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IoT-based LPG Leakage Detector System with Safety Alert Mechanism

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Abstract: The Internet of Things (IoT) is a growing network of physical devices that are connected to various kinds of sensors and are capable of exchanging data with the presence of an internet connection. One of the systems that using IoT is a gas leakage detector. This study aims to design a liquefied petroleum gas (LPG) leakage detector system with the aid of IoT and safety alert mechanism. The main issue of gas leakage is people do not realize when it happens, therefore the method and purpose of this paper to build a gas leak detector device with IoT apply and with several ways to notify user the presence of a gas leak. The circuit of the LPG leakage detector system is created using Proteus software. The IoT Platform use in this project is Blynk mobile application for user to easily connect and monitor the device by using smartphones. The theory of the circuit is based on the gas sensor to measure the gas leakage in percentage and parts per million (ppm). Besides, for the testing conditions, the gas leakage detector device is tested in two situations, first at open surroundings with different distances between the device and the source of gas, and second test in a different volume of the box. In a conclusion, the gas leakage detector system works as intended, the results show that the system would alert the user when the gas leakage is detected. User will receive a text message, email, and alarm that connected to the device once the system detects the presence of gas leakage.

Keywords: LPG, IoT, Leakage Detector System, Gas Leakage Sensor

1. Introduction

Liquefied Petroleum Gas (LPG) or liquid petroleum gas is the mixture of flammable hydrocarbon gases that include propane, butane, isobutene and the mixture of gas [1]. At room temperature, both gases are colourless and odourless. Under moderate pressure or in cooler conditions, LPG turns into a liquid state [2]. LPG in domestic cylinders used for cooking generally consists of more butane than propane, as the fuel value per kilogram of butane is higher than propane and it melts under much lower pressure than propane and thus its handling is safer [2]. As a matter of fact, the LPG only appears when these fuels are refined. After the production from natural gas has been completed, there is about 60% left over for extraction from crude oil, leaving about 40% to be extracted from the fuel oil [3]. Liquefied petroleum gas is regarded as a fuel source to be safer than liquid hydrocarbons and much cleaner than carbon because during the combustion there are no particles release [4]. Since LPG does not usually

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have an odour, a bit amounts of ethanethiol are applied to smell harmful gas leaks [5]. Gas sensors can monitor and classify various types of gases, often referred as the gas detectors. They are widely used to track poisonous or explosive gases and to determine the quantity of gas. Gas detectors have been used to spot gas leakage and to track smoke and carbon monoxide in residences [6]. The MQ-2 gas sensor can be used to detect the existence of LPG, propane and hydrogen. It can also be used to detect fuel vapour and it is low-cost and ideal for numerous applications [7]. Gas sensor as a main component in detect the gas leakage. The MQ-2 gas sensor is an electronic sensor which is used to detect gas concentrations in the air. The gas sensor is often referred to as a chemical resistor. It comprises a sensing substance, the resistance of which varies when the gas is in contact. For gas detection, this shift in the value of resistance is used [8]. Gas leakage detector system allow user to keep alert on the surrounding when there is a gas leak detect by the device. Through this detector system, the MQ-2 sensor sense the presence of LPG gas leak; then the Arduino microcontroller will process the data and it will trigger the alarm that act as a safety alert mechanism. The Internet of Thing (IoT) help user to keep on track the gas leakage by using mobile applications which is Blynk apps. User can keep monitor the state of device on a real time and when the gas is leak, user will automatically receive an alert message. So user can take a proper action to prevent the gas leakage from spread widely to the surrounding air.

Previous work related has been chosen and compare the study on how previous author design their gas leak detector device. Various IoT platform is being used in the project such as TurtleBot, ThingSpeak, LoRa Gateway, and Ubidots. This IoT platform help user to monitor the device using cloud system in a real time view. Other than that, various application also used in the previous research such as mobile sensor by using SLAM method and LiDAR sensor, Push-Bullet A review, Node-RED, and Relay mechanism. All of this application is use in order to build a better gas leak detector device. Lastly, there are several method and technique used such as send alert message using GSM, monitor the usage of LPG on a regular basis and to alert about any hazards that may occur due to LPG leakage, gas leak detection in indoor and closed environments by using a mobile robot, use of Intel Edison Board and the Arm Cortex Family, integrates two sensors to detect gas and smoke levels MQ-6 and MOC7811, IFTT web service and lastly by using MQTT Protocol on LoRa Communication Module.

2. Methodology

2.1 Project flow chart

This project is built by referring to two flow chart as shown in Figure 1 and Figure 2 respectively. Figure 1 shows that the flow chart for project design from starting the project with research data to find the suitable project to be conduct by considering and referring to previous research paper. Next is select and listing all the component needed corresponding with the selected project design and then construct the desire circuit. The next step is write coding for the Arduino and have to make sure there is no error with the coding or any other way, the coding need to rewrite again until it can run successfully. After the Arduino coding successfully run, next step is try to build the circuit on breadboard. The connection between the component need to check carefully to make sure it placed on the right way to prevent failure on the circuit. When the circuit can work successfully, then the next step is to develop the parameter in IoT platform which is Blynk mobile application.

Figure 2 shows that the flow chart for project procedure when the gas leakage detector device detect the presence of gas leak. First, when the device detect the presence of gas leak, the microcontroller will process the data and it will transfer the data through the network. When the percentage of gas leak did not exceed the limit, the LED on the device will glow green meanwhile if the LED glow red and the buzzer is trigger, it means that the percentage of gas leak is exceed the limit when the reading is fifteen percent and above. In this situation, user will receive text message that notify user the gas is leak and require the user to take action immediately. The reading of the gas leak in percentage is send to the Blynk mobile application dashboard. User can monitor the percentage of gas leak via Blynk apps.

