Development of LPG Leakage Detector System using Arduino with Internet of Things (IoT)

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***Abstract*— LPG is highly inflammable and can burn even at some distance from the source of leakage. One of the preventive measures to avoid the danger associated with gas leakage is to install a gas leakage detector at vulnerable locations. This project focuses on issues such as for the working householder that are very busy at their workplace, which will minimise their time at home, and for people who have a low sense of smell especially old folks. The objective of this project is to develop a cost effective system based on Arduino microcontroller, which can detect domestic LPG leakage with some awareness action. This system is fitted with gas leakage sensor of MQ2, and comprises of ESP8266 Wi-Fi Module that makes use of the 'Internet of Things' to send the warning message through an email to the user with the help of Blynk application as long as there is an internet connection. The proposed is a system designed to meet the UK occupational health and safety standards with respect to gas leakage detection in residential and commercial premises.**

***Index Terms*— Arduino Microcontroller; Internet Of Things (Iot); LPG Leakage.**

I. Introduction

Nowadays, the explosion of domestic LPG is becoming more serious. Liquid petroleum gas (LPG) is usually used at home for focal warming, boiling water and essentially for cooking purposes. This energy source is a highly flammable chemical compound that composed of propane and butane. It can be very dangerous as it contributes to the explosion and causing a fire in buildings. However, in the media, the losses brought on by this risk are yet regular news.

There is a deficiency for a system to detect LPG leakage because when 1% of gas leak occurs it takes nearly 60 minutes [1] [2] to detect it. A monitoring system of the gas detector by a wireless system needs to be developed in order to solve the problem. In this project, an embedded system designed using Arduino Mega 2560 with a gas sensor of MQ2 for the purpose of detection of toxic gas leakage, which in turn neglects the dangers that have adverse effects on human lives. This unit consists of an alarm unit to sound an alarm if any LPG leakage, it then activates the exhaust fan to blow the gas out. The sensor gives a quick response time and has good sensitivity. If any leakage is detected, a message to the family member or authorised person using Wi-Fi module called ESP8266 will automatically send based on Internet of Things (IoT).

The system is reasonable and can be implemented in chemical factories and in localities which are surrounded by the chemical industries or plants. The system also has the provision to provide real-time monitoring of the concentration of the gases, present in the atmosphere. As this system is real time, the information can be given rapidly which can save human lives in time.

II. System Overview

The system block diagram comprises parts as shown in Figure 1 below. It consists of a microcontroller (Arduino Mega 2560), the Gas sensor (MQ-2), Wi-Fi module (ESP 8266), display (LCD), DC Motor, Exhaust fan, LED and Buzzer.

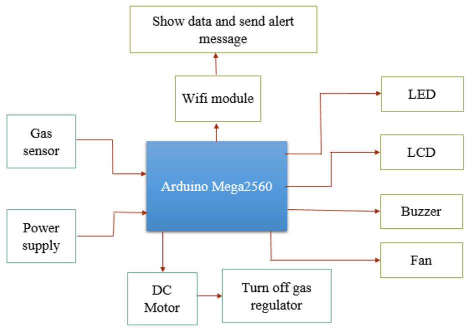

Figure 1: LPG Leakage Detector System

A. *Microcontroller*

Arduino is an open-source gadget stage in view of simple to-utilise equipment and programming. Arduino board can read sources of information, for example, light on a sensor, a finger on a button, and transform it into an output for initiating an engine, turning on a LED, distributing something on the web. It is an open-source physical PC stage that depends on a basic microcontroller board, and advancement of condition for composing programming for the board [13].

The Arduino board is reasonable and economical compared with other microcontroller platforms. The least expensive form of the Arduino module can be assembled by hand, and even the pre-collected Arduino modules cost not as much as MYR 60. Other than that, the Arduino board can cross platforms which the Arduino programming can run on Windows, Macintosh OSX, and Linux operating system. It can work in different operating systems, however, the greater part of microcontroller frameworks are restricted to Windows. Other than that, Arduino makes a more straightforward way toward working with a microcontroller next to it gives some advantage to educators and students.

The Arduino software is easy to use even for beginners, and it is sufficiently adaptable for innovative clients to exploit. For educators, it is helpfully in light of the Processing programming condition for instructing, so the student can figure out how to program in a better condition.

The Mega 2560 is a microcontroller board in light of the ATmega2560. It has 54 digital input/output pins which 15 can be utilised as PWM yields, 16 simple data sources, 4 UARTs (equipment serial ports), a 16 MHz precious crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything expected to bolster the microcontroller, basically interface it to a PC with a USB link or power it with an AC-to-DC connector or battery to begin. The Mega 2560 board is perfect with most shields intended for the Uno and the previous boards Duemilanove [13].

B. Gas Leakage Detector

A gas detector is a device that detects the nearness of gasses in a range, regularly as a major aspect of a security framework. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alert to the administrators in the range where the hole is happening, giving them the chance to clear out. This type of device is important because there are many gases that can be harmful to organic life, such as human or animals.

Gas leak indicators can be utilised to distinguish ignitable, combustible, harmful gases, and oxygen consumption by sensors. These sensors are usually capable of being heard to caution individuals when a hazardous gas detected. Exposure to poisonous gasses can likewise happen in operations such as fumigation, fuel filling, development, exhuming of tainted soils, and landfill operations. Regular sensors incorporate flammable gas sensors, photoionisation identifiers, infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and semiconductor sensors. More recently, infrared imaging sensors have come into utilisation.

C. MQ-2 Gas Sensor

The MQ-2 gas sensor module is useful for gas leakage detection whether in the home or in industrial areas. It is highly sensitive to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam. Due to its high sensitivity and fast response time, measurements can be taken as soon as possible. The sensitivity of the sensor can be adjusted by using the potentiometer. It is low cost and suitable for different applications [14].

D. Wi-Fi Module ESP8266

The ESP8266 Wi-Fi Module is an independent SOC with incorporated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is prepared to either facilitate an application or offload all Wi-Fi organising capacities from another application processor. Each ESP8266 module comes pre-customised with an AT summon set firmware that attaches this to the Arduino board, and gets about as much Wi-Fi-capacity. The ESP8266 module is a greatly low cost board with a colossal and continually developing group [17].

III. SYSTEM OPERATION

There are two flow charts for gas leakage detection, which is for low-level warning and high-level warning as described in Figure 2-4.

