A Project Report on

SMOKE DETECTION SYSTEM IN AN AIRCRAFT

Submitted in partial fulfillment of the award of the

BACHELOR OF SCIENCE IN

AERONAUTICS
(AVIONICS)

By

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BONAFIDE CERTIFICATE

This is to certify that project report titled **"SMOKE DETECTION SYSTEM IN AN AIRCRAFT''**, is a bonafide record of work carried out by **Mr. RIZWAN ISRAIL ALI** during the final semester from **October 2020** to **June 2021** under my guidance, in partial fulfillment of the requirements for the award of **Bachelor of Science** in **Aeronautics (Avionics).**

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DECLARATION

I, **RIZWAN ISRAIL ALI** hereby declared that this project report titled **SMOKE DETECTION SYSTEM IN AN AIRCRAFT** submitted in partial fulfillment of the requirement for the award of **"BACHELOR OF SCIENCE -in AERONAUTICS (AVIONICS)''** is my original work and it has not formed the basis for the award of any other degree.

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Table Of Content

Acknowledgment

Abstract

1. Introduction

2. History

3. Types of Smoke Detectors

3.1. Photoelectric

3.2. Ionizing.

4. Aspirating of Smoke Detector

5. Auto Aligning Optical Smoke Detector

6. Heat Alarm

7. Components

7.1. MQ2 Sensor

7.2. Battery 9V

7.3. Connecting Wire

7.4. LED

7.5. Micro Controller (Arduino Nano)

7.6. Buzzer

7.7. Printed Circuit Board

8. Circuit Design

9. Procedure

9.1. STEP 1: The Parts & Tools

9.2. STEP 2: Solder Wires to Sensors

9.3. STEP 3: Wiring The Sensor

9.4. STEP 4: Adding The LCD

9.5. STEP 5: Demo

10. Working

11. Specific Risks of Smoke Detector

12. Legal Requirements in An Aircraft

13. Smoke Detector Maintenance

13.1. Once a Month

13.2. Every 6 Months

13.3. Every Year

13.4. Every 10 Years

14. Applications

15. Advantages

16. Drawbacks

17. Project Images

18. References

Table of Diagram

Sr. No.	Figure Name	Page No.
1.	Smart Fire & Smoke System in Home	10
2.	1970's Model of Smoke Detector	11
3.	Internal Parts of Photoelectric Smoke Detector	12
4.	Photoelectric Smoke Detector	13
5.	Ionizing in Smoke Alarm	13
6.	Ionizing Smoke Detector	14
7.	Aspirating smoke Detector	15
8.	Fireray 5000Motorized Reflective Type Beam Detector	15
9.	Optical Beam Smoke Detector	16
10.	Ship Alarm System	16
11.	Components in Alignment	17
12.	MQ-2 Smoke & Combustible Gas Sensor	17
13.	MQ-2 Gas Sensor	18
14.	Green & Red LED	19
15.	LED's	19
16.	Arduino Uno R3 Breadboard	19
17.	B-3 Buzzer	20
18.	Printed Circuit Board	20
19.	Circuit Diagram of Smoke Detector	21
20.	Demo Image of Circuit Diagram	22
21.	Fire & Carbon Monoxide Detector	23
22.	Smoke in Cabin	24
23.	VIP Jet Configuration	25
24.	Cabin/Lavatory Smoke Detector	27
25.	Smoke & Thermal System	27
26.	Smoke Detector	27
27.	Project Image 1	29
28.	Project Image 2	29

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SHWETA RAJESH PANDE

(2018-A-032)

Date:_____/_____/_____.

ABSTRACT

In this work, the approach of the design was to achieve a fast response to smoldering fire, low false alarm and low failure rate. The result of the design showed that it's an efficient smoldering smoke detection system with a uniform actuating alarm tested via simulating the design with proteus software and arduino ide c language burnt into the arduino un (ATmega328 microcontroller). The simulation showed the working principle of the design by 5volt being developed through the 78L05 voltage regulator and send across the relay coils, thereby actuating the common of the relays which are tied to pin 2 and pin 3 of the Arduino digital input then resulting in the actuating of other sensors including the buzzers and Light emitting diodes.

The virtual terminal displays the string E as evidence that an email has been sent to those concern parties that can arrest the fire. Also from the result according to the measurement talking.

The building has a flat horizontal ceiling of open areas with the area of the open office spaces ranging from 14 m2 to 107.2m2 and also the height from the floor to the ceiling ranging from 2.92m to 3m, so the maximum area one smoke detector covered was 50m2 and the maximum distance between any points of an area to the smoke detector was 7.5m, maximum spacing between detectors was reduced when obstruction were present such as walls or partitions while minimum distance between detector and wall or partition was 500mm.

1. INTRODUCTION

A smoke detector is an electronic fire-protection device that automatically senses the presence of smoke, as a key indication of fire, and sounds a warning to building occupants.

Commercial and industrial smoke detectors issue a signal to a fire alarm control panel as part of a building's central fire alarm system. By law all workplaces must have a smoke detection system.

