INTERNET OF THINGS

GAS LEAKAGE MONITORING AND ALERTING FOR INDUSTRIES

PROJECT REPORT

IBM PROJECT – TEAM ID:PNT2022TMID02133

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1. INTRODUCTION:

1.1 PROJECT OVERVIEW:

A In recent years, gas leakage of any kind has been a problem, whether it occurs in a home, a lace of business, a cafe, or a canteen. The construction of a gas waste monitoring, leakage detection, and warning system using the Internet of Things is suggested in this study. This essay elaborates on the design of an accident-prevention system that will help save petrol. The system nd the cooker must be interconnected. Ultrasonic sensors built into the technology determine whether or not the cooker is being used for cooking. The gas supply is shut off automatically y the system if it is determined that the cooker is not in use. Users will be notified via SMS ia GSM the instant a gas leak is likely to be detected, allowing them to address the problem as soon as feasible. Through a flame sensor, the system will keep an eye on fire and flame. The buzzer starts to buzz when a fire is discovered. In addition to that, the system also supports cloud storage. This cloud storage option allows for the tracking of each user's daily gas consumption. Ultimately, this process will help in determining natural gas usage per user. The system has been tested, and it can track gas leakage and wasting while also sending the user an SMS. The performance that followed shown its ability to save a sizable amount of the gas wasted in household.

1.2 PURPOSE:

The design of a sensor-based automatic gas leakage detector with an alert and control system has been proposed. This is an affordable, less power using, lightweight, portable, safe, user friendly, efficient, multi featured and simple system device for detecting gas. Gas leakage detection will not only provide us with significance in the health department but it will also lead to raise our economy, because when gas leaks it not only contaminates the atmosphere, but also wastage of gases will hurt our economy. The need for ensuring safety in workplaces is expected to be the key driving force for the market over the coming years.

2. LITERATURE SUREVEY:

Survey 1:

Pal-Stefan Murvay,Ioan Silea(2012)

'Journal of Loss Prevention in the Process Industries'

The main purpose of this paper is to identify the state-of-the-art in leak detection and localization methods. Additionally we evaluate the capabilities of these techniques in order to identify the advantages and disadvantages of using each leak detection solution.

Survey 2:

Srinivasan, Leela, Jeyabharathi, Kirthik, Rajasree;(2014)

'Adapted approach for Species Classification'

In this research paper they told about gas leakage detection and control. In this paper, the gas leakage resulting into fatal inferno has become a serious problem in household and other areas where household gas is handled and used. It alerts the subscriber through the alarm and the status display besides turning off the gas supply valve as a primary safety measure. This simplicity results in a high instruction turnout and spectacular real time interrupt response from a tiny and cost-efficient processor core. The microcontroller provides the data to the coil valve to shut its knob. The coil valve consists of a disc that's in touch with the spring. Once the gas leaks the disc comes in touch with the spring so it stops the flow of gas. Finally the gases area unit thrown out the disc moves so the gas flows. At that point the buzzer starts direful thereby to alert the neighbors. A Buzzer or electronic device is a signal device, typically electronic,generally used in cars, manage appliances.such as microwave kitchen appliance or game shows.

Survey 3:

Prof.M.Amsaveni, A.Anurupa, R.S.AnuPreetha, C.Malarvizhi, M.Gunasekaran;(2015)

"GSM based LPG leakage detection and controlling system"

They proposed their methodology that the system takes an automatic control action after the detection of 0.001% of Gas leakage. This automatic control action provides a mechanical handle for closing the valve. We are increasing the security for human by means of a relay which will shut down the electric power to the house. Also by using GSM, we are sending an alert message to the users and a buzzer is provided for alerting the neighbors about the leakage.

Survey 4:

V Suma, Ramya R Shekar, Kumar AAkshay(2019)

'Gas Leakage Detection Based on IOT'

The aim of this paper is to present a new system automatically books a cylinder when the gas is about to empty is by sending a notification to the gas agency using wifi using Internet of Things approach.

Survey 5:

Adil Ahmad, Shaik Shaheeda

Department of Information Science and Engineering, Bengaluru Gas Leakage Detection Based System(ICEA2017).

The author has observed gas leakage and LPG levels where gas leakage occurs automatically. The authors suggests that gas leakage is performed by various gas sensors. Whose author has worked on gas leaks and mentions that we can take care if a found using a sensor and gas booking can be done automatically when a small amount of gas is taken closed.

Survey 6:

Mohd Abid PG student

Design and Embedded system, VTU PG centre kalaburagi, India IJETER volume 6,issue 4,April (2018).

Through this paper important parameters are used to find the level of gas in the container. The good purpose of this project is to get notification of gas leak to user when gas leakage is started. Arduino was originally created as a tool for fast sampling and activities for students with no knowledge for electronics. This paper uses a microcontroller, buzzer and a

gas sensor to detect gas leakage system. When a gas leak is detected by a gas sensor ,the microcontroller turn on the buzzer in critical condition. The author suggest that this message or instruction may be displayed using an LCD display for LPG monitoring.

Survey 7:

Kulothungan. S, Gukan. A , Arunprabu.K.B

Student, IFET College of Engineering. IJEDR 2019.

The proposed system detects LPG leaks and alerts customers. The alarm starts when the system notice and increases in LPG leakage concentration by sending an alarm and sending a message to specific mobile phone. The device assures safety and prevents explosions. A microcontroller based system based on gas sensor(MQ6) has been developed in proposed system to detect LPG leakage .The unit is also integrated with an alarm unit to detect signal a leak.