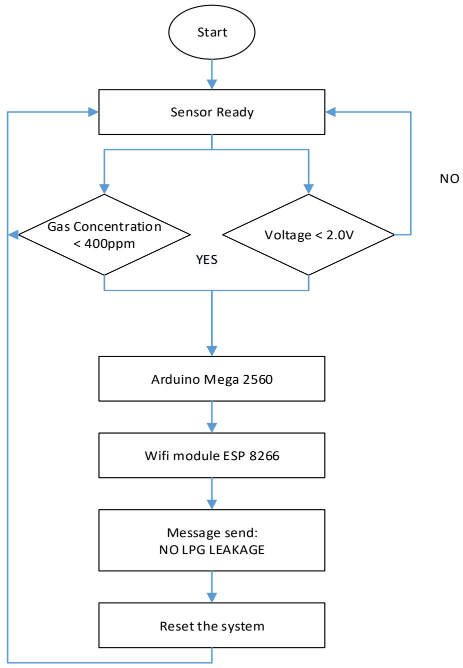

Figure 2: Work flow of safe level condition

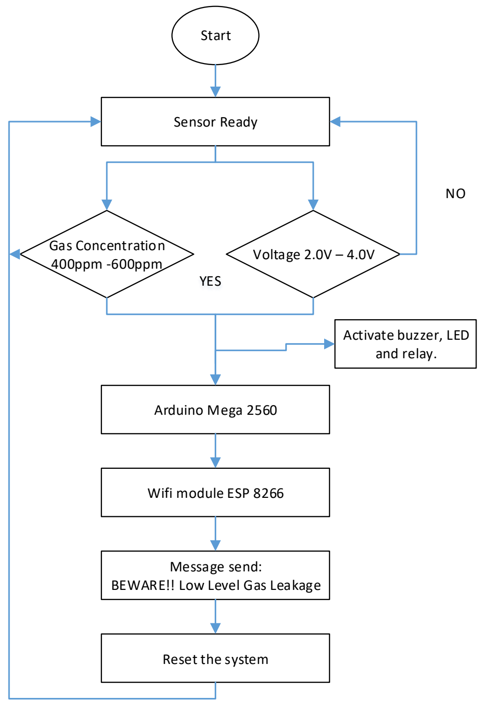

Figure 3: Work flow of low level warning condition

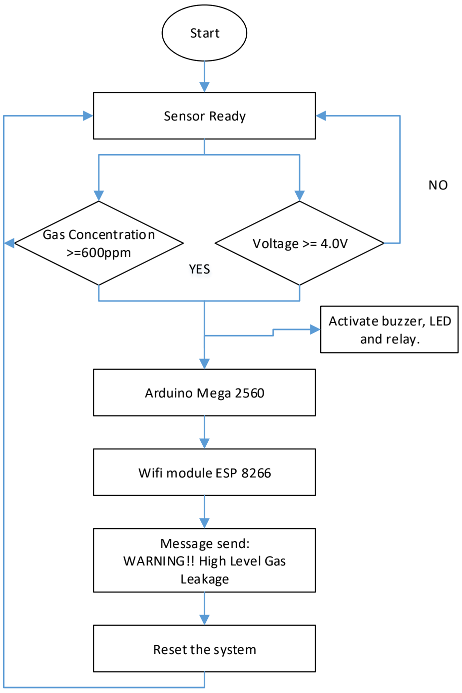

Figure 4: Work flow of high level warning condition

IV. Results And Discussion

This system guarantees constant monitoring of the gas levels. In the event that the gas level increments over the ordinary edge level of 400 ppm butane (LPG), the system begins to issue an early warning message, which infers low level gas leakage. If the level increases to 575 ppm of butane (LPG), the system activates the buzzer, LED, DC motor and fan to warn the user to evacuate to a safe place. To guarantee the user's safety, these functions will not turn off until the level of gas achieves the typical levels of 400ppm. These gas leakage levels are compared to the UK occupational safety standards as appeared in Table 1.

Table1
Gas concentration and voltage levels of butane gas according to UK occupational safety standards [18] [19].

Gas Concentration	Voltage range
≤400ppm	≤1.2V
400ppm – 600ppm (Lower exposure limit)	≥1.2V to ≤4.0V (Low level early warning)
≥600ppm (Upper exposure limit)	≥4.0V (High level dangerous warning)

A. Experiment 1: Level condition of Safety

a. Safe Level Condition

When no lighters are attached to the MQ-2 gas sensor, the gas concentration and voltage range at the normal condition, which is below 400 ppm and 1.2 V respectively. In this part, the LCD will show the message of “NO LPG DETECTED” and the LED, buzzer, DC motor and fan are not activated. Besides that, both readings are also displayed on the Blynk application in order to make the user aware of the gas concentration. The results for this part can be referred to in Figure 5 and Figure 6.

Figure 5: The gas concentration and voltage range displayed on the LCD.

