10bit ADC which has 13 channels, there are 40 pins in total, the RAM size is 512 bytes, the memory

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type is flash and the program memory is 8KB. Also there is a brown-out module which is programmable.

There are many features for the PIC18F4321 here are a few:

- 40 Pins
 - 36 I/O Pins
 - Possible 12 Analogue and a Possible 36 Digital Pins
- Flash Program Memory
 - 8KB
 - 4096 single word instruction
- Data Memory
 - SRAM – 512 bytes
 - EEPROM – 256 bytes
- 10-bit A/D
 - 13 channels
- Low Power
- Operating Voltage
 - 2V to 5.5V
- Timers
 - 1 x 8 bit
 - 3 x 16 bit
- CPU Speed
 - 10 (MIPS)

These two PIC Microcontrollers have some similarities and some differences, when deciding what PIC to use there are a few features that effect the decision. For the Fire and Gas alarm the minimum number of pin that are need are 11, which proves that both PIC's are adequate for the project. Also the ADC channels that are required is a minimum of two and both have more than 10 channels providing more than enough ADC channels.

Furthermore the Program memory and Data memory is excellent for this project and the difference between the PIC is not that much in terms of program memory and Data memory size.

The PIC that is more adequate for this project is the PIC16F883 the reason why this PIC is better for this project is that it has 28 pins which is prefect just more than what is required in comparison to

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the PIC18F4321 which has 40 pin which vast exceed what in required and would be unwise to have too many pins that are not needed and won't be used.

Another reason why the decision to choose the PIC16F883 over the PIC18F4321 was the number of ADC channels this project requires a minimum of 2 ADC channel and both PIC have more than 10 but the PIC18F4321 has 13 whereas the PIC16F883 has 11 the difference is not much but there is no need for 13 ADC channel therefore the PIC16F883 is more than suitable for this project.

Although the decision to use the PIC16F883 is the best option the PIC used for this project was the PIC16F873 the reason for choosing this PIC was that it is very similar to the PIC16F883. The PIC16F873 is just the older model of the PIC16F883 and the PIC16F873 was already available at the time of the design so the waiting period for the component to arrive wasn't going to effect the amount of build time available.

See appendices 12.2 for comparison table.

5.5 COMPONENTS LIST

This section of the report will give the description of the components used in this project.

5.5.1 Voltage Regulator

The voltage regulator is an important part of the project as it protects all the components from having too much voltage being supplied to them and damaging them. The voltage regulator used for this project was a 5V regulator. The 5V regulator was used for the reason of the PIC has a maximum 5.5V supply and Fire and Gas sensor also have a 5V required supply.

The 5V voltage regulator is a small circuit device that is used with another circuit to limit or regulate the supply voltage inputted to that circuit. The voltage regulator provides a fixed voltage thus protecting the components for the circuits supply voltage. The reason the voltage regulator is needed is when the circuits supply voltage exceeds the maximum voltage required to power the components within the circuit.

The voltage regulator used for this project was the L7805.

The Figure 43 show the L7805CV voltage regulator.



Figure 43 - L7805 Voltage Regulator

5.5.2 OPB708

The OPB708 is a sensor that is being used for the Fire sensor part of the project. The reason for choosing this sensor was explained in the Component Identification and Selection.

The OPB 708 is a reflective object sensor which has an infrared emitter and a NPN phototransistor in cased in a hard plastic. The infrared emitter and the phototransistor are positioned side by side to one another but angled. The infrared emitter emits a beam of infrared light which with the uses of a reflective surface bounce back to the phototransistor.

The figure44 illustrates the OPB708 used for this project.

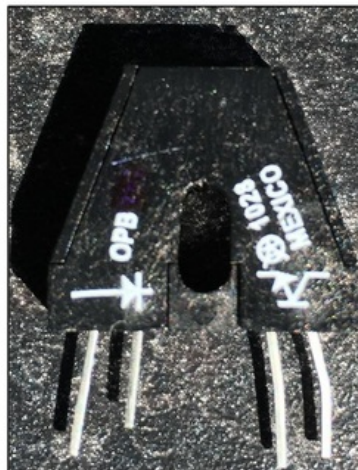


Figure 44 - OPB708

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The infrared emitter is an infrared LED that gives out a light energy that is in the infrared spectrum. The infrared LED in the OPB708 has a wavelength of 935nm, the minimum reflective distance is 2.04mm and the maximum is 7.62mm but the optimum distance is 3.81mm making the reflective process most effective.

This sensor make use of an infrared emitter as already stated but is also used with a phototransistor which act as a receiver for the infrared light. The phototransistor is a transistor with light sensitivity. The phototransistor could be considered as a typical transistor which is housed in a case which allows its semiconductor junctions to be exposed to external light.

The Figure45 show the Phototransistor symbol.

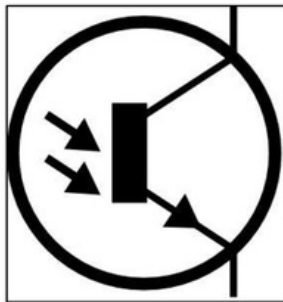


Figure 45 - Phototransistor Symbol(37)

The OPB708 is known as an Optocouples device which is explained in the research. The Optocouples comes under the Optoelectronics category. Optoelectronics can be defined as “the study of any device that produces an electrically induced optical (visible - invisible) light output or optically-induced electrical output/and of the electronic techniques and circuitry used to control such devices.”(14)

5.5.3 Figaro TGS2600

The Figaro TGS2600 is an air contaminants sensor that is used to detect Carbon Monoxide that is present in the surrounding air. The TGS2600 is a small device, which is a sensing element that has a metal oxide semiconductor layer formed that is on an alumina substrate. This is with a sensing chip with an integrated heater.

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The Figure 46 show the Figaro TGS2600 sensor.



Figure 46 - Figaro TGS2600

When the sensor is on and the detectable gas is present the conductivity of the sensor increases, with a simple circuit the change in conductivity can be converted into an output signal that will correspond to the gas concentration.

The sensor is a four pin device Pin1 is the heater Pin2 is the sensor electrode (-) Pin3 is the electrode (+) Pin4 is a heater. The heater is an internal heater that when a 5V supply is given this is to maintain a specific temperature for the optimal sensing.

5.5.4 PIC16F873

The PIC16F873 is an 8bit CMOS flash PIC Microcontroller which is a 28 pin device that is used for controlling a circuit. This PIC is perfect for this project as it has more than enough pins for the number of inputs and outputs. Although this PIC is the older model of the PIC16F883 the difference are not that drastic, there are very little difference. see Appendixes 12.2

The PIC16F873 has a flash program memory type which has a program memory of 7KB the same as the PIC16F883. Also the PIC16F873 has 192 bytes of RAM which is more than enough for this project, the EEPROM is 128 bytes this is more than adequate for the use in this project. There are two 8bit timers or one 16bit timer and the operating voltage is between 2V and 5.5V. The number of 10bit ADC channels is 5 which is more than needed, as the project has two analogue input which need to be converted from Analogue to Digital.

The PIC has a CPU speed of 5 (MIPS), the power consumption is low, it has a brown out detection which is used for brown out reset. There is a watchdog timer although it was not needed. This PIC is a mid-range PIC in the 8bit family range, the PIC has 3 ports A, B and C. There is no internal crystal oscillator therefore an external crystal oscillator was required.

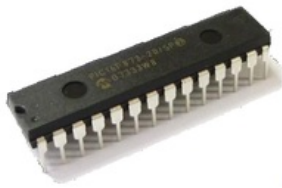


Figure 47 - PIC16F873

5.5.5 Buzzer

The buzzer is an output device which is used to produce a sound. This component is used in this project to provide a sound to warn that there is a fire or Carbon Monoxide leak.

The Buzzer that was used for this project was a generic 12V buzzer which provides a loud alarm noise. It is a very small device which is also known as piezoelectric buzzer. This buzzer has a 90dB sound level. Piezoelectric is "the ability of certain materials to generate an electric charge in response to applied mechanical stress." (38)

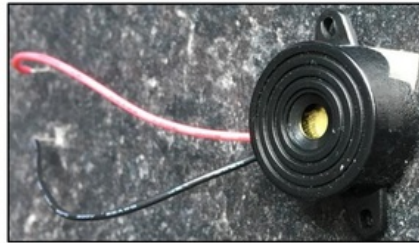


Figure 48 - Buzzer

5.5.6 LED

The LED is an output device that produce light (Light Emitting Diode). For this project the LED is use for a number of things. One LED is used for demonstrating that the Fire and Gas alarm has power to it and it does this by flashing. The other LED's in the circuit are used to show that the Fire and or Gas alarm are active they flash to show this.

An LED is a small device who characteristics are similar to those of a normal diode, as it only allows current to flow through it in one direction. The figure49 shows an LED circuit symbol "which has the electrical characteristics similar to those of a normal diode (i.e. it passes current in one direction and blocks it in the other), but emits light when biased in the forward direction." (14)

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The Figure49 show the circuit symbol for a LED and Figure50 show two LED that were used.

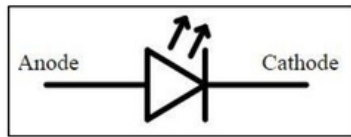


Figure 49 - LED Circuit Symbol

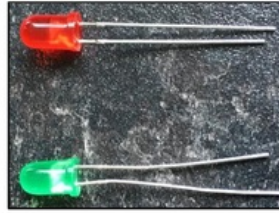


Figure 50 - LED's

The other components that were used for this project were:

- Button for testing – Figure51
- External Crystal – Figure51
- Resistors and capacitors – Figure51
- Potentiometer – Figure51

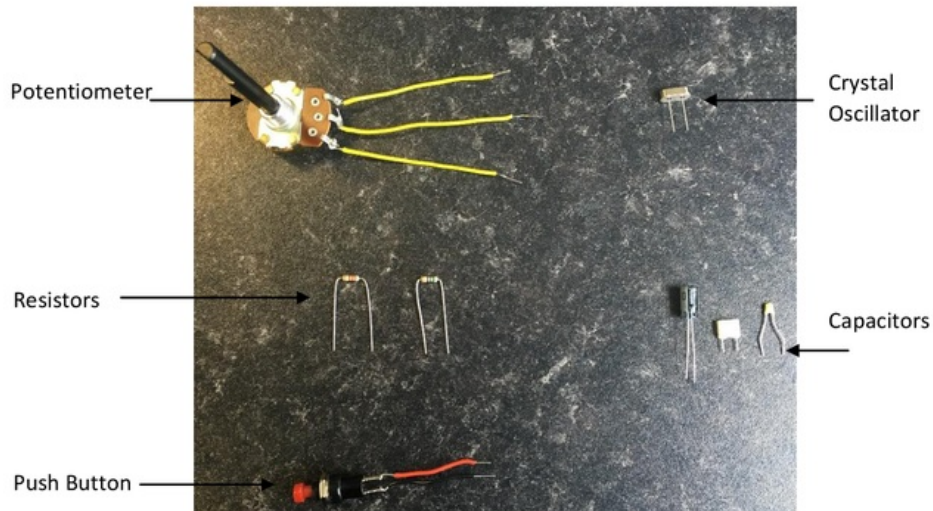


Figure 51 - Components

The figure51 display the components potentiometer, button, crystal, resistors and capacitors.

For cost of components see appendixes 12.1

5.6 PRODUCT MARKETABILITY

The marketability of this project is very feasible from the research conducted this is a product that everyone needs it is an essential safety device that can save life by alerting them to the danger. This project can be a very cheap product when the sensors and components are bought in bulk. The producing of this product in a bulk format can reduce cost of the overall build creating a cheap, cost effective 2in1 fire and gas alarm that everyone can afford and is as good as leading market product.

For full marketability see appendices 12.6

5.7 PROTEUS CIRCUIT DIAGRAMS AND SIMULATIONS

This section of the report will show the Proteus circuit designs and simulations created for this project. The designs will include a full Proteus circuit designs and simulations and a breakdown of the individual part of the full circuit design.

5.7.1 Full Proteus Design

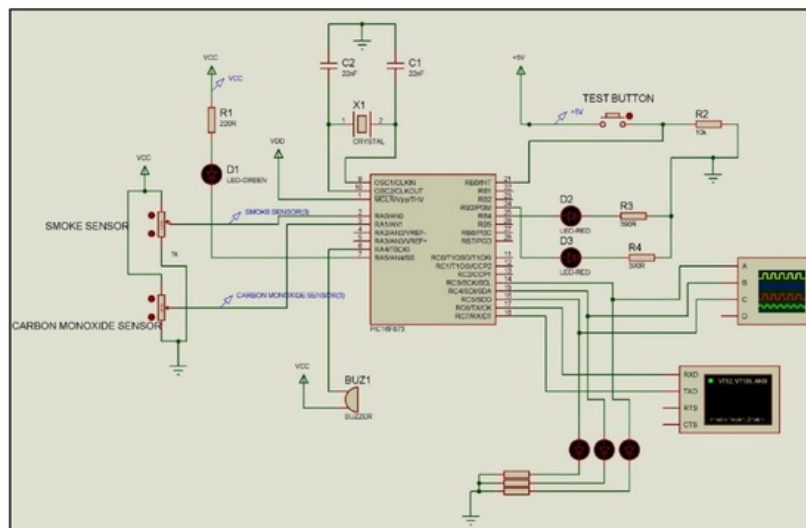


Figure 52 - Full Proteus Circuit Design

The figure52 displays the full Proteus circuit diagram that will be broken-down into the individual part of the circuit and the explanation of what they do and what their out-come was, will also be given.

5.7.2 Voltage Regulator Design

The voltage regulator is a voltage limiting device design to reduce the amount of voltage that is supplied to a circuit to protect vital components.

The voltage regulator used for this project was the L7805. This is a small device with 3 pins as show in figure53. With the uses of 2 capacitors either side of the L7805 it will produce 5V from a 9V input. The capacitors used were two 22 μ F electrolytic and two 0.1 μ F. The figures53 and 54 show the arrangement of the capacitors with the L7805.

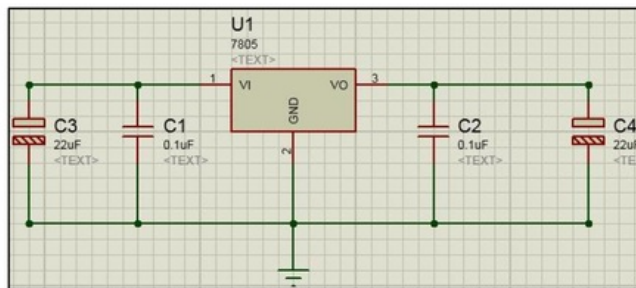


Figure 53 - Proteus Voltage Regulator Design

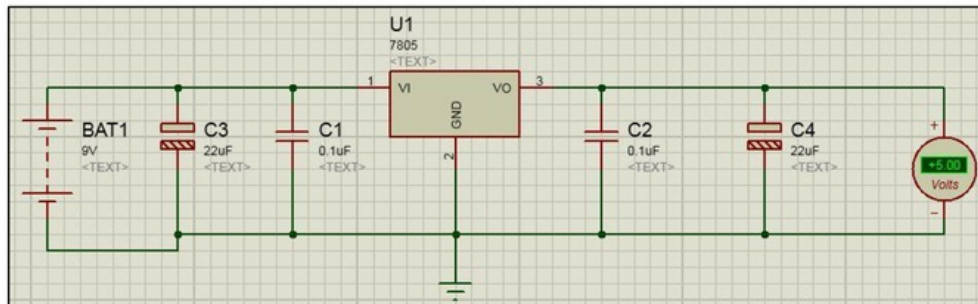


Figure 54 - Proteus Voltage Regulator Simulation

The figure54 is the Proteus design and simulation of the voltage regulator. This demonstrates how the voltage regulator will work. There is a 9V battery supply which is display as BAT1 on figure54 with the L7805 in the centre takes the voltage in and then regulating the 9V to the output. At the output there is a voltmeter and it is displaying the regulated 5V.

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5.7.3 Power ON LED

The power on LED is used to provide an indication that the circuit is receiving power.

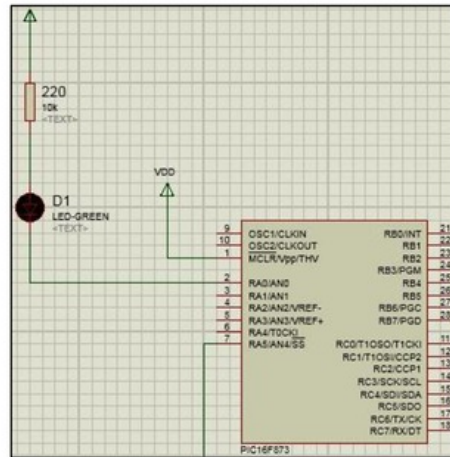


Figure 55 - Proteus Power LED Design

The Figure55 Show the setup for the Power LED. When there is power to the circuit the GREEN LED will be on and it will flash.

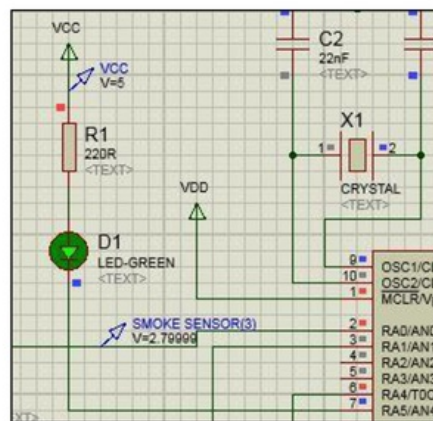


Figure 56 - Proteus Power LED Simulation

The figure56 demonstrates that the circuit has power as the GREEN LED is on

5.7.4 Fire Sensor OPB708

The Fire sensor is the OPB708 which is a reflective object sensor. This Optical sensor uses infrared emitter phototransistor pairing. This small 4 pin device (which can be seen in figure44) use infrared to detect smoke, this happens when the IR beam is broken outputting a high voltage.

In order to demonstrate the Fire sensor on Proteus a potentiometer was used in place of the OPB708 as Proteus does not have the OPB708 component.

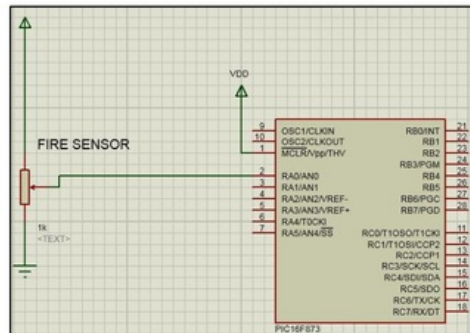


Figure 57 - Proteus Smoke Sensor Design

Figure57 displays the setup of the fire sensor the potentiometer is used to simulate the OPB708. The potentiometer work on the same bases of the OPB708 it starts off a base voltage which is 3.3V then when the potentiometer is moved above 3.5V the sensor will be active.

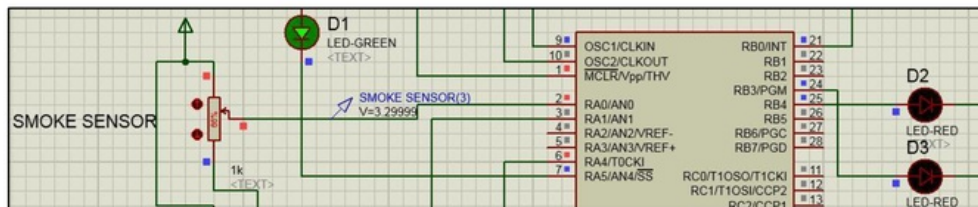


Figure 58 - Proteus Smoke Sensor Simulation not Active

The figure58 demonstrates the Fire sensor element of the design. This show the sensor as not active as it is at the base voltage of 3.3V. The reason for knowing that the sensor is on but not active is that the Green LED is on showing that there is power to the circuit. But the two RED LED's are not on displaying that the sensor is not active at 3.3V

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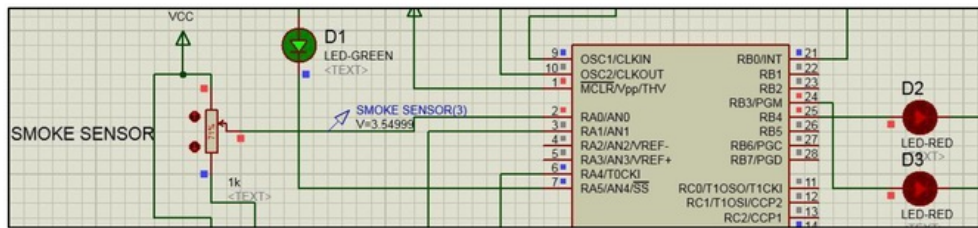


Figure 59 - Proteus Smoke Sensor Simulation Active

The figure59 demonstrates the smoke sensor as active. The evidence for this is that the two RED LED's are on. As stated before the fire sensor will only be active when the potentiometer goes above 3.5V, as the figure59 show the voltage is 3.54999V which is above 3.5V thus turning the two RED LED's on.

5.7.5 Gas Sensor TGS2600

The gas sensor is the Figaro TGS2600 which is an air contaminants sensor. The device has 4 pins (see figure46,) it is very small device.

When demonstrating the gas sensor on Proteus similar to the fire sensor a potentiometer was used, the reason for this is that the Figaro TGS2600 is not available on Proteus.

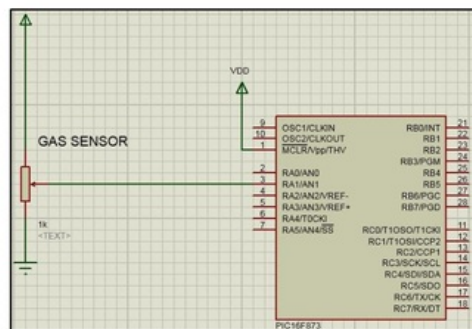


Figure 60 - Proteus Gas Sensor Design

The figure60 illustrates the gas sensor displayed as a potentiometer instead of the Figaro TGS2600.

The gas sensor work similarly to the fire sensor with it having a base voltage but when the voltage drop to or below 1.65V the sensor will be active.

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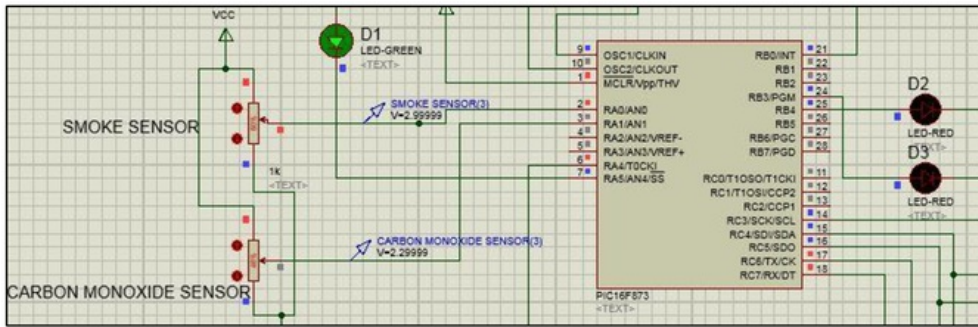


Figure 61 - Proteus Gas Sensor simulation not active

The figure61 shows the full setup of the Gas sensor design with the output LED's. The figure show the Gas sensor as not active, the reason for that is the sensor is at a base voltage where it is not active. Another reason to prove this is the circuit has power as the GREEN LED is on but the sensor is at 2.2999V which will not be active the evidence for this is that both the RED LED' are not on.

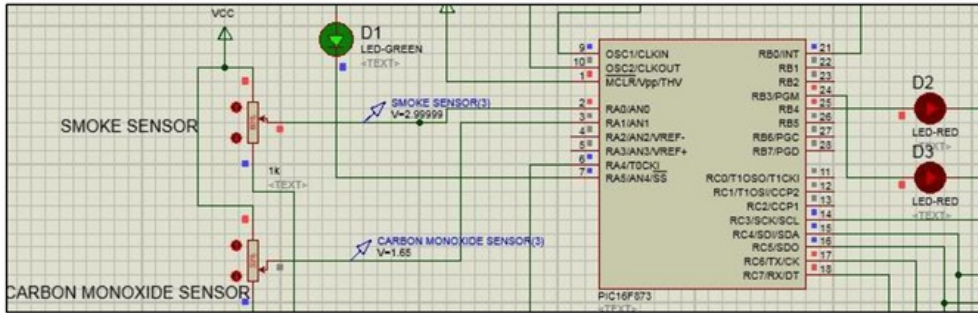


Figure 62 - Proteus Gas Sensor Simulation Active

The figure62 demonstrate that the Gas sensor is active. The verification for this is that there is power to the circuit displayed by the GREEN LED being on, the Gas sensor is at its activation point of 1.65V and the two RED LED's are on. This proves that the sensor is active, performing and doing as its design to do.

5.7.6 Test Button

The Test button is a feature that is used on this Fire and Gas alarm to test that the alarm is function as it is supposed to do.

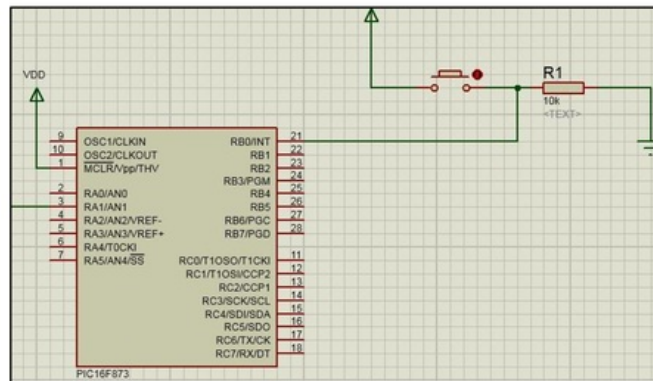


Figure 63 - Proteus Test Button Design

The figure63 is the displaying of the test button. The button is powered by 5V and used with a Pull down resistor. The Pull down resistor is used to pull the button low until the button is pressed. When the button is pressed the button become active sending a signal to the PIC setting off the Alarm.

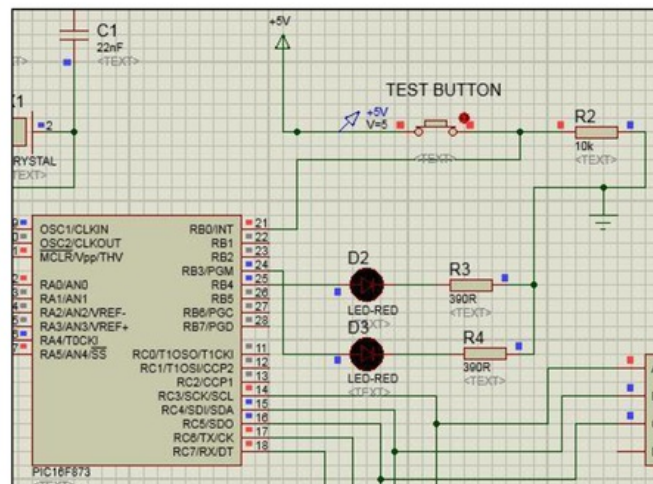


Figure 64 - Proteus Test Button Simulation

The Figure64 shows the test button pressed and active. The evidence show it is active is that the red little squares in the figure are high and it enters to the PIC.

5.7.7 Output LED's

The output LED's were used to show that the sensors were active and working. It is an indication that the alarm is working.

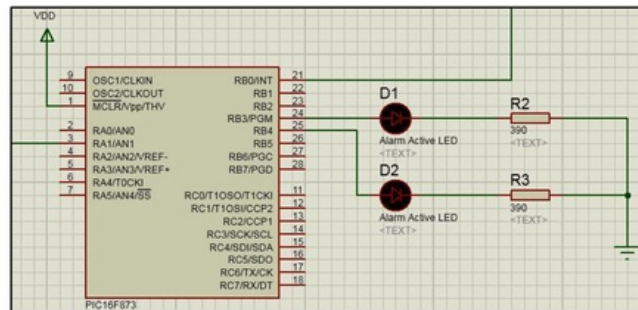


Figure 65 - Proteus Output LED's Design

The figure65 shows the design of the two output RED LED's with pull down resistors. These LED's will only become active or switch on when the Fire or Gas sensor is active. Once either of the two sensor are active the RED LED's will flash to indicate that there is a Fire or Gas leak in the surrounding area.

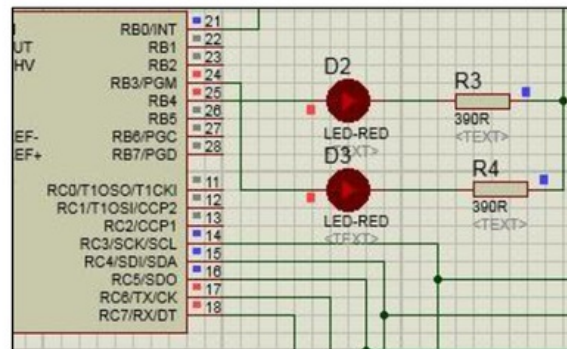


Figure 66 - Proteus Output LED's Simulation

The figure66 demonstrates the RED LED's as on which means that the sensors are active and working.

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5.7.8 Buzzer

The buzzer is used for this project to output a sound as a warning when either the Fire or Gas is active.

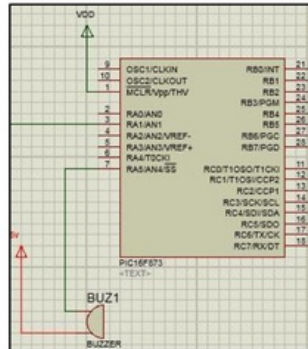


Figure 67 - Proteus Buzzer Design

The figure67 shows the design setup of the buzzer, it is connected to 5V power and connected into the PIC.

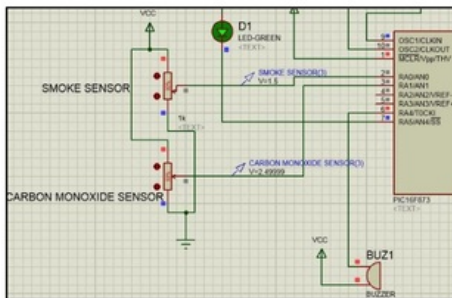


Figure 68 - Proteus Buzzer Output high not active

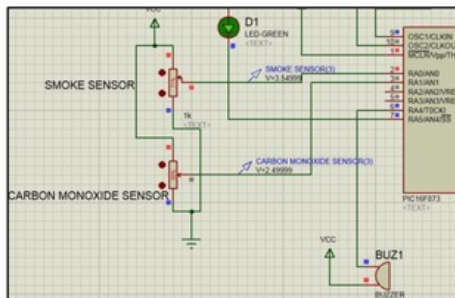


Figure 69 - Proteus Buzzer Output low active

The figure68 displays the buzzer as non-active there is no sound output. The evidence for this is that in order for the buzzer to be active it must go low, but the buzzer is currently high as shown by the little red square on the buzzer side that is entering the PIC.

The figure69 demonstrates the buzzer as active and there is a sound output. The evidence that this is correct is that the little red square has now changed to blue, this means that it is now low which activates the buzzer. The reason the buzzer is active is that the Fire sensor has gone above 3.5V which is the activation point.