Household smoke detectors, or smoke alarms, issue an audible and/or visual alarm locally from the detector itself. They can be battery-powered single units or several interlinked hardwired (mains- powered) devices backed up by batteries. The latter must be installed in all new buildings and after major refurbishments.

Fig. 1.1 Smart Fire & Smoke System in Home

2. HISTORY

Ionization smoke detectors were first sold in the United States in 1951; they were used only in major commercial and industrial facilities in the next several years due to their large size and cost. In 1955 simple home "fire detectors" for homes were developed, detecting high temperatures. The United States Atomic Energy Commission (USAEC) granted the first license to distribute smoke detectors using radioactive material in 1963. The first low-cost smoke detector for domestic use was developed by Duane D. Pearsall with Stanley Bennett Peterson in 1965, an individual replaceable battery-powered unit that could be easily installed. The "SmokeGard 700" was a beehive-shaped, strong fire-resistant steel unit. The company began mass-producing these units in 1975. Studies in the 1960s determined that smoke detectors respond to fires much faster than heat detectors.

The first single-station smoke detector was Invented in 1970 and made public the next year. It was an ionization detector powered by a single 9- volt battery. They cost about US$125 and sold at a rate of a few hundred thousand per year. Several technological developments occurred between 1971 and 1976, including the replacement of cold- cathode tubes with solid-state electronics, which greatly reduced the detectors' cost and size, and made it possible to monitor battery life. The previous alarm horns, which required specialty batteries, were replaced with horns that were more energy-efficient, enabling the use of commonly available batteries. These detectors could also function with smaller amounts of radioactive source material, and the sensing chamber and smoke detector enclosure were redesigned for more effective operation. The rechargeable batteries were often replaced by a pair of AA batteries along with a plastic shell encasing the detector. The 10- year- lithium-battery-powered smoke alarm was introduced in 1995.

The photoelectric (optical) smoke detector was invented by Donald Steele and Robert Embark of Electro Signal Lab and patented in 1972.

Fig. 2.1 **1970's Model of Smoke Detector**

3. TYPES OF SMOKE DETECTOR

There are two basic types of passive smoke detectors: **Photoelectric (optical) and Ionization (physical process)**. A combination of the two types of alarm (dual sensor smoke alarm) is recommended for maximum protection from both fast flaming and slow smoldering fires.

Combined optical smoke and heat alarms and combined smoke and carbon monoxide alarms are also available.

3.1 PHOTOELECTRIC SMOKE DETECTOR:

Photoelectric detector senses sudden scattering of light when smoke enters the detector chamber, triggering the alarm.

Photoelectric smoke detectors respond an average of 15 to 50 minutes faster to fire in its early, smoldering stage, before it breaks into flame, than ionization alarms. They can be installed near kitchens. Some dual optical models are available.

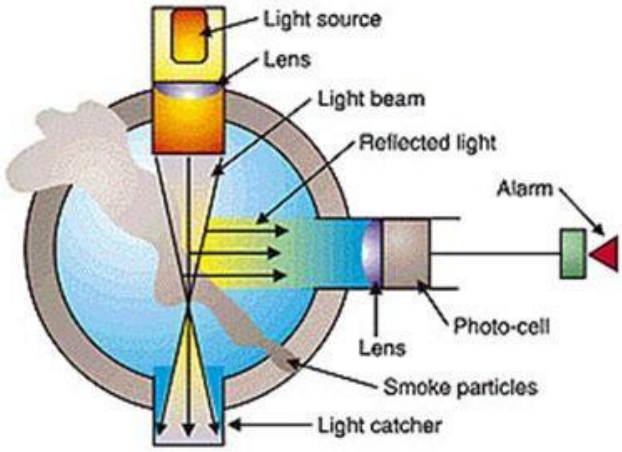

Fig. 3.1.1 Internal Parts of Photoelectric Smoke Detector

Fig. 3.1.2 Photoelectric Smoke Detector

3.2 IONISING SMOKE DETECTOR:

Ionization smoke alarms are highly sensitive to small smoke particles and typically respond about 30 to 90 seconds faster to fast flaming fires than photoelectric smoke alarms, but not to smoldering fires. They may be too easily set off if they are installed too close to kitchens, or garages.

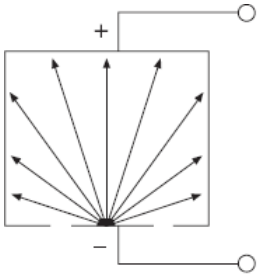

Figure 1: Particle Radiation Pattern

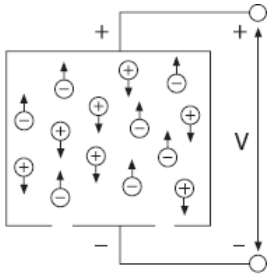

Figure 2: Ion Distribution

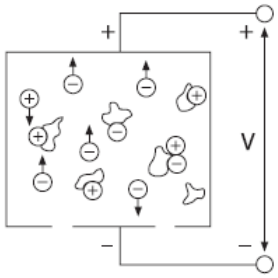

Fig. 3.2.1 Ionizing in Smoke Alarm

Ionization alarms carry a small amount of radioactive material between two electrically charged plates, which ionize the air and causes current to 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.