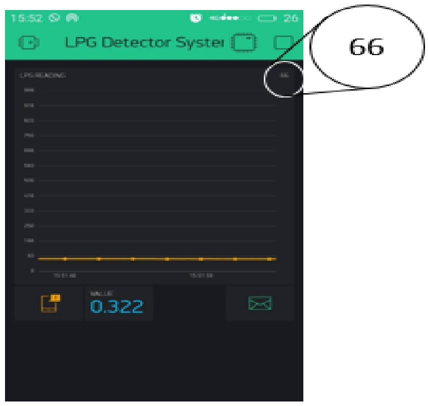

Figure 6: The gas concentration and voltage range displayed graphically on the Blynk application.

b. Low Level Warning Condition

For this part, the sensor was tested by releasing some gas from the lighter. The lighter was pressed slowly to ensure that not too much gas goes out. By adopting the UK safety standards, the range for the low level early warning for gas concentration and the voltage was set between 400 ppm and 600 ppm and between 1.2 V to 4.0 V respectively. Therefore, when the sensor detected the readings within these ranges, the buzzer, LED, fan and DC relayed motor is automatically turned on to prevent further gas leakage. The results of both readings are shown in Figure 7.

Figure 7: The gas concentration and voltage range that display on the LCD.

In this part, the user will receive a notification from the Blynk application and an email to notify them that a small leakage had occurred at their home. Both results are shown in Figure 8 and Figure 9 respectively.

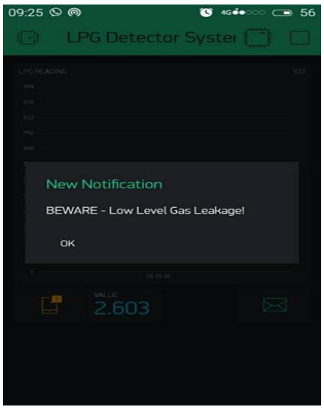

Figure 8: Pop-up notification by the Blynk application.

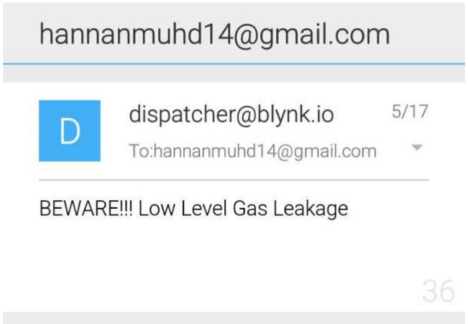

Figure 9: Beware notification that sent to the user through an email.

c. High Level Warning Condition

By using the same method as the low-level condition, this part will use more gas to reach high-level condition. The lighter was pressed with full pressure continuously toward the sensor to blow out all the gas. By referring to the UK safety standards, the concentration of gas and voltage ranges reached a high-level dangerous warning are above 600 ppm and 4.0 V respectively. The results are shown in Figure 10.

Figure 10: The gas concentration and voltage range displayed on the LCD.

For this part, the user also received the notification but in different forms of the message which is shown in Figure 11 and Figure 12 below.

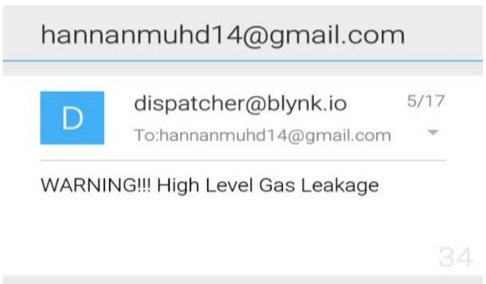

Figure 11: Warning notification that sent to the user through an email

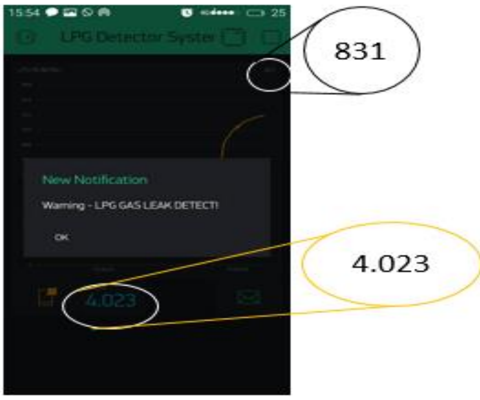

Figure 12: Pop-up notification by the Blynk application.