5.8 CIRCUIT DIAGRAMS DESIGNS

This section of the report will show the full circuit diagram of the fire and Gas alarm. Also the individual parts of the circuit. The Fire sensor, Gas sensor, voltage regulator and the crystal oscillator.

5.8.1 Full Circuit diagram

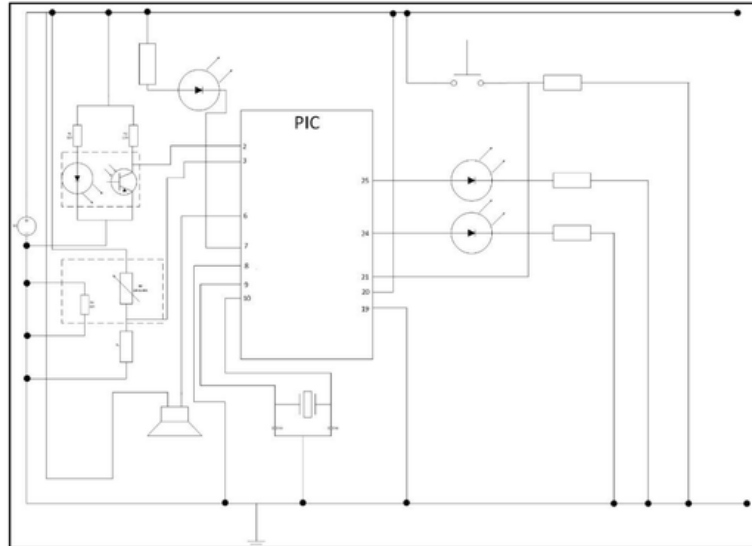


Figure 70 - Full Project Circuit Diagram

The figure70 displays that completed circuit diagram for the Fire and Gas alarm. It shows the different inputs, outputs and the control which is the PIC Microcontroller.

5.8.2 Voltage Regulator

The figure71 illustrates the circuit diagram for the voltage regulator, which was used to limited the voltage supply to protect the circuit.

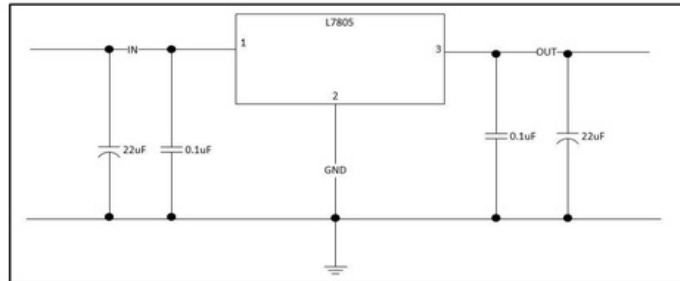


Figure 71 - Voltage Regulator Circuit Diagram

5.8.3 Fire sensor

Figure72 shows the circuit diagram for the fire sensor OPB708. This sensor is used to detect smoke. The setup for the OPB708 is in the common-emitter circuit.

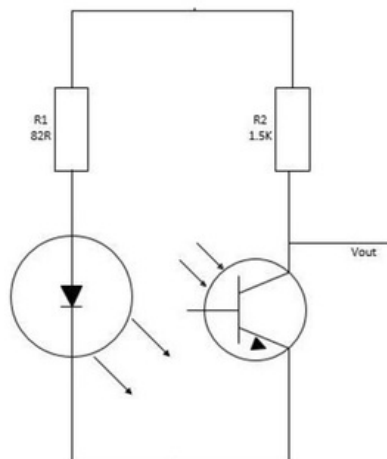


Figure 72 - OPB708 Circuit Diagram

The resistors for the OPB708 were calculate in the following way and with the information for the datasheet.

These are the calculation for R1:

$$R1 = \frac{(V_{cc} - VF)}{IF}$$

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$$R1 = \frac{5V - 1.7V}{40mA}$$

$$R1 = 82.5\Omega$$

The nearest placed values for 82.5Ω is 82Ω therefore R1 = 82Ω

These are the calculation for R2:

$$R2 = \frac{(V_{cc} - V_{CEsat})}{I_{C(on)}}$$

$$R2 = \frac{(5V - 0.40V)}{3mA}$$

$$R2 = 1,533.3$$

The nearest placed value to 1,533.3Ω is 1.5K therefore R2 = 1.5K

5.8.4 Gas Sensor

Figure73 demonstrates the Figaro TGS2600 circuit diagram it has an internal variable resistor that changes dependent on the gas present and an internal heat resistor which is 83Ω at room temperature.

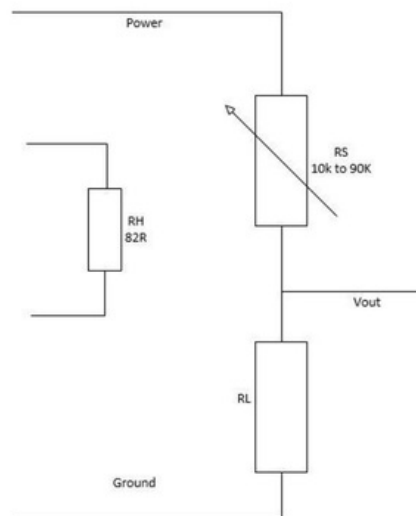


Figure 73 - Figaro TGS2600 Circuit Diagram

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Within the figure73 there are two internal resistor RH which is the Heater Resistor and RS which is the sensor Resistor. The RL is the Load Resistor which is external to the sensor.

5.8.5 PIC16F873

The Figure 74 illustrates the PIC16F873 circuit diagram which show all the pins.

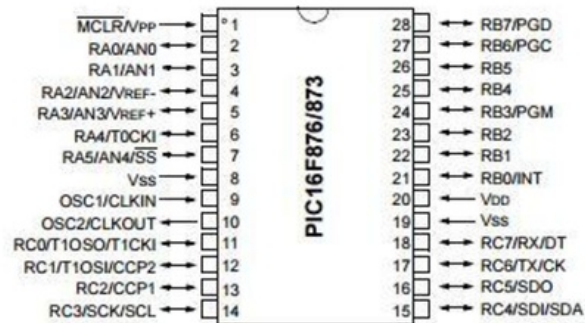


Figure 74 - PIC16F873 Circuit Diagram

5.8.6 Crystal Oscillator

The figure75 displays the external crystal oscillator which produces 4MHz clock.

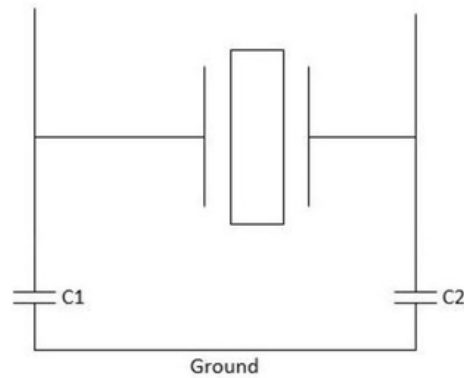


Figure 75 - Crystal Oscillator

To see a list of hardware and software used see appendixes 12.8

6 CHAPTER VI - IMPLEMENTATION

The Chapter of the report is of the implementation of the project. This Chapter will show the final design circuit build, completed and tested. The test will consist of the different parts of the project with images to provide evidence that the project is working. Also the explanation of the program code that was created for the project.

The implementation of this project will consist of a few things:

- The building of the completed circuit diagram on to a breadboard.
- The Implementation of program code to the microcontroller
- The testing of the full circuit and the individual parts.

6.1 VOLTAGE REGULATOR

The voltage regulator is the protect circuit for the project as it limits the amount of voltage that is supplied to the circuit. The voltage regulator for this project in 5V.

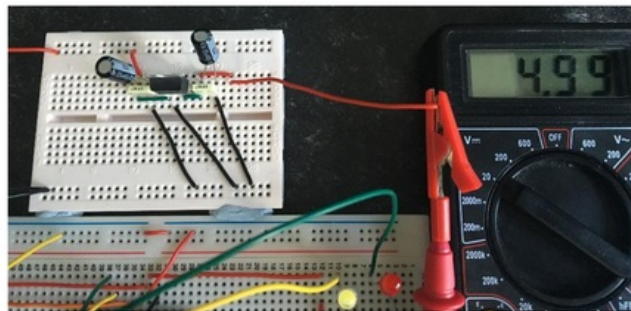


Figure 76 - Voltage Regulator Testing

The figure76 demonstrates the voltage regulator functioning as it supposed to do limiting the voltage from 9V to 5V to protect the circuit.

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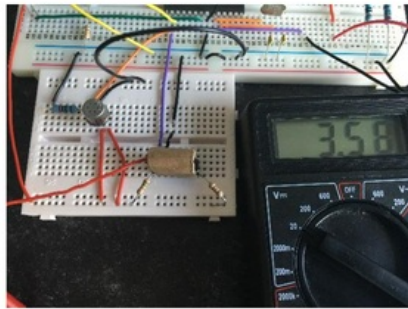


Figure 80 - OPB708 start state

The figure80 illustrates the OPB708 at the start state of 3.5V. This show that the sensor is not active as the activation point is one third of the start voltage.

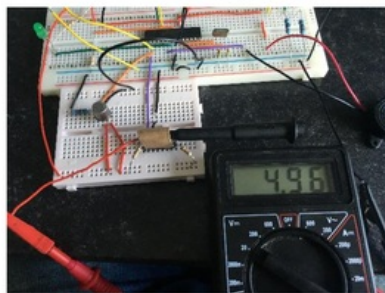


Figure 81 - OPB708 active

The figure81 show the OPB708 as active as it has increased the voltage by 1/3 of the start voltage. To test that the sensor was functioning a small black piece of plastic was used to break the infrared beam.

6.3 FIGARO TGS2600

The Figaro TGS2600 was used to detect the presence of gas. The sensor works on the principles of when the voltage drops below 1.65V then sensor should be active. The start voltage of this sensor is about 3.0V.

To simulate the gas sensor as Carbon Monoxide Gas was not available at the time of testing a potentiometer was used.

