Tinkering Lab project

SMART GAS LEAKAGE DETECTION SAFETY SYSTEM

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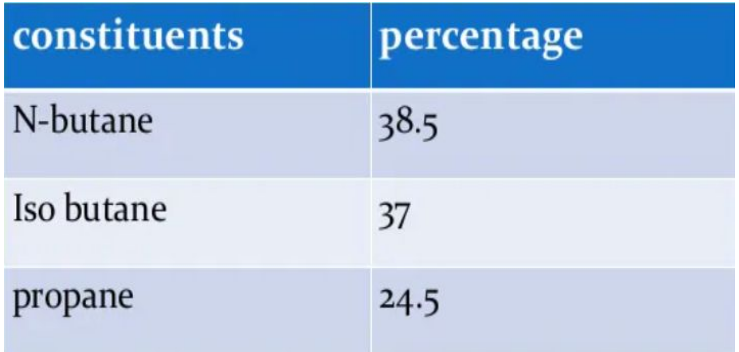
Introduction

- LPG (Liquefied petroleum gas) is a colourless odourless liquid that readily evaporates into a gas.
- Upon evaporation, it forms a highly flammable mixture of hydrocarbon gases like butane, propane. etc and is classified as a carcinogen and mutagen if it contains more than 0.1% of butadiene.
- Combustion equation:

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$$



constituents	percentage
N-butane	38.5
Iso butane	37
propane	24.5

Fig-1: Average composition of LPG (Source)

Bhopal Gas Tragedy

Fig 1: Bhopal Pesticide Plant (image source: link)

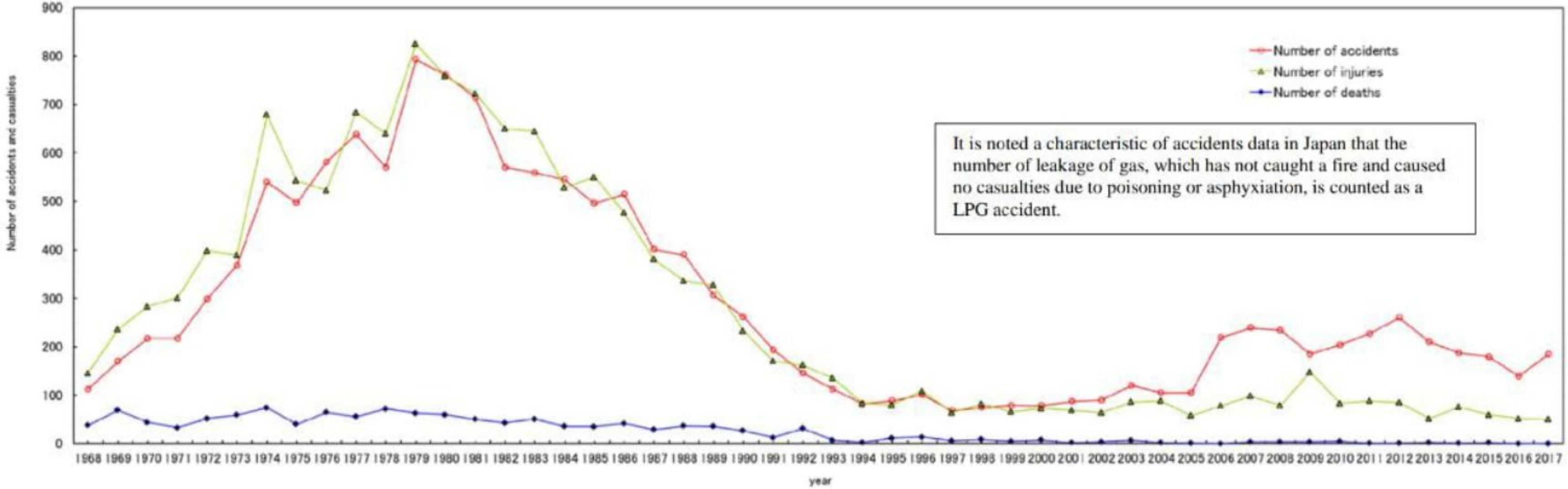
- Unintentional flow gaseous product from a containment (ex. Pipeline) into the surroundings is termed as a gas leak.
- The Bhopal gas tragedy that occurred on December 3, 1984 involved leakage of more than 40 tons of methyl isocyanate gas from a pesticide plant in Bhopal.
- Many victims suffered from chemical burns on eyes and skin because of the reaction of methyl isocyanate with organic tissues.
- Gas leakage has serious consequences, thus it is important to have proper safety measures.

As it is wisely said

“Precaution is better than cure.”

LPG accidents

Occurrences of accidents in the past



It is noted a characteristic of accidents data in Japan that the number of leakage of gas, which has not caught a fire and caused no casualties due to poisoning or asphyxiation, is counted as a LPG accident.

Figure 1: Accident occurrences and casualties by year

Problem definition / Objectives

The leakage of LPG, eventually evaporating into a highly flammable gas is disastrous. A few gas leak detection systems have already been made but we aim to make improvisations and come up with a smart gas detection system that does the following:

