ARDUINO-BASED GAS DETECTOR IN RESIDENTIAL HOMES

Presentation · July 2021

DOI: 10.13140/RG.2.2.35245.77283

5 authors, including:

Jhon Christian Rey Tolop
Accenture Inc.

James Kenneth Almerol
Bohol Island State University

Cherrilyn Sistoso
Bohol Island State University

Aileen Tandoc
Bohol Island State University

ARDUINO-BASED GAS DETECTOR IN RESIDENTIAL HOMES

**Jhon Christian Rey Tolop, James Kenneth M. Almerol, Cherrilyn M. Sistoso,
Aileen B. Tandoc, and MAX ANGELO PERIN**

IMAGINATIVE ABSTRACT

Gas leakages, fire accidents, and explosions are few of the pressing problems that most families encounter in their respective homes. Without any form of surveillance that detects anomalies in one's LPG, leakage may eventually lead to carbon monoxide poisoning to the inhabitants and increases the risk of explosion and fire. This paper presents a monitoring system designed to detect gas leakage in residential homes using the Internet of Things (IoT). The device is powered through Arduino – a microcontroller board that manages the controls and processes of each input and output command. An MQ2 sensor is embedded into the device that detects LPG, i-butane, propane, methane, alcohol, hydrogen, and smoke. If the sensor detects gas higher than 680 (a predefined threshold), an alarm/buzzer will go off which alerts people that there is a gas leakage. The device is also equipped with 16x02 LCD that displays whether the gas is detected or not. This paper aims to minimize chances of fire and explosion, gas leakages in the LPG, and to monitor the gas level in the area.

CCS Concepts

CCS➞ Hardware➞ Emerging technologies➞ Electromechanical systems➞ Microelectromechanical systems

Keywords

Arduino resistors;; LCD; 16x02 LCD; MQ2 sensor; gas sensor; piezo Buzzer; gas leakage; smoke

1. INTRODUCTION

Liquefied Petroleum Gas (LPG) is a prominent fuel source, especially in urban areas, because it is more eco-sustainable than firewood and charcoal [1]. In the Philippines, the consumption of LPG is a popular necessity for household appliances. It is widely used as a fuel for cooking food. Moreover, the use of LPG is budget-friendly in the present era, particularly for families. Aside from its affordability, using of LPG gas is very common for the Filipinos especially those who are living in the heart of the city where coal is difficult to find. However, gas leakage is an important concern not only to the industrial sector, but also in the residential buildings. Nowadays, vulnerability to fire and explosions becomes a serious concern due to increasing number of gas leaks.

Because of its high flammability and the possibility of hypoxia if inhaled, LPG waste can be extremely dangerous [2], [3]. Prolonged exposure to LPG may result to heart, lung, and kidney damages. Human senses could identify LPG leaks – sight, where we can see the gas escaping from a container – smell, where there would be a distinct scent of gas – and sound, where we can hear a 'hissing' noise. Those are only conceivable if the gas leakage is situated extremely close to a person or if there is a significant amount of leakage which may be too late if detected in a distant place.

To prevent major threats and potential hazards, awareness and monitoring are important. Individuals should have an immediate alert notification system whenever there is a gas leakage to avoid potential home safety threats and dangers. Residents can quickly mitigate the risks and potential risks associated with gas leakage if such warning information is provided. This context is the primary impetus for this study and the development of the alert system to assist the residents in monitoring the safety of their homes. The purpose of this project is to build a technological system that combines an MQ2 sensor that detects gas, a piezo buzzer, and an LCD. Additionally, this project will build a low-cost, simple, rapid and a low-maintenance prototype for gas leak detection.

2. REVIEW OF RELATED LITERATURE

LPG leakage is one of the prominent causes of explosions, poisoning of every death. The researchers of this study have intended to find and investigate previous research related to the current undertaking conducted by various researchers and scholars. These materials will serve as a basis and guide while the researchers work on the study.