The appropriate type of smoke detector must be installed to avoid them being disabled because dust or condensation sets them off falsely. A more appropriate detector, such as UV or infrared system which is not triggered by particles, should be installed if that is the case.

Fig. 3.2.2 Ionizing smoke Detector

4. ASPIRATING OF SMOKE DETECTOR

There is also an increasing number of aspirating smoke detectors (ASD) on the market – more advanced, highly-sensitive, technologies that provide earlier warning detection and are used as part of active fire protection.

ASD systems work by drawing in air from each room through small, flexible tubing. The air is then analyzed to identify the presence of minute smoke particles in a continuous process. They are not reliant on room air flow, so can detect smoke before it is even visible.

Aspiration systems are widely used and preferred in challenging situations such as areas of high airflow, where condensation is present, or where very early detection is required in locations such as communications and computer rooms.

VESDA (very early smoke detection apparatus) systems, a brand name of Honeywell, are laser- based advanced ASDs that give a pre-fire warning. They are beneficial in areas where high smoke sensitivity and easy access is required, such as computer rooms, cold rooms and high-ceilinged buildings like warehouses and churches, because the detectors can be located at accessible levels for maintenance purposes.

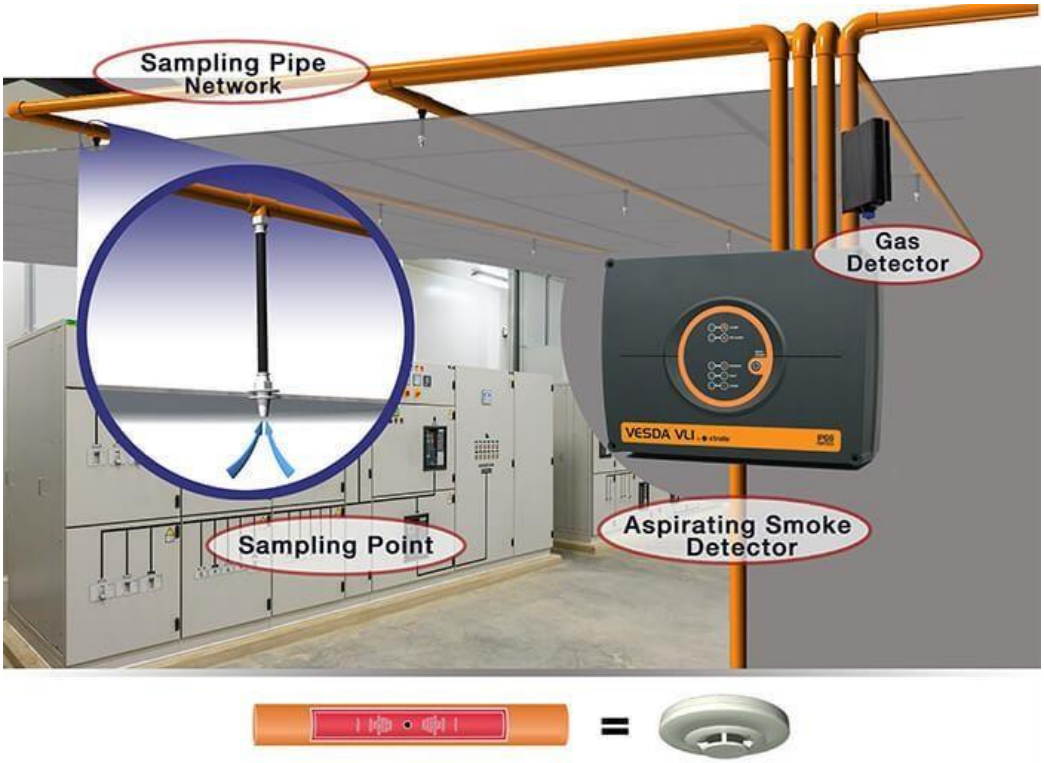

Fig. 4.1 Aspirating Smoke Detector

5. AUTO ALINGING OPTICAL SMOKE DETECTOR

The latest type of intelligent smoke detector is a laser-assisted infrared optical beam smoke detector that self-aligns in less than a minute. They are used to protect large commercial and public spaces such as theatres, shopping malls and sports centers with large skylights, lofty ceilings or condensation issues.

Some models can be installed with up to four detector heads per system.

Incidentally, some smoke detectors are not smoke detectors at all, but security devices incorporating hidden cameras.

Fig. 5.1 Fireray 5000 Motorized Reflective Type Beam Detector

Fig. 5.2 Optical Beam Smoke Detector

6. HEAT ALARM

Heat alarms detect an increase in temperature caused by a fire, although they are insensitive to smoke. They are suitable for use in a kitchen, garage, or dusty room but should not be the sole means of fire detection.