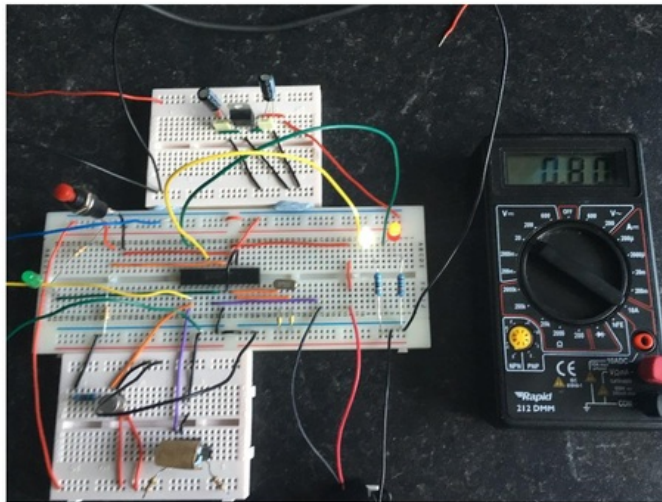


Figure 82 - Figaro TGS2600 Sensor active

The figure 82 demonstrates that the gas sensor is active but the activation point at which the sensor becomes active is 0.80V not the expected 1.65V. The evidence that the sensor is still working is that the two LED's are lit up.

Therefore based on the evidence provided by figure81 the Figaro TGS2600 is not active when the voltage out is more than 0.80V.

6.4 TEST BUTTON

The test button has the function of being able to test the alarm device at any time. The test button is for safety purposes and should always work.

The test button works on the bases that it is always low this meaning that the voltage of the button is always low. Therefore when the Test button is pressed the voltage must go high and the button and alarm become active

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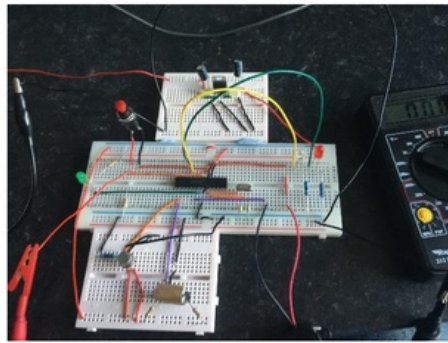


Figure 83 - Test Button Not Active

Figure83 displays the evidence for the test button as being not active. This is shown by the voltage meter displaying 0V at the test button when not being pushed.

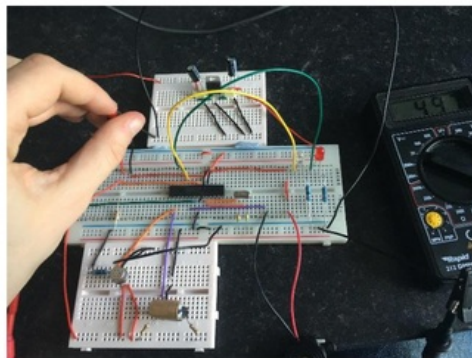


Figure 84 - Test Button Active

The above figure illustrates the test button as active. This statement is true as the figure84 show the test button being pressed and the voltmeter is displaying 4.98V. This shows that the test button function is working correctly as the voltage starts off low when the button is pressed then the voltage goes high.

6.5 OUTPUT LED'S

The output LED's are used as an indicator to warn people that the alarm is sounding and there is danger. These LED's have a constant low voltage which keeps the LED's switched off. When one or both sensors are active the LED's get a voltage from the PIC powering them on. They flash on an off.

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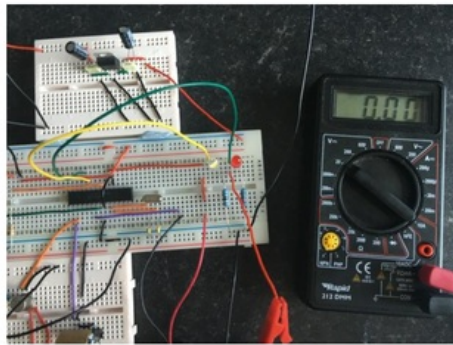


Figure 85 - Output LED's not active

The figure85 displays the evidence for the output LED's as being not active. This means that the alarm is not sounding neither of the sensor are active therefore there is no voltage going to the LED's.

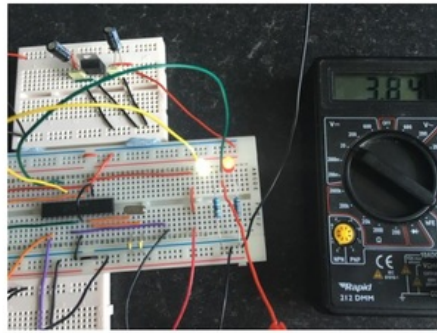


Figure 86 - Output LED's Active

In the figure86 the demonstration that the output LED's are active is shown. The LED's are active because one or both sensors are active, therefore the LED's are given a voltage thus powering them to flash on and off.

6.6 BUZZER

The buzzer in this circuit is for sounding and alerting the users that there is fire and or a Carbon Monoxide leak. The buzzer has a constant high pin connection when the sensor is not active. When the sensors become active the buzzer becomes logic low.

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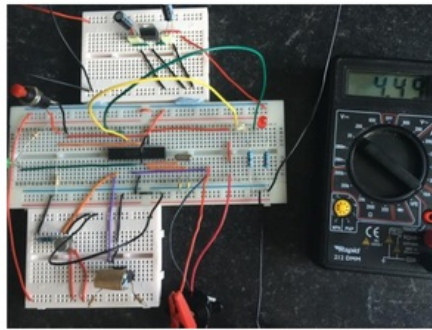


Figure 87 - Buzzer not active

The figure 87 shows the buzzer as not active, even though the voltage at the buzzer is 4.49V the buzzer will not be active until the voltage decreases significantly. In order for the buzzer to sound the sensors or test button must be active and then the voltage will decrease setting off the alarm.

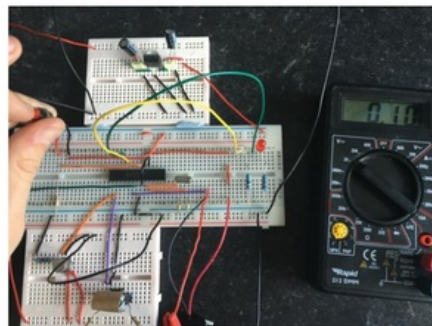


Figure 88 - Buzzer Active

The figure 88 gives the evidence that the buzzer is active and sounding. The buzzer is active because the test button has been pushed. The voltage of the buzzer has decreased from 4.49V to 0.10V as expected the buzzer works when the sensor or test button is active the buzzer voltage drops and the buzzer sounds.

6.7 FULL COMPLETED CIRCUIT

This section will demonstrate the complete circuit which was build on to a breadboard.

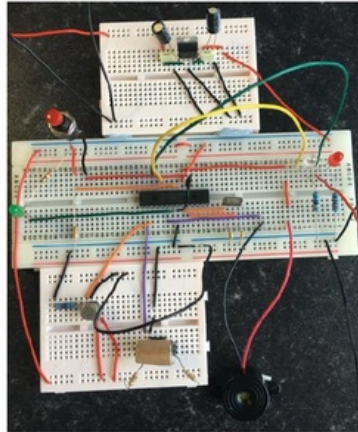


Figure 89 - Complete Circuit Top view

The figure 89 shows the top view of the complete circuit.

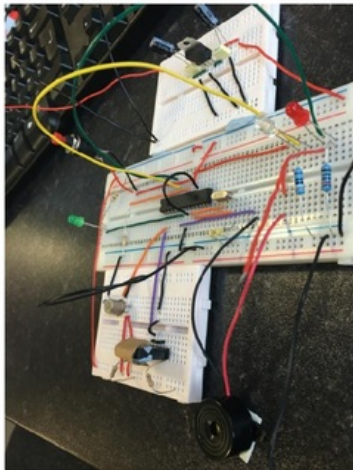


Figure 90 - Side view of circuit

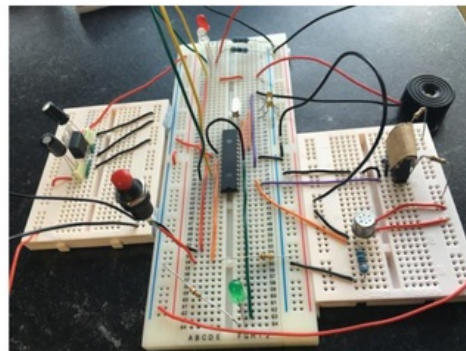


Figure 91 - Side view of complete circuit

6.8 PROGRAM CODE

The program code for this project was created to bring together the different parts and elements so that they could work together. To implement the code the use of proteus and CCS were used to create the code and to finally program the code to the PIC microcontroller with the use of MPLab IPE. Along with the Pikit3 and MPLab the programming of the code was simple just connect up the correct pin to the Pikit3 and with the HEX file from Proteus the code was implement to the PIC within second.

The evidence that the program code worked was shown above in the different section of the implementation, as the individual parts of the circuit all work together as one Fire and Gas Alarm.

```

45     temp=temp/3; // divide by 3 integer
46     sensor trig=temp-temp; // set triggerpoint to read value +1/3 of remainder
47
48
49     while(true)
50     {
51         output_high(main_led);
52         delay_ms(500);
53         sensor();
54         light();
55         output_low(main_led);
56         blink();
57     }
58 }
59
60
61 void blink(void)
62 {
63     {
64         output_low(LED);
65         delay_ms(DELAY);
66         output_high(LED);
67         delay_ms(DELAY);
68     }
69 }
70
71 void sensor(void)
72 {
73     {
74         output_high(sensor_led);
75         delay_ms(500);
76         if((sensor[0]>sensor trig) || (sensor[1]<sensor trig) || (input(Button)))
77             output_low(Buzz);
78         else output_high(Buzz);
79         output_low(sensor_led);
80     }
81 }
82
83 void light(void)
84 {
85     output_high(light_led);
86     delay_ms(500);
87     if((sensor[0]>sensor trig) || (sensor[1]<sensor trig))
88     {
89         output_toggle(PIN_B4);

```

Figure 92 - Program code

This is a figure92 demonstrating some of the code created for this project. The code has three function blink which is used to flash the power LED on and off to indicate that there is power in the circuit. The Sensor function is for the two sensors and the test button which outputs to the buzzer sounding it and the light function is for the two output LED's that toggle between on and off when the sensors are active.

See Appendixes 12.4 for full code.

7 CHAPTER VII - EVALUATION

7.1 INITIAL EVALUATION

The initial evaluation of the project report shows the following outcomes were achieved.

- The research section which was created to identify the relevant and key specific needed to create a Fire and Gas alarm device.
- The research methodology that was identified and used gave a efficient way to conduct the research of the project.
- The market research was a successful section giving an idea of what other had done and how it could help the design of the project. Also gave an idea of what could be done in the future.
- A design simulation created on proteus was a success and influenced the overall circuit design.
- The implementation of the software code to the Microcontroller was success and the build of the complete Fire and Gas alarm was a successful attempt.
- The overall project was a successful endeavour as the Fire and Gas alarm was fully functional.

7.2 RESEARCH AND LITERATURE REVIEW AND MARKET RESEARCH EVALUATION

From the research and literature review and market research there are a number of outcomes and conclusion that were achieved.

The following achievement were an outcome of the research and literature review and the market research:

- The identification of the ideal sensor type that could have been used
 - Statistical information that influenced the decision making about sensor types to use.
-

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- The relevant laws and regulation surrounding the fire and gas within the home.
- The idea for the number of people harmed by fire or gas directly or indirectly influenced the fire and gas alarm.
- The research into the different products and their features identifying what's available and what feature could be or could have been implemented into the project.
- Also the research methodology influenced the way in which the research was conducted.

7.3 DESIGN AND IMPLEMENTATION EVALUATION

The evaluation of the Design and implementation stage reveal that there were a number outcomes.

The outcomes of the evaluating the design and implementation were:

- The proteus design and simulation provided a successful idea of how the project might work.
- The design and simulation of the proteus circuit took longer than anticipated thus extending the build period as the simulation was not yet complete.
- The implementation of the build was initially unsuccessful as the circuit wasn't acting as expected. This was due to the code implementation.
- Once correcting the code the circuit implementation was completed.
- Finally the fully functional circuit was completed and it was a success acting as expected.

7.4 QUESTIONNAIRE

The questionnaire results showed up a few of key points:

- 70% of the people who completed the questionnaire said they had 1-2 fire alarms, when the recommended is a minimum of 3 alarms
 - 80% of the people said they don't have a Carbon monoxide alarm.
-

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- When asked how often they test their fire alarm 30% said that they never check and 40% said every 6 months. When the recommended is a least once a month.
- 40% of people said that they were not aware of the symptoms of Carbon Monoxide.
- Finally 40% of people said they were only willing to pay £10 or under for a fire and or gas alarm.

For questionnaire see Appendixes 12.7

7.5 OVERALL EVALUATION OF THE PROJECT

Overall the project was a success as the overall aim of the project was to have a fully functional Fire and Gas alarm. The overall evaluation of the project was that the aims and objectives were mostly met and completed. The project was an attempt to create, design and build a Fire and Gas Alarm the aim was successfully completed thus making the project an overall success.

8 CHAPTER VIII - CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

Throughout this project report, there were different aims and objective undertaken. These aim and objectives involved research into regulation, different sensor types and market research. Also, the design, simulate, build and test of the completed project.

The research was completed with detailed review of the basic fire and gas regulation outlining the regulations that are require when using a fire and gas alarm. Also the detailed review of the different sensor type for fire and gas detection was completed. This aided the selection and design process for this project.

The research methodology that was used in this project report was effective in outlining the way in which the research was conducted and carried out.

The market research was a successful and effective way of seeing what was available the market and how these product could be used to aid design and build. Also it aided in the ideas for any future enhancements.

The design process for this project was aided by the research and market research through outlining the different sensor types and what was already available on the market. The sensor types used were Photoelectric and semiconductor which are commonly known sensor types. Also the simulation of a proteus design was conducted simulating how the alarm device might function.

The implementation carried out for this project involved the build of the fire and gas alarm. This build was based upon the proteus design and the circuit design created, the build process was a short process but the software was a bit time consuming but was completed and implemented to the microcontroller.

Overall the main aim of the project to design and build a functioning Fire and Gas Alarm. Which was completed although there were issues through the duration of the project the overall aim was completed.

8.2 RECOMMENDATIONS

In the event of the continuation of the project to further the project there are the number of ideas that could be implemented for improvement. These ideas are from the research and market research conducted:

- The implementation of two separate sensors alarms Fire and Gas that communicate through RF. In the event of a fire or gas leak if one alarm sound then both alarms will sound.
 - The implementation of display or some sort of high intense lighting that flashes to alert people with hard of hearing.
 - Another implementation would be have mains instead of battery as the primary source of power. Also with the mains have a backup which would be battery.
 - In the fire alarm have more than one sensor type involved in the detecting of the fire (i.e. photoelectric with heat detection) improving the success rate of the fire alarm.
 - The creation of a central hub which can access different alarms and test them from one point instead individually check each alarm.
-

9 CHAPTER IX - REFLECTIONS

9.1 REFLECTION

When looking back and reflecting on this project the decision to choose a Fire and Gas alarm was a decision made based on the safety aspect. Personally the Fire and Gas alarm was a interesting project to tackle as it has two different detection elements and the safety aspects.

Upon reflecting on the project a few things could be concluded:

- When the project was started the knowledge of the various sensor type that fire and gas alarms used was very minimal to no knowledge at all but throughout the duration of this project the knowledge gained has been greatly help with the understanding of how the project work.
- The reading into optoelectronics and understanding that there many different uses and types of sensor that could be use for it.
- When the research was completed the basic understanding for the many laws and regulations that must be abided by when it comes to fire and gas alarms.
- The statistical information research gave a wider and greater understanding for the different aspect that is involved with fire and gas. The knowledge gained vastly influenced the way in which this project was conduct and completed.
- The fundamental knowledge about the programming of a PIC Microcontroller was gain and understood, improving the basic knowledge for future projects.
- The appreciation for the use of datasheet, block diagrams and circuit diagram to help in the aid of completing the project.
- Throughout this project time management has been a difficult factor to handle, therefore the handling of time has to be something to improve, so setting goals and target to be met in a specific time scale.
- The use of simulation software which help provided an understanding of how the project might work gave the understanding for how future project can be work out and understood.

Overall this project was a big learning curve as it provided difficulty that needed to be figured out through different way of understanding. Therefore this project has help in the development of the basic and fundamental understanding of the aspect that are needed to complete a project.

10 CHAPTER X - REFERENCES

1. How Fire Works [Internet]. HowStuffWorks. 2002 [cited 2016 Apr 17]. Available from: <http://science.howstuffworks.com/environmental/earth/geophysics/fire.htm>
 2. Fire safety [Internet]. [cited 2016 Apr 17]. Available from: <http://www.hse.gov.uk/toolbox/fire.htm>
 3. Fire Statistics UK [Internet]. [cited 2016 Apr 17]. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456652/Fire_Statistics_Great_Britain_2013-14__PDF_Version_.pdf
 4. Home Structure Fires [Internet]. [cited 2016 Apr 17]. Available from: <http://www.nfpa.org/research/reports-and-statistics/fires-by-property-type/residential/home-structure-fires>
 5. Fire Risk Assessment – A Guide [Internet]. [cited 2016 Apr 17]. Available from: <http://www.welhat.gov.uk/CHttpHandler.ashx?id=1814>
 6. The consequences of fire [Internet]. [cited 2016 Apr 17]. Available from: <http://www.nfpa.org/press-room/reporters-guide-to-fire-and-nfpa/consequences-of-fire>
 7. Types of Smoke Detectors and Alarms - Quick Tips #366 - Grainger Industrial Supply [Internet]. [cited 2016 Apr 17]. Available from: <http://www.grainger.com/content/qt-types-smoke-alarms-detectors-366>
 8. PTC thermistor - Positive Temperature Coefficient » Resistor Guide [Internet]. [cited 2016 Apr 17]. Available from: <http://www.resistorguide.com/ptc-thermistor/>
 9. PTC Thermistor [Internet]. [cited 2016 Apr 19]. Available from: http://www.conrad.com/medias/global/ce/5000_5999/5000/5000/5004/500441_BB_00_FB.EPS_1000.jpg
 10. Thermistor.jpg (360×360)NTC [Internet]. [cited 2016 Apr 19]. Available from: <http://p.globalsources.com/IMAGES/PDT/B1070516810/Thermistor.jpg>
 11. NTC thermistor » Resistor Guide [Internet]. [cited 2016 Apr 17]. Available from: <http://www.resistorguide.com/ntc-thermistor/>
 12. Why is NTC thermistor widely used in automotive industry? What are its advantages? - Quora [Internet]. [cited 2016 Apr 17]. Available from: <https://www.quora.com/Why-is-NTC-thermistor-widely-used-in-automotive-industry-What-are-its-advantages>
 13. Thermistor Graph [Internet]. [cited 2016 Apr 19]. Available from: https://infosys.beckhoff.com/content/1033/el32xx/Images/png/1525821067__Web.png
 14. Marston RM. Optoelectronics Circuits Manual. Elsevier; 2013. 191 p.
 15. optical.jpg (472×322) [Internet]. [cited 2016 Apr 19]. Available from: <http://www.apollo-fire.co.uk/media/753726/optical.jpg>
-

Major Project Report

16. Ionization vs photoelectric [Internet]. [cited 2016 Apr 17]. Available from: <http://www.nfpa.org/safety-information/for-consumers/fire-and-safety-equipment/smoke-alarms/ionization-vs-photoelectric>
 17. smoke114.gif (350×280) [Internet]. [cited 2016 Apr 19]. Available from: <http://teachnuclear.ca/wp-content/uploads/2013/05/smoke114.gif>
 18. CO-moleculecrop2.jpg (960×400) [Internet]. [cited 2016 Apr 19]. Available from: <http://www.mysafela.org/wp-content/uploads/2014/09/CO-moleculecrop2.jpg>
 19. Choices NHS. Carbon monoxide poisoning - NHS Choices [Internet]. 2015 [cited 2016 Apr 17]. Available from: <http://www.nhs.uk/Conditions/Carbon-monoxide-poisoning/Pages/Introduction.aspx>
 20. Carbon monoxide poisoning sends 4,000 people to A&E each year - News stories - GOV.UK [Internet]. [cited 2016 Apr 17]. Available from: <https://www.gov.uk/government/news/carbon-monoxide-poisoning-sends-4-000-people-to-a-e-each-year>
 21. Gas Stats [Internet]. [cited 2016 Apr 19]. Available from: <http://www.co-gassafety.co.uk/wp-content/uploads/2015/07/Charts-for-presspack-Jan2016.pdf>
 22. UK map for carbon monoxide poisoning by area [Internet]. [cited 2016 Apr 19]. Available from: <http://www.co-gassafety.co.uk/wp-content/uploads/2015/07/Map-from-Kadee-with-notes-etc..pdf>
 23. Sensor Technology - Delphian Corporation [Internet]. [cited 2016 Apr 17]. Available from: <http://www.delphian.com/sensor-tech.htm>
 24. Electrochemical gas sensor. In: Wikipedia, the free encyclopedia [Internet]. 2015 [cited 2016 Apr 17]. Available from: https://en.wikipedia.org/w/index.php?title=Electrochemical_gas_sensor&oldid=673486001
 25. Electrochemical Gas Sensors | [Internet]. [cited 2016 Apr 17]. Available from: <http://www.membrapor.ch/electrochemical-gas-sensors/>
 26. What is the difference between Catalytic & Infrared sensors [Internet]. [cited 2016 Apr 17]. Available from: http://www.rkiinstruments.com/pages/faq/Catalytic_Infrared_Sensors.htm
 27. Infrared Sensor [Internet]. [cited 2016 Apr 19]. Available from: http://mipex-tech.com/assets/images/mipex_3d_en.jpg
 28. Combustible Gas Safety Monitoring: Infrared vs. Catalytic Gas Detectors [Internet]. [cited 2016 Apr 17]. Available from: <http://www.gmigasandflame.com/article-infrared-vs-catalytic-gas-detectors-april2013.html>
 29. Smoke, Fire & Gas Detection [Internet]. [cited 2016 Apr 17]. Available from: <http://www.safelincs.co.uk/smoke-fire-and-gas-detection/>
 30. Fike Twinflex Pro 2 Zone Fire Alarm Kit 603-0002 - Fike Twinflex Pro - Fire Alarm Systems - Fire Protection [Internet]. [cited 2016 Apr 19]. Available from: <http://www.sdfirealarms.co.uk/fire-protection/fire-alarm-systems/fike-twinflex-pro/fike-twinflex-pro-2-zone-fire-alarm-kit-603-0002.html>
-

Major Project Report

31. Research Onion [Internet]. [cited 2016 Apr 17]. Available from: <https://onion.derby.ac.uk/onion.pdf>
 32. What is difference between phototransistor and photodiode? - Quora [Internet]. [cited 2016 Apr 17]. Available from: <https://www.quora.com/What-is-difference-between-phototransistor-and-photodiode>
 33. tgs2602_1.jpg (360×360) [Internet]. [cited 2016 Apr 19]. Available from: http://www.figarosensor.com/products/images/tgs2602_1.jpg
 34. TGS2600 [Internet]. [cited 2016 Apr 19]. Available from: http://www.conrad.com/medias/global/ce/1000_1999/1800/1830/1833/183304_BB_00_FB.EPS_1000.jpg
 35. medium-PIC16F883-SPDIP-28.png (300×300) [Internet]. [cited 2016 Apr 19]. Available from: http://www.microchip.com/_images/ics/medium-PIC16F883-SPDIP-28.png
 36. medium-PIC18F4321-PDIP-40.png (300×300) [Internet]. [cited 2016 Apr 19]. Available from: http://www.microchip.com/_images/ics/medium-PIC18F4321-PDIP-40.png
 37. Phototransistor [Internet]. [cited 2016 Apr 19]. Available from: <http://www.clker.com/cliparts/3/5/2/1/12507831911554938917fototransistor-npn-schalt.svg.med.png>
 38. The Piezoelectric Effect - Piezoelectric Motors & Motion Systems [Internet]. Nanomotion. [cited 2016 Apr 17]. Available from: <http://www.nanomotion.com/piezo-ceramic-motor-technology/piezoelectric-effect/>
 39. RS [Internet]. RS. Available from: <http://uk.rs-online.com/web/>
 40. Fire Alarm Grades [Internet]. Safelincs Fire Safety Solutions. Available from: <http://www.safelincs.co.uk/pages/bs5839-6.html>
-

11 CHAPTER XI - BIBLIOGRAPHY

<http://www.gmigasandflame.com/article-infrared-vs-catalytic-gas-detectors-april2013.html>

http://www.rkiinstruments.com/pages/faq/Catalytic_Infrared_Sensors.htm

<http://www.enggcyclopedia.com/2011/11/infrared-gas-detectors/>

<http://www.apollo-fire.co.uk/media/56242/pp2260%20alarmsense%20application%20guide%20for%20hmos%20issue%202.pdf>

<http://www.sdfirealarms.co.uk/Domestic-Fire-Alarms-Categories/>

<http://www.snapsurveys.com/blog/what-is-the-difference-between-qualitative-research-and-quantitative-research/>

https://is.vsfz.cz/el/6410/leto2014/BA_BSeBM/um/Research_Methods_for_Business_Students__5th_Edition.pdf

<https://books.google.co.uk/books?id=a8jU-2xyw5EC&pg=PA44&lpg=PA44&dq=principles+of+fire+protection&source=bl&ots=RLp8c3fveE&sig=ToLKKwD-fB3ZriZFBHVDLp0hFTk&hl=en&sa=X&sqi=2&ved=0ahUKEwjHsabfpJrMAhWFChoKHQ7QA8cQ6AEIITA#v=onepage&q=principles%20of%20fire%20protection&f=false>

<http://www.hsdi.us/news/post/what-is-the-difference-between-co2-and-co>

<http://www.dailymail.co.uk/health/article-2534890/Killed-bed-carbon-monoxide-leak-house-door-Doctors-fear-danger-gas-triggering-heart-attacks-brain-damage-strokes.html>

<http://www.co-gassafety.co.uk/information/co-gas-safety-statistics-of-deaths-and-injuries/>

<http://www.rla.org.uk/landlord/guides/carbon-monoxide-requirements.shtml>

<http://www.rospa.com/home-safety/advice/carbon-monoxide-safety/>

<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6303a6.htm>

<http://www.nhs.uk/conditions/carbon-monoxide-poisoning/Pages/Introduction.aspx>

<http://www.safefiredirect.co.uk/Page/27/what-is-carbon-monoxide.aspx>

<http://www.co-gassafety.co.uk/wp-content/uploads/2015/07/Map-from-Kadee-with-notes-etc..pdf>

<http://www.co-gassafety.co.uk/wp-content/uploads/2015/07/Charts-for-presspack-Jan2016.pdf>

<http://www.circuitstoday.com/fire-alarm-circuit>

<http://www.electroschematics.com/wp-content/uploads/2009/04/fire-alarm-circuit1.jpg>

<http://www.electroschematics.com/2534/fire-alarm-circuit/>

<http://www.electroschematics.com/wp-content/uploads/2010/03/smoke-sensor-alarm-circuit.gif>

<http://www.electroschematics.com/7995/photoelectric-smoke-detector/>

Major Project Report

<http://www.premierfiresystems.co.uk/guide-to-fire-detection-alarm-design-bs5839/>

<http://www.murcogasdetection.com/choosing-the-right-gas-sensors-for-your-installation/>

<http://www.hse.gov.uk/offshore/strategy/fgdetect.htm>

<http://www.fireservice.co.uk/safety/smoke-alarms>

<http://www.sdfirealarms.co.uk/fire-protection/smoke-heat-co-home-fire-protection/heat-alarms.html?limit=25>

Book: Infrared optoelectronics: devices and applications

author: Nunley, William.

ISBN-10: 0824775864

BOOK: Thermistors

author: Hyde, F. J.

ISBN-10: 0592028070

BOOK: Optoelectronics Circuit Manual

author: Marston, R. M.

ISBN-10: 0750641665

BOOK: Principles of fire protect

ISBN: 9780877653455

Datasheets for the OPB708

Datasheet for the TGS2600

Datasheet for the PIC16f873

Datasheet for the LED's

12 APPENDICES

12.1 COST TABLE

Component :	Image:	Price:	Website
OPB708		£1.51	uk.rs-online.com/web/
Figaro TGS2600		£16.88	
PIC16F873		£3.57	
Button		£1.81	
L7805		£0.32	
Crystal Oscillator		£0.218	
LED's		£0.35	
Buzzer		£2.17	
TOTAL COST:		£26.83	

All information, Prices and images sited for RS Online(39)

12.2 PIC COMPARISON TABLE

PIC16F873		PIC16F883	
Not Recommended for new designs		In Production	
Parameter Name	Value	Parameter Name	Value
Program Memory Type	Flash	Program Memory Type	Flash
Program Memory (KB)	7	Program Memory (KB)	7
CPU Speed (MIPS)	5	CPU Speed (MIPS)	5
RAM Bytes	192	RAM Bytes	256
Data EEPROM (bytes)	128	Data EEPROM (bytes)	256
Digital Communication Peripherals	1-A/E/USART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)	Digital Communication Peripherals	1-UART, 1-A/E/USART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	2 CCP	Capture/Compare/PWM Peripherals	1 CCP, 1 ECCP
Timers	2 x 8-bit, 1 x 16-bit	Timers	2 x 8-bit, 1 x 16-bit
ADC	5 ch, 10-bit	ADC	11 ch, 10-bit
Temperature Range (C)	-40 to 85	Comparators	2
Operating Voltage Range (V)	2 to 5.5	Temperature Range (C)	-40 to 125
Pin Count	28	Operating Voltage Range (V)	2 to 5.5
		Pin Count	28
		Cap Touch Channels	11

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12.3 PIC SELECTOR

Product	Program Memory Size (Kbytes)	RAM (bytes)	EEPROM / HEP	Pin count	Max. CPU Speed Mhz	Internal Oscillator	Total # of A/D channels	Max A/D Resolution (bits)
 PIC16F685  PIC16F686  PIC16F687  PIC16F688  PIC16F689  PIC16F690  PIC16F691  PIC16F692  PIC16F693  PIC16F694  PIC16F695  PIC16F696  PIC16F697  PIC16F698  PIC16F699  PIC16F700  PIC16F701  PIC16F702  PIC16F703  PIC16F704  PIC16F705  PIC16F706  PIC16F707  PIC16F708  PIC16F709  PIC16F710  PIC16F711  PIC16F712  PIC16F713  PIC16F714 PIC16F715 PIC16F716 PIC16F717 PIC16F718 PIC16F719 PIC16F720 PIC16F721 PIC16F722 PIC16F723 PIC16F724 PIC16F725 PIC16F726 PIC16F727 PIC16F728 PIC16F729 PIC16F730 PIC16F731 PIC16F732 PIC16F733 PIC16F734 PIC16F735 PIC16F736 PIC16F737 PIC16F738 PIC16F739 PIC16F740 PIC16F741 PIC16F742 PIC16F743 PIC16F744 PIC16F745 PIC16F746 PIC16F747 PIC16F748 PIC16F749 PIC16F750 PIC16F751 PIC16F752 PIC16F753 PIC16F754 PIC16F755 PIC16F756 PIC16F757 PIC16F758 PIC16F759 PIC16F760 PIC16F761 PIC16F762 PIC16F763 PIC16F764 PIC16F765 PIC16F766 PIC16F767 PIC16F768 PIC16F769 PIC16F770 PIC16F771 PIC16F772 PIC16F773 PIC16F774 PIC16F775 PIC16F776 PIC16F777 PIC16F778 PIC16F779 PIC16F780 PIC16F781 PIC16F782								

[illegible]

12.4 PROGRAM CODE

```
#include <main.h>

unsigned int sensors[2];
int channel=0;
unsigned int sens0trig=0,sens1trig=0;

void sensor(void);
void light(void);
void blink (void);

#INT_TIMER2
void TIMER2_isr(void)
{
    sensors[channel] = read_adc(ADC_START_AND_READ);
    channel++;
    if(channel>1) channel=0;
    set_adc_channel(channel);
}

void main()
{
    //port_b_pullups(0xFF);
    unsigned int temp,temp1;
    setup_adc_ports(AN0_AN1_AN3);
    setup_adc(ADC_CLOCK_INTERNAL);
    setup_timer_2(T2_DIV_BY_1,133,15);

    enable_interrupts(INT_TIMER2);
    enable_interrupts(GLOBAL);

    set_adc_channel(0);
    delay_us(30);
    temp=read_adc(ADC_START_AND_READ);
    temp1=255-temp;
    temp1=temp1/3;
    sens0trig=temp+temp1;

    set_adc_channel(1);
    delay_us(30);
    temp=read_adc(ADC_START_AND_READ);
    temp1=temp;
```

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```
        temp1=temp1/3;
        sens1trig=temp-temp1;
while(true)
{
    output_high(main_led);
    delay_ms(500);

    sensor();
    light();
    output_low(main_led);
    blink();
}

}

void blink (void)
{
    output_low(LED);
    delay_ms(DELAY);
    output_high(LED);
    delay_ms(DELAY);
}

void sensor(void)
{
    output_high(sensor_led);
    delay_ms(500);
    if((sensors[0]>sens0trig) | (sensors[1]<sens1trig)|(input(But1)))
        output_low(Buzz);
    else output_high(Buzz);
    output_low(sensor_led);
}

void light(void)
{
    output_high(light_led);
    delay_ms(500);
    if((sensors[0]>sens0trig) | (sensors[1]<sens1trig))
    {
        output_toggle(PIN_B4);
        output_toggle(PIN_B3);
    }
    else
    {
```

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```
    output_low(PIN_B4);
    output_low(PIN_B3);
}

output_low(light_led);
}
```

12.5 FIRE ALARM GRADING SYSTEM

Fire Alarm Grade	
Grade :	Description:
A	Fire detection system incorporating control and indicating equipment to BS EN 54-2, and power supply to BS EN 54-4, installed to BS 5839: Pt.1 with some very minor exceptions
B	Fire detection and alarm system comprising fire detectors (other than smoke alarms), fire alarm sounders and control and indicating equipment to either BS EN 54-2 (and power supply to BS EN 54-4), or to Annex C of BS 5839: Pt.6
C	System consisting of fire detectors and alarm sounders (which may be smoke alarms) connected to a common power supply, comprising normal mains and stand-by supply, with central control equipment.
D	System incorporating one or more interlinked mains powered smoke alarms (and heat alarms if required), each with an integral stand-by supply. The interlink can be hardwired or radio-interlinked.
E	System of interlinked mains powered smoke alarms (and heat alarms if required) with NO stand-by supply. The interlink can be hardwired or radio-interlinked. Please note that Safelincs Ltd will not sell Grade E alarms, as we only recommend alarms with backup batteries.
F	System of one or more battery powered smoke alarms (and heat alarms if required)

Information Cited form Safelincs.co.uk(40)

12.6 PRODUCT MARKETABILITY

If this product was to go to market there are a few area that to need to be addressed. The areas are Cost, safety, design etc. These are essential for the product as they are the key foundations that will make the product sell.

The main focus for this product would be the safety aspect as this is a safety device that is a critical life and death device then it must pass rigorous test that would put the Fire and Gas Alarm through its paces.

This testing would involve:

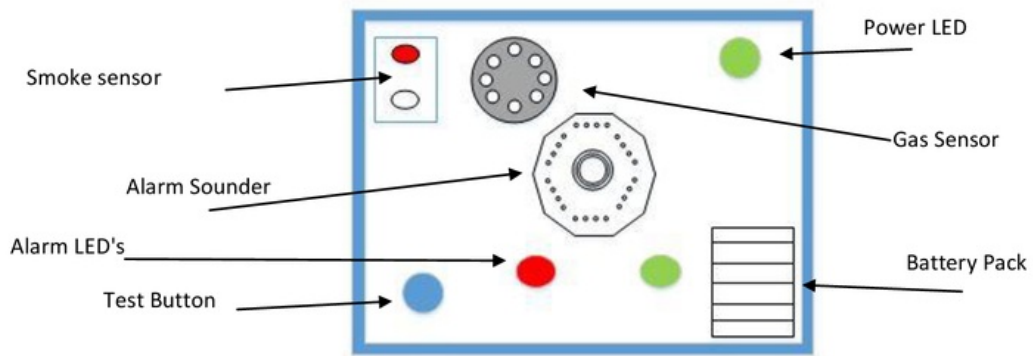
- How long can it with stand a certain Temperature.
- Can the sensor work over a certain distance from the fire?
- Is the alarm sound loud enough for people to hear when sleeping?
- How effective is the Alarm.
- How fast is rate of response to a fire?

Provided that the produce can pass these test and other test to ensure that the device is safe, the next important thing is the cost what will the cost of this alarm? Based on the cost table (Appendices 12.1) the cost of one is £26.83 this is when sensors and components are bought individually increasing the overall price.

In the event of this product going to market the price is a big factor nobody wants to pay over the top but they don't want to buy super cheap as the quality won't be as good. There has to be a balance between price and quality. Therefore buying the sensors and components in a bulk quantity the overall cost will be reduced and the quality is still of a good standard.

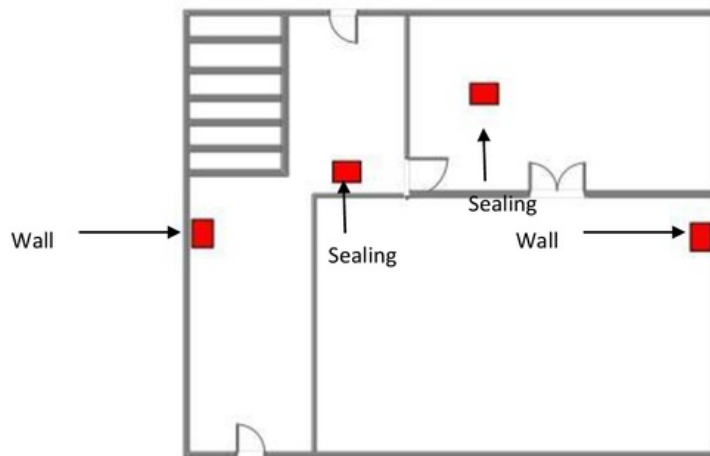
The product design of the product can also be a factor. The ascetics of the this product would look something similar to this:

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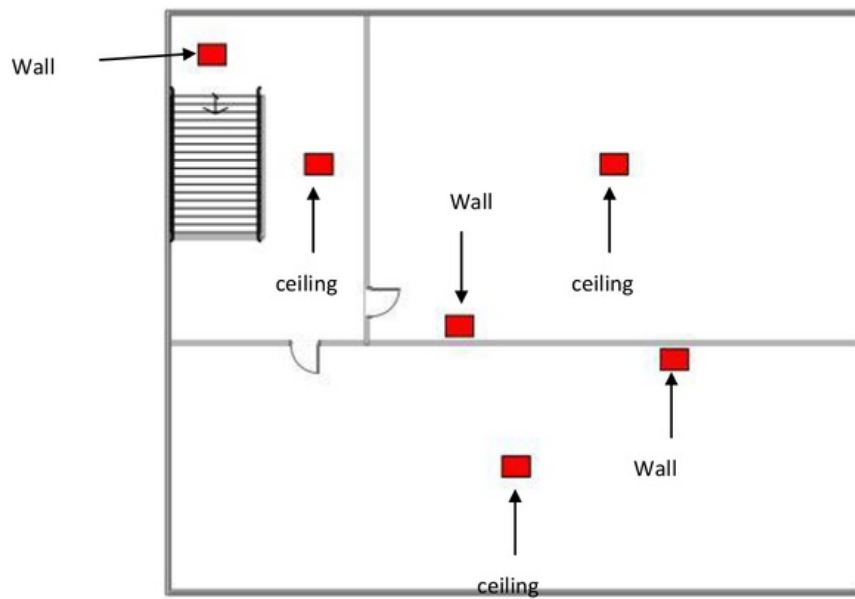
This is a basic concept design of the how the product may look in a compact design.

The guide for the number of alarm to have in the house is about 3 minimum for safety. Here is a diagram showing the layout of a house where the possible placement of alarms.



This design is of a downstairs in a house the red square represent the alarms and where they can be placed.

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This design is of and upstairs of a house. These digram provide a guide where best place the alarm can be placed and also provides a idea of the how this product is market by giving an outline of where the product could be used.

12.7 QUESTIONNAIRE

1. How many Fire Alarms do you have in your home?

- None - 0%
- 1-2 - 70%
- 3 or more - 30%

2. How many Carbon Monoxide Detector do you have in your home?

- None - 80%
- 1-2 - 10%
- 3 or more - 10%

3. If you have a Fire Alarm and/or Carbon Monoxide Detector how is it powered?

- Battery - 70%
- Mains - 30%

4. If you have a Fire Alarm how often do you check its working?

- Never - 30%

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- Once a Months - 10%
- Every 6 Months - 40%
- One a Year - 20%

5. If you have a Carbon Monoxide detector how often do you check its working?

- Never - 30%
- Once a Months - 0%
- Every 6 Months - 20%
- One a Year - 0%
- Don't have one - 50%

6. Have you or do you know of anyone who has been in or harmed by a house fire?

- Yes - 10%
- No - 90%

7. Have you or do you know of anyone that has been harmed by a Carbon Monoxide leak?

- Yes - 0%
- No - 100%

8. Do you know the difference between Carbon Dioxide and Carbon Monoxide?

- Yes - 100%
- No - 0%

9. Do you know the symptoms of Carbon Monoxide poisoning?

- Yes - 60%
- No - 30%
- Not sure - 10%

10. How much are you willing to pay for a fire alarm and or Carbon Monoxide?

- Under £10 - 40%
- £10 - £20 - 20%
- £20 - £50 - 30%
- £50 and over - 10%

12.8 HARDWARE AND SOFTWARE

Hardware:

- Oscilloscope
- Multimeter
- Soldering iron
- Computer
- Pickit3

Software:

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- Proteus
- CCS
- MPLab IPE