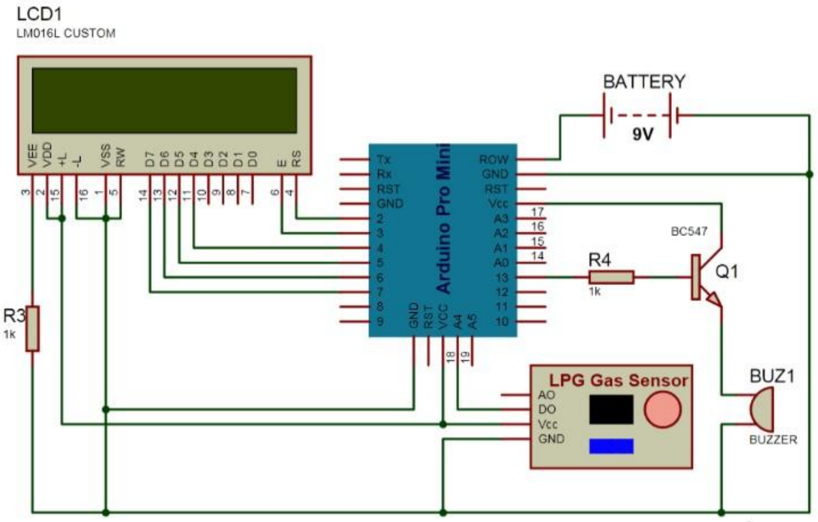
1. Detects LPG gas leakage with the help of an MQ5 sensor.
2. Sounds an alarm upon gas leak and turn off the alarm once the gas leak is under control.
3. Notifies house owner through SMS alert.
4. Sends GPS location of fire site to the nearest fire department as a precautionary measure to prevent explosions.
5. Prevents possible explosions from gas leakage by turning on the water sprinkler system.
6. Turns off all electrical appliances when gas leakage level becomes fatal.

Similar Solution

- <u>Existing Technologies:</u>

  The existing technology uses an MQ5 gas leakage detector along with a buzzer to alert the gas leakage that occurs.

  <u>Circuit Diagram:</u>



Limitations of the Existing Model:

- In the existing model, the buzzer alerts the gas leakage. But what if there is no one present around at that time to immediately act on this leakage?

- What if electricity is unintentionally switched on during the gas leakage? The **inflammable LPG can catch fire** due to an electrical spark. In this situation, if there is no one around it can result in **material damage/loss.**

Thus, we need to tackle the above limitations and improve the gas leakage alarm system !

Our Proposal

- SMS alert: In this, the registered mobile number of the owner will receive a text message upon detection of gas leakage.

- SMS alert + GPS location: An SMS alert along with live location of the affected area is sent to the fire department as a precautionary measure. This type of system is expected to be very helpful in cases when no person is physically present to inform the fire brigade.

- Water sprinkler: The water sprinkler system is added as a precautionary measure to prevent fires and possible explosions. The damage from a gas leak is hence kept to a minimum amount.

- Circuit Breaker: LPG is a highly flammable gas. When exposed to electric spark caused due to switching on electrical appliances it may catch fire. In order to avoid this, our model proposes that as soon as the gas leakage reaches a fatal amount, the relay system will be turned off in order to avoid electrical usage.

Methodology: PROJECT COMPONENTS

Fig: MQ5 gas sensor

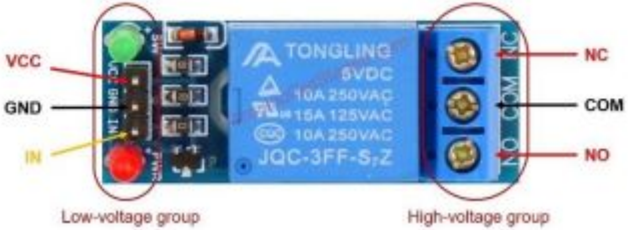


Fig: Relay module

Fig: Buzzer for alarm

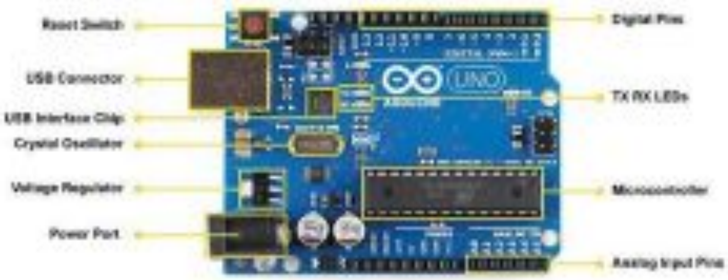


Fig: Arduino board

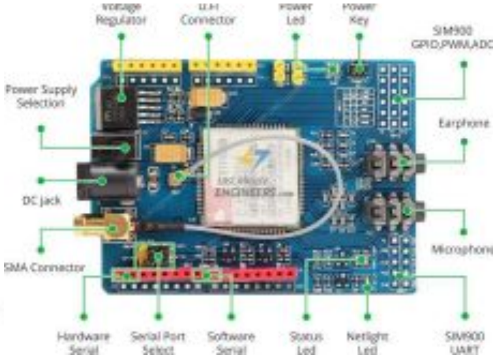
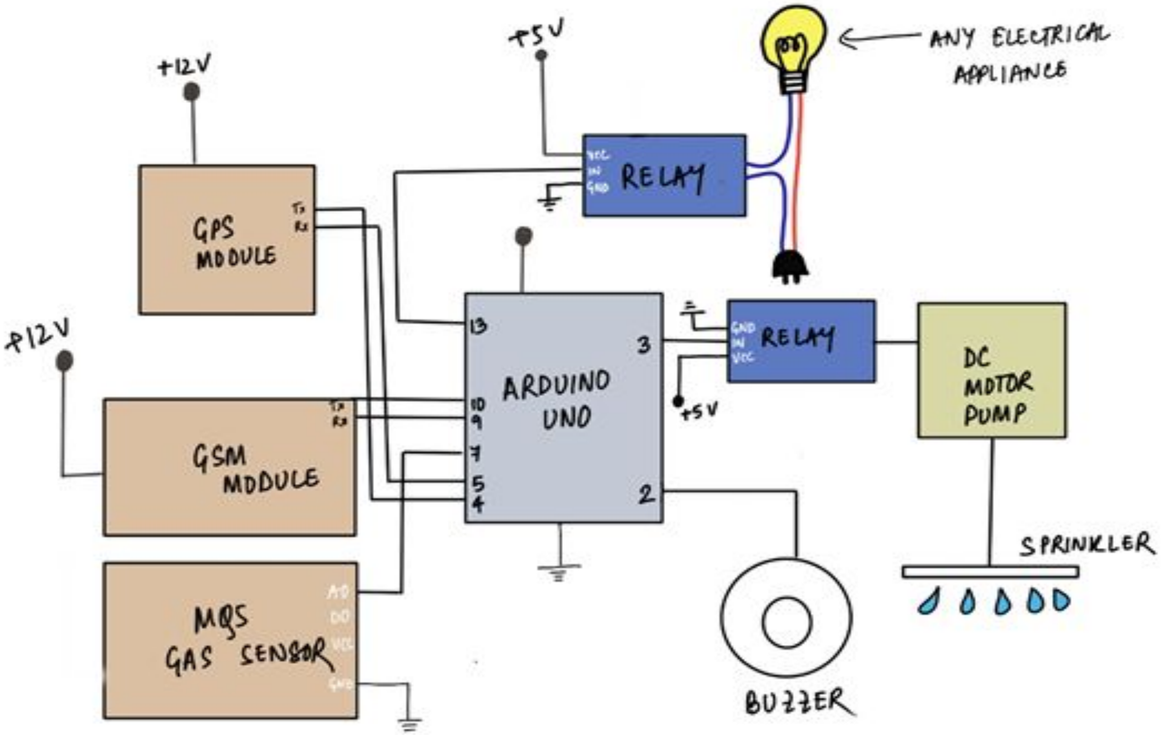


Fig: GSM module

- GPS Module
- DC Motor Pump

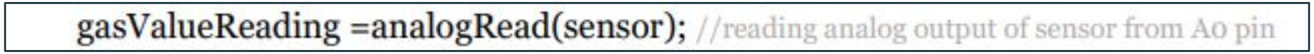
ORGANIZATION OF ELEMENTS



Code Explanation

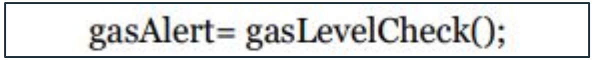
<u>Variables used in code:</u>

a) **gasValueReading:** this stores the gas level value which is read from the MQ5 sensor



```
gasValueReading =analogRead(sensor); //reading analog output of sensor from Ao pin
```

b) **gasAlert:** this stores the gas level value when there is a potential gas leak

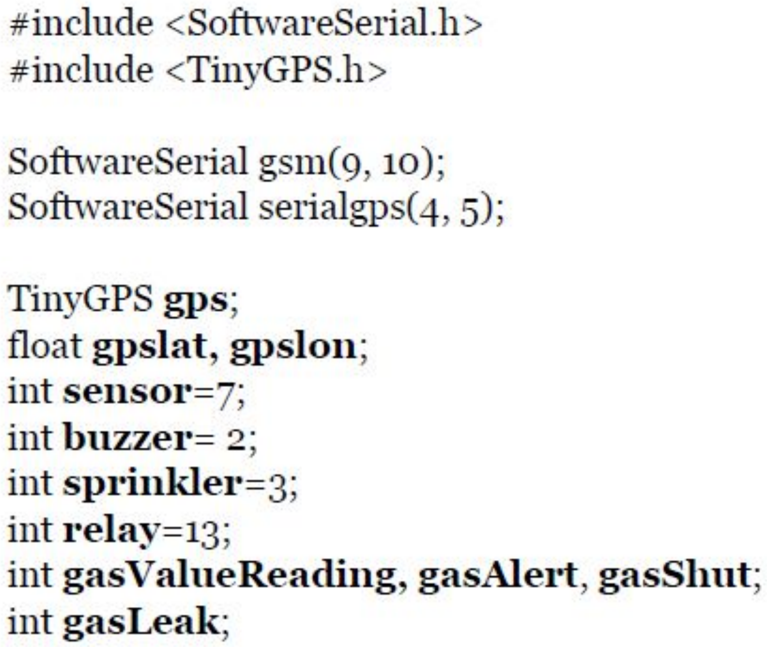


```
gasAlert= gasLevelCheck();
```

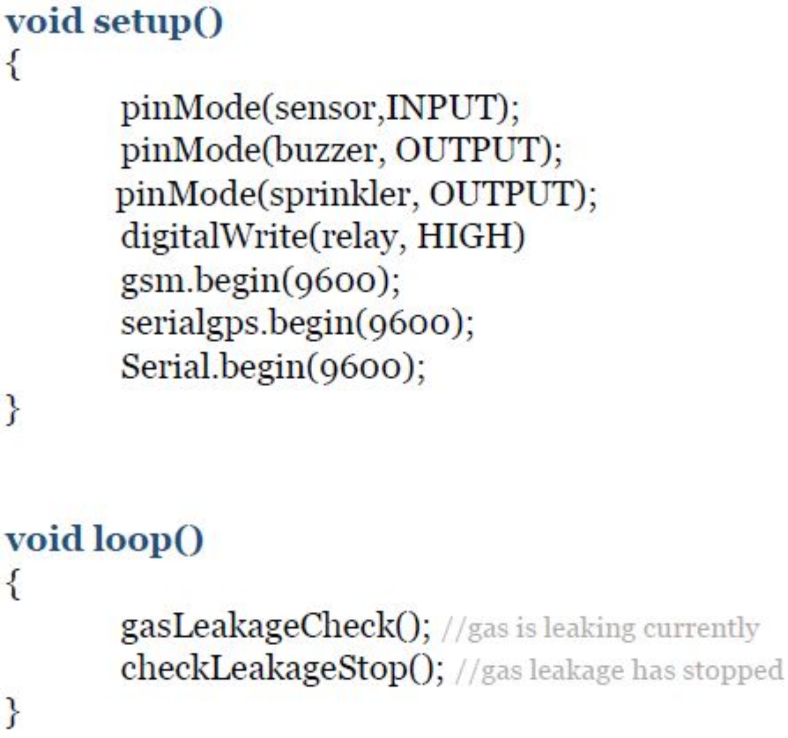
c) **gasLeak:** this value takes 0 or 1, depending upon the current status of gas leaking

d) **gasShut:** this stores the gas level value when there is gas leakage should have stopped

setup() and loop() functions of the code



```
#include <SoftwareSerial.h>
#include <TinyGPS.h>

SoftwareSerial gsm(9, 10);
SoftwareSerial serialgps(4, 5);

TinyGPS gps;
float gpslat, gpslon;
int sensor=7;
int buzzer= 2;
int sprinkler=3;
int relay=13;
int gasValueReading, gasAlert, gasShut;
int gasLeak;
```