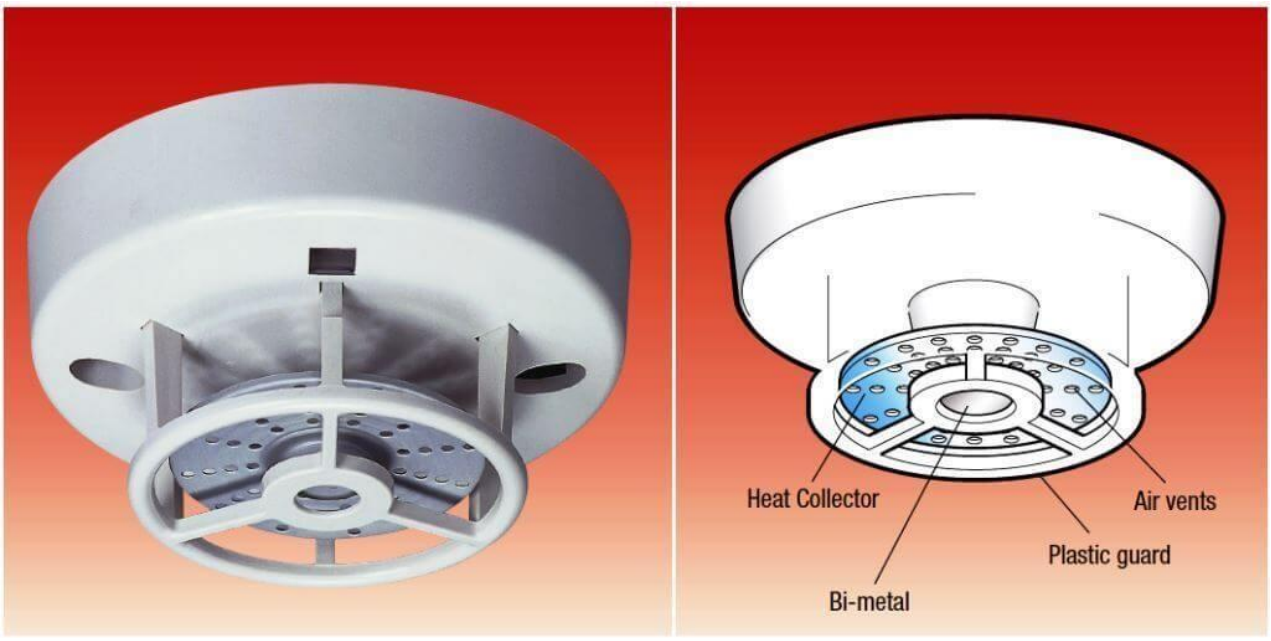

Fig. 6.1 Ship Alarm System

7. COMPONENTS

7.1 MQ2 Sensor
7.2 Battery 9V
7.3 Connecting wire
7.4 LED
7.5 Microcontroller (Arduino nano)
7.6 Buzzer
7.7 Printed circuit board

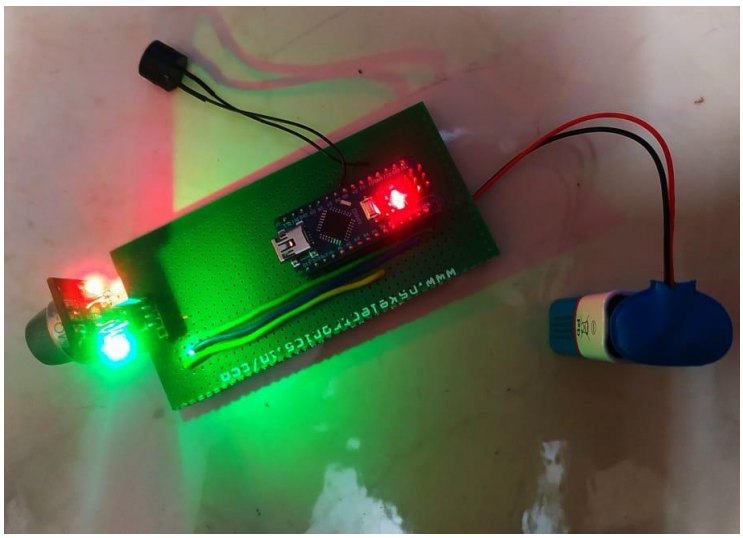

Fig. 7.1 Components in Alignment

7.1 MQ2 Sensor:-

MQ2 is one of the commonly used gas sensors in MQ sensor series. It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemo resistors as the detection is based upon change of resistance of the sensing material when the Gas comes in contact with the material. Using a simple voltage divider network, concentrations of gas can be detected.

Fig. 7.1.1 MQ-2 Smoke & Combustible Gas Sensor

Fig. 7.1.2 MQ-2 Gas Sensor

7.2 Battery 9v:-

The nine-volt battery, or 9-volt battery, is a common size of battery that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in smoke detectors, gas detectors, clocks, walkie- talkies, electric guitars and effects units.

7.3 Connecting Wire :-

Connecting wires allows an electrical current to travel from one point on a circuit to another because electricity needs a medium through which it can move. Most of the connecting wires are made-up of copper or aluminum.