EXISTING PROBLEM:

- No prevention of fires possible with kit.
- Applicable only as an indicator/alarming device.
- It works only when at 5V power supply is given.
- Its sensitivity depends on Humidity and temperature.
- It is a little sensitive to smoke

REFERENCES:

1. Pal-Stefan Murvay,Ioan Silea
'Journal of Loss Prevention in the Process Industries'-2012
2. Srinivasan, Leela, Jeyabharathi, Kirthika, Rajasree
“GAS LEAKAGE DETECTION AND CONTROL”Scientific Journal of Impact Factor(SJIF): 3.134 March- 2014.
3. Prof.M.Amsaveni, A.Anurupa, R.S.AnuPreetha, C.Malarvizhi, M.Gunasekaran
“Gsm based LPG leakage detection and controlling system” the International Journal of Engineering and Science (IJES) ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805 Pages 112-116 March- 2015'
4. V Suma, Ramya R Shekar, Kumar AAkshay
'Gas Leakage Detection Based on IOT'-2019
5. Adil Ahmad, Shaik Shaheeda.
Bengaluru Gas Leakage Detection Based System(ICEA2017).
6. Mohd Abid PG student Dept of VLSI Design and Embedded system.
VTU PG centre kalaburagi, India IJETER volume 6,issue 4,April (2018).
7. Kulothungan. S, Gukan. A , Arunprabu.K.B Associate Professor.
Student, IFET College of Engineering. IJEDR 2019

PROBLEM STATEMENT & DEFINITION:

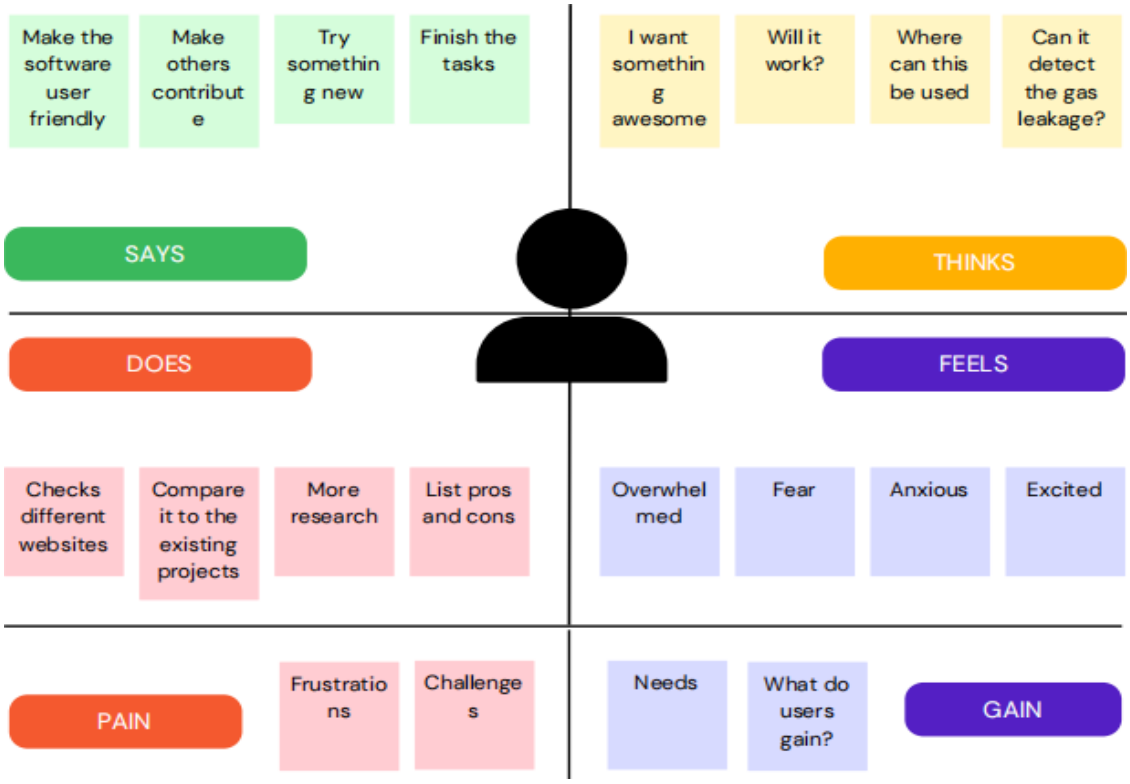
Problem Statement 1:

Problem Statement 2:

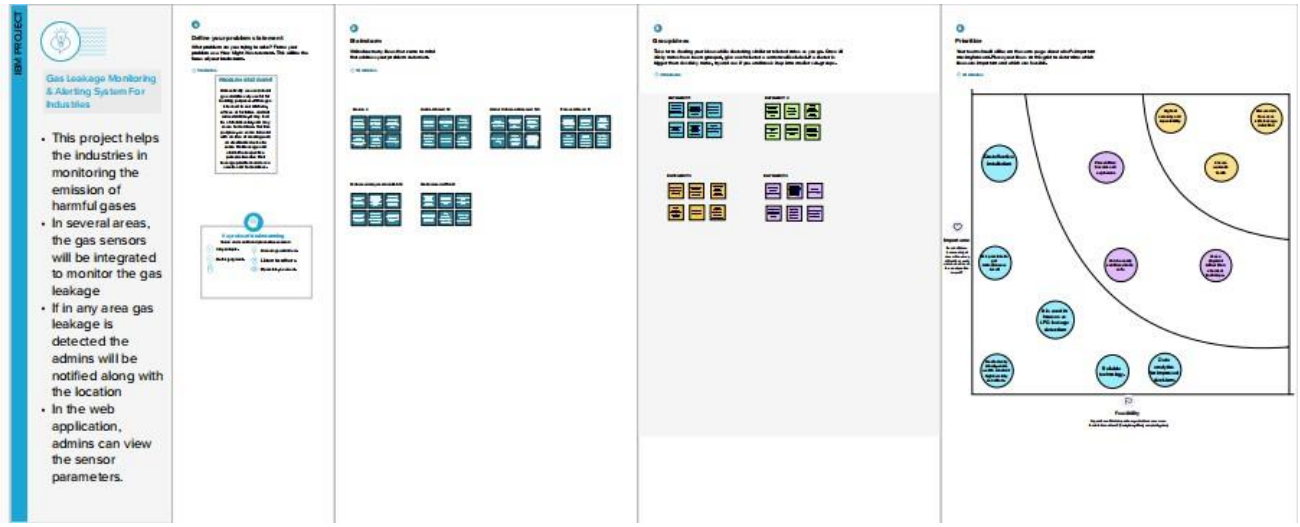
Problem Statement (PS)	I am (Customer)	I am trying to	But	Because	Which makes me feel
PS-1	Industrialist	Monitor gas leakage in the industry	I don't have any system for monitoring	The affordable of the system is high and the systems are sometimes making disasters	Unsafe
PS-2	Industrialist	Control the gas leakage	Also, the installation process is too complicated	The number of sensors is unpredictable and the positioning of equipment is improper	Disastrous

