Design of Internet of Things Based Air Pollution Monitoring System Using ThingSpeak and Blynk Application

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Abstract. This paper presents the design of an IoT based air pollution monitoring system to measure carbon dioxide gas, butane gas, humidity and temperature. The hardware consists of MQ-2 gas sensor, ESP8266 Wi-Fi module, DHT22 temperature and humidity sensors. Meanwhile, the software used in this prototype is the Arduino Integrated Development Environment (IDE) written in function C and C++. The monitoring system indicate air quality is below than 100 AQI for safety air quality and more than 200 AQI for hazardous air quality. The green LED illuminated indicates there is no hazardous gas detected. Meantime, when the butane gas or carbon dioxide gas is identified, the red LED is illuminated. All the data are sent through ThingSpeak and Blynk applications. In ThingSpeak and Blynk applications, the data are displayed and updated after detected by the sensors in every 15 seconds and 1 second. In the Blynk application, when the hazardous gas is detected, the Blynk application sends a notification to alert the users immediately.

1. Introduction

The rapid economic development over the past 25 years has resulted in increasingly frequent evolution; such as chemical industrial park construction. This venture has caused the increase of probability of an air pollution accident and severe issues to the earth. Over decades, air pollution is one of the monstrous issues occurs in South East Asia, predominantly upsetting Malaysia due to air and water contamination, depletion of fisheries and contagion by toxic wastes, which turns out to be progressively basic in Malaysia in recent years [1]. Malaysia has trilled the experience of one of the least contaminated urban circumstances in Asia. Air pollution comprises of two sorts, such as, natural air pollution and man-made air pollution. It happens when fumes or smoke, dust particles, gases or odour is emitted to the air, causing great harm or even outrageous annihilation to both human and environment [2].

The extreme ecological contamination which has caused respiratory ailment, climate change, loss of biodiversity, acid rains, land degradation, global warming, changes in hydrological systems and the provisions of fresh water is lessening the wellbeing impacts of air contamination on public health [3].
A portion of the air toxins produced through human activities are carbon dioxide gas (CO\textsubscript{2}), carbon monoxide (CO), sulphur oxides (SO\textsubscript{2}), nitrogen oxides (NO\textsubscript{2}), volatile organic compounds (VOC), ammonia (NH\textsubscript{3}) and methane gas (CH\textsubscript{4}) [4]. At the point when a portion of these compound toxins is uncovered into the air and the environment, it will increase the occurrence of ailments for example, pneumonia, lung malignant growth, ceaseless bronchitis, asthma, constant respiratory infections and coronary artery disease [5].

Henceforth, there is a developing interest in natural contamination monitoring systems. The fundamental cause of air pollution is, commonly, human activities. The six significant derivations of air contamination from human activities in Malaysia are power stations, vigorous sources, mechanical fuel consuming, manufacturing processes, residential, commercial incinerator and open fire activities at a solid waste disposal place [6]. A carbon dioxide, or CO\textsubscript{2}, is a significant ozone harming substance that contains two oxygens atoms and one carbon atom [7]. Additionally, it is colourless, odourless and non-combustible gas with a slightly sour taste particle.

The CO\textsubscript{2} concentration ascended by 105 parts per million (ppm) for the last 50 years has caused an immediate effect on human health that is liable for a variety of respiratory illness, for example, asthma. Methane, or CH\textsubscript{4}, is an essential part of natural gas that contain one atom of carbon and four atoms of hydrogen from group-14 hydride. Consistently, it is radiated from the oil and gas industries, agriculture activities, during production and transportation of coal or decomposition of waste [8]. The methane is noxious in the vaporous structure. At the point when the high concentration is in the air, it can reduce the oxygen level causing asthma and unconsciousness. Moreover, liquid methane when interacts with skin can cause frostbite [9].

2. Air Quality Index (AQI)

Nowadays, the air quality monitoring system has become a necessity as the air pollution level is increasing exceptionally. Consequently, the air quality in Malaysia is a major concern, as the nation inspires to become an industrial nation by 2020. In Malaysia, the air quality index (AQI) is utilized to regulate the degree of air quality [10]. The Department of Environment in Malaysia has formulated the air quality rules for air contamination in 1989.

Fig. 1 shows the status marker of AQI is partitioned into a couple of classifications. For example, great, medium, unhealthy for sensitive groups, unhealthy, very unhealthy and hazardous which can be of an air quality administration level or choice-making for information translation forms. The index structure known as the AQI is the basic complete methodology for characterizing air quality status that can be seen effectively by the overall population [11].

![Air Quality Index (AQI) Table]

| Air Quality Index (AQI) Values | Levels of Health Concern | Colors |
|-------------------------------|-------------------------|--------|
| When the AQI is in this range: | air quality conditions are: | as symbolized by this color: |
| 0 to 50 | Good | Green |
| 51 to 100 | Moderate | Yellow |
| 101 to 150 | Unhealthy for Sensitive Groups | Orange |
| 151 to 200 | Unhealthy | Red |
| 201 to 300 | Very Unhealthy | Purple |
| 301 to 500 | Hazardous | Maroon |

**Figure 1.** Ranges in air quality index (AQI).

The advantage of the AQI is that, it is created in handily comprehended ranges of quality in reporting the quality of air as opposed to utilizing the actual concentrations of air pollutants by the public [12].
Furthermore, the upside of utilizing AQI for approaches and administrative activity is that the indicator can uncover the air quality status and its impacts on human wellbeing. Besides that, AQI can give back its impact on human wellbeing as the quality of air is ranged from good to hazardous.

