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Home and Industrial Safety IoT on LPG Gas Leakage Detection and Alert System

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Abstract

Gas leakage is usually the result of poorly fitted, badly maintained or faulty appliances like boilers and cookers. Gas leaks can lead to the presence of dangerous gas in the house. As it is responsible for killing 20 people every year, it is essential to know how to detect a leak. The main focus of this project is to detect and monitor the gas level using gas sensor and send gas level to the Ubidots via Internet of Thing (IoT). This project measures the gas level within the house or Industrial factory and update and keep a safe gas level and stored data into Ubidots's dashboard. The gas level is analyzed and an alert notification is sent to the owner if there is a gas leakage in the house through social media on the smartphone. The gas level data are analyzed by Ubidots to determine the gas level throughout the day and week. At the end of this project, the user can easily monitor the safety of the house or industrial places in case of gas leak even from afar. The system successfully implemented using the gas sensor connected to Intel Edison that published the gas level data to Ubidots Cloud via IoT and send telegram to owner in case of gas leakage occurs. The owner can login and check the the gas level using Ubidots dashboard.

Keywords: *Gas Leakage Detection System; Gas sensor; IoT Cloud; Liquefied Petroleum Gas; Ubidots*

1 Introduction

Natural gas has become a widespread energy source because it's highly combustible, which means that it can produce large amount of heat when user burn small amounts. Consequently, a natural gas leak can increase the risk of fire and explosion since it spreads quickly. An electrical spark or fire source can set this off if there is a gas leak in the house. There are many type of gases such as liquid petroleum gas (LPG), sulfur dioxide (SO2), hydrogen sulfide (H2S), carbon monoxide (CO), ammonia (NH3), methane (CH4) gas and many more[1]. Some of this gases do bring benefits to human. For an example, LPG contain in gas tank that been used widely for cooking and ammonia used for plant (insect pesticide). However, there are several hazardous gas that harmful to user or human if not handle properly or because of the device failure that cause gases leakage. Gases leakage can possibily leads to fire and as well as can cause gas poisonous to the person/group that been highly exposed to the leakage.

For individuals, the first sign of a gas leak may be a headache. While many of people experience headaches on a daily basis, sudden or unexplainable headaches should never be ignored. If the headache doesn't go away after going outside for a while, or while at work, consider the idea that there may have a natural gas leak. Individuals may experience bouts of dizziness along with a headache. Along with headaches and dizziness, individuals exposed to a natural gas leak may also experience nausea[2]. Such symptoms may be exacerbated if the house is closed up or if the garage or basement isn't properly ventilated.

In this project, liquefied petroleum gas (LPG) will be the main focus because every house used it. LPG is primarily combination of butane(C4H10) and propane(C3H8) to form flammable mixture used in heating home appliances and vehicles [3]. Unlike natural gas, LPG is denser than air itself that means it will flow through basements [4]. When it happened, the main dangers that may be faced is a possible explosion if a mixture of LPG and air with present of ignition spark source. Furthermore, it can cause suffocation because decreasing of oxygen concentration in air within that compounded area [5]. However, LPG is a beneficial and can be used as a power source for combined high temperature and power technologies (CHP). CHP is a procedure that combined both electrical power and useful heat from a sole fuel source. This engineering had allowed LPG to be practiced not only as fuel for heating and cooking, but also for de-centralized generation of electricity. LPG can be stashed away

in many ways. LPG as well as other fossil fuel can be blended with renewable energy source to offer tremendous reliability while still achieving helps to reduce carbon monoxide CO2 emission. [6].

IoT is the internetworking of physical devices, vehicles, buildings and other items [7,8]. The IoT is related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities that allows objects to be sensed and/or controlled remotely across an existing network infrastructure [9]. IoT transform all things that human does in their daily life by real life tracking and monitoring all sensor object that collected data. To correspond with this technology in safeguard the public home safety, a LPG gas leakage detection and alert system is developed via Ubidots IoT using a gas sensor to detect the leakage and alert the home owner through social media platform on smartphone. MQ2 gas sensor is connected to Intel Edison to collect the all data and sends and store to Ubidots Cloud services. An alert is send to the home owner when certain threshold limit of leakage gases is detected from the gas sensor at their home via media social such telegram or emails.

This paper presents a LPG gas leakage alert system using IoT technology on Ubidots Cloud. The remainder of the paper is organized as follows. Section 2 gives some insight on the topic and recently published related works. Section 3 describes the system development of a LPG gas leakage alert system overall design approach. Section 4 discussed the experimental result of an IoT LPG gas leakage alert system. Finally, section 5 draws our conclusions and point out the ideas for future extension of this work.

2 Related work

The LPG gas leakage detection system is an important safety measure for public safety this day due to large usage of LPG gas in domestic appliances. Deploying gas leakage system reduces the possibility of major fire and explosion incident by providing SMS alert of gas leakage to the mobile users by using GSM network or IoT Cloud. Concentrating on these concepts, we divided the related work into two subsections:

2.1 GSM based Gas Leakage Detection System

In 2017, S. Unnikrishnan et al[10] proposed a Liquefied Petroleum Gas (LPG) monitoring and leakage detection system on site with LCD display to monitor the usage of LPG on a regular basis and buzzer to alert about any hazards that may occur due to

LPG leakage. In 2016, Khyati Bhargava et al [11] proposed a GSM gas leakage detection and prevention system using a MQ-6 gas detection sensor and interface it with microcontroller along with GSM modem. The GSM modem sends out an alert message to the authorized people or owners on the android application. The owner can handle the issue by closing the valve through the application itself. Furthermore, the electric power supply system can shut down to prevent fire accidents. However, both works shown no result on the completion of proposed system. In 2016, T. Arpitha et al [12] present an FPGA –GSM based gas leakage detector with a warning call initiating feature to the first response team. The FPGA detects the leakage and initiates a warning call through a GSM module. M. Georgewill et al [13] present the design and implementation of SMS based Industrial/Homes Gas Leakage Monitoring and Detection Alarm System using MQ-9 Gas sensor and embedded Arduino microcontroller with SIM 900 GSM modem to detect gas leakage and alert users through alarm action by using buzzer and send alert SMS through GSM modem. In 2015, Srinivasan et al [14] developed a gas leakage detection and control system. The gas leakage is detected by an ARM microcontroller with the gas sensor that is fitted on the LPG cylinder. The system alerts customer using a GSM module, while activating the alarm and exhaust fan and automatically controls the leakage of gas using solenoid valve by closing LPG knob. T.H. Mujawar et al [15] implement a wireless gas leak detection system, the MQ-2 gas sensor is connected to an analog port of the Arduino with a XBee. The wireless sensor node will detect a gas leakage XBee sends the data from gas sensor to the monitoring system that is displayed on LabVIEW GUI. The gas leakage response can be obtained and send to the mobile users saved in Arduino GSM shield and also displayed on the monitoring system. D. Ganesh et al [16] proposed gas leakage detection that the sensor node equipped with a PIC16F877A microcontroller, a wireless modem, a power supply, and MQ-5 gas sensor. Whenever a hazardous gas is detected in the atmosphere, the network coordinator alarms an operator by the GSM message. In 2014, J. Tsado et al [17] proposed design and construction of an SMS based Gas Leakage Alert System. Two gas sensors (MQ-6) were used to detect gas leakages in a particular location; their outputs are then interfaced with an 8051microcontroller programmed in assembly language. A dedicated GSM phone with a line is connected through relays to the output of the microcontroller. The GSM phone is configured to send gas leakage alerts in the form of a short message service (SMS) message indicating the location to another GSM phone to enable prompt necessary action. Tanvira Ismail et al [18] present GSM Based Gas Leakage Warning System that used MQ-6 gas sensor with GSM modem for SMS notification. From all work above there are many type of MQ sensor range that integrate with a few type of microcontroller ARM, Intel 8051, Arduino and also FPGA and GSM modem is utilized to send message to user or for calling the user. Although useful, all the existing system

does not give the medium interface for user to reassess the intensive time-sensitive information and current situation of gas leakage at premises.