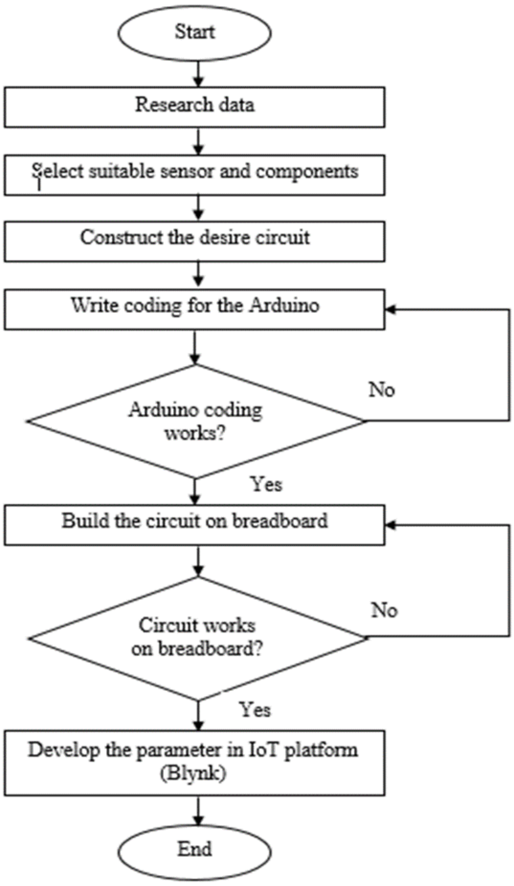

Figure 1: Flow chart for project design

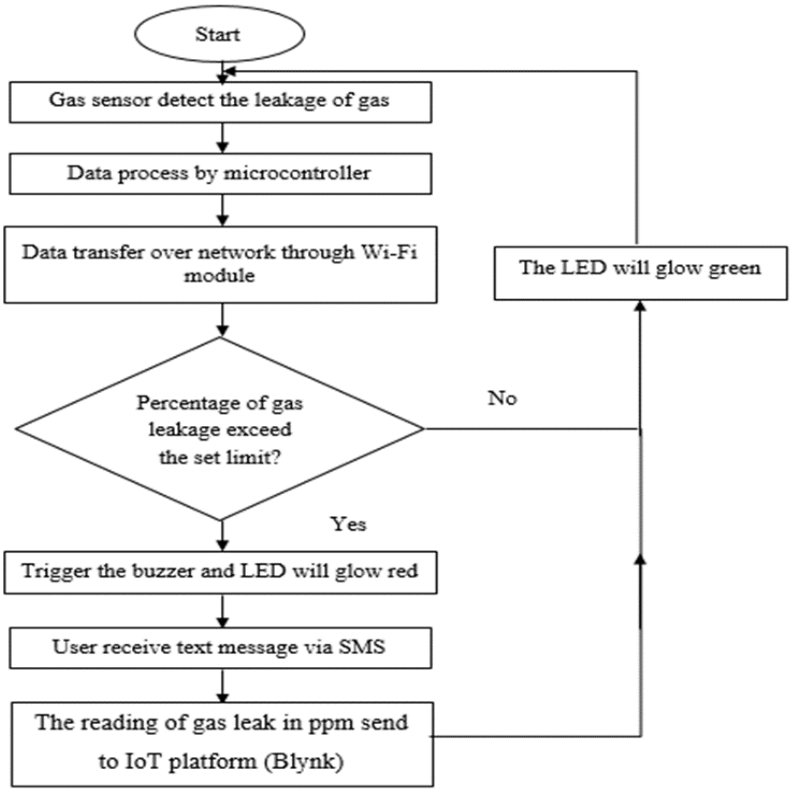

Figure 2: Flow chart for project procedure

2.2 Block diagram

The block diagram in Figure 3 shows the main path of the project. When MQ2 gas sensor detect the presence of gas leakage, it will send the data to the microcontroller (Arduino Uno) and then Arduino Uno will process the data. If the gas leakage reading above 12 ppm, it will trigger the alarm system then user instantly receive text message via GSM module. IoT platform (Blynk) read the amount of gas leak in ppm. User also receive alert message via Blynk application through the email. The LCD will display the percentage of gas leak so user can keep monitor if the gas leak percentage keep ascending or descending. If the gas percentage back to normal reading, the alarm system will stop and the percentage of gas leak going back to normal.

The data is transmitted into the cloud computing through ESP8266. Cloud computing is the storing and accessing data and programs over the internet. The ESP8266 will send the information to a server created and store in cloud. The information now can be display in real time by accessing the IoT platform using electronic device like computer and smartphone.

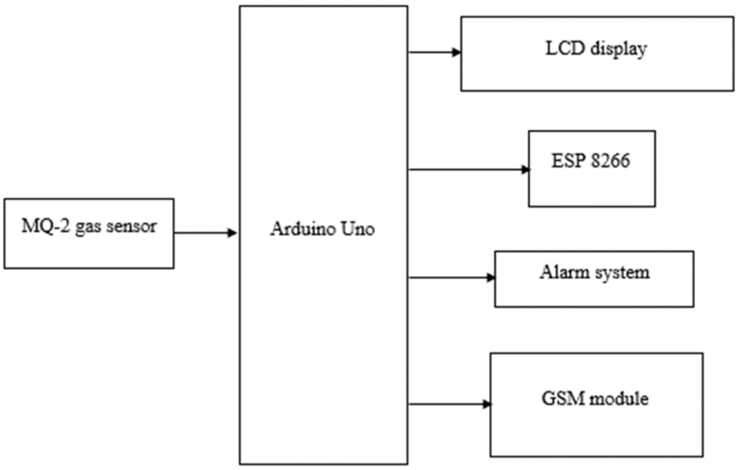

Figure 3: Block diagram of the project

2.3 List of hardware and software

The list of component use to build gas leakage detector device in this project is MQ-2 gas sensor, Arduino Uno R3, LCD display (LM016L), Wifi module ESP8266, buzzer and GSM module. This six components is a main part for the device to operate as a gas leakage detector. The explanation of each component as shown as below:

i. MQ2 gas sensor
   - Gas sensor is used to detect the presence of gas leakage and to specify the amount of gas leak through the air.

ii. Arduino Uno R3
   - It is a microcontroller board that will process the data. It will convert analog to digital reading.

iii. LCD display (LM016L)
   - Display the percentage of gas leakage for user to keep monitor the percentage leak.

iv. Wi-fi module ESP8266
   - Open-source firmware and development kit that helps to prototype at the receiver. It includes firmware which runs on the ESP8266 WiFi based on the ESP12 module.

v. Buzzer as an alarm system
   - Buzzer will trigger once the gas sensor detect the gas leak. User can know there is gas leak occur by the sound of buzzer.

vi. GSM module

- Enable communication between the device and user through the text message direct to user's mobile phone.

This project use two type of software, Arduino (IDE) and Blynk mobile application. Arduino (IDE) is a software for Arduino Uno R3 coding meanwhile Blynk mobile application is an IoT dashboard for user interface to monitor the gas leakage device detector. The further explanation of software use in this project were explain below:

i. Arduino software (IDE)
   - Main text editing program for Arduino programming by using a coding that can receive input from gas sensor and controlling the output.

ii. Blynk mobile application
   - Can display and store data from the sensor for user to keep track from their mobile phone

3. Results and Discussion

Through the implementation of IoT, the gas leakage detector device can be monitor via the user's smartphone. Besides, to test the device accurately to the real life testing, two experiments were conducted. First is testing the device by recording the time taken for it to trigger when detect the presence of gas leak vary with distance. The second experiment is by recording the time taken for the device to trigger in different sizes of the box. Both experiments are conducted by using portable gas. The gas leakage detector device and the portable gas locate at the same place but with different distance and different volume of box respectively.

3.1 Gas leakage detector device with the implent of IoT

In this part, the device successfully detects the presence of gas leakage. The LCD read the percentage of gas leak and the notification alert will be send to the mobile phone via GSM module. In a normal condition the LED will glow green and when there is gas leakage occur the alarm system will trigger and the LED will turn red. After a while, it will back to normal again and the percentage reading is in normal condition. Also the reading of gas in ppm will show on the LCD when the MQ-2 sensor not detecting any gas leakage. Figure 4 shows that the gas leakage device in a normal condition without the presence of gas leak. The percentage and ppm reading of LCD in normal condition is 15% and 5 ppm respectively. Also on this state, the LED is glow green and the alarm system is not trigger.

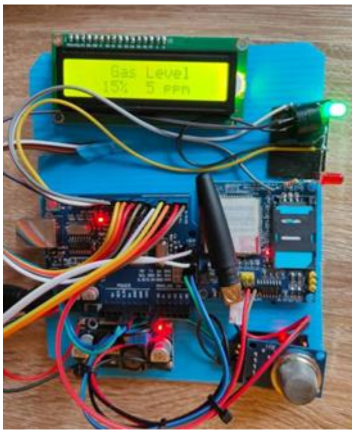

Figure 4: Device in a normal condition

Based on the Figure 5, the MQ-2 sensor sense the gas leakage and the percentage of the gas level is high which is 61%. At this state, the alarm system is trigger and the LED is turn to red colour to show and notify user that the gas is leak. When the sensor voltage read the analog input over than 12 reading, the data will send to the microcontroller and microcontroller will read the output in a percentage and in ppm. The output can be seen clearly on the LCD. On the other side, the GSM module will push a text message to user mobile phone. Based on the Figure 5, the MQ-2 sensor sense the gas leakage and the percentage of the gas level is high which is 61%. At this state, the alarm system is trigger and the LED is turn to red colour to show and notify user that the gas is leak. When the sensor voltage read the analog input over than 12 reading, the data will send to the microcontroller and microcontroller will read the output in a percentage and in ppm. The output can be seen clearly on the LCD. On the other side, The GSM module will push a text message to user mobile phone.