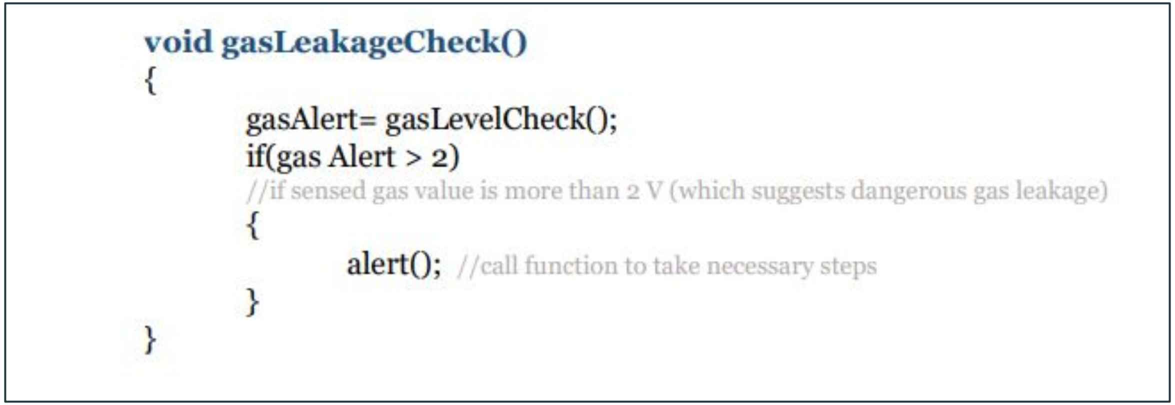


```
void setup()
{
        pinMode(sensor,INPUT);
        pinMode(buzzer, OUTPUT);
       pinMode(sprinkler, OUTPUT);
        digitalWrite(relay, HIGH)
        gsm.begin(9600);
        serialgps.begin(9600);
        Serial.begin(9600);
}


void loop()
{
        gasLeakageCheck(); //gas is leaking currently
        checkLeakageStop(); //gas leakage has stopped
}
```

Functions used

1) **gasLeakageCheck() :** This function is invoked to check if gas is leaking at the moment.

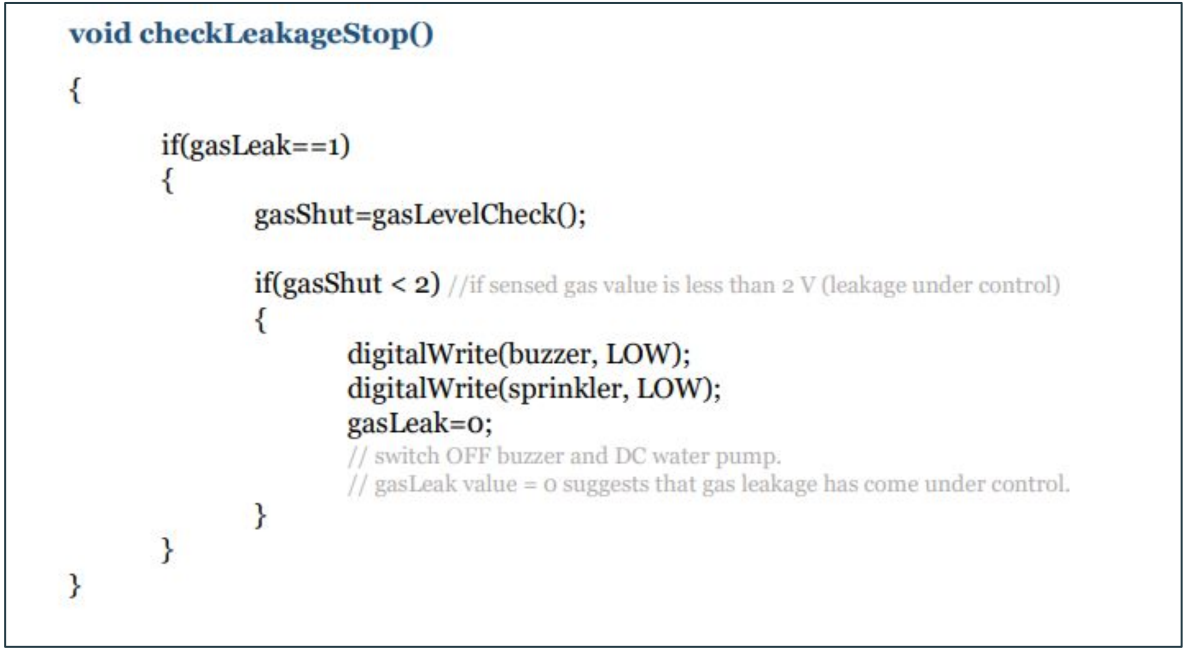
It puts the current gas value read by the sensor in gas Alert and subsequently calls the alert( ) function which does all the necessary actions to tackle the leak.



```
void gasLeakageCheck()
{
        gasAlert= gasLevelCheck();
        if(gas Alert > 2)
        //if sensed gas value is more than 2 V (which suggests dangerous gas leakage)
        {
                alert(); //call function to take necessary steps
        }
}
```

Functions used

2) checkLeakageStop( ) : This is the method to check if gas leakage has stopped or not.

