CHAPTER 1

AMMONIA GAS LEAK ALERT SYSTEM FOR LABORATORY USING MQ-135 GAS SENSOR AND GSM APPLICATION

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ABSTRACT

Mobile Alert System for Ammonia Gas Leak using Arduino and GSM application is a system that helps to detect the presence of ammonia gas in the laboratory thus alerting the person in charge such as laboratory technician. The system is based on Arduino UNO, GSM SIM900 module, and MQ-135 gas sensor. The prototype consists of a single sensor, which is MQ-135 gas sensor that is mainly responsible for detecting ammonia gas. The function of this prototype is whenever the ammonia gas is detected within the gas sensor's range inside the laboratory, it will trigger an alarm sound thus giving an alert message to the laboratory technician. Besides, this project has also identified the best placement to implement the sensor in the laboratory. It is based on the analysis of different distances between the gas sensor and the gas released. This system is very beneficial to the people who are using the laboratory because it can give immediate alert to them for fast action in case when there is a chemical accident occurs that releases harmful gas without anyone

noticing it. Furthermore, when there is an increase of distance between the gas sensor and the gas released, the response time required to trigger the alert would also increase. Hence, the optimal implementation to place the gas sensor would be at a range of 80 cm from the gas sensor to the gas chamber, as it requires the shortest time to trigger the alert with a reasonable distance.

Keywords: GSM, gas, SMS, ammonia, Arduino

1.0 INTRODUCTION

Ammonia gas is one of the hazardous gas that is considered harmful enough to harm human at a certain concentration (New York State Department of Health, 2004). This is because the ammonia gas is very toxic and dangerous to breathe, not just for human, but for all living things (Costa, Accioly, & Cake, 2003; Pyatt, 2003).

Recently, gas sensing, has received increase attention in both industry and academic. Gas sensing technology has become more significant because of its widespread and common application that would be very beneficial to its user who implement it in daily life. In order to evaluate the performance of gas sensing methods or gas sensors, several indicators should be considered as sensitivity, selectivity, response time, energy consumption, reversibility and absorptive capacity (Yunusa, Hamidon, Kaiser, & Awang, 2014).

Every sensor that has involved with the gas must ensure that they are well designed for the market guarantee of stability of their operation. In other word, they should exhibit a stable and reproducible signal for a period of time. Not every gas sensor can work perfectly well due to some flaws and certain defects that might have interrupted some of its functionalities.

This research has come up with a low-cost solution to overcome this problem. The proposed method is to use Wireless Sensor Network (WSN) technology to develop a Mobile Alert System for Ammonia Gas Leak using Arduino and GSM application. This will possibly contribute to decrease the numbers of death that caused by ammonia gas leak and explosion. This alert system will trigger an alarm in the lab and forward alert message to the laboratory technician as well. This will prevent the risk of ammonia gas leak, as it is a corrosive gas that can cause severe respiratory tract irritant that may be fatal if inhaled. This research aims to develop an alert system that detects ammonia gas leak using MQ-135 gas sensor thus triggering alarm sound and giving alert using SMS.

2.0 LITERATURE REVIEW

2.1 Gas Sensor

Gas sensors are chemical sensors that have multiple uses, which can greatly serve community as well as society. A chemical sensor comprises of a transducer and an active layer for converting the chemical information into another form of electronic signal like frequency change, current change or voltage change. The air surrounding us contains different amount of gases, which could be hazardous to human health, atmospheric pollutants or a significance to an industrial or medical process. It becomes very imperative to detect the presence of these gases since the environment that we live in consists of many living organisms such as human, plants and animals. Therefore, safety is the utmost priority.

Basically, traditional detection methods which produce systems that sounds an audio alarm to notify people when there is a gas accident that is harmful or poisonous is not quite correct because it is required to get the precise real-time results of the concentration of the target gas (Costa et al., 2003). However, for many decades, different gas sensor technologies have been applied for different gas detection including semiconductor gas sensor, optical gas sensors, electrochemical gas sensors and acoustic gas sensors (Miles, Branton, & Lott, 2004). The performance characteristic of every sensor is based on some properties including sensitivity, selectivity, detection limit, response time and recovery time (3M Company, 2008).