7.4 LED :-

Light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light- emitting phosphor on the semiconductor device.

Fig. 7.4.1 Green & Red LED

Fig. 7.4.2 LED's

7.5 Microcontroller :-

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.

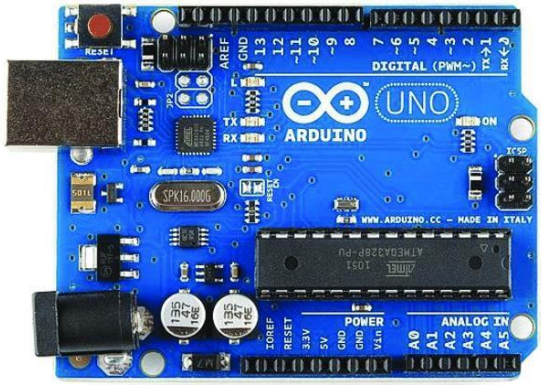

Fig. 7.5.1 Arduino Uno R3 Breadboard

7.6 Buzzer :-

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Fig. 7.6.1 B-3 Buzzer

7.7 Printed Circuit Board (PCB) :-

Printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate.
Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.

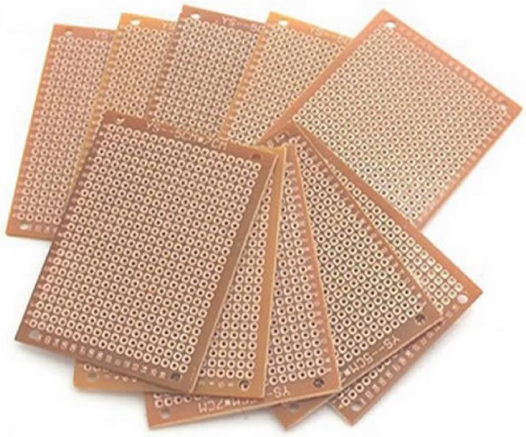

Fig. 7.7.1 Printed Circuit Board

8. CIRCUIT DESIGN

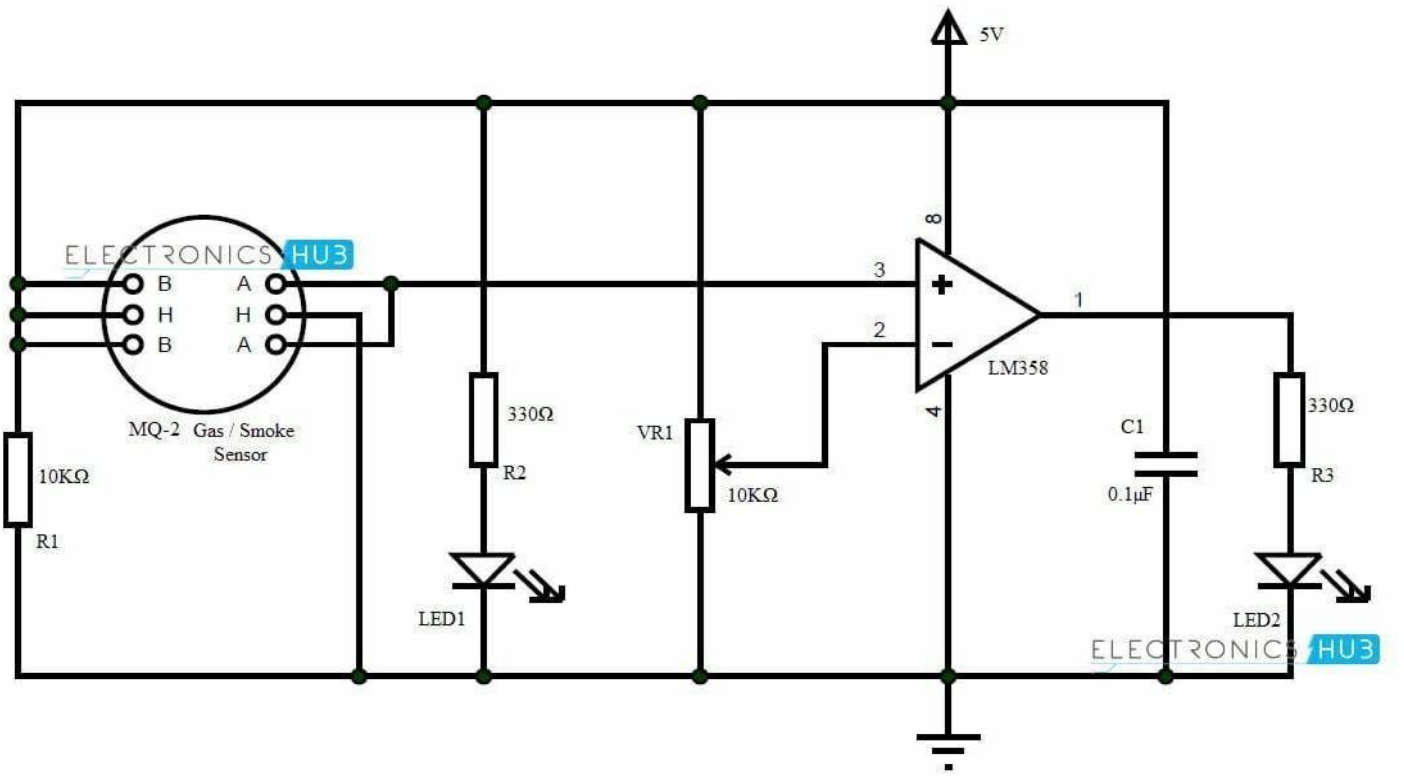

Fig. 8.1 Circuit Diagram of Smoke Detector

9. PROCEDURE

9.1 STEP 1: THE PARTS AND TOOLS

This is a fairly simple project. You will need the following:

1x Arduino (I was using an Arduino Uno) 1x MQ-7 Carbon Monoxide Sensor 1x Breadboard

Connecting wire 1x

10K Resistor 1x

220 Resistor 1x

16x2 LCD

Soldering Iron + Wire

+5V Power supply

(Optional) A lighter and a pack of cigarettes

9.2 STEP 2: SOLDER WIRES TO SENSOR

Solder 4 wires onto the sensor. Two wires on the both H pins, one wire on one of the A pins (any) and another on any of the B pins.

9.3 STEP 3: WIRING THE SENSOR

To connect the sensor, you have to connect one of the H pinto +5V Supply and the other one to Ground GND).

Pin A is connected to the 5V pin. And the B pin is connecting to the GND Pin and Pin A0 as shown on the pictures.

Once you have the circuit in place, upload the attached code on to the Arduino and open the serial monitor of the IDE.

9.4 STEP 4: ADDING THE LCD

Modify the circuit to add an LCD as shown in the picture. Edit the code so that it uses the screen as output.

9.5 STEP 5: DEMO

Power up you circuit and give it a try.

Here is a demo of the project. It is powered using a Voltaic 6W Solar Charger Kit. If you don't have one, you can use any 5V power supply. But I recommend you get one. It's perfect for Arduino Projects.

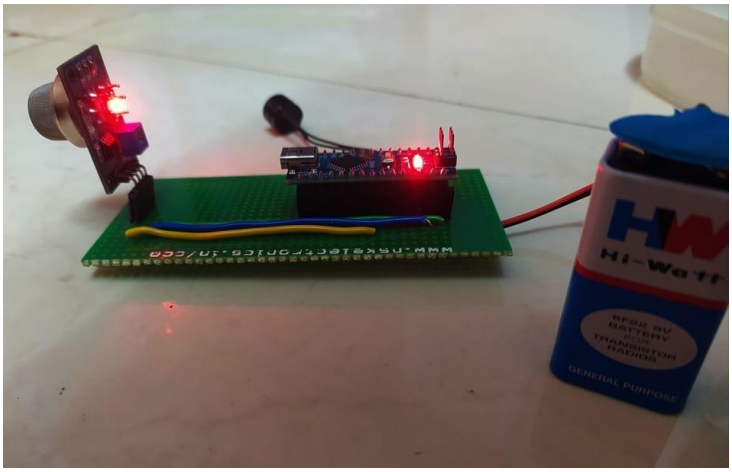

Fig. 9.5.1 Demo Picture of Circuit Design

10. WORKING

Smoke Detectors are amazing devices as they are small, cheap yet very useful. In this project, we implemented a simple Smoke Detector Circuit with adjustable sensitivity.

We used a Smoke Sensor MQ-2 as the main sensory device. The working of the circuit is simple and is explained below.

LM358 acts as a comparator in this circuit. The inverting terminal of LM358 is connected to POT so that the sensitivity of the circuit can be adjusted.

The output of LM358 is given to an LED as an indicator although a buzzer can be used as an alarm. The non-inverting terminal of LM358 is connected with output of smoke sensor.

Initially, when the air is clean, the conductivity between the electrodes is less, as the resistance is in the order of 50KΩ. The inverting terminal input of comparator is higher than the non-inverting terminal input. The indicator LED is OFF.

In the event of fire, when the sensor is filled with smoke, the resistance of the sensor falls to 5KΩ and the conductivity between the electrodes increases.

This provides a higher input at the non-inverting terminal of comparator than the inverting terminal and the output of comparator is high. The alarming LED is turned ON as an indication of presence of smoke.

Fig. 10.1 Fire & Carbon Monoxide Detector

11. SPECIFIC RISKS OF SMOKE

The toilet compartments have some specifics that set them aside from other parts of the aircraft and therefore require special attention when fire detection and suppression is involved:

- Toilet compartments do not offer a clear view to the flight crew. Therefore, in case a fire starts, it might remain undetected for a considerably long period of time, thus allowing it to spread.
- Toilet compartments contain highly combustible materials (e.g. paper) which are susceptible to ignition by objects discarded by passengers.
- Toilet compartments offer the passengers privacy, which may result in the use of tobacco products even on a non-smoking flight.