Fig. 2 shows the air contamination index, which has been known as one of the significant pointers of air quality that used to record the relationship between air contamination and human health. The graph has a perusing of 1,010 AQI index identified at the US embassy by more sensitive air quality sensor. On 8 November 2016, pollution reported by AQI is very high by monitoring stations, the route over the high peak in hazardous and worst category.

![Air Quality Index](image)

**Figure 2.** Air quality reported in Delhi.

3. Design and implementation

3.1 Block diagram

Fig. 3 shows the block diagram, whereby the IoT system uses two sensors and one microcontroller, for example, the DHT22 sensor, the MQ-2 gas sensor and ESP8266 Wi-Fi module to connect to the internet network. The block diagram has three blocks consist of input, process, and output. The input contains two sensors, the process has one of the microcontrollers and the output consists of the two LEDs, Thing Speak and Blynk platform applications.

![Block Diagram](image)

**Figure 3.** Block diagram of the air pollution monitoring system.

The MQ-2 sensor measures butane gas and carbon dioxide gas while the DHT22 measures the temperature and humidity. Next, the ESP8266 module collects the data, processes the data, and displays the real-time readings in which to be displayed at the mobile application. The notification will be sent to Blynk application if the reading of the air quality is more than 200 of air quality index (AQI).
3.2 Circuit design
Fig. 4 shows the DHT22 temperature sensor, MQ-2 gas sensor and two LEDs are connected to the pin of ESP8266 Wi-Fi module microcontroller in a complete circuit design. The temperature sensor (DHT22) is a digital sensor and it is connected onto the GPIO4 pin. The analog pin of the MQ-2 gas sensor is connected to the ADC pin. The red LED is connected to GPIO16 pin and the green LED is connected to GPIO14 pin.

![Circuit Diagram](image)

Figure 4. Circuit design.

It is useful to alert the users when the AQI reading is high lighting up the LED. There are two LEDs that indicate whether the air quality is in a good condition or the hazardous condition, which is indicated by the green LED and the red LED respectively. When the air quality is hazardous, the red LED will light up to alert the users and send a notification via a mobile phone application. The other pin connection is connected to the ground (GND) and power supply (VCC).

This circuit design is beneficial as it can be closely monitored from time to time with a real-time notification in a mobile phone for air pollution monitoring system and users are able to get the real-time measurement readings of the carbon dioxide gas level when haze is circulating in the surroundings [17]. Therefore, the building is always in good air quality and people will be alerted of danger through a notification via the Blynk application. The ThingSpeak and Blynk applications are monitoring the air quality from time to time in the building environment.

3.3 Prototype
The air pollution monitoring system via the Internet of Things (IoT) application is designed using an Arduino MQ-2 gas sensor, Arduino DHT22 temperature and humidity sensors. The air pollution monitoring system only measures the carbon dioxide gas, butane gas, temperature and humidity. All the parameters are tested in the indoor condition.

Fig. 5 shows the complete prototype circuit designed to alert the users who are monitoring air pollution. This prototype is designed to achieve all the objectives, in which to measure the temperature, humidity, and hazardous gases. It is very valuable to be recommended to building area environment with the IoT system reliability.
The diverse hazardous gas level detection is tested by victimization the gas sensor to analyze the amount of gas level in varying forms. The vary ought to be set to ascertain the value of the hazardous gas level in two ranges. These two ranges of gas level detection are beneath than 100 air quality index (AQI) and in excess than 200 air quality index (AQI) as air quality within the indoor environment. The alarm system and application warning are designed to give a notification via Blynk application, once the hazardous gas is distinguished and it will appear on a mobile phone screen. Meanwhile, the ThingSpeak application can only monitor the hazardous gas and temperature parameters without the notification alert even reaches the limit of the range readings.

3.4 Software design

The software used for the implementation of this project is the Arduino Integrated Development Environment (IDE) that is written in function from C and C++, one of the cross-platform applications. It is utilized to compose and transfer programs to Arduino boards.

Fig. 6 shows one of the programming codes to measure hazardous gases from the MQ-2 gas sensor. The gas sensor is connected to the analog pin (A0) as the input data. Therefore, in Arduino IDE software, the pin of the gas sensor is set as the A0 to read the data. After the data is collected, there are two conditions to meet in order to light up the red or green LEDs. If the analog value obtained is more than 200 (n > 200), the output pin 16 (red LED) is high and a notification alert is sent as (hazardous gas detected) via a mobile phone and displayed at Blynk application.

```c
38 void loop()
39 {
40   Blynk.run();
41   timer.run();
42   mq2analogRead(A0);
43   Serial.println(n);
44   if(n<100)
45     digitalWrite(14, HIGH);
46   digitalWrite(16, LOW);
47   if(n>200)
48     Blynk.notify("Hazardous Gas Detected!!!");
49     digitalWrite(16, HIGH);
50     digitalWrite(14, LOW);
51 }
```

Figure 5. The prototype diagrams,

Figure 6. The programming code to measure the hazardous gases.
4. Measurement
The IoT based GPS bus tracker with automated passenger-counting system is successfully designed and tested. The bus location is tracked using Neo-6M GPS, ESP8266 Wi-Fi and Arduino board. Meanwhile, the number of passengers on the bus is counted by IR sensors. The Blynk is employed to monitor bus location and the number of passengers through mobile app. The bus tracker system is constantly tracking and updating exact location of the bus continuously. The proposed system helps the students to know the current location of the bus, the next bus stop and the crