Smart Gas Leakage Detection and Alert System Over GSM Network

(Sistem Pintar Pengesanan Kebocoran Gas dan Sistem Penggera di Atas Rangkaian GSM)

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Abstract

Gas leakages are a major problem in industrial, residential areas, and hospitals that greatly cause damage to life and property. Furthermore, gas leaks can be hazardous to human health, which leads to breathing problems and nausea as well as to the environment. A little sparking can cause an immediate explosion. To avoid such situations, a considerable amount of effort has been devoted to the development of reliable techniques for detecting gas leakage and leakage location by implementing sensors. This project aims to reduce the risks of gas leakage by developing a smart gas detection system that automatically detects the leakage of the Liquefied Petroleum Gas (LPG) employing a gas sensor. The system comprises an LPG gas leakage detector that communicates and sends the warning signal to the Arduino Uno Microcontroller. The warning signal is then sent via Global System for Mobile Communication (GSM) network to alert the specified mobile phone users via Short Message Service (SMS). This system also triggers a ventilation fan and buzzer simultaneously to regulate the air as well as to alert the nearby users. In comparison to the traditionally used manual method, this auto-detection and alert system successfully implemented the fastest response time possible and accurate detection of an emergency, thus helping to disseminate the critical situation faster.

Keywords: Smart smoke detection system, Liquefied Petroleum Gas, Global System for Mobile Communication

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INTRODUCTION

Liquefied petroleum gas (LPG) is the most commonly used mixed hydrocarbon gases in the industrial sector, residential households, hospitals (Hussien et al., 2020) and heavy-duty commercial use. It is implemented in households for cooking, hot water systems, heating, refrigeration and backup generator purposes. Despite having LPG as an environmentally friendly gas, it is classified as a highly flammable gas and can cause major damage to life and property if it leaks. This is because the main feature of LPG is being heavier than air, wherein it does not disperse easily and may lead to suffocation when inhaled. Additionally, the leaked gases when ignited may lead to explosion. These combustible gasses can threaten life and create potential danger, particularly when the areas are unattended or when the users are away from the area. Gas leaks can occur at any time of day or night, and they can occur at any time of day. It is difficult to detect a minor gas leak even though there are people around in the buildings and homes especially infant, little kids, pregnant women and patients with breathing problems (Wu et al., 2019). Exposure to hazardous gases in confined spaces can result in dizziness, nausea, and even mortality (Soh et al., 2019). Owing to this, the number of deaths due to the explosion of LPG gas cylinders has been increasing in recent years.

Thus, extensive research had been carried out in order to solve this issue. One of the preventive measures to overcome the gas leakage is to install a smart leakage detection system in the area of potential hazards caused by LPG leakage. Unnikrishnan et al. (2017) suggested installing and on-site LPG monitoring and leakage detection system with LCD display for LPG usage monitoring. A buzzer has been mounted to warn people in the area of the gas leak. Khan (2020) proposed a low-cost sensor-based gas leakage detector system. It is based on the gas sensor Arduino UNO R3 and MQ-6. The LCD, LED and buzzer are connected and act as an alert output. Evalina and Azis (2020) proposed detection and monitoring gas leakage using MQ-6 sensor and embedded with AtMega8 microcontroller. Once the sensor is triggered due to the presence of gas leakage, audible and visual alert are activated. The studies, however, pay more attention only on-site detection and monitoring. The device does not provide the emergency services with the wireless notification of any gas leakage incidents, particularly if no one is at the site. Thus, the system becomes even more effective when it is connected to wireless technology, such as the WIFI, Bluetooth, Global System for Mobile Communication (GSM) (Nuga et al., 2017) and Telegram application (Rahmalisa et al., 2021) for alert sending purposes.

The issue of detecting and warning systems motivates the researchers to develop a gas level surveillance or monitoring system that minimizes the risk of big fire and explosion. This manuscript describes the development of an automatic smart gas leakage detection system particularly for home users. The system consists of three main components, LPG sensor to detect the level of gas leakage, message alert sending system using Arduino Uno via GSM network, exhaust system and buzzer. The MQ2 sensor is sensitive to LPG, i-butane, propane, methane, alcohol, hydrogen and smoke, typically as an indicator of fire. It is suitable to be used in gas leakage detecting equipment whereby the resistance of the sensitive component changes as the concentration of the target gas changes. Once the concentration of the gases exceeds the predetermined threshold, the system will activate the ventilation fan and buzzer. The ventilation system is vital as it can control the indoor air quality by diluting and displacing indoor pollutants. It can also be used to control indoor temperature, humidity and air motion to benefit thermal comfort, satisfaction with other aspects of indoor environment. In addition, the developed system is also linked to the GSM network where Short Message Services (SMS) warning messages will be sent to the specific users. This manuscript is structured as follows: Section I introduces the background of the proposed system. Section II describes the system overview. The proposed system is explained in Section III and in Section IV, the results and discussion are presented. Finally, Section V concludes the findings and recommendations.

SYSTEM DEVELOPMENT

The main concept of developing this system is to monitor the gas level detected by gas sensor in households. Figure 1 illustrated the block diagram of the gas detection system development. In Figure 1, the developed system comprises of an MQ2 gas sensor, an Arduino Uno microcontroller that is interconnected with the sensor, buzzer, GSM module and a 5V relay that is connected to a ventilation fan for ventilation purposes.

This system uses MQ2 gas sensor because of its high sensitivity towards LPG, propane, butane, alcohol, hydrogen, methane, carbon monoxide, smoke concentrations from 200 until 10000ppm at any location. MQ2 is one of MQ sensor series' common gas sensors and are based on the change of resistance in sensor material upon contacting with the gas.

Arduino Uno is a digital-based microprocessor that uses AtmelATmega328P microcontroller. It consists of an internally built-in Analogue-to-Digital Converter (ADC) wherein the analog data from the sensors are converted into digital data.

GSM module is an embedded piece of hardware unit that is powered by a 5V DC supply. It is connected to a remote network through GSM technology, allowing a mobile device to communicate with the system. GSM module also support the Real Time Clock (RTC) as the system operates in real time. In addition, it requires a Subscriber Identity Module (SIM) card in order to activate communication with the (General Packet Radio Signal) GPRS network. In order for the GSM to communicate with the mobile devices, AT-command coding is added using the command "AT+CMGS".

A relay is a type of circuit element that operates via electromagnetic induction. When a current flow through it, it acts as an electrical switch, enable the loads, ventilation fan attached to be turned on and off. The switching concept is based on the electromagnetism principle whereby the coil, pallet, and contact are the three components that make up a relay. The coil component serves as the relay's input and the coil is not electrically connected to the pallet or contact part. By applying small current and voltages, the relay provide vast current and voltage control without being affected by the load frequency.

An active piezoelectric buzzer is used in the buzzer module. The buzzer is controlled by Arduino which triggers it in response on the signal it receives. Upon receiving a high signal, the buzzer activates.

In the event where a sudden gas leakage occurs in a room or a location where the devices are installed, MQ2 gas sensor will automatically detect and immediately send a signal to the Arduino Uno microprocessor. Upon receiving the signal, the microcontroller processes the signal. By referring to [ ], the dangerous level of gas that affect human is at 2000ppm. In this system, the gas threshold level predefined for the MQ2 sensor to activate 800ppm or higher. This is due to the fact that the gas used in the experiment is lighter, and lighter gas is unable to achieve a concentration of more than 2000 ppm (Wu et al., 2019).

When the signal exceeded the predefined threshold values of 800ppm, the system will automatically trigger the other external devices, consist of GSM module, buzzer and ventilation fan attached as a sign of warning to alert the users and to reduce the risk of gas confined in the spaces. The devices include a buzzer, exhaust system and an GSM network. The buzzer works as an audible alerting system to the nearby users while the relay will activate the ventilation fan. Exhaust fan are implemented to remove the leakage air in the residential and premises. It aids in the circulation of air throughout the spaces, which helps in the removal of the gas leaked. There will be also an automatic messaging generation operation which sends notification to the predetermined mobile numbers via GSM network.

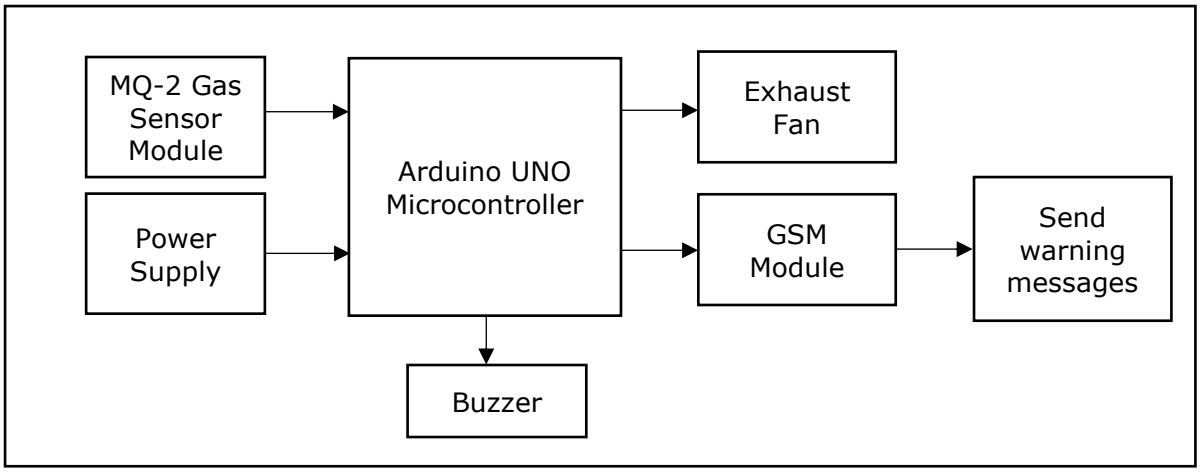

Figure 1: Gas Detection System Block Diagram

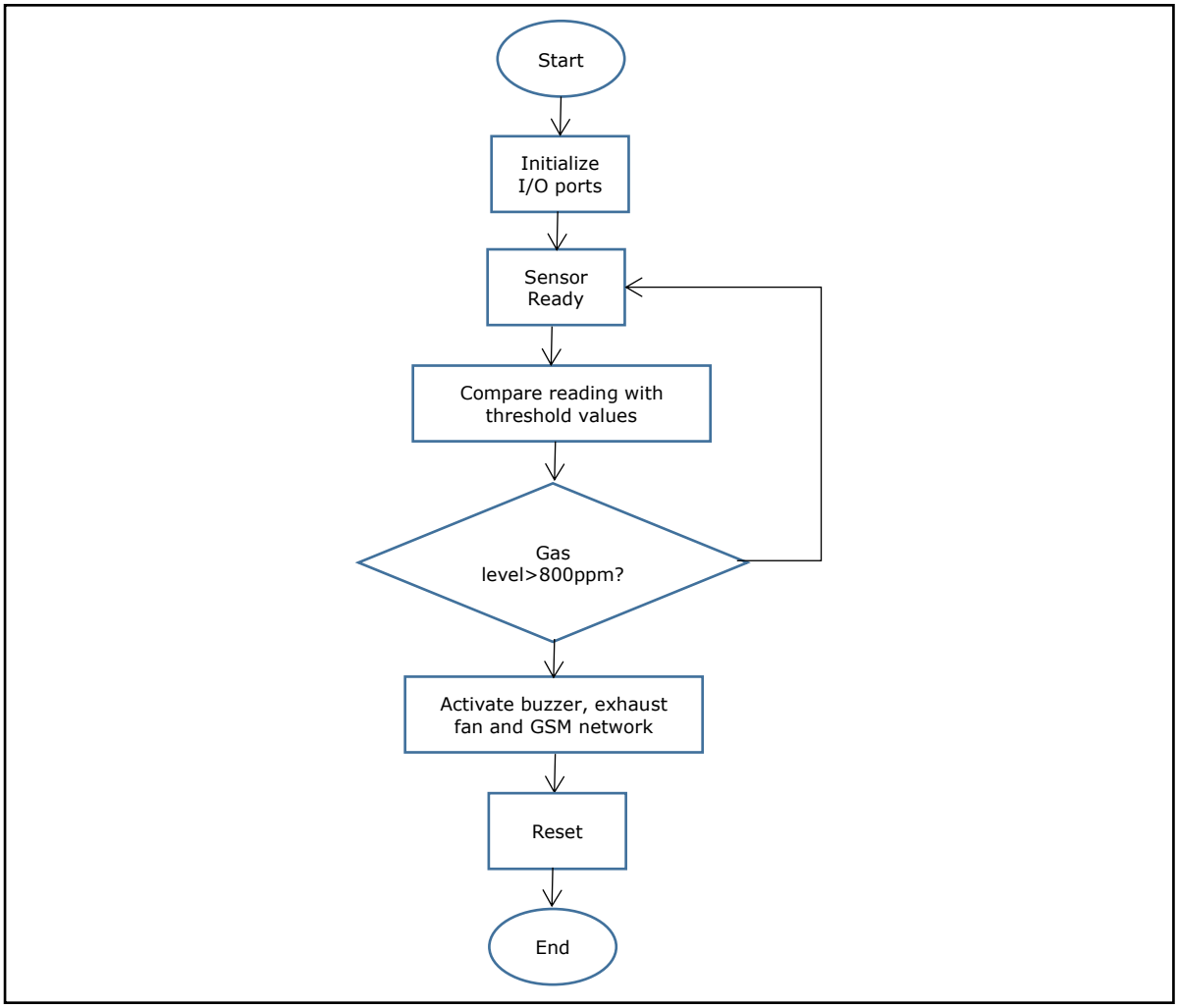

Figure 2. Flow Chart of the Gas Detection System

Figure 2 shows the flow chart of the gas detection system. The first section of the code defines the data types, which are *int* for detecting the value of the gas sensor (MQ2) and *string* for the GSM module to send messages to the numbers specified in the code, f1001 and f1002 respectively. Then, set the baud rate (9600) of the GSM module and initialize the input/output port: one pin to input, which is the gas sensor (MQ2), and the other three pins to output, which is a relay to activate the exhaust fan, buzzer and GSM network.

Then, the range of values from MQ2 to execute the three outputs are configured. When the value range set in the coding is greater than 800ppm, the three output pins are set to HIGH, activating the three outputs. On the contrary, the coding for the three outputs will be set to LOW, deactivating the three outputs, if the smoke value does not exceed 400. The final step is to configure the text that will be sent as a notification to the predetermined users' mobile phone. Since the content of the messages contains both numerals and letters, the coding is written in *char* (data types for letters) and *int* (data types for numbers.