IDEATION & PROPOSED SOLUTION:

3.1 EMPATHY MAP:



3.2 IDEATION & BRAINSTROMMING:



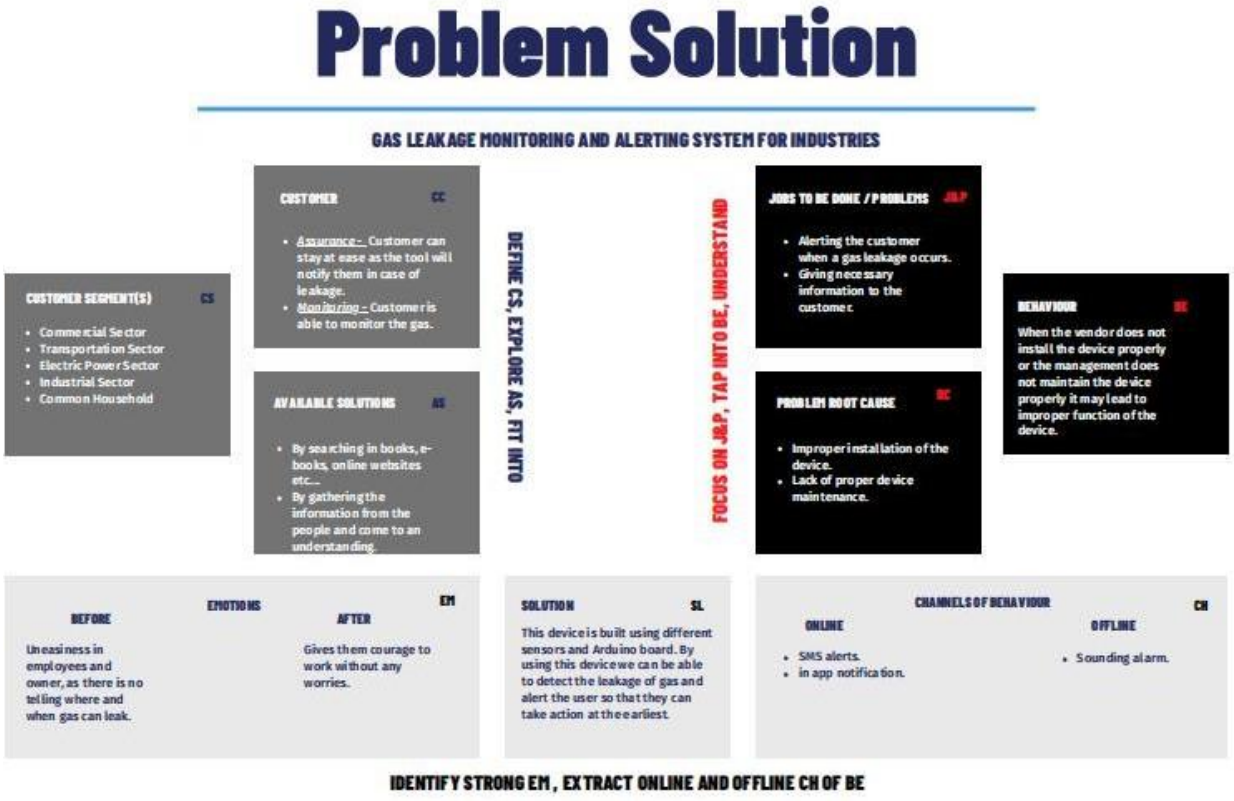
3.3 PROPOSED SOLUTION:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Workers who are engaged with a busy industries packed with gas either harmful or harmless needs a way to monitor their gas pipelines continuously and detect early if there is any leakage of gas in their surroundings so that they can work efficiently on major crises rather than worrying about monitoring or leakage of gas, this will indeed reduce the manpower of that industry and create a peaceful environment.

2.	Idea / Solution description	The system can be taken as a small attempt in connecting the existing primary gas detection methods to a mobile platform integrated with IoT platforms. The gases are sensed in an area of 1m radius of the rover and the sensor output datas are continuously transferred to the local server. The accuracy of MQ sensors are not upto the mark thus stray gases are also detected which creates an amount of error in the outputs of the sensors, especially in case of methane. Thus the system at this stage can only be used as a primary indicator of leakage inside a plant.
3.	Novelty / Uniqueness	Even though there are many existing solutions for this problem they failed to satisfy the needs of customer. Some of the solutions are only detecting some particular gases where some others failed to alert the main department and other solutions are with some delays. Our solution not only notify the industry person but also notify the fire fighters so that can take control over the situation and our solution will alert the workers even there is a small leak of gases.
4.	Social Impact / Customer Satisfaction	Our solution will be very helpful for the workers and the society which is associated or located nearby the industries. Our solution will prevent great disasters like Bhopal Gas Tragedy so that so many lives can be saved. Through this project the workers mental pressure will be reduced so that they can concentrate on other works or by relaxing them.

5.	Business Model (Revenue Model)	The main target of our solution is Industries so we have planned to visit industries and explain them about the benefits of our products. So that they can aware of the importance of this solution and use it.
6.	Scalability of the Solution	Our solution can be integrated for further future use because the solution we have provided will be lay on the basic or initial stage of any upgraded version.