2.1 Intelligent LPG Gas Leak Detection tool with SMS Notification

A gas is a free, formless, and opaque molecule that can transform into a liquid or solid at specific temperatures and pressures. LPG gas is needed for industrial and home use, particularly for cooking. However, in Indonesia, it is a frequent source of flames, often associated with LPG because of broken gas regulators. As a result, preventative and security measures are necessary to limit fires. Seeing this and considering the technical advancements, an intelligent Arduino-based gadget was designed to address this issue. This instrument has MQ-2, SIM800L, and buzzer gas sensors. In an embedded device, the system converts the input data from the sensor Mq-2 to detect propane and butane gas, and then sends the real data through short messages to the mobile phone number registered in the system. Apart from sending SMS, the device also emits a sound created by the buzzer. [4]

2.2 A Wireless Home Safety Gas Leakage Detection System

In this article, a portable safety device for detecting gas leaks has been proposed. The device is intended for household safety purposes in situations where liquid petroleum gas (LPG) appliances and heaters may pose a risk. Additionally, the system may be utilized for various industrial applications or facilities that operate on LPG or natural gas. It is composed of two major modules: one for detection and transmission and another for reception. The detection and transmission module detects changes in the gas concentration using a specially designed sensor circuit. This module determines if a change in the concentration has reached a predefined threshold. When the sensor detects a concentration shift, an audiovisual alert sound and signal are sent to the receiver module. The receiver module functions as a mobile alert device, allowing for freedom of movement throughout the house. The system was tested with LPG and the alarm was being triggered in response to a concentration change. [5]

2.3 IoT Gas Leakage Detector and Warning Generator

This research discusses the design of a monitoring system that makes use of the Internet of Things (IoT). The gas sensor (in this case, the researchers used MQ-5) collects data that is then transmitted to a data cloud. In a given situation, the sensor detects gas leakage. All parts are operated by an Arduino microcontroller (in this case, the researchers used UNO-1) that serves as the setup's main processor unit. When the sensor detects a gas leak, an alert is being triggered through the buzzer sound. This alarm is complemented by the LCD display that indicates the area of the leak. It then notifies the observer and activates the exhaust fan in the specific section to remove the leakage. The goal of a gas detection system is not only for air quality monitoring, but also for aiding in gas leakage prevention, therefore minimizing the danger of fire and property damage. [6]

2.4 Wireless Sensor Network on LPG Gas Leak Detection and Automatic Gas Regulator System Using Arduino

Majority of the LPG explosions occur due to undetected gas leaking under pre-detection settings. As a response, a method for detecting LPG is necessary. This system aims to detect gas leaks, neutralize them, and avert explosions. Gas leakages might occur as a result of incorrect regulator installation or a damaged hose. This monitoring should not be limited to a single place due to the possibility of gas leaking into the gas valve and its line. As a result, Wireless Sensor Networks (WSNs) are an effective approach for detecting gas leaks across a large region. This technique employs two or more gas sensors that detect leaks at two or more sites surrounding the gas pipe and its distribution line. The WSN system is based on the MQ-6 gas sensor and the Bluetooth HC-05 wireless module. A buzzer, an exhaust fan, as well as an automated gas regulator, constitute the explosion protection system. If the gas leaks, the sensor wirelessly transmits data to the Arduino. Then, the alert system for explosions will be triggered. The system will trigger the alarm/buzzer, immediately disengage the gas regulator, and use the exhaust fan to neutralize the air. Both systems are completely controlled by the Arduino microcontroller. [7]

2.5 Gas Detecting Alarm System In Southern Star Ordinary Public Buses Throughout Bohol: An Arduino Project

Leakage of gas is a serious issue that can result to dangerous mishaps, such as explosions, fires, and asphyxiation. Gas leakage has been detected in a variety of settings, including homes, industries, and even vehicles such as buses. The purpose of this article is to propose a concept for a Gas Detecting Alarm System (GDAS) which will be put on Southern Star regular public buses across Bohol to detect, warn, and regulate gas leakages. The system utilizes an Arduino UNO R3 fitted with a buzzer, an LCD, and a gas sensor. GDAS is a critical system because it detects toxic gases, oxygen deficiency, and flammable or combustible gases. Electrochemical sensors are available in a variety of configurations for the detection of hazardous and poisonous gases. A MQ2 sensor is utilized in this project. Whenever the sensor detects gas in the atmosphere, it outputs an analogue signal of more than 680, whereas when no gas is detected, the sensor outputs an analogue signal of less than 680. The Arduino will act as an analogue input for the sensor output. If the sensor output exceeds the threshold value, the buzzer begins tuning, and the LCD indicates that gas has been detected and its level. If the output of the sensor is less than the predefined threshold, the buzzer is not tuned. The LCD will indicate that no gas has been detected, displaying the gas level. This mechanism serves as a critical and beneficial role. It is an essential technology for a secure environment as it helps in avoiding catastrophic occurrences that may end to death.[8]