The system can only be reset on site until the gas leakage is under control. Figure 3 depicts the system prototype created by integrating the software, Arduino coding with the hardware components.

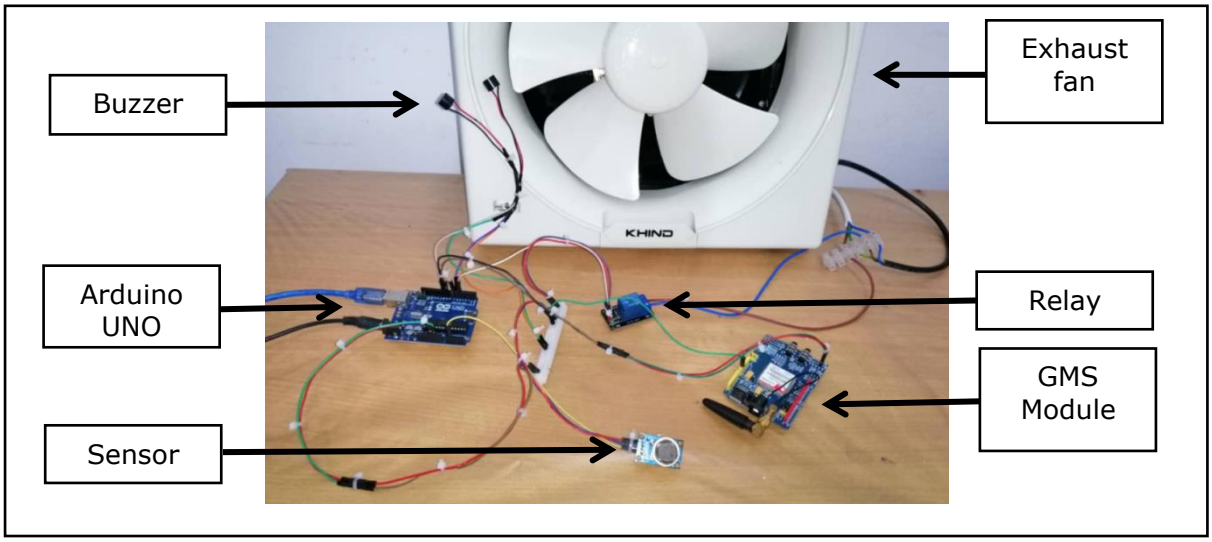

Figure 3: Prototype of Smart Gas Detection System

RESULTS AND DISCUSSION

A gas lighter was used to test and evaluate the device. The gas level threshold was set to 800 ppm for testing purposes. Table 1 shows that when MQ-2 sensor does not sense gas that is less than 800 ppm, the buzzer and exhaust fan are in ready condition and turned off, meaning there is no gas leakage. When the MQ2 sensor senses gas which is more than 800ppm, the buzzer and exhaust fan automatically activates as a warning alarm, indicating the presence of gas. The buzzer acts as an audible warning to the nearby individuals and the exhaust fan removes pollutants from the indoor air in a home or commercial space. Moreover, the MQ-2 sensor will also automatically send warning messages to the mobile phone(s) by adding a SIM900-based GSM module via RS232 serial communication port to the Arduino UNO microcontroller as shown in Figure 1.

Table 1. Testing of Gas Leakage Detection System

Gas Level (ppm)	Sensor	Buzzer	Exhaust Fan	Condition
< 800	Inactive	Inactive	Inactive	No gas leaks
>800	Active	Active	Active	Gas leaks detected

Figure 4 shows the message sent via SMS to the specified contact number when the MQ-2 sensor detect the gas presence that exceed the predetermined threshold, 800ppm. Even when the users are outside, they can easily track their home's security. People have benefited greatly from this system as an early warning system against potential dangers.

From data collection to the actual processing of gas level data, this device runs smoothly. The MQ-2 sensor can detect the air quality in the immediate area while also detecting any gas leaks. The detected gas leaks are processed by the Arduino UNO and successfully sent as an alert message via the GSM module, which is a simple yet effective technology. Under Industry 4.0, this networking environment has a mechanism that allows for the transfer of necessary information, especially emergency at today's industry communication speeds.

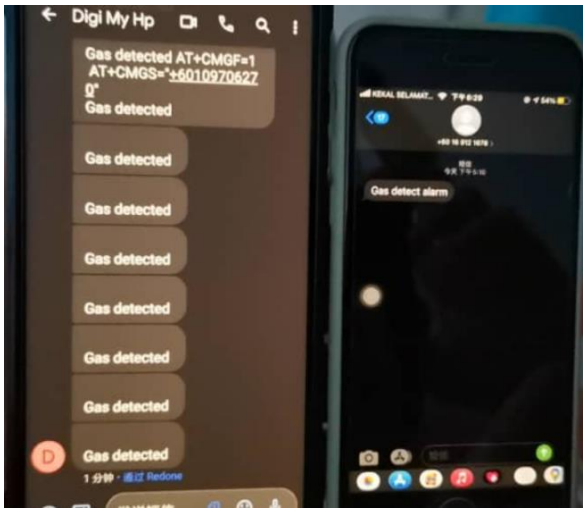

Figure 4. The Display of Message Received Via GSM 900

The sensor was tested by setting it at different displacement from the gas source. Table 2 demonstrates the analysis of two parameters, which are the sensor's displacement from the gas source and the sensor's reaction to the leakage gas in terms of the response time taken. The system is tested using three different types of gases that are smoke from cigarette, butane and LPG. The reaction time of the sensor detection system increases as the sensor's displacement from the gas source is further away and vice versa. Since it may affect the system's sensitivity and effectiveness, displacement is a significant consideration during installation. If the sensor is too far away, the gas leakage cannot be identified in a timely manner.

Table 2: Parameters Measured During Test Condition

Distance (cm)	**Time Taken (s)**		
	Smoke from Cigarette	Butane	LPG
20	13	20	46
40	24	48	92
60	38	106	132
80	45	120	162
100	60	151	180

Aside from that, it is worth noting that the sensor can detect three different types of gases, and the sensor's affectability varies depending on the gas. Since the time difference between tests corresponds with the same distance from the sources, the sensor responds quickly to cigarette smoke, followed by Butane and LPG.

CONCLUSION

This system allows for the collection and review of data on gas leakage. Readings at different gas sensor positions are observed by analyzing the extent of gas leakage. This aids in locating the source of the gas leak. Furthermore, by integrating the GSM device with the gas leakage sensor system, the gas leakage can be easily tracked or monitored anywhere and at any time. Furthermore, the users are able to monitor the residential or industrial spaces from afar. In the event of a gas leak, they will be alerted to a gas leak in the immediate vicinity. Aside from sending messages to users, the system also activates the buzzer to alert nearby people and the exhaust fan to clear the gas leak from the confined area. The system allows users to take immediate action to prevent the leak from becoming dangerous, potentially saving lives. The system can be further improved by implementing the telegram application as well as web-based monitoring application.

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