3.4 PROBLEM SOLUTION FIT:



4. REQUIREMENT ANALYSIS:

4.1 FUNCTIONAL REQUIREMENTS:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Gmail Registration through Mobile
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Detection	The said system can be deployed in homes, hotels, factory units, LPG cylinder storage areas, and so on. The main advantage of this Arduino based application is that it can determine the leakage and send the data over to a site.
FR-4	Monitoring	The leakage can be monitored and can be optimized for detecting toxic gasses.
FR-5	Alerting	Along with monitoring the leakage it can alert the registered user and people in the vicinity are alerted by sounding the buzzer this can help in preventing any disaster.
FR-6	Communication	The registered user is able to get alert from the system through a SMS and can also be able to get notification in app.

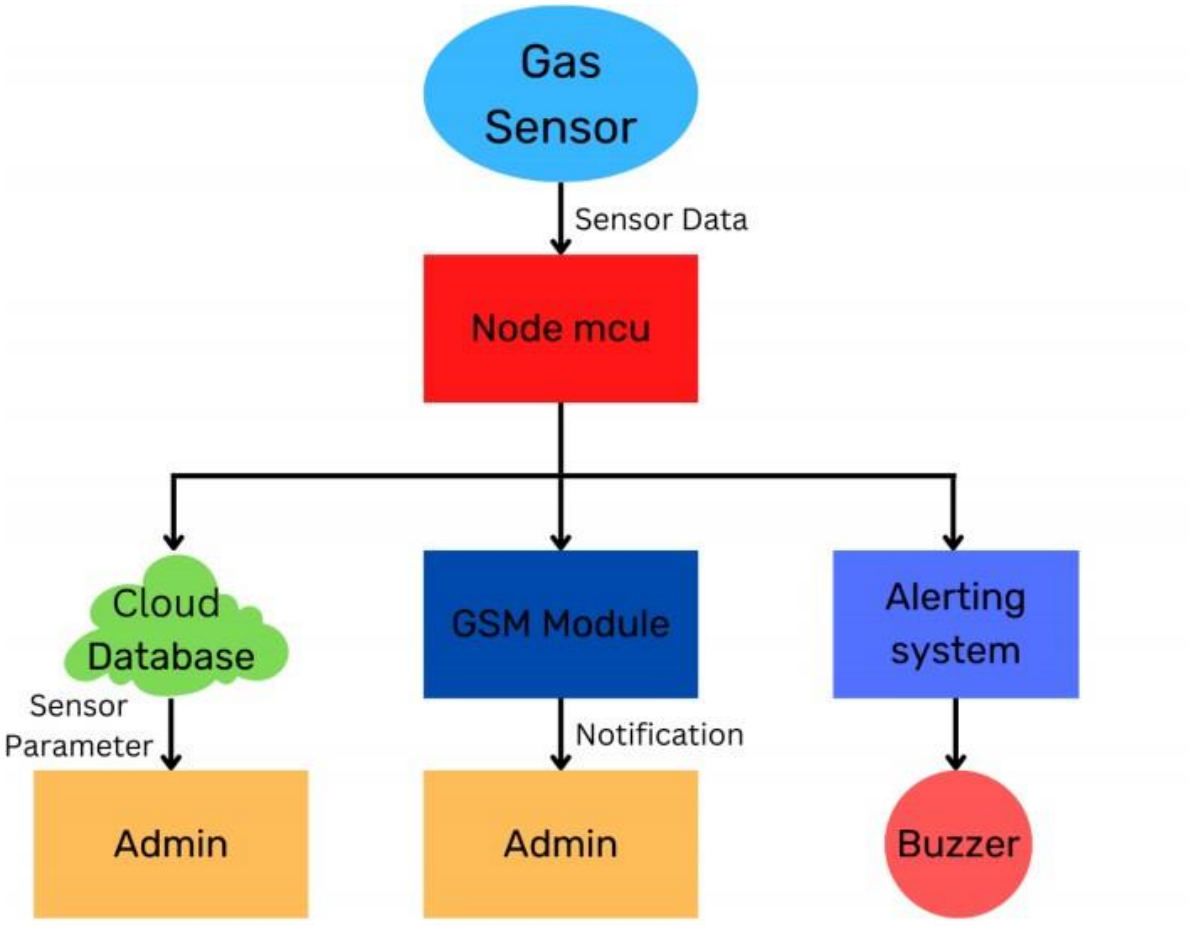
4.2 NON FUNCTIONAL REQUIREMENTS:

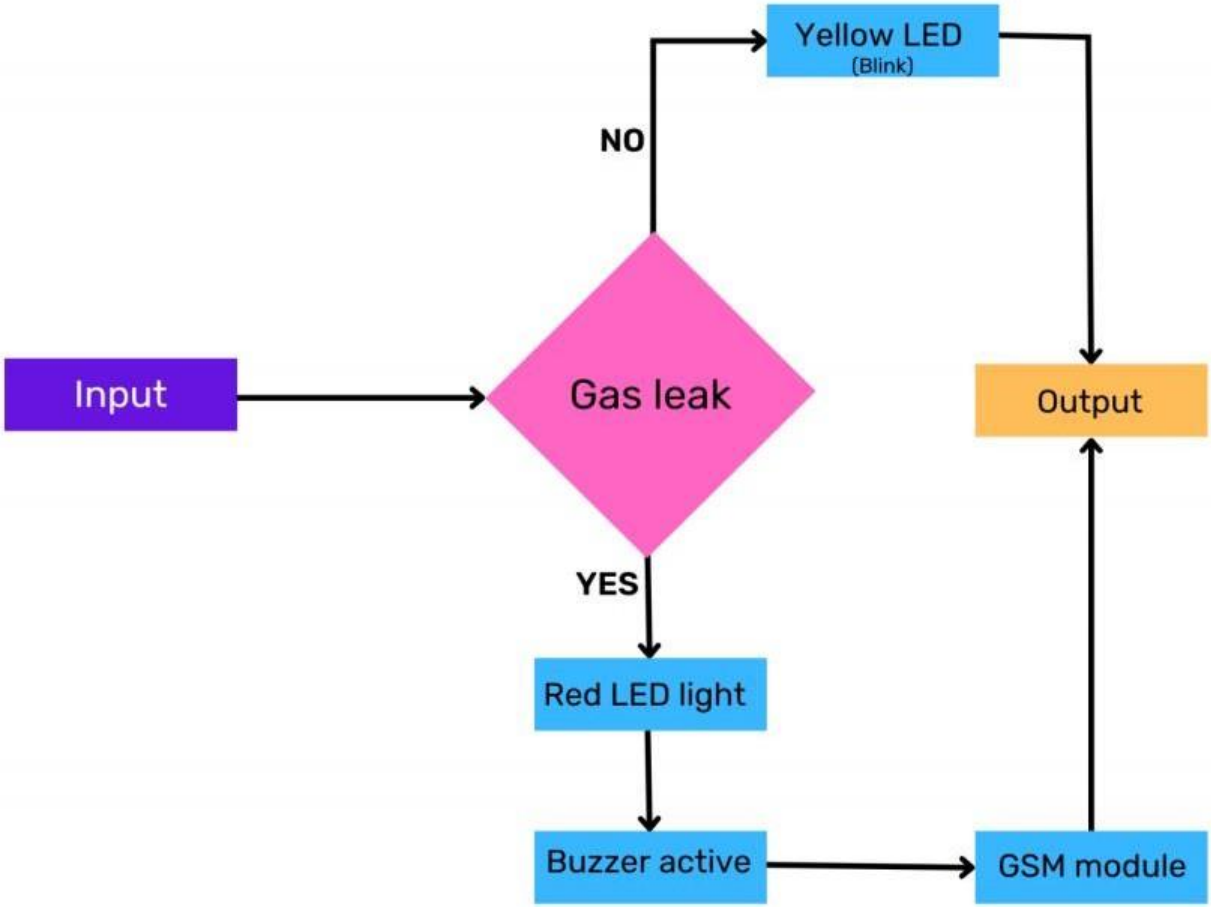
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	This tool verifies that usability is a special and important perspective to analyse user requirements, which can further improve the tool quality. In the model process with user experience as the core, the analysis of users' usability can indeed help designers better understand users' potential needs, behaviour and experience.
NFR-2	**Security**	By identifying the danger of hazardous gas leakage with prior notification people can evacuate in time.
NFR-3	**Reliability**	By the use of various sensors we can detect various gas leakage and can identify the location of the leakage
NFR-4	**Performance**	In this technique the gas sensor sends the signal to the Arduino UNO after detecting the gas leakage . Arduino to other externally connected devices such as buzzer and GSM send vigorous signals. SMS is sent by GSM module to the provided mobile number as a result. IN practice, results are noticed by the people surrounding by the area are alerted by buzzer sound indicate the danger to the people by making beep sound.
NFR-5	**Availability**	By developing & deploying resilient tool we alert the user by sounding the alarm and sending a SMS to a registered user.

NFR-6	**Scalability**	By using this system that detects the gas leakage applicable usefully in the industrial and domestic purpose. In danger situations we are able save lives by using this system.

5. PROJECT DESIGN:

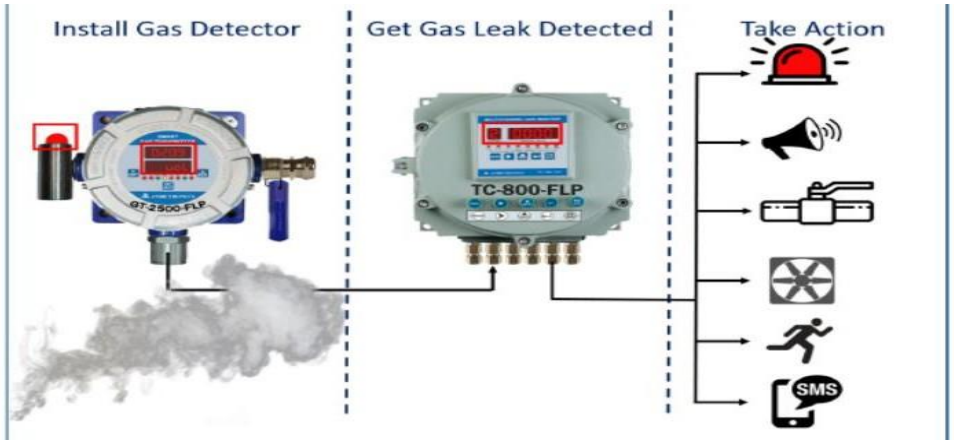
5.1 DATA FLOW DIAGRAMS:





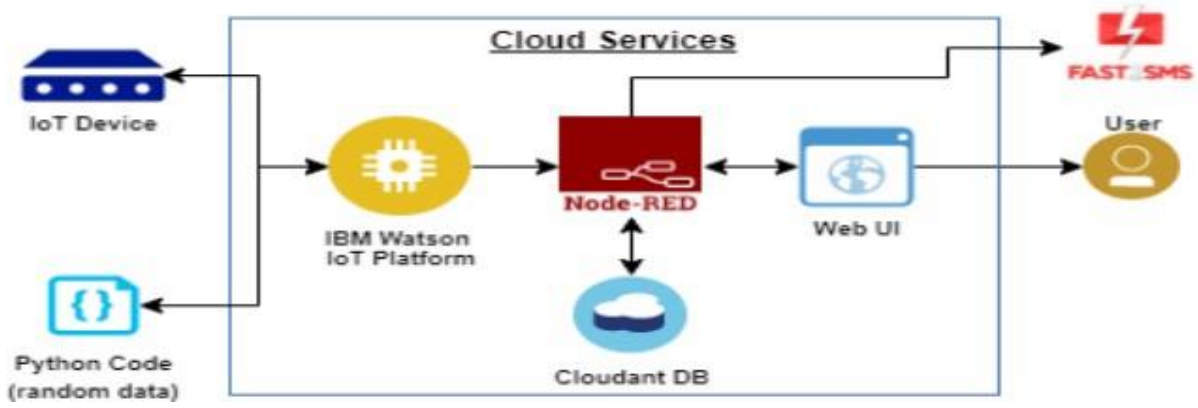
6. SOLUTION AND TECHNICAL ARCHITECTURE:

6.1 SOLUTION ARCHITECTURE:



6.2 TECHNOLOGY STACK:

Technical Architecture



COMPONENTS & TECHNOLOGIES :

S.No	Characteristics	Description	Technology
1.	Open-Source Framework	Opensource frameworks for connecting to raspberry pi and node red	Working with Raspberry PI Wiring Pi, Pigpio, Gpiozero, Rpi. GPIO
2.	Scalable Architecture	Justify the scalability of architecture (3 – tier, Micro-services)	Data , models, operate at size, speed , consistency and complexity
3.	Availability	The availability of application (e.g. use of load balancers, distributed servers etc.)	Numerous area leakage detection.
4.	Performance	Design aspects for the performance of the application (number of requests per second, use sensors) etc.	Full and effective detection using Raspberry pi for Industries.

APPLICATION CHARACTERISTICS :

S.No	Component	Description	Technology
1.	User Interface	Web UI or Website	HTML, CSS.
2.	Application Logic-1	Sensor initialization	Node RED
3.	Leakage detector	To detect the leakage of gas in the industries in case of arrangement	Non-dispersive infrared sensors, or NDIR
4.	Infrastructure (Server / Cloud)	Application deployed on cloud server	IBM Watson IoT Platform

5.3 USER STORIES

User Stories:

User Type	Functional Requirements (EPIC)	User Story Number	User Story/Task	Acceptance Criteria	Priority	Release
Customer (application)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmatio n email & click confirm	Medium	Sprint-1
		USN-3	As a user, I can register for the application through Gmail		Medium	Sprint-1

	Login	USN-4	As a user, I can log into the application by entering email & password		High	Sprint-1
	Dashboard	USN-5	As a user, I can login with my credentials to see my dashboard	I will be able to see my dashboard and the application	High	Sprint-2
Customer (Web user)	Dashboard	USN-6	As a web user, I will go to the application's URL and login by entering my credentials	I will be able to login and view my dashboard	Medium	Sprint-2
Customer Care Executive	Helping the customers	USN-7	As a customer care person, I will respond to the customer's queries	I will be able to see the customer's difficulties, queries and feedback	High	Sprint-3
Administrat or	Working with data	USN-8	As an administrator, I can login to the	I will be able to view the applications data server	High	Sprint-3

			application's server			
	Asking and responding	USN-9	As an administrator, I can ask and respond to the customer's questions	I will be able to answerable to the customers	Medium	Sprint-4
	Maintaining the database	USN-10	As an administrator, I will be able to view the database	I will be able to view, modify and maintain the application' s database	High	Sprint-4
	Managing the overall process	USN-11	As an administrator, I can control the overall process	I can control and maintain the overall application' s process	High	Sprint-4

6. PROJECT PLANNING & SCHEDULING:

6.1 SPRINT PLANNING AND ESTIMATION:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

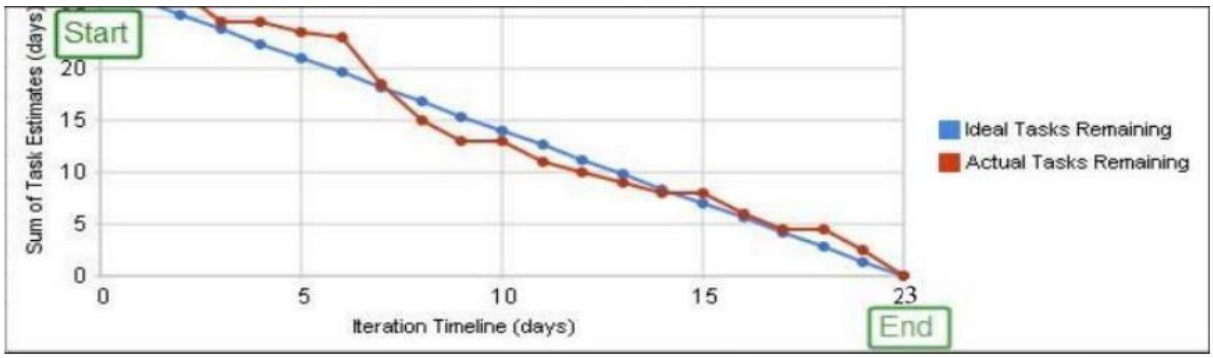
6.2 SPRINT DELIVERY SCHEDULE:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Analyzing the gas leakage	USN-1	The owner who wants to save his employees or a person who wants to save their family from explosion takes necessary actions	2	High	Gurusharan S Abdul Rahman Gokul J Dhananjay kumar
Sprint-1	Preventing from explosion	USN-2	The fire officers worries about any explosions due to gas leakage which may cause many death	1	High	Gurusharan S Abdul Rahman Gokul J

						Dhananjay kumar
Sprint-2	To detect the gas leakage	USN-3	The owner can take necessary steps by deploying gas detectors in their surroundings	2	Low	Gurusharan S Abdul Rahman Gokul J Dhananjay kumar
Sprint-3	Testing and training of the model device	USN-4	The programmer can design an gas leakage detection model by training the dataset	2	Medium	Gurusharan S Abdul Rahman Gokul J Dhananjay kumar
Sprint-4	Notification	USN-5	The gas leakage detected by the model can be notified using SMS or alarming system	1	High	Gurusharan S Abdul Rahman Gokul J Dhananjay kumar

REPORTS FROM JIRA:

BURNDOWN CHART:



7. CODING AND SOLUTIONING

7.1 READ THE VALUE FROM GAS SENSOR:

The Value is read from the sensor and is constantly displayed in the lcd screen the sensor detects the leakage and this value is stored.