3. PROPOSED METHODOLOGY

Leakage of gas results in a myriad of accidents, resulting in both monetary loss, injuries, and even death. The number of fatalities caused by gas cylinder explosions has been growing in the recent years. Last 2019, An alleged gas tank leak triggered a fire that gutted a two-story townhouse along Craig Street corner España Boulevard, Sampaloc, Manila. Due to the unfortunate event, a resident sustained third-degree burns and caused property damages worth PHP 200,000. [9]. The other case was last June 26, 2021 when Kapuso Mo, Jessica Soho featured a skit of a woman who had third degree burns due to LPG explosion [10]. In conclusion, this paper aims to catch gas leakages in the LPG, monitor the gas level in the area, and prevent irreversible damages such as house fires, third degree burns, gas poisoning, and etc.

Figure 1 represents the visual diagram of the proposed system. The microcontroller Arduino (in this case, the researchers used Arduino Mega 2560) powered by a 9v battery or a chargeable USB power bank, serves as the central unit that receives the input coming from the gas sensor, and produces the output – the 16x02 LCD display and triggered piezo buzzer sound.

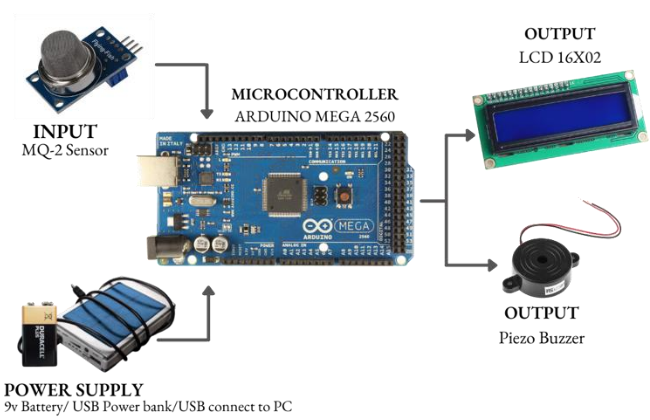

Figure 1 - Visual Diagram of the proposed system

3.1 Hardware Description

Arduino Mega 2560 - is a microcontroller that features 54 digital input/output pins (15 of which are PWM outputs), 16 analog inputs, four UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power connector, an ICSP header, and a reset button [11].

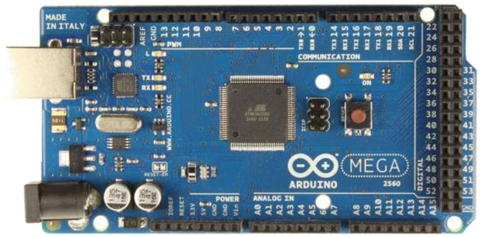

Figure 2 - Arduino

MQ-2 Gas Sensor - is handy in detecting gas leaks whether in a residential or industrial setting. It can detect H2, LPG, CH4, CO, Alcohol, Smoke, or Propane. Due to its great sensitivity and rapid reaction time, measurements may be obtained immediately. The potentiometer may be used to alter the sensor's sensitivity [12].

Figure 3 – MQ2 Sensor

LCD 16x02 - is used for displaying the inputs being fed to the microcontroller, as well as the outputs obtained from the it. LCD can display either a group of characters, numerical figures, or the combination of both. It is one of the most common types of LCDs used alongside with Arduino microcontrollers.

Figure 4 – MQ2 Sensor

Resistors - are electronic components with a constant electrical resistance. The resistance of a resistor limits the passage of electrons in a circuit [13]. In this research, 3 resistors were used; a 330 ohms, 2 kilo-ohms and a 330 kilo-ohms.

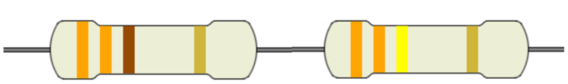

Figure 5 – Resistors- 330 ohms, 2 kilo-ohms and a 330 kilo-ohms.

Piezo Buzzer - a type of electronic device that is used to produce a tone, alarm or sound. [14].