B. Experiment 2: Sensitivity of Gas Sensor

This part was observed that when the LPG detector was tested by setting it at an alternate separation from the gas source, the reaction time of the LPG system increase as the separation from the gas source further away and vice versa. Other than that, the affectability of the gas sensor was high in the clean air as recorded. The gas sensor's affectability differed with temperature over dampness while the reference voltage stayed constant after some time mistake off. At consistent concentration, the detected voltage will dependably be 2.0 V or more. The gas sensor has a quick response to LPG since the time difference between tests comes out with same concentration is little while the contrast between the detected voltages is high.

Table 2 demonstrates the analysis for two parameters, which are the different readings for voltage and the separation of the sensor’s reaction to the leakage gas. Distance is one of the vital parts for recognising any leaked gas because if the separation of leakage gas is too far it cannot be identified by the sensor.

The time Table 2 demonstrates the range for the gas sensor to distinguish LPG leakage. Voltage and distance play an imperative parameter because of their impact on each other. The shorter the distance of the gas sensor, the higher the reading of the voltage will be. Table 2 shows that the shorter distance that is 0.5cm created a higher voltage at LCD display. With respect to the longer distance that is 2.5 cm, the voltage produced at LCD display was 0.43 V. The outcome demonstrates that the distance is the principle parameter that affects the reading of the sensor for LPG leakage.

Table 2
Table of parameter measured during test condition

Distance from the sensor (cm)	Voltage Range (V)	Time is taken to detect gas (ms)
0.5	2.80	0.2
1.0	2.05	0.5
1.5	1.62	0.8
2.0	1.18	1.1
2.5	0.47	1.5

Table 3 beneath demonstrates the rundown of test condition and the outcomes produced. As stated, the buzzer, LED, DC motor and fan are activated when the voltage reading is 2.0V or more. Thus, it can be concluded that the region is not yet safe until the LPG leakage is under control.

Table 3
Summary of test condition and results

Voltage Range (V)	Buzzer	LED	Fan
2.85	ON	ON	ON
2.07	ON	ON	ON
1.72	OFF	OFF	OFF
1.50	OFF	OFF	OFF
1.37	OFF	OFF	OFF
1.25	OFF	OFF	OFF

V. CONCLUSION AND RECOMMENDATION

This system is extremely compelling, particularly for individuals who have a weak sense of smell, especially old people. The possibility of this project additionally turned out to help individuals who are not at home or far away from their kitchen due to being busy at their workplace. The advantage of this system over the manual technique is that it offers fast response times, is simple to utilise, is easy to implement and simple in design.

The objective of this research can be outlined as a microcontroller-based item that can be implemented in residential regions, like home and other premises in order to alert users on the hazard of LPG leakages at their places. This system also incorporates an automatic alert system by using the DC relayed motor that will stop the gas supply. Lastly, this system succeeds in connecting an Internet of Things base on monitoring system with a Blynk application that can alert the user by a sending warning notification through an email and pop-up notification. With the aid of this product, at the same time, the users can check their LPG cylinder storage once they receive an alert notification immediately. So, any hazards or fatal accidents due to LPG leakage may be prevented and avoided.

For the future work as further research of the adequacy of this project, an empty cylinder can be replaced automatically by applying the booking system. It will be displayed on the LCD with the measurement of the weight of LPG cylinder whether the gas quantity is less or equal to threshold value1, the system will automatically book the cylinder by sending a text message to a gas dealer. Besides that, it will inform the family members by sending a message to refill the cylinder when cylinder weighs less than or equal to threshold value 2. In addition, by applying the SCADA system, the future project will help the user to monitor and control their LPG cylinder in logistic areas such as industries.

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