// Initializing the values

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(6, 7, 8, 9, 10, 11);
float gasPin = A0;
float gasLevel;
int ledPin = 2;
int buttonPin = 3;
int buzzPin = 4;
int buttonState;
int fan = 5;

void setup(){
  pinMode(ledPin, OUTPUT);
  pinMode(buttonPin, INPUT);
  pinMode(gasPin,INPUT);
  pinMode(fan,OUTPUT);
  Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.setCursor(0,0);
  lcd.print(" Welcome");
  lcd.setCursor(0,2);
  lcd.print("PNT2022TMID51246");
  delay(500);
  lcd.clear();
}

void loop(){
  // Read the value from gas sensor and button
  gasLevel = analogRead(gasPin);
  buttonState = digitalRead(buttonPin);
 }
```

7.2 AUTOMATIC ALARM AND FAN ON:

If the value exceeds a certain limit that is already predefined the alarm starts to buzz and the fan is also switched on automatically to enable the gas to leave the premesis and reduce the risk of fire outbreak.

```
    // call the function for gas detection and button work
  gasDetected(gasLevel);
  buzzer(gasLevel);
  exhaustFanOn(buttonState);
}

// Gas Leakage Detection & Automatic Alarm and Fan ON
void gasDetected(float gasLevel){
  if(gasLevel >= 200){
   digitalWrite(buzzPin,HIGH);
   digitalWrite(ledPin,HIGH);
   digitalWrite(fan,HIGH);
   lcd.setCursor(0,0);
   lcd.print("GAS:");
   lcd.print(gasLevel);
   lcd.setCursor(0,2);
   lcd.print("FAN ON");
   delay(1000);
   lcd.clear();
  }else{
   digitalWrite(ledPin,LOW);
   digitalWrite(buzzPin,LOW);
    digitalWrite(fan,LOW);
```

```
    lcd.setCursor(0,0);
   lcd.print("GAS:");
    lcd.print(gasLevel);
   lcd.setCursor(0,2);
   lcd.print("FAN OFF");
   delay(100);
   lcd.clear();
  }
}

//BUZZER
void buzzer(float gasLevel){
if(gasLevel>=200)
  {
  for(int i=0; i<=30; i=i+10)
  {
  tone(4,i);
  delay(400);
  noTone(4);
  delay(400);
  }
  }
}
```

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

TESTING:

8.1 USER ACCEPTANCE TESTING:

DEFECT ANALYSIS:

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

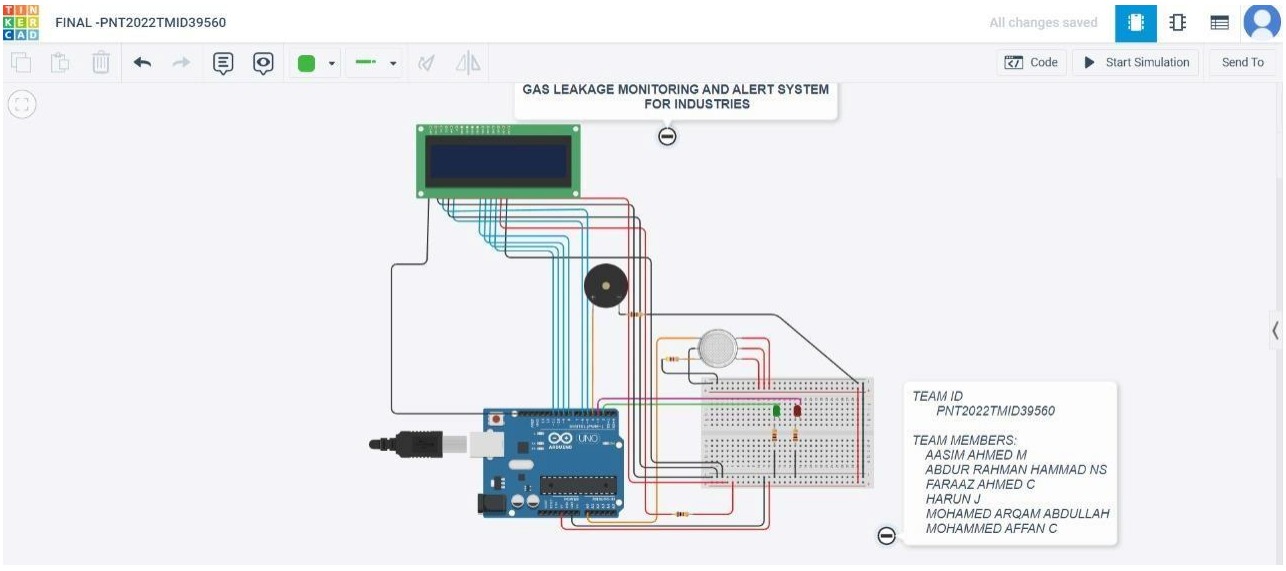
Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	77

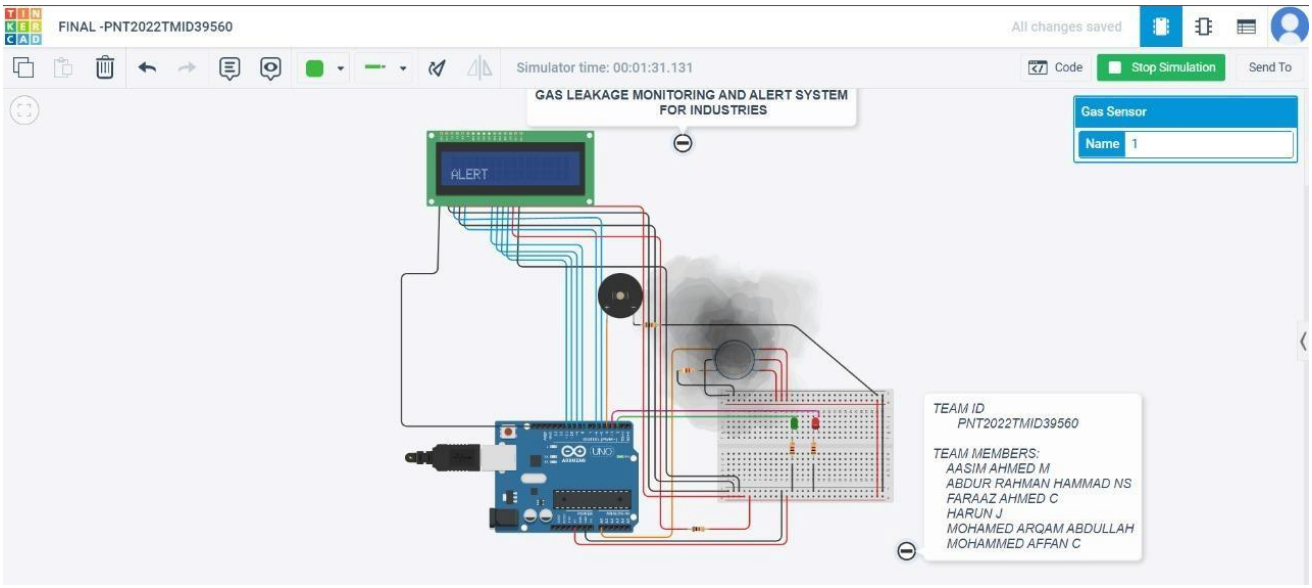
TEST CASE ANALYSIS:

This report shows the number of test cases that have passed, failed, and untested

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

9. RESULTS :





9.1 PERFORMANCE METRICS:

NFT - Risk Assessment									
S.No	Project Name	Scope/feature	Functional Changes	Hardware Changes	Software Changes	Impact of Downtime	Load/Volume Changes	Risk Score	Justification
1	GAS LEAKAGE ALERTING AND MONITORING FOR INDUSTRIES	New	Low	No Changes	Moderate	22, 109, 990	>5 to 10%	ORANGE	As we have seen the changes

NFT - Detailed Test Plan				
S.No	Project Overview	NFT Test approach	Assumptions/Dependencies/Risks	Approvals/SignOff
1	GAS LEAKAGE ALERTING AND MONITORING FOR INDUSTRIES	>5	NIL	Approved

			End Of Test Report					
S.No	Project Overview	NFT Test approach	NFR - Met	Test Outcome	GO/NO-GO decision	Recommendations	Identified Defects (Detected/Closed/Open)	Approvals/SignOff
1	GAS LEAKAGE ALERTING AND MONITORING FOR INDUSTRIES	>5	29	Pass	GO	Nil	None	Approved`

10. ADVANTAGES AND DISADVANTAGES:

ADVANTAGES:

- Low cost
- Low power consumption
- High accuracy
- The sensor has excellent sensitivity combined with a quick response time

DISADVANTAGES:

- No prevention of fires possible with kit.
- Applicable only as an indicator/alarming device.
- It works only when at 5V power supply is given.
- Its sensitivity depends on Humidity and temperature.
- It is a little sensitive to smoke

11. CONCLUSION:

After this project performance, can conclude that detection of the LPG gas leakage is incredible in the project system. Applicable usefully in the industrial and domestic purpose. In danger situations we are able to save the life by using this system. An alert is indicated by the GSM module. A sensor node senses gas like CO2, oxygen, propane. The estimated range of transmission and consumption of power is obtained. The simple procedures and Arduino UNO Microcontroller area used to build the sensor.

12. FUTURE SCOPE:

With recent development in technology, Temperature display during periods wherein no message buffers are empty is one such theoretical improvement that is well possible. Another very interesting and significant improvement would be to accommodate multiple receiver MODEMS at different positions in the geographical area carrying duplicate SIM cards. Multilingual display can be another added variation in the project. Audio output can be introduced to make it user Friendly.

13. APPENDIX:

13.1 SOURCE CODE:

```
#include <LiquidCrystal.h>


LiquidCrystal lcd(6, 7, 8, 9, 10, 11);

float gasPin = A0;

float gasLevel;

int ledPin = 2;

int buttonPin = 3;

int buzzPin = 4;

int buttonState;
```

```
int fan = 5;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  Serial.begin(9600);
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  lcd.setCursor(0,0);
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  delay(500);
  lcd.clear();
}


void loop(){
  // Read the value from gas sensor and button
  gasLevel = analogRead(gasPin);
  buttonState = digitalRead(buttonPin);


  // call the function for gas detection and button work
  gasDetected(gasLevel);
```

```
  buzzer(gasLevel);
  exhaustFanOn(buttonState);
}

// Gas Leakage Detection & Automatic Alarm and Fan ON
void gasDetected(float gasLevel){
  if(gasLevel >= 200){
   digitalWrite(buzzPin,HIGH);
   digitalWrite(ledPin,HIGH);
   digitalWrite(fan,HIGH);
   lcd.setCursor(0,0);
   lcd.print("GAS:");
   lcd.print(gasLevel);
   lcd.setCursor(0,2);
   lcd.print("FAN ON");
   delay(1000);
   lcd.clear();
  }else{
   digitalWrite(ledPin,LOW);
   digitalWrite(buzzPin,LOW);
   digitalWrite(fan,LOW);
   lcd.setCursor(0,0);
   lcd.print("GAS:");
   lcd.print(gasLevel);
```

```
   lcd.setCursor(0,2);
   lcd.print("FAN OFF");
   delay(100);
   lcd.clear();
  }
}
//BUZZER
void buzzer(float gasLevel){
if(gasLevel>=200)
  {
  for(int i=0; i<=30; i=i+10)
  {
  tone(4,i);
  delay(400);
  noTone(4);
  delay(400);
  }
  }
}
// Manually Exhaust FAN ON
void exhaustFanOn(int buttonState){
  if(buttonState == HIGH){
  digitalWrite(fan,HIGH);
  lcd.setCursor(0,0);
```

```
   lcd.print("Button State:");
    lcd.print(buttonState);
    lcd.setCursor(0,2);
    lcd.print("FAN ON");
    delay(10000);
    lcd.clear();
  }
}
```