Figure 6 – Piezo Buzzer

3.2 Hardware Implementation

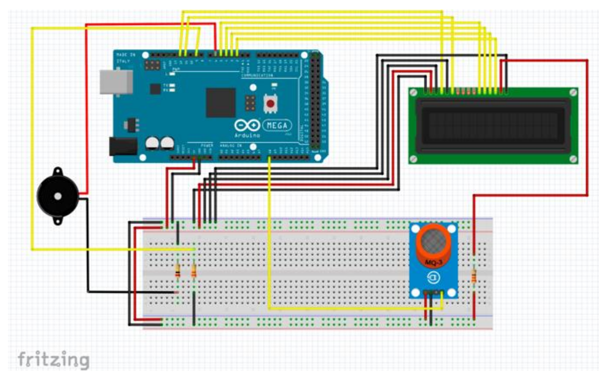

Figure 7 – Wiring Scheme via Fritzing

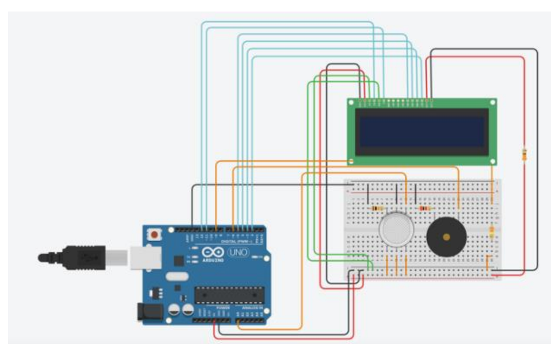

Figure 8 – Visualized Proposed System using TinkerCad

After checking the connections using TinkerCad, the researchers are now ready for the hardware implementation.

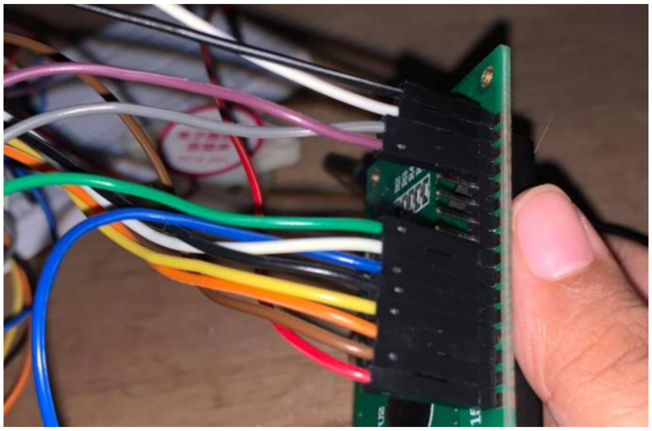

Figure 9 – LCD with headerpins

The researchers soldered the header pins into the 16x02 LCD for easy connection using jumper wires.

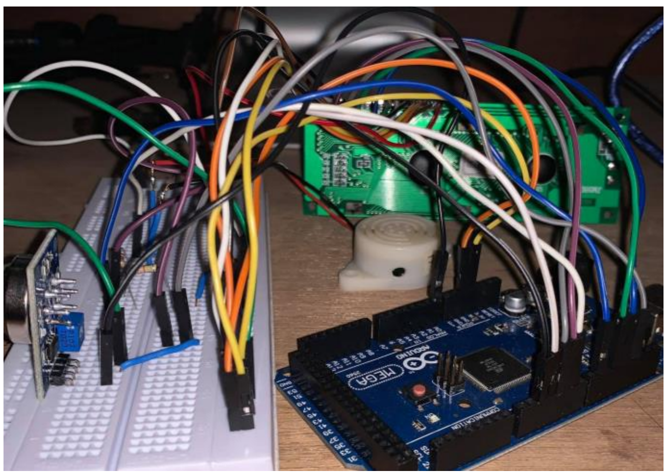

Figure 10 – hardware of the system

The researchers opted to use a breadboard and jumper wires (female-to-male and male-to-male) for easier reconnection if ever a mistake was made.

3.3 Software Implementation

The MQ-2 sensor serves as the primary bases for the input in the system. Gases that MQ-2 sensor detects have quantitative data that are proportional to its concentration. The data coming from the MQ-2 sensor is transmitted to the microcontroller, which establishes the conditions for the output devices – piezo buzzer and the 16x02 LCD Display.

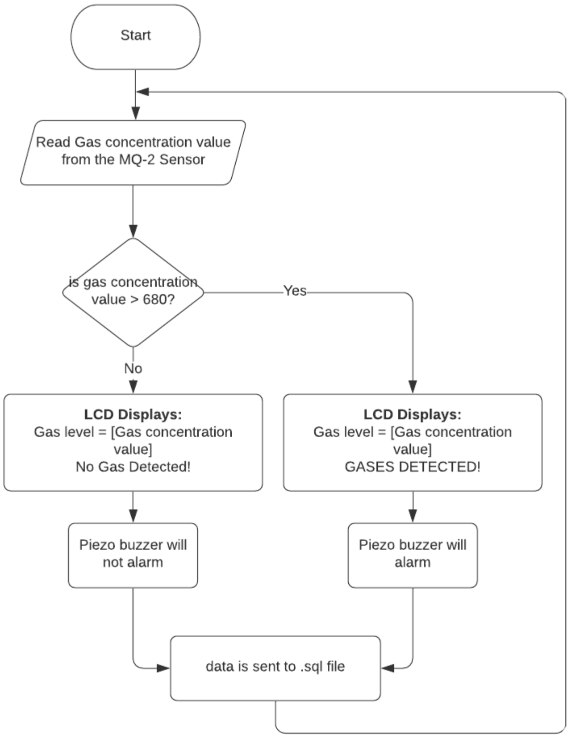

Figure 11 - Flowchart of the Proposed System

Before starting the actual wiring, the researchers utilized an efficient simulator named TinkerCad to ensure its functionality. Since the MQ-2 sensor module is unavailable, an alternative gas sensor with six pins is used.

The alternative sensor reads gas concentrations from 0 to 876, where 0 represents the lowest concentration and 876 represents the highest possible value.

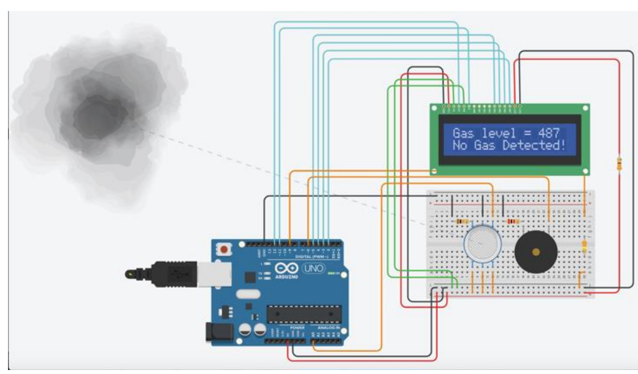

Figure 12 – Simulation of the Proposed System using TinkerCad When Gas Concentration Value <= 680

If the gas sensor detects a gas concentration value less than 680, the LCD shows "Gas level = [gas concentration value]" and the phrase

"No Gas Detected!". Additionally, the buzzer will not produce any alarm sound.

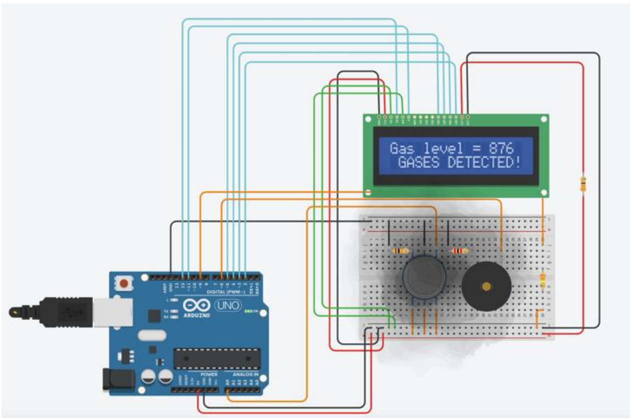

Figure 13 – Simulation of the Proposed System using TinkerCad When Gas Concentration Value >= 680

When the gas sensor detects a concentration higher than 680, the LCD shows "Gas level = [gas concentration value]" and "GAS DETECTED!". Moreover, the buzzer will produce an alarm sound.

```
#include <LiquidCrystal.h>
int g;
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
void setup()
{
  lcd.begin(16, 2);
    pinMode(A0,INPUT);
    pinMode(6,OUTPUT);
    pinMode(9,OUTPUT);
}

class gasSensor
{
  public:
    int gas()
    {
      int a = analogRead(A0);
      return a;
    }
    bool condition(int g)
    {
      if(g>680){ return true; }
      else{ return false; }
    }
    void tru()
    {
      digitalWrite(9,HIGH);
      lcd.setCursor(0,0);
      lcd.print("Gas level = ");
      lcd.print(g);
      lcd.setCursor(0,1);
      lcd.print(" GASES DETECTED!");
      tone(6, 1000, 2000);
      delay(100);
    }
    void fal()
    {
      digitalWrite(9,LOW);
      lcd.setCursor(0,0);
      lcd.print("Gas level = ");
      lcd.print(g);
      lcd.setCursor(0,1);
      lcd.print("No Gas Detected");
      noTone(6);
      delay(100);
    }
};

void loop()
{
    gasSensor system;
    g = system.gas();
    bool con = system.condition(g);
    Serial.begin(19200);
  if(con)
    {
    system.tru();
    Serial.print(g);
    Serial.print(",");
    Serial.println("GAS DETECTED");

    }
    else
    {
    system.fal();
    Serial.print(g);
    Serial.print(",");
    Serial.println("No Gas Detected");
  }
    delay(1000);
}
```

Figure 14 – System Code Snippet

3.4 Inserting Data from Arduino to .sql file using Python

Before anything else, a crucial step should be observed – the code uploaded into the Arduino microcontroller should print the data accumulated from the gas sensor to a serial There are two files needed for the databasing: a pre-written .sql file and the python file, which receives the data from the Arduino.

```python
import serial
import datetime
import time


def add2sql(timer,date,value,note):
    f = open("DATABASE.sql", "a")
    f.write("INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES ('{}','{}',{},'{}');
\n".
            format(timer,date,int(value), note))
    f.close()

def serial2python():
    arduinodata =
serial.Serial('/dev/cu.usbmodem14301', 19200,
timeout=2)
    while arduinodata.inWaiting:
        val=arduinodata.readline().decode('ascii')
        return val


while 1:
    value,note = serial2python().split(',')
    value = value.strip()
    note = note.strip()
    mytime=datetime.datetime.now()

timer='{}:{}:{}'.format(mytime.hour,mytime.minute,myt
ime.second)

date='{}/{}/{}'.format(mytime.month,mytime.day,mytime
.year)
    print("Time: {} || Date: {} || Gas Concentration
Value: {} || Verdict: {}".
          format(timer, str(date), int(value), note))
    add2sql(timer,str(date), int(value), note)
    time.sleep(1)
```

Figure 15 – Python File; code snippet

The python file serves as the "bridge" between the microcontroller and the .sql file. The function serial2python reads data from the serial monitor and decode it to a readable character. Once the reading and decoding are done, the decoded text is returned to the loop. The add2sql function uses an open() function to open the .sql file and write() function to pass the data from the serial monitor to the .sql file.

```sql
DROP TABLE IF EXISTS gasSensor;
CREATE TABLE gasSensor (
   ID INT AUTO_INCREMENT PRIMARY KEY,
   DATE_ CHAR (12) DEFAULT NULL,
   TIME_ CHAR (12) DEFAULT NULL,
   GCV INT (12) DEFAULT NULL,
   VERDICT CHAR (25) DEFAULT NULL
);
```

Figure 16 – .sql File – Pre-written Code (empty)

```sql
DROP TABLE IF EXISTS gasSensor;
CREATE TABLE gasSensor (
   ID INT AUTO_INCREMENT PRIMARY KEY,
   DATE_ CHAR (12) DEFAULT NULL,
    TIME_ CHAR (12) DEFAULT NULL,
    GCV INT (12) DEFAULT NULL,
    VERDICT CHAR (25) DEFAULT NULL
);

set autocommit=0;
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:43','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:45','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:47','7/7/2021',337,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:50','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:52','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:54','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:56','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:28:58','7/7/2021',338,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:18','7/7/2021',341,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:21','7/7/2021',342,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:23','7/7/2021',339,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
```

```
('22:32:25','7/7/2021',339,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:27','7/7/2021',341,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:29','7/7/2021',339,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:31','7/7/2021',341,'No Gas
Detected');
INSERT INTO gasSensor
(DATE_,TIME_,GCV,VERDICT) VALUES
('22:32:33','7/7/2021',340,'No Gas
Detected');
```