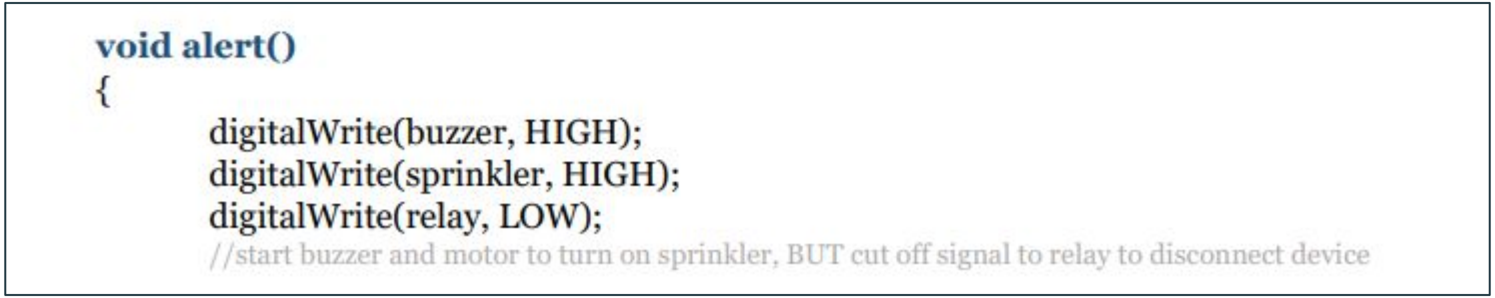


```
void checkLeakageStop()

{

        if(gasLeak==1)
        {
                gasShut=gasLevelCheck();

                if(gasShut < 2) //if sensed gas value is less than 2 V (leakage under control)
                {
                        digitalWrite(buzzer, LOW);
                        digitalWrite(sprinkler, LOW);
                        gasLeak=0;
                        // switch OFF buzzer and DC water pump.
                        // gasLeak value = 0 suggests that gas leakage has come under control.
                }
        }
}
```

Functions used

3) **alert( ):** This is the main driver function which does all the necessary things to alarm about the leakage.

- ➢ It turns on the buzzer and the sprinkler by turning them into HIGH state. The Input to the relay which connects the target device (IN) is set to LOW, thus disconnecting the device (like switching off bulb, oven etc.)

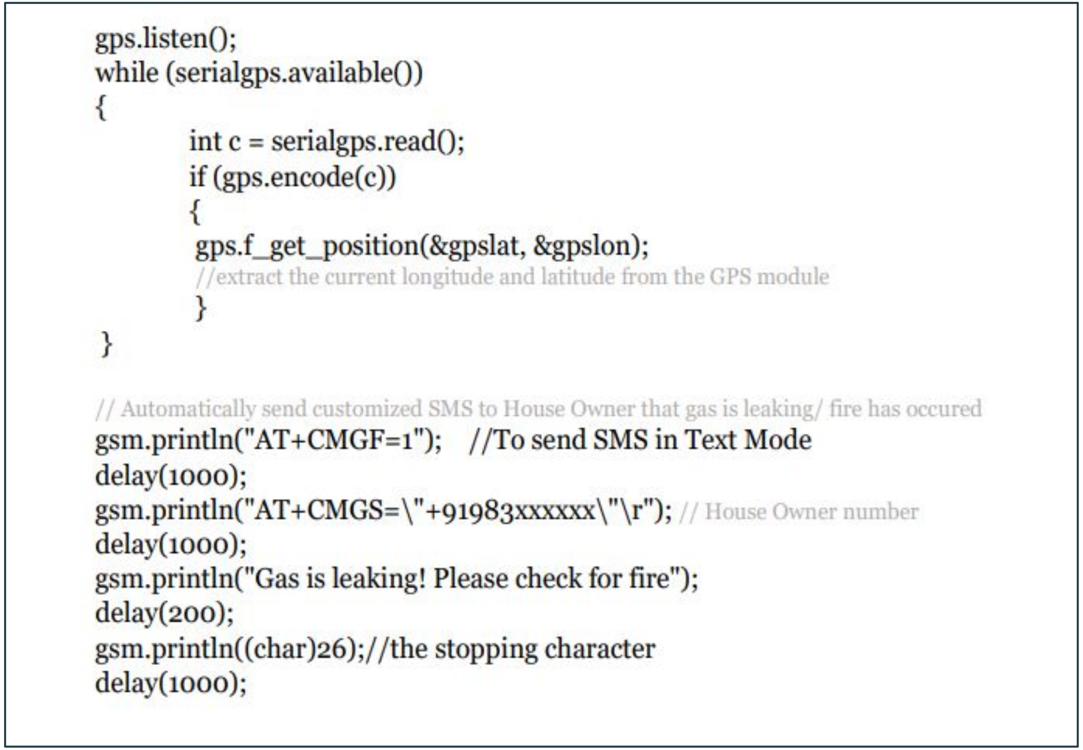


```
void alert()
{
        digitalWrite(buzzer, HIGH);
        digitalWrite(sprinkler, HIGH);
        digitalWrite(relay, LOW);
        //start buzzer and motor to turn on sprinkler, BUT cut off signal to relay to disconnect device
```

Functions used

3) alert( ): This is the main driver function which does all the necessary things to alarm about the leakage.

- ➢ It also sends a customized SMS to given mobile number using the GSM module.

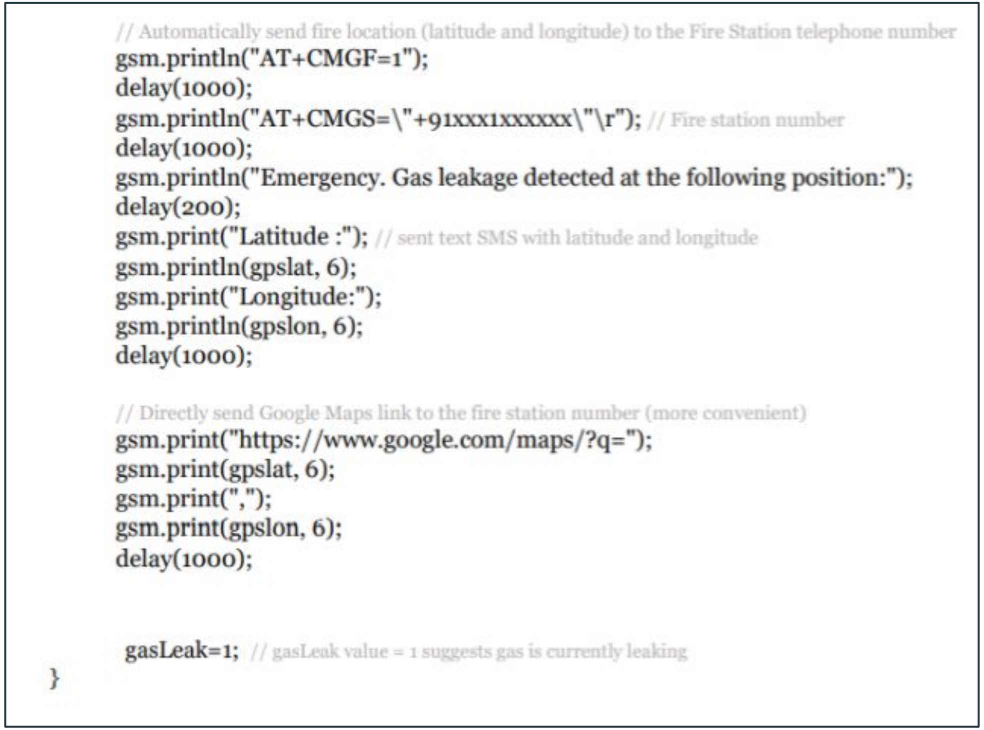


```
gps.listen();
while (serialgps.available())
{
          int c = serialgps.read();
          if (gps.encode(c))
          {
           gps.f_get_position(&gpslat, &gpslon);
           //extract the current longitude and latitude from the GPS module
           }
 }

// Automatically send customized SMS to House Owner that gas is leaking/ fire has occured
gsm.println("AT+CMGF=1");   //To send SMS in Text Mode
delay(1000);
gsm.println("AT+CMGS=\"+91983xxxxxx\"\r"); // House Owner number
delay(1000);
gsm.println("Gas is leaking! Please check for fire");
delay(200);
gsm.println((char)26);//the stopping character
delay(1000);
```

Functions used

3) alert( ):

- ➢ Using the GPS module, it sends SMS alert to the phone number of the Fire Station and sends the latitude, longitude of the fire site. It also sends a Google Maps link for the fire site. This is achieved using the TinyGps module which is imported in the code.
- ➢ Also, it makes the Boolean variable gasLeak to 1 (suggesting that gas is currently leaking)

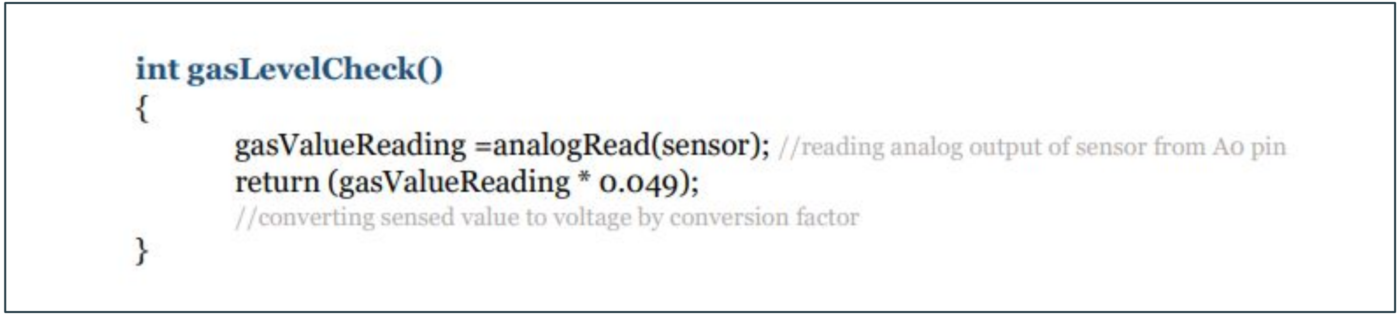


```
    // Automatically send fire location (latitude and longitude) to the Fire Station telephone number
    gsm.println("AT+CMGF=1");
    delay(1000);
    gsm.println("AT+CMGS=\"+91xxx1xxxxxx\"\r"); // Fire station number
    delay(1000);
    gsm.println("Emergency. Gas leakage detected at the following position:");
    delay(200);
    gsm.print("Latitude :"); // sent text SMS with latitude and longitude
    gsm.println(gpslat, 6);
    gsm.print("Longitude:");
    gsm.println(gpslon, 6);
    delay(1000);

    // Directly send Google Maps link to the fire station number (more convenient)
    gsm.print("https://www.google.com/maps/?q=");
    gsm.print(gpslat, 6);
    gsm.print(",");
    gsm.print(gpslon, 6);
    delay(1000);


     gasLeak=1; // gasLeak value = 1 suggests gas is currently leaking
}
```

Functions used

4) gasLevelCheck( ): an added method which reads the current gas value from the MQ5 sensor and returns the value. The value is read through the analogRead( ) function using the sensor (Ao port connected to the Arduino board)

This is invoked when we want to obtain the gas value currently in gasLeakageCheck( ) and checkLeakageStop( ).



```
int gasLevelCheck()
{
        gasValueReading =analogRead(sensor); //reading analog output of sensor from Ao pin
        return (gasValueReading * 0.049);
        //converting sensed value to voltage by conversion factor
}
```

How is MQ5 sensor reading used in this project?