2.2 IoT based Gas Leakage Detection System

IoT based remote monitoring systems have been suggested by various researchers due to their high efficiency in delivering intensive time-sensitive information to the users. In 2017, Shruti et al [19] proposed framework for continuously monitor the surroundings for any leakage. In case of any leakage detection by using MQ-6 gas sensor, it alerts the user via a buzzer and by using the Ethernet shield module and an Android application to alert the user about the environmental conditions like the gas level and temperature of that location of installation using social media sites like Twitter or via an email notification. Anandhakrishnan S et al [20] also proposed a conceptual framework system aims to detect the leaked gas and send the data to internet via IoT to android app. The android app controls the gas leakage by closing the valve automatically and the booking of gas cylinder automatically from gas agency. Asmita Varma et al [21] propose to use the IoT technology in making a Gas Leakage Detector and Smart Alerting techniques involving calling, sending text message and an e-mail to the concerned authority and an ability to predict hazardous situation so that people could be made aware in advance by performing data analytics on sensor reading. However, all above framework shown no result on the completion of proposed system. In 2017, Sayali Bhogate et al [22] proposed and developed gas leakage monitoring system via Cloud using ZigBee, Arduino, MQ-2 gas sensor and Cloud. The data is fed on cloud using Wamp server and a sms is send to alert on the gas leakage to the mobile of home owner and fire brigade with model number, location, date and time. Kumar Keshamoni and Sabbani Henmath [23] utilize MQ-2 gas sensor that connected to ARM microcontroller with ESP8266 Wi-Fi to connect to ThingSpeak.com network. In 2017, Mohsen Rahmati et al [24] proposed a neural network-based method for leakage detection of a gas pipeline by using gas flow pattern. The pipe is divided in several segments and each segment is modeled by considering input/output pressure of the gas flow. All the required information is gather using IoT for detection of the leakage point and used neural network on attained data from pipeline gas flow. This work is useful on predicting the location of gas leakage using gas flow pattern without using any external sensor unlike previous method. Although, there are a few existing works proposed and developed using IoT, there are no work that implement the dashboard display and cloud event management provided at IoT Cloud for management of gas leakage detection system.

3 The System Development

The main goal of this system development is to monitor gas level (leakage) detected by gas sensor and send to Ubidots via IoT, the data can be read back from Ubidots's dashboard and to give early notification to the owner about the leakage. Referring to the block diagram in Figure 1 below, the developed system consist of a 1) sensor node that implemented using an Intel Edison board connected with buzzer, LEDs and MQ2 gas sensor; 2) Wi-Fi router that interconnected the sensor node to Ubidots IoT Cloud platform and 3) Ubidots Cloud platform that consist secured IoT devices organization, Ubidots Dashboard to display and visualize the gas level data and Ubidots Data Analytic to analyses the threshold limit of gas leakage detection level that invoke an alert of gas leakage to home owner via telegram/sms on smartphone.

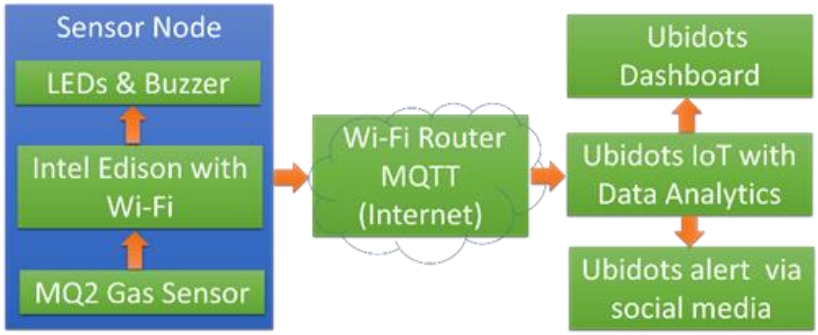

Fig. 1. Block Diagram of LPG Gas Leakage Alert System

The main operation of this system is based on detection of gas leakage in homes, restaurant workplace and other. Firstly, the design will be continuously operated because it need to collect all the data about the gas leakage based on users need. Gas leaked happened without notice, it can happen at morning, evening as well as night. Even when there are people in the house, it hard to recognize small gas leak. So in this system gas sensor will be one of the main focus here because, without it, this project cannot be completed. The gas sensor will detect any gas that have on the surrounding based on what MQ type the user use. MQ-2 gas sensor is used in this project because it had the ability to detect the LPG as well as propane and butane. The function of this sensor is to detect gas like LPG, ammonia, sulfur dioxide, hydrogen sulfide, carbon monoxide, methane gas and many more. MQ-2 is very sensitive to gas. It also can detect smoke, but not efficient like when detecting a gas. The usual reading for gas leakage is around 500ppm. Ppm stand for "parts per million". But, in this project, the threshold is at 800ppm because to make the analysis process easier. MQ-2 and MQ-5

is rather the similar gas sensor but different in sensing ability of a LPG. MQ-2 can sense from range 200ppm to 5000ppm whereas MQ-5 can sense more than that which is until 10000ppm. In this project both MQ-2 and MQ-5 is used sense the gases [25].

The gas level data collected is consistently send data to Ubidots IoT Cloud via Intel Edison based sensor node. All the data that are being collected and sent by Intel Edison then is stored in the Ubidots database. The Intel Edison sensor node is connected with internet router by Wi-Fi connection to send data to Ubidots IoT Cloud. In Ubidots, there are dashboard interface and display for device management and event management. The dashboard display is graphical illustration of collected data that provide access or view the summary of gas level in their houses. The visualization of the data is informative and well organized that can easily monitor their house even from their workplace. In event of gas leakage, the gas sensor detected gas more than 800ppm an indication of gas leakage in the air, sensor node will sound the buzzer and turn on the red LED for on-site alarm alert. The gas leakage data level is also send to Ubidots IoT and a notification event is send to alert owner about the gas leakage.

4 Result

In this section all the result and data obtained from the MQ-5 and MQ-2 gas sensor experiment or demonstration is described. First the detection of spreading of gas in the surrounding area is been investigated by using 3 MQ-5 gas sensor on respective location on West, North and East in relation the gas leakage point. Based on Fig. 2, the gas sensor must be warmed up about 2-3 minutes before it can achieve stable reading. The gas sensor has different initial value for every sensor. Therefore, it is quite hard to implement multiple sensor as they may have different initial value, which makes hard to synchronize the reading and results.

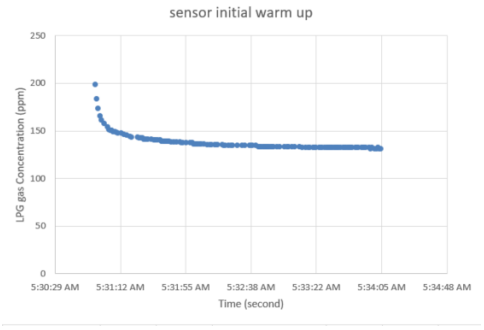

Fig. 2. Sensor Initial warn up gas level value

Due to difference of the initial value of the gas sensors as shown in Fig 3, it needed to be calibrated so that they will have same initial value as shown in Fig 4. This is to ease monitoring and synchronize dangerous threshold among the sensors.