Figure 5: Device when the MQ-2 sensor detects the presence of gas leakage

Figure 6 shows the interface of IoT by using Blynk mobile application. When the gas leakage is detected by the device, the percentage and the ppm reading is clearly shown in the Blynk mobile application. Based on that, user can always monitor the gas leakage device via their smartphone. Meanwhile, Figure 7 shows the email received by user when the gas is leak, user can received email alert through their mobile phone to remind and alerting user so that user can take action immediately regarding the situation. The alert message is “Alert! Gas is leak please take action now!”

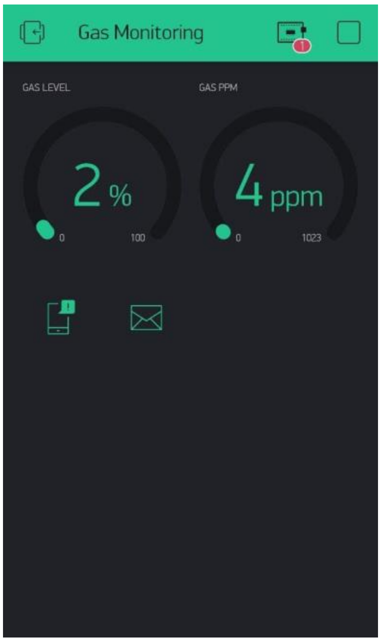

Figure 6: Blynk mobile application interface

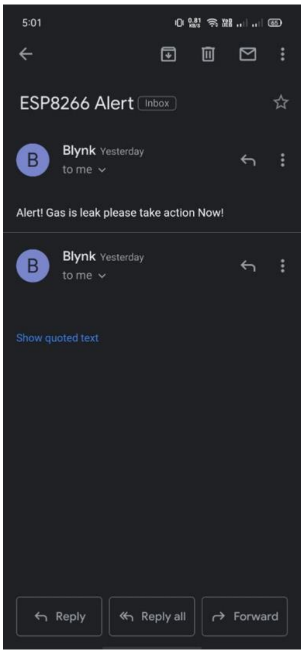

Figure 7: Email alerting user

3.2 Analysis testing

In this experiment, it focus on testing the device with real life experience by using portable stove. When testing in open surrounding, the portable stove and the gas leakage device detector were placed with a certain distance to record the time taken for the device to detect the gas leakage. Next, the gas leakage device detector is tested in closed surrounding by using a box with different size and volume. The recorded data observe is the time taken for the device to trigger when it detect the gas leak. Lastly, the next testing is related to percentage of gas where the recorded data were obtain from Blynk mobile application. The gas leakage device detector and the portable stove were placed with a certain distance to observe the percentage of gas leak. The percentage is recorded once the device is trigger by the presence of gas. Figure 8 shows that the portable stove, the gas leakage device detector and measurement tape use in testing the experiment. Meanwhile, Figure 9 shows the experiment in a closed box. The portable stove and the gas leakage detector device were placed end to end inside the box.

Figure 8: Real life device testing

Figure 9: Device in a closed box

Figure 10 shows the constant in testing condition for experiment distance over times taken and volume of box over times taken. From the figure, the level of gas is between minimum and maximum. This constant level of gas is use in each experiment respectively to make sure the source of gas leak at the same level for both testing.

Figure 10: Level of gas constant

Figure 11 shows that the result for recorded analysis of distance over time taken where the distance is in centimeter and the time taken is in second. The purpose of this experiment is to observe the efficiency of gas leakage device by recorded the time taken for the device to trigger to the presence of gas leak vary with distance. Testing is conduct on real condition with proposed location of the sensor within standard size of room for domestic use. From the graph it clearly shown that, when the distance of portable stove and the gas leakage detector device increase the time taken for the gas leakage detector device to trigger is also increase. This is due to the surrounding area where the portable stove and the device is placed at open area consider the presence of wind that can make the reading is vary. For this part of experiment the suggestion of suitable distance to place the device between the portable stove is 40 cm to 50 cm because must consider the direct heating to the device when using the stove.