The sensitivity of a sensor is determined, as alpha where alpha is the change in analytic concentration (Pyatt, 2003). It is expressed in the terms of the chemical compound (Gong et al., 2011). The selectivity is based on the characteristics that determine whether a sensor can respond selectively to an analyse or a group of analytic that can be detected by the sensor under given conditions (Miles et al., 2004). Response time is the time it takes for a sensor under given conditions. Recovery time is the time it require for signal to return to its initial value after a step concentration value (Zhengzhou Winsen Electronics Technology Co. Ltd., 2014).

Other factors that make a sensor more attractive to consumers include small size, low power consumption and capability of being wireless. In order

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to have knowledge on development of gas sensors, some reviews have been made on different gas sensors. Different gas sensor technologies is presented for the detection of different target gases without emphasis on a particular gas (Yunusa et al., 2014).

2.2 MQ-135 Gas Sensor

The standard ammonia (NH_3) sensor used in Bio systems instruments shows an excellent response to ammonia sulphide (NH_3SO_4) In fact, the response is about 3.1:1 in favour of NH_3SO_4, making it ideal for monitoring for this contaminant. There are some important considerations to bear in mind when making use of an ammonia sensor for this purpose. Although the ammonia gas sensor is 2 times more responsive than any regular gas sensor model, it will respond to hazard. A sensor, which has been calibrated for the detection of NH3, then exposed to a concentration of 3.1 ppm ammonia, will still show a reading of 2 ppm (Dawson et al., 2014). It works the other way as well. If you calibrate the sensor to ammonia, then expose it to 2 ppm NH_3 it will show a reading of 2.1 ppm. We take advantage of this cross sensitivity ratio when calibrating the sensor (3M Company, 2008).

Bio systems normally suggests using the same mixture of 5 ppm ammonia (balance nitrogen) for calibrating the sensor for the detection of either hazard. If the sensor is calibrated for the detection of ammonia, simply adjust the readings of the sensor when exposed to the 5-ppm calibration gas to register 5 ppm. On the other hand, if the sensor is being calibrated for the measurement of ammonia oxide, the readings should be adjusted to register 1.7 ppm. Because 1.7 ppm of NH_3O_2 produces the same electrical output from the sensor as 5 ppm ammonia, a concentration of 1 ppm NH_3 will produce a reading of 1 ppm when the instrument is adjusted in this manner.

Sensitive material of MQ-135 gas sensor model is Sn02, which with fewer conductivity in clean air. When the target gas tend to be higher combustible gas exist, the sensor reactivity is higher whenever the concentration of the gas is high (New York State Department of Health, 2004). Figure 1 shows the gas sensor with model MQ-135 that is specialized in detecting hazardous gas such as ammonia.

Figure 1: MQ-134 Gas Sensor for Detecting Ammonia

2.3 Wireless Sensor Network (WSN)

WSN is a various component of electrical device that transforms one form of energy into another with a communication infrastructure on diverse locations, which has developed for monitoring and recording real-time condition. Its technology has a prodigious prospective to be employed in critical situations (Padmavathi, Shanmugapriya, & Kalaivani, 2010). It is also a reliable and efficient solution involving sensors to monitor different parameters such as temperature, moisture, motion, speed and vital body functions.

A WSN can also enable the interaction between the users and computers, thus controlling the environment as needed (Yinbiao et al., 2014). The users of WSN devices will also be provided with significant processing, memory and wireless communication capabilities.

WSN has been used broadly all around the world in numerous applications such as smart home, industrial civilian, health, habitat monitoring, environmental, office application, military, smart grid and in an automobile (Ramle et al., 2018). Users from various fields such as manufacturers and academic community were relishing this technology because of its distinctive benefits (Bagula, 2010).

Global System for Mobile Communication (GSM) is a digital cellular technology that is used to transmit the mobile voice and data services. In second generation of the wireless cellular system in the world, the one that most widely deployed is GSM for wireless (Gu & Peng, 2010). This research used the well-known notification system that has been implemented which is Short Messaging System (SMS). Since 2005, the SMS notification alert system technology has been started which was relevant to the business and to the organizations that needed the alert notification system as one of the communication medium (Karolidis, Papadakis, Prentakis, & Samarakou, 2005).

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3.0 METHODOLOGY

This research has developed an alert system that detects ammonia gas leak using MQ-135 gas sensor thus triggering alarm sound and giving alert using SMS. The architecture started from the MQ-135 gas sensor, which was placed near a gas chamber to produce the real-time data as the input. It will detect the spreading of ammonia gas specifically in a laboratory. Then, the information from the sensor will be conveyed to the system whether it exceeds the limit of ppm value or not thus will trigger an alarm and forward SMS alert notification to the user for a hazardous air.

Figure 2 shows the Network Diagram of the Ammonia Gas Leak Alert System. It depicts the overall mechanism of process that relates the gas sensor and the alert notification system. The function of MQ-135 gas sensor is to detect the ammonia gas leak in order to send the data to the Arduino board. The sensor that has been used is able to provide real-time input to the users.

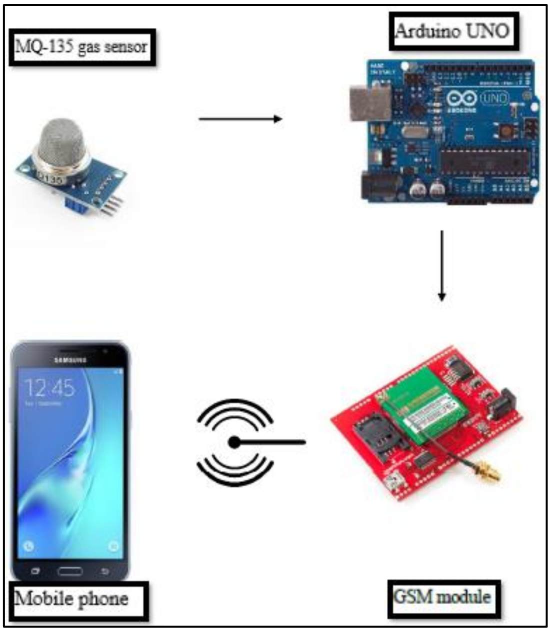

Figure 2: Network Diagram of Ammonia Gas Leak Alert System

The microcontroller that is used in this research is Arduino Uno board with USB cable. This board is used to send the information of the gas that has been captured. This prototype used 9V alkaline battery. It also used GSM SIM900 Module for sending alert through SMS. All devices were connected successfully through Wireless Sensor Network technology combined with GSM technology. The GSM plays a very important role where its function is to transmit data and message from the sensor to the mobile phones that will give notification to the targeted user.

The elements that have been used in this research are Arduino UNO board, GSM SIM900 module, MQ-135 gas sensor, jumper wires, USB cable, laptop, NH_3 solution and 9V alkaline battery. The Arduino IDE software has been downloaded for free.

Figure 3 shows the flow of this alert system. The MQ-135 gas sensor will detect the presence of ammonia gas inside the lab. The maximum value has been set to 75 ppm. The sensor will send information of the ppm value to the Arduino board. If the value exceeds 75 ppm, the Arduino board sends a message using a GSM module and the user will receive an SMS notification on ammonia gas leak through his mobile phone. The alarm from the board also triggered as a response of gas leak. The incoming SMS will alert the laboratory technician on corrosive gas in the lab so that corrective action could be taken instantly.

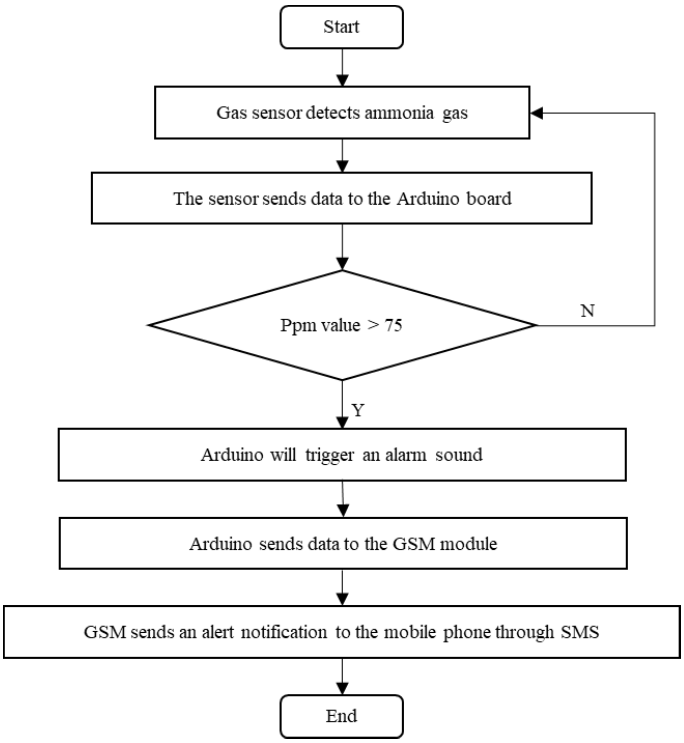

Figure 3: Flowchart of Ammonia Gas Leak Alert System

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Figure 4 shows the physical view of this system's prototype during the experimental phase. Several factors have been considered before conducting the experiment such as to ensure that the condition of air inside the laboratory is normal and does not contain any other gas except the ammonia gas to avoid any interruption when the sensor is detecting the ammonia gas and to obtain the most accurate result as possible.

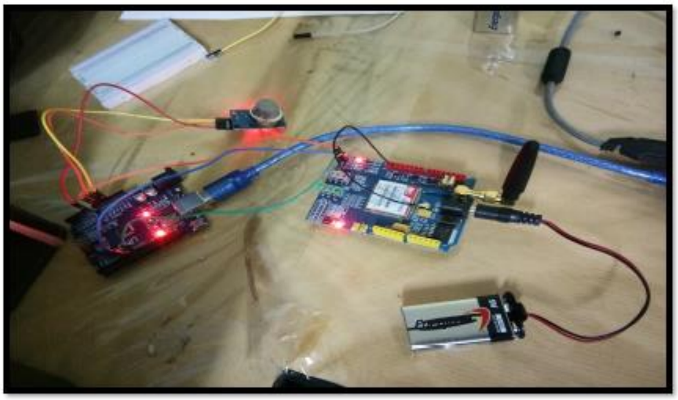

Figure 4: The Prototype of Ammonia Gas Leak Alert System

There are various types of sensor which need to be interfaced according to the output and belonging of the sensor. Certain sensors do not have any external circuit in order to be connected with an application while others need an external circuit. The MQ-135 gas sensor is implemented with only Arduino UNO and GSM SIM900 module connected via jumper wires and did not need any external circuit such as breadboard.

4.0 RESULTS AND DISCUSSIONS

4.1 Functionality Testing on the Alert System

The experiment for this research has been set for three different distances between the gas sensor and the gas released which are 80, 100 and 120 cm. In this experiment, the mobile phone is used to display message of alert notification to the intended user, which in this project would be the laboratory technician whenever the ammonia gas is detected in the surroundings. The experiment has been held in a laboratory. The experiment has emphasized on the best placement to put the sensor in the laboratory and to acquire the data regarding on the relationship between the sensor placement and the gas released with respect of response time through SMS. This experiment also ensured that the prototype has been functioning as it was designed. Hence, the SMS, which is the alert notification system, should be triggered accurately during the experimental process. The results of the experiment were collected and gathered when the distance between gas sensor and gas released has been increased.