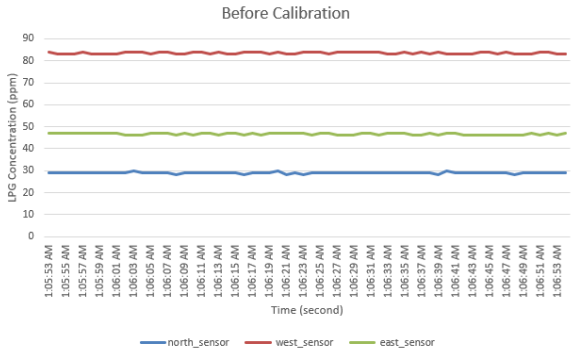

Fig. 3. Before Calibration of the multiple MQ-5 sensors

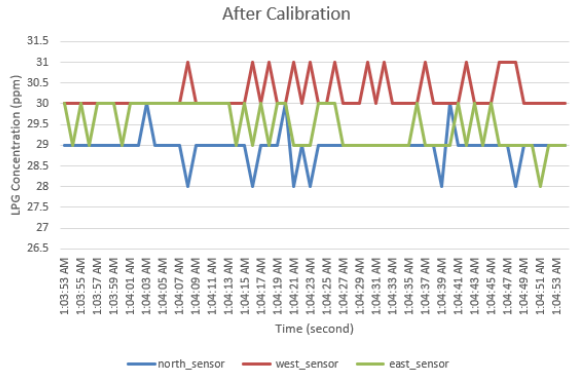

Fig. 4. After Calibration of the multiple MQ-5 sensors

A real-life experiment test was performed, where LPG gas was released from 1 meter away from the gas sensor. The gas sprayed is constant and the wind speed also were constant in this experiment. The gas was sprayed directly to the west sensor. Therefore, based on Fig 5, west_sensor had a sudden spiked at 12:51:09 AM where it successfully detected the presence of LPG gas. The difference between initial and detected value is 99ppm. Furthermore, the north_sensor and east_sensor also had a small spiked that indicated presence of LPG gas due to the small area used in this experiment and the direction of the wind which is uneven that caused the LPG gas spread widely. The LPG remain in the surrounding area for a few minutes after the

leakage end and dissolve in air before the LPG gas level concentration reach their normal air quality. The experiment indicates that the gas leakage detection level is higher for the nearer MQ-5 sensor to point of leakage.

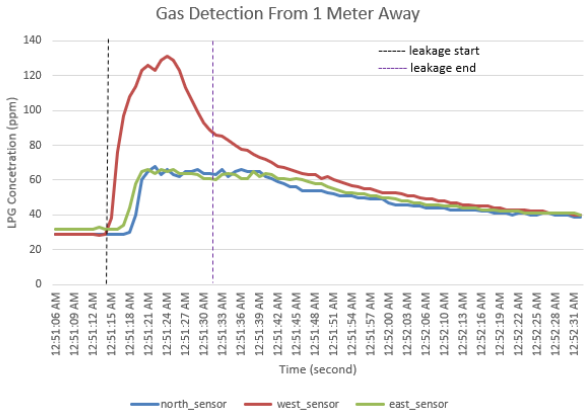

Fig. 5. Gas Detection using multiple MQ-5 sensors from 1 Meter away

In Fig 6, the gas leakage is release on the air from 2 meter from the nearest MQ-5 sensor at west sensor and the results shown that a bigger spike from west_sensor, medium spike from east_sensor and a small spike from the north_sensor. However, the spike is smaller compared to previous experiment of 1 meter away from sensor with the highest LPG concentration recorded of 87 ppm and 133 ppm respectively. This also indicate that that the nearer the point of gas leakage to a sensor the higher the gas leakage level detected. Besides that, a deduction can be made that the source of leakage may came from West and flew through the East side of the area and lastly went to North area.