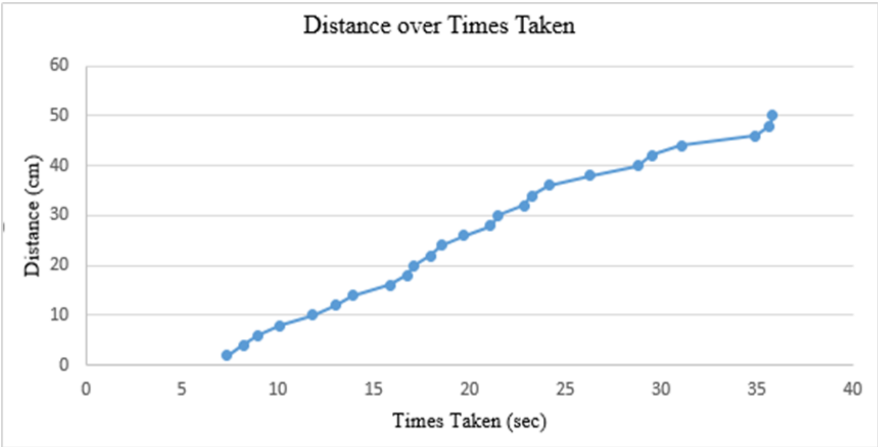

Figure 11: Distance over time taken graph

The next analysis to test the gas leakage detector device is by using several different size of box. The portable stove and the gas leakage detector device were placed together inside the box. The purpose of this test is to record the time taken of the gas leakage device detector trigger to the presence of gas leak in a different size and volume of box. The calculation for volume of box by multiplying the length, width and height of each of the box. The lid of the box is always close to ensure the gas not leak to the surrounding. Figure 12 shows that the graph of the recorded data of volume in centimeter cube over times taken in second. From the graph it clearly shown that the increasing size of box effect the times taken for the gas leakage device detect the presence of gas leak. Similarly, when the volume of box is increasing, the times taken for device to detect the presence of gas leak is also increase.

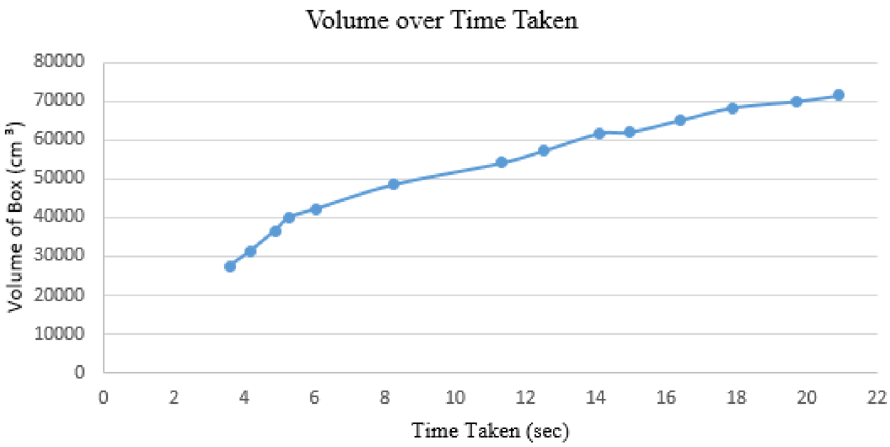

Figure 12: Volume over times taken graph

The next observation is to record the percentage reading in Blynk mobile application with difference distance at open air. The purpose of this test is to measure the sensitivity of the device towards gas leak vary with distance. The ppm reading is obtain from the Blynk dashboard, each of the recorded data in ppm are list during the experiment. It can be observed from the graph in Figure 13, the decrease in LPG gas concentration does not follow a linear relationship with regard to the measurement distance. The value of each measurement distance of gas concentration decreases as the distance between the two points increases. The slope of the graph, with an average difference of approximately 1.5 percent between the two points.