Figure 17 – .sql file – Pre-written with Data Accumulated from Arduino

4. REFERENCES

[1] Dr. Mohammad Khan. 2020. Sensor Based Gas Leakage Detector System. Proceedings of 7th International Electronic Conference on Sensors and Applications (2020). DOI: http://dx.doi.org/10.3390/ecsa-7-08278

[2] T. Soundarya and J. V. Anchitaalagammai, “Control and Monitoring System For Liquefied Petroleum Gas (LPG) Detection And,” Int. J. Innov. Res. Sci. Eng. Technol., vol. 3, no. 3, pp. 696–700, 2014.

[3] A. Spiewak and W. Salabun, “A Mobile Gas Detector with an Arduino Microcontroller,” Int. J. Comput.Technol. Appl., vol. 6, no. August 2015, pp. 636–641, 2016.

[4] Muhammad Siddik Hasibuan, Syafriwel, and Iswandi Idris. 2019. Intelligent LPG Gas Leak Detection Tool with SMS Notification. Journal of Physics: Conference Series 1424 (2019), 012020. DOI: http://dx.doi.org/10.1088/1742-6596/1424/1/012020

[5] Luay Fraiwan, Khaldon Lweesy, Aya Bani-Salma, and Nour Mani. 2011. A wireless home safety gas leakage detection system. 2011 1st Middle East Conference on Biomedical Engineering (2011). DOI: http://dx.doi.org/10.1109/mecbme.2011.5752053

[6] B.F. Alshammari and M.T. Chughtai. 2020. IoT Gas Leakage Detector and Warning Generator. Engineering, Technology & Applied Science Research 10, 4 (2020), 6142–6146. DOI: http://dx.doi.org/10.48084/etasr.3712

[7] L. Dewi and Y. Somantri. 2018. Wireless Sensor Network on LPG Gas Leak Detection and Automatic Gas Regulator System Using Arduino. IOP Conference Series: Materials Science and Engineering 384 (2018), 012064. DOI: http://dx.doi.org/10.1088/1757-899x/384/1/012064

[8] Tutor, Karl & Perin, Max Angelo & Mendez, Toni Angie & Gamutin, Genil Luke & Pino, Michael Andri & Yucot, Vernie. 2021. GAS DETECTING ALARM SYSTEM IN SOUTHERN STAR ORDINARY PUBLIC BUSES THROUGHOUT BOHOL: AN ARDUINO PROJECT.

[9] Dhel Nazario. 2019. Fire triggered by gas leak consumes two-story townhouse in Sampaloc. (March 2019). Retrieved July 6, 2021 from https://mb.com.ph/2019/03/02/fire-triggered-by-gas-leak-consumes-two-story-townhouse-in-sampaloc/

[10] GMA Public Affairs. 2021. *Kapuso Mo, Jessica Soho: KATAWAN NG BABAE, NALAPNOS AT NAMAGA MATAPOS MASABUGAN NG TANGKE NG LPG*, YouTube.

[11] Arduino.cc. 2021. Arduino Mega 2560 Rev3. (2021). Retrieved July 6, 2021 from https://store.arduino.cc/usa/mega-2560-r3

[12] Macfos. 2021. MQ Series Gas Sensor. (June 2021). Retrieved July 6, 2021 from https://robu.in/mq-series-gas-sensor/

[13] Sparkfun. 2021. Resistors. (2021). Retrieved July 6, 2021 from https://learn.sparkfun.com/tutorials/resistors/all

[14] APC International. Piezo Buzzers. Retrieved July 6, 2021 from https://www.americanpiezo.com/standard-products/buzzers.html

REVIEW

Date Submit	Comments
July 5, 2021 [V1]	• Follow IMRAD, Introduction (RRL), Methodology, Results and Discussion (Optional) • On your methodology, put your tinkercad and fritzing • Also, add code snippets • Change ccs follow **CCS-Hardware-Emerging technologies-Electromechanical systems-Microelectromechanical systems** • Review your grammar
July 9, 2021 [V2]	• Some figures are not referenced in the text. All figures should be properly referenced in the text of the paper • Code is not readable
July 9, 2021 [V3]	• Accepted

REVIEWED BY: M. Perin