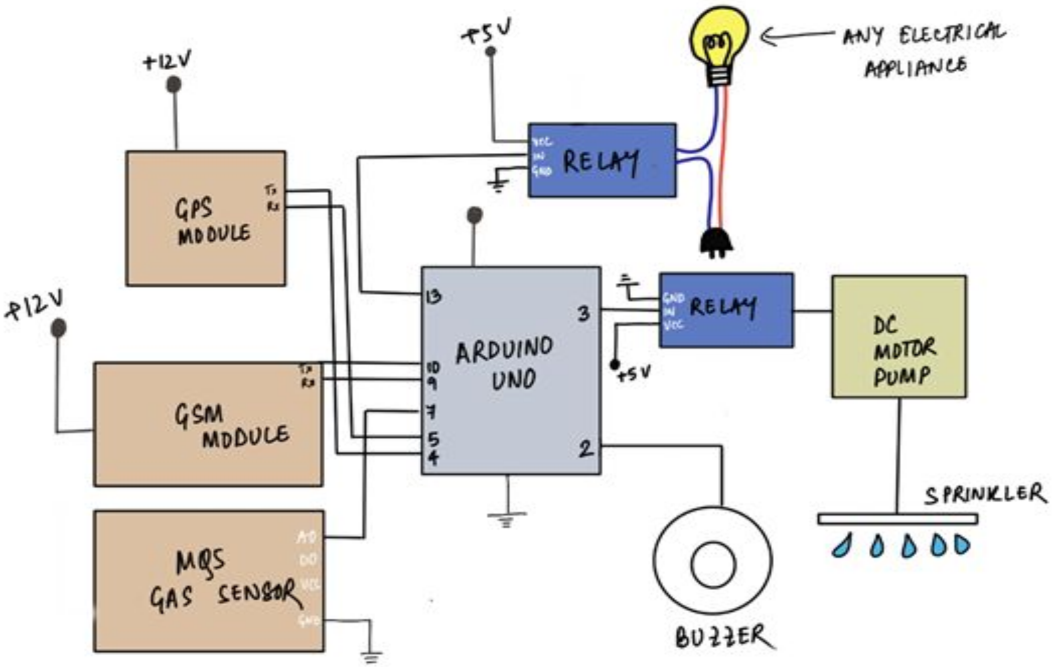
We use the A0 (analog port) pin of the MQ5 sensor and analogRead( ) function in Arduino:

Arduino board contains a 10 bit analog-digital converter. It maps input voltages between 0 and operating voltage (3 V or 5 V) into integer values between **0** to **1023**. This makes the conversion factor **5/1024 = 0.0049 V** (or 4.9 mV) per unit.

We researched in internet to find that under no gas leakage, analogRead( ) value read from MQ5 gas sensor module is around **47-48**, and under subsequent gas leakage (LPG or CH4 or smoke), it is **874-876**.

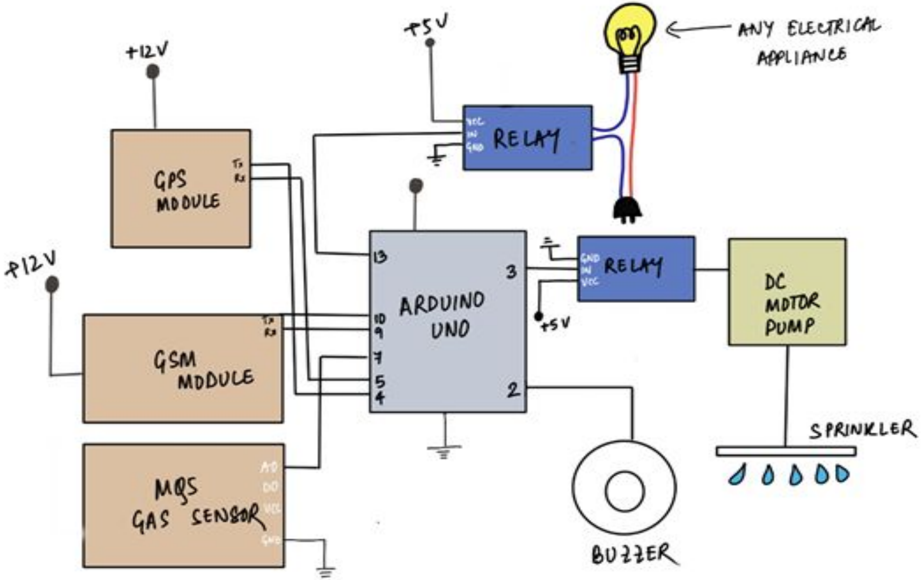
This when put in the conversion factor of 0.0049 gives, **0.2303 V** to **4.2875 V** as the voltage range detected. We take the average value of this (around 2 V) and use this value to conclude whether gas has leaked (**value > 2 V**) or hasn't leaked (**value < 2 V**)

ORGANIZATION OF ELEMENTS



Connection to the GSM Module:

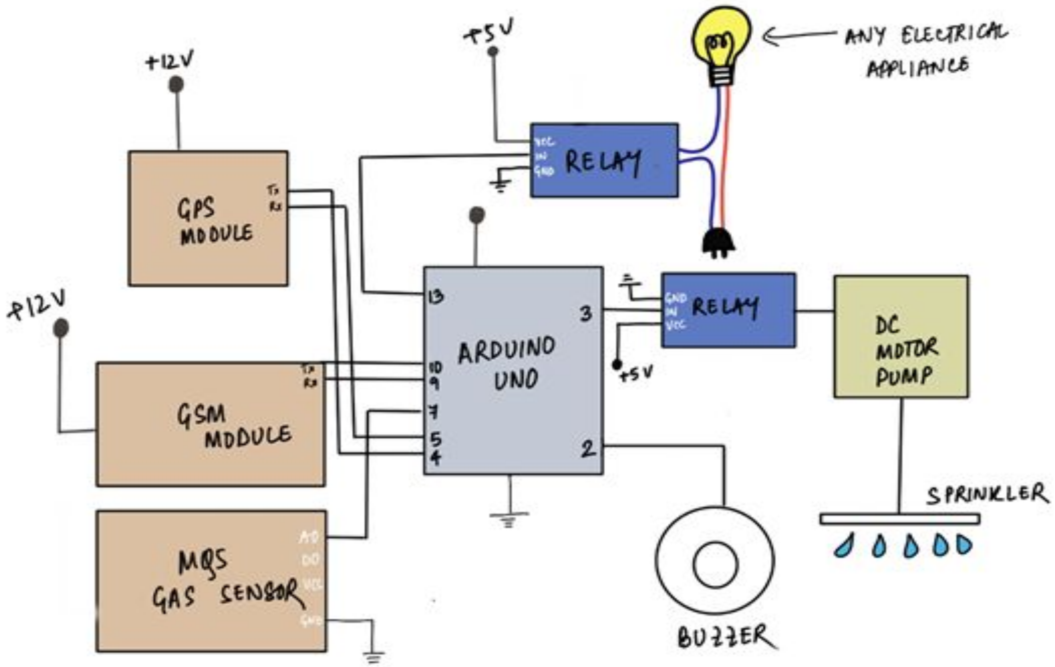
- ➢ We are selecting two digital pins of Arduino which are used for serial communication (two PWM enabled pins of Arduino)
- ➢ We are using pins 9 and 10 (which are PWM enabled pins).
- ➢ This method is made possible with the SoftwareSerial Library of Arduino.
- ➢ SoftwareSerial is a library of Arduino which enables serial data communication through other digital pins of Arduino.