Fig. 11.1 Smoke in Cabin

12. LEGAL RQUIREMENTS IN AN AIRCRAFT

Provisions regarding the requirements for toilet compartment fire detection and suppression equipment are contained in the relevant documents (e.g. for the EU such a document is "Certification Specifications and AMC for Large Airplanes CS- 25" by EASA). Although there may be slight differences from country to country, the main points usually are:

- Lavatory fire protection requirements apply to airplanes with a passenger capacity of 20 or more.
- Installation of smoke detectors that provide warning signals in the cockpit and in the passenger cabin. It is worth noting that these detectors are not considered critical for the flight safety and therefore the flight continues normally in case of detector malfunction.
- Installation of automatic fire extinguishers in the lavatory trash receptacles.
- Placing "no smoking" signs on both sides of lavatory doors.
- Informing the passengers during the in-flight briefing that smoking is prohibited in the lavatories.
- Placing ashtrays at conspicuous locations both inside and outside the lavatories regardless of whether smoking is allowed in any other part of the airplane.
- The use of Halon in lavatory fire extinguishers is restricted. For the EU, the cut-off date is 31st December 2011 and the end date is 31st December 2020. Research and testing have shown that there are suitable alternatives meeting the standards for effectiveness, volume, weight and toxicology.

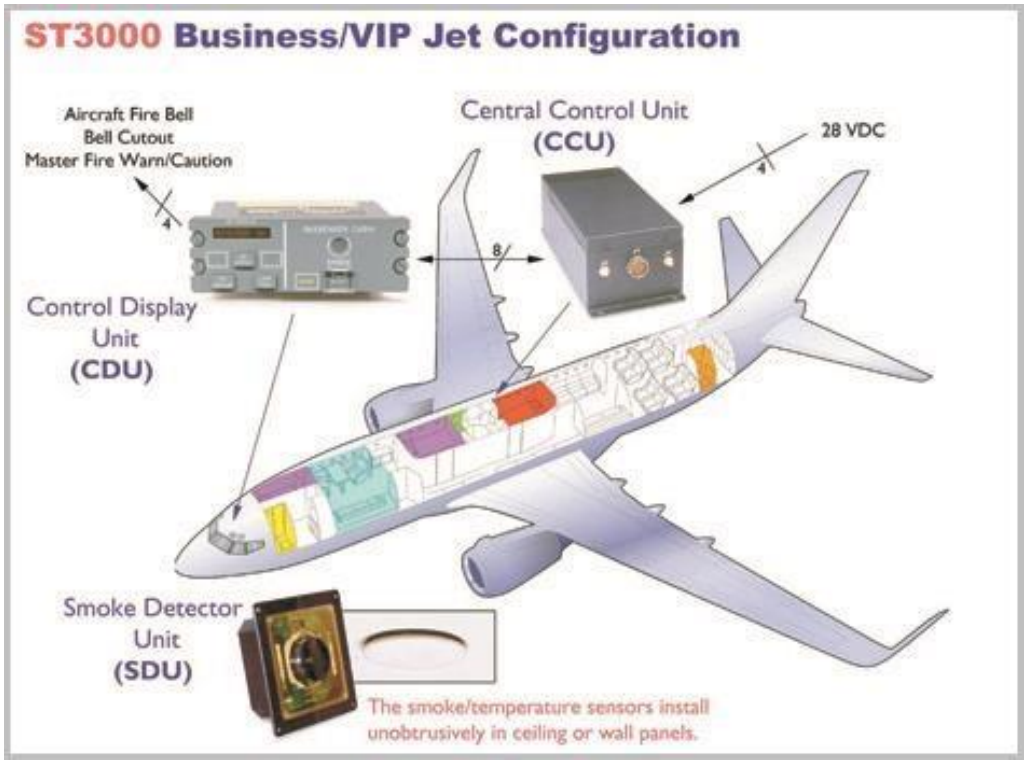

Fig. 12.1 VIP Jet Configuration

13.SMOKE DETECTOR MAINTENANCE

13.1 Once a month:-

Test your smoke alarm batteries every month by pressing and holding the test button for at least five seconds until you hear the beeps.

13.2 Every 6 months:-

Vacuum dust off your smoke alarms every six months.

Keeping your smoke alarm free of particles to help reduce false alarms and ensure smoke can easily reach the internal sensor.

13.3 Every year:-

Replace lead or alkaline batteries every 12 months.

13.4 Every 10 years:-

Replace all smoke alarms with new 10-year lithium powered smoke alarms every 10 years or earlier if specified by the manufacture.

14. APPLICATIONS

14.1 A Smoke Detector is an electronic fire protection device that automatically senses the presence of smoke.

14.2 As a key indication of fire, and sounds a warning to building occupants.

14.3 Commercial and industrial smoke detector issue a signal to a fire alarm control panel as part of a buildings central fire alarm system.

14.4 In household application detector should be installed inside every bedroom, outside each sleeping area and on each level of the home.