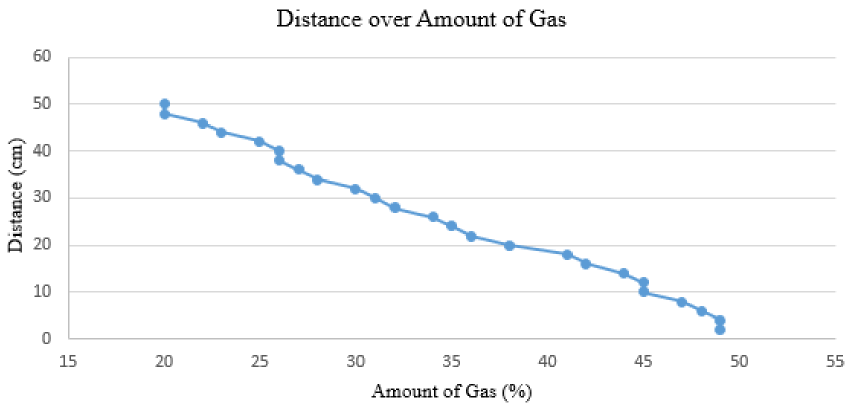

Figure 13: Concentration of LPG gas

Below shows the calculation on how the percentage of amount of gas obtain for percentage concentration of gas leakage. The calculation is set in the Arduino coding and the reading of percentage is obtain through the Blynk application dashboard.

$$\text{Percentage of gas} = (adc\_chnlA0 - SMKscale)/100 \quad \text{Eq.1}$$

where *adc_chnlA0* is the analog input at channel A0 on Arduino UNO and *SMKscale* is the sensivity of sensor

3.3 Discussion

Based on the results and the overall analysis obtained from this project, it found out that the performance and the times taken for the gas leakage device detector to detect the presence of gas is increase when the distance also increase. The suggestion of suitable distance to place the device between the portable stove is 40 cm to 50 cm because must consider the direct heating to the device when using the stove. When test in closed area which is conduct the experiment in a different volume of box, the times taken for the device to detect the presence of gas leak increase when the volume of box increase. This is because the concentration of gas are different in both situation. The distance and the volume play an important role as when the device and portable stove place far away or place in a larger volume of box, it will take longer time for gas leakage detector device to trigger. Next, for the analysis of gas percentage, clearly can be seen that the percentage of gas concentration were higher when the distance of gas leakage detector device and portable stove is near. The distance were set from 2 cm until 50 cm with the interval of 2 cm. As the overall finding, the distance and the volume affect the time taken to trigger the gas leakage device detector. The gas detection device not only monitors the surrounding environment constantly, but it also prevents additional leaking of gas into the environment, thus reducing the risk of a fire arising.

4. Conclusion

The first objective of this project is to design the circuitry of gas leak detection device. When designing the simulation circuit for a gas sensor, the Arduino UNO as the primary component. It acts as a microcontroller, reading the input from the sensor and converting the output into a reading on an LCD, turning on an LED, activating the GSM module, and triggering the alarm system when have the presence of gas leak. The circuit of gas leak detector were successfully design so the first objective were successfully achieved. The second objective is to evaluate the performance of prototype based on sensitivity of MQ-2 sensor towards gas. As the gas leakage device detector need to test the performance in real life situation, two condition of testing were conduct by using portable stove. First condition is test in open area with a certain distance meanwhile the second condition were test in closed area which is in a different size and volume of box. The times taken for the device to trigger were recorded to analyse the performance of the device towards the gas leak. Lastly, the third objective is to test and analyse the prototype with the IoT apply towards the reading in percentage and ppm on the amount of gas leak. The recorded data for third objective were conduct in open surrounding and the percentage concentration of gas were obtain by using Blynk mobile application. It can be conclude that the third objective of this project is achieved.

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