Connection to MQ5 sensor:

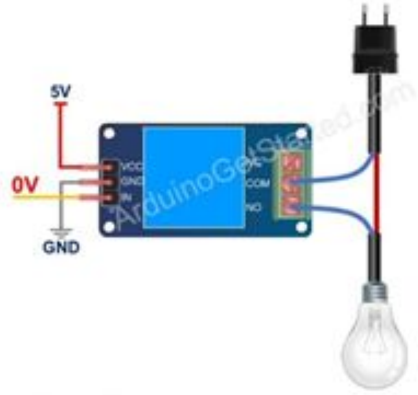
- ➢ We connect the digital pin 7 of the Arduino board to the D0 (digital out) of the MQ5 sensor module.

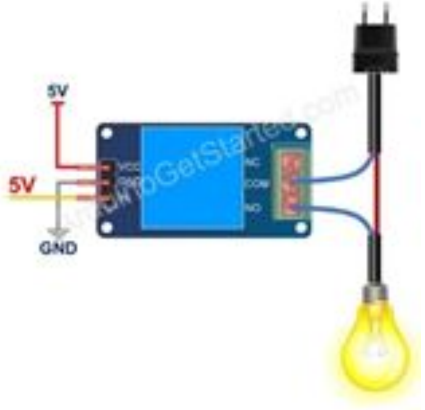
- ➢ The analog out (A0) has been used to detect Gas leakage and to measure volume of Gas leakage (by doing proper calculation of the sensor output inside program) in specific units (say ppm).



Connection to the relay and water pump:

- The submersible pump is placed inside a spacious water container.
- The DC motor is powered by a 5V battery.
- To increase the volume of water pumped, or to increase the water pressure of the sprinkler, a higher allowance set of motor and battery can be used (12V or 20V).





- **Connection of Relay to the output device we want to disconnect:**

  The Relay has two pin groups:

➢ low voltage group (GND, Vcc and IN) : connected to the Arduino

➢ High voltage groups(COM, NO, NC): connected to the device.

COM pin is used in both open and closed mode of the relay. NO pin is the normally open pin and the NC pin is the normally closed pin. We use the normally open mode for this project.

If the IN pin is HIGH, then switch is closed and bulb glows. If the IN pin is set to LOW, the bulb doesn't glow.

Conclusion

- Gas Leakage detection prevents disasters and loss of life and property.

- Modifications have been incorporated into the existing module to address the limitations. They are:
  1. SMS Alert System: generates alert message to the owner’s mobile number and the fire brigade in case of gas leakage.
  2. GPS Tracking System: sends GPS location of the affected place along with the SMS alert to the fire brigade.
  3. Relay System: breaks the circuit as soon as a fatal amount of gas leakage is detected.

Milestones Achieved

1. **Milestone 1 :** Buzzer for alarm after gas leakage.
2. **Milestone 2:** Water sprinkler in case of fire. For a large site, multiple sprinklers can be installed to tackle the fire from all locations.
3. **Milestone 3:** SMS alert to house owner and buzzer system in case of gas leakage.
4. **Milestone 4:** SMS alert to fire station along with location coordinates(When no one is present around).
5. **Milestone 5:** Breaking the circuit through relay to avoid any electrical usage. Hence avoid any possibility of fire.

More possible improvements?

- Finding nearest Fire station using GPS search and alerting them
- Instead of circuit breakers to disconnect one component at a time, whole MCB can be tripped at once
- Use better fire extinguishing equipment to tackle fire
- Heat protection system to protect furniture and interior

Bibliography

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2. LPG Gas leakage detector source code: https://circuitdigest.com/microcontroller-projects/arduino-based-lpg-gas-leakage-detector-alarm

3. Industrial Gas Detectors: 7 Types Of Industrial Gas Detectors: #7 Is The Best (nevadanano.com)

4. MQ5 Sensor Working: Liquid Petroleum Gas (LPG) - Health and Safety Authority (hsa.ie)

5. Arduino to Digital Converter: analogRead() - Arduino Reference

6. Interfacing MQ5 LPG GSM module to Arduino: Interface MQ5 LPG Sensor to Arduino with Code and Circuit Diagram (circuitstoday.com)

Thank you!

- **Arduino UNO:**
- **MQ5 Gas sensor:**
- **SIM900 GSM Module:** This module supports communication in 900MHz band. This was used in our project to send SMS messages.
- **Relay:** A relay is a programmable electrical switch, which can be controlled by Arduino or any micro-controller. It is used to programmatically control on/off the devices.
- **GPS Module:** This module uses the TinyGPS.h library to fetch the location coordinates (latitude and longitude) of the place.
- **DC Motor Water Pump:** This is Micro Submersible Water Pump DC 3V-5V, which draws water from an inlet and delivers to an outlet.
- **Buzzer:** Piezo speakers which can emit a sound when a particular trigger is used. Here, it is utilized as a alert/alarm system to produce alert beeps when a gas is detected.
- **Water Sprinkler spray:** Connected to DC motor pump and gives off water.
- **Power supply/ batteries:** We need 5V and 12V supplies to drive the Arduino Board, the GSM module, the MQ5 gas sensor. A 5V (or higher, depending upon water intake) power cell/battery is used to drive the DC powered motor pump.