The analysis contains scenario one to three which used to determine the average of response time at different distances. Relatively, when the distance between the gas sensor and the gas released increased, the changes of time taken that is being pass to the Arduino UNO will be determined via time display in laptop. During this experiment, the ammonia solution will emit a pungent gas and was put at a fixed position. However, the MQ-135 gas sensor has been moved around the laboratory with different distances starting from 80 cm, 100 cm and 120 cm. When the gas sensor detects the ammonia gas, it will send an alert notification to the user’s phone via SMS. During this experiment, each scenario was repeated three times to ensure that the data is conclusive and able to obtain the average value. Figure 5 illustrates the average response time of SMS alert notification with the effects of increasing distance.

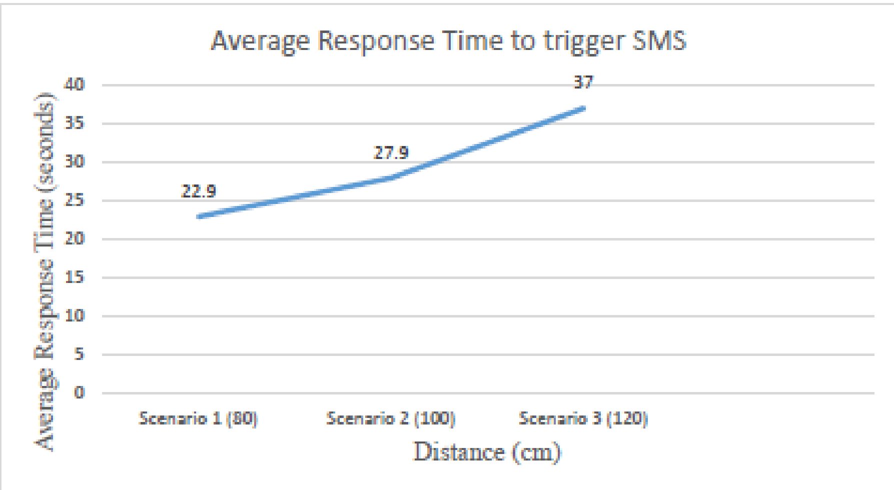

Figure 5: The Average Response Time for SMS Alert

Based on Figure 5, the scenario 1 with a distance of 80 cm between gas sensor and gas released obtained an average value of 22.9 seconds to give an alert. The second scenario conducted with a distance of 100 cm obtained

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an average response time of 27.9 seconds to give an alert. The third scenario with 120 cm of distance obtained an average response time of 37.0 seconds to give an alert. The average response time from scenario 1 to scenario 2 shows an increase of response time from 22.9 to 27.9 seconds, which took 7 seconds, and average response time of scenario 2 to scenario 3 shows an increase in average response time of 9.1 seconds from 27.9 to 37.0 seconds.

4.2 Usability Testing

The total number of respondents who gave feedback of the system were 41 people, which consists of 16 males and 25 females. Table 1 depicted the results of the survey. In order to make it easy to analyse, the mean result is differentiated to low, medium and high. The low scores will be below 2.3 [1 + 4/3], high scores above 3.7 [5 − 4/3], and medium scores in between those two (Zainal-Abidin & Yusuf, 2019).

Table 1: Usefulness and Ease of Use

Questions	Mean	Score
By using this system, I can monitor the laboratory's gas condition remotely.	4.3	High
I found that the SMS notifications is useful.	4.5	High

From the table, mean for both usefulness and ease of use questions scored high with all answers towards the higher end of the score. It shows that the system is able give an alert to lab technician at site and technician off site when there is possibility of gas leak. These respondents also acknowledged that the system, in general, is rather easy to use with further training and improvement.

5.0 CONCLUSION

The result shows that the prototype significantly capable of detecting ammonia gas even at low concentration in laboratory if chemical accidents happened. The objectives of this research have been achieved as this alert system can detect the presence of hazardous gas, which is ammonia gas, and will trigger an alarm sound thus give an alert message to the laboratory technician before the gas spread out. Based on the findings of this project, this gas sensor alert system can be recommended for any laboratory that has a high potential for chemical accident tragedy.

For future recommendation, it is suggested that this system will be powered by secondary power supply to avoid misdetection in case of the primary power source corrupted due to explosion or fire.

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