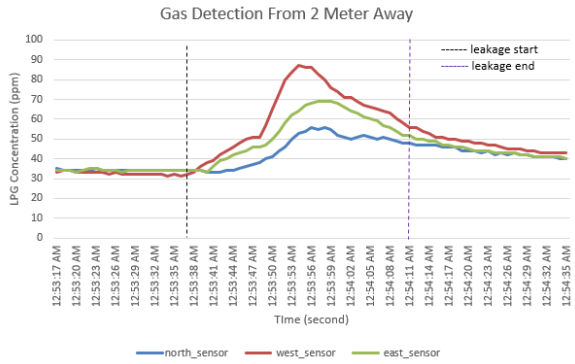

Fig. 6. Gas Detection for multiple MQ-5 sensors from 2 Meter away

From this experiment onward, the MQ-2 sensor is used as the LPG gas sensor. A Figure of gas level data before and after the gas is released near the gas sensor, the comparison graph and message send to the user when alert happen are illustrated here for these second experiment. The gas threshold level set before any alert is send to user for the MQ-2 sensor is equal or greater than 800ppm. The dangerous level that can harm human is at 2000ppm. [26] The reason the threshold is set at 800ppm because the source of gas that used for this experiment is from lighter. The lighter gas cannot reach until 2000ppm. By referring to Fig. 7, the gas level value appears to be the normal air quality. At this state, no gas being release near the sensor which means that the sensor can detect the normal air quality. In Fig. 8, the gas level value shown as 887ppm because gas is being supplied or exposed to the gas sensor. The sensor detected the gas presence and show the gas level value at Ubidot's dashboard.

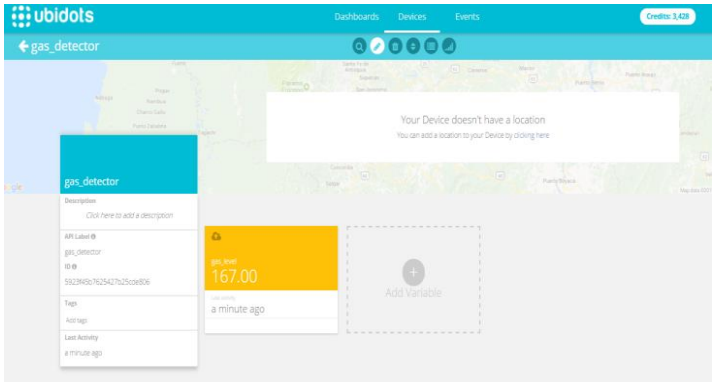

Fig. 7. Image in Ubidots when the gas level of 167ppm indicating no gas leakage.

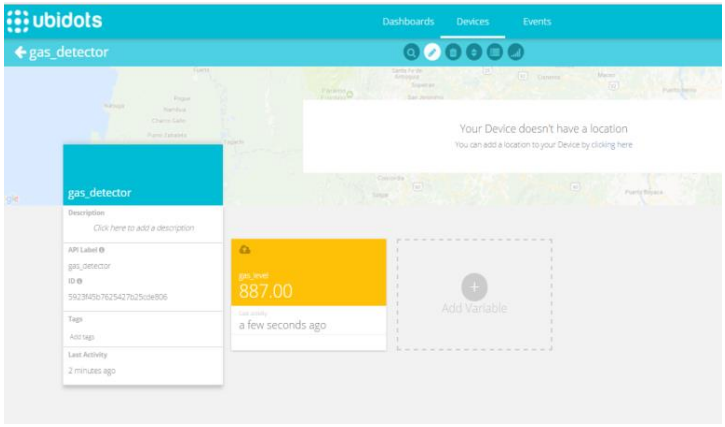

Fig. 8. Image in Ubidots when the gas level of 887ppm indicating gas leakage.

In Fig. 9, the graph presents the gas level during both period of no gas leakage and when gas leakage presence. The graph indicates that when there is no gas, the graph of gas level maintains horizontally and when the sensor detected gas presence, the graph will rise up as shown at 2 points above.

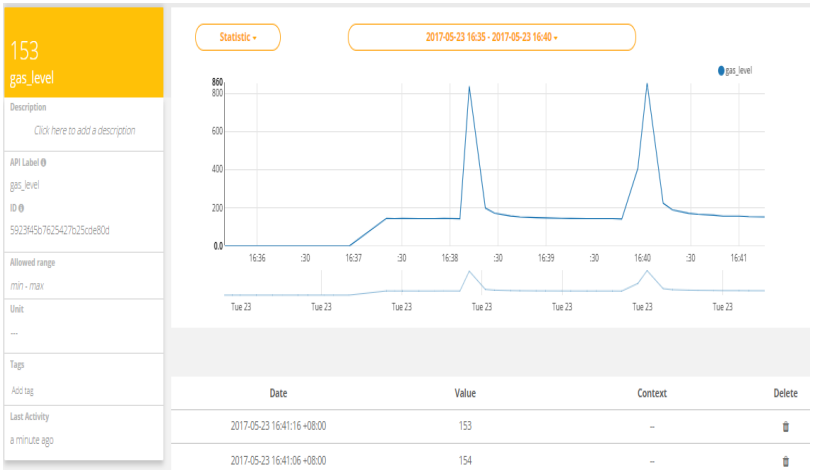

Fig. 9. Image of graph after combining both event in Figure 7 and 8.

In Fig. 10, Ubidots also provided an extension to visualize the data more creatively. As shown above, by using the indicators, the gas level value can be obtained more precise and can see the difference in reading more easily.

Fig. 10. Image of dashboard of indicator that can indicate the value of gas level at 155ppm.

Fig. 11. Image shows that when the gas detected exceeded the set value, the user will get a telegram message.

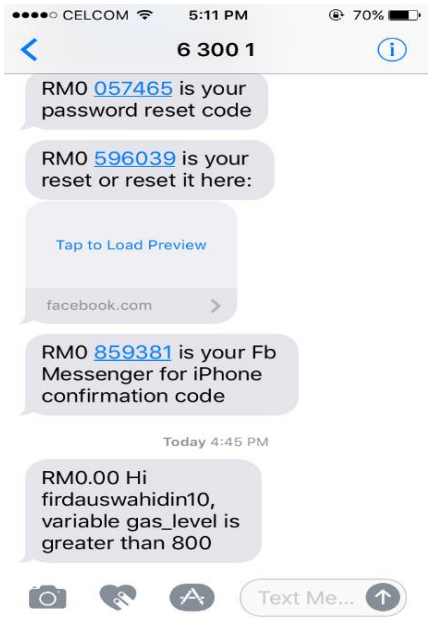

Fig. 12: Image shows that when the gas detected exceeded the set value, the user will get a message sent to their phone.

In Fig. 11 and 12, when the sensor detecting gas presence that exceed the limit, alerts will send messages and telegram to the user through their specified contact number in the alerts system. Users can easily monitor the safety of their house, even when they are outside. This system has been very benefial to people as an early precaution from the danger that may happen. This system works smoothly from data collection until the visualization of gas level data itself. The MQ-2 sensor able to detect the surrounding's air quality whist detecting the any gas leakage simultaneously. The Ubidots Cloud is simple yet powerful technology because it can send alert message via many mediums such as telegram, SMS as well as email and Webhooks.

5 Conclusion

In the nutshell, gases are fundamental in our surrounding due to today's developments. Gases are everywhere. Gases helps human and gases also can harm human if not handle properly. From this project, the hope is very high to make it successful because this innovation can bring benefits to human life. This project enable collection of the data about the gas leakage and analyze it. The estimated source location of gas leakage can be determined by analysing the gas leakage level reading detected on different gas sensor position. Furthermore, by combining IoT system, the gas leakage can easily be analyzed everywhere. All the data can be read back in Ubidots's dashboard. At the end of this project, the user can easily monitor the safety of the house or industrial places in case of gas leak even from afar. The system successfully implemented using the gas sensor connected to Intel Edison that published the gas level data to Ubidots Cloud via IoT and send telegram to owner in case of gas leakage occurs. As user been notify about the gases leak in the surrounding early, they can take a precautions step to prevent it from reaching a hazardous level and can save lives.

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