Fig. 14.1 Cabin/Lavatory Smoke Detector

Fig. 14.2 Smoke and Thermal Systems

Fig 14.3 Smoke Detector

15. ADVANTAGES

1. Cheaper than photoelectric smoke sensors.
2. Ionizing smoke alarms outperform photoelectric smoke alarms when detecting fast flaming fires with little visible smoke.
3. Ionization smoke detectors are quick acting- - Provides for earlier detection than other types of smoke detectors or thermal detectors.
4. Detects invisible products of combustion.

16. DRAWBACKS

1. Very sensitive, which can lead to false alarms as a product of cooking.
2. Not as responsive to smoldering fires – they are minutes slower than photoelectric Sensors in detecting smoke particles from smoldering fires.
3. Use of radioactive material is a concern.
4. Detects the presence of smoke only, not toxicity.
5. Has a potential for high false alarm rate.

17. PROJECT IMAGES

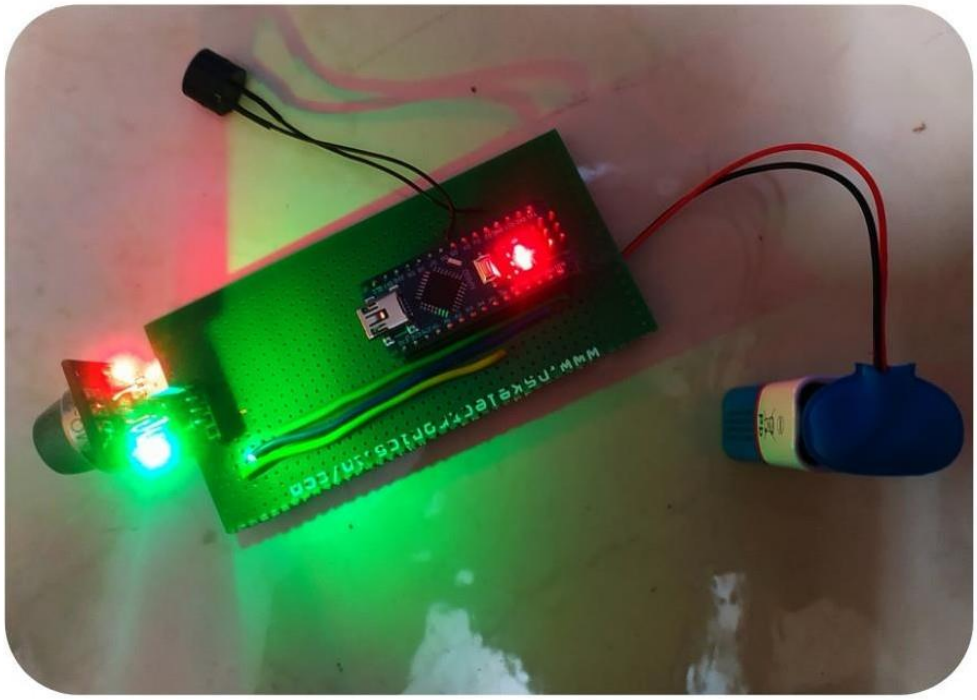

Fig. 17.1 Project Image 1

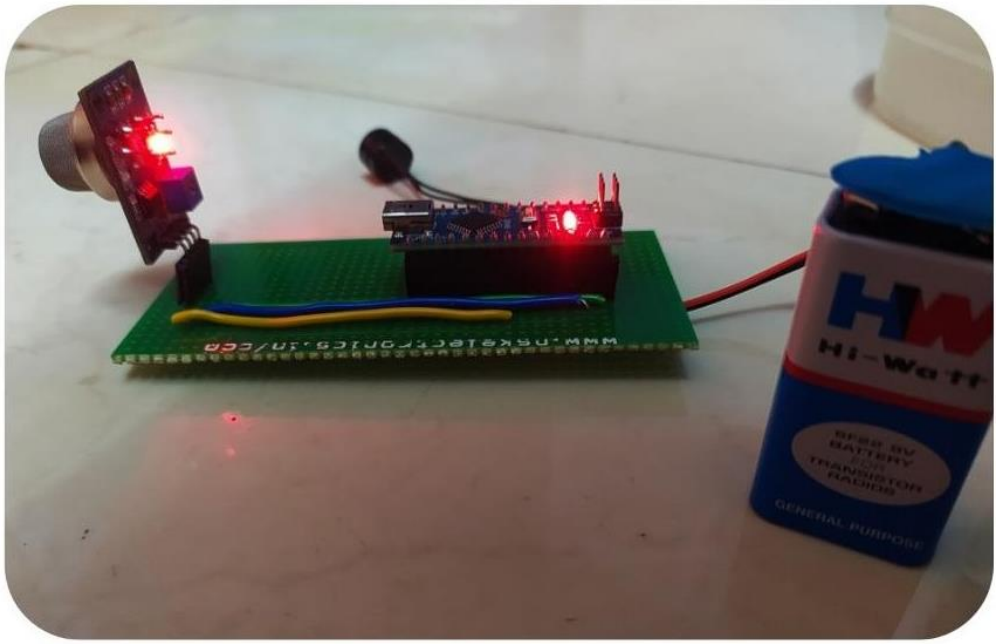

Fig. 17.2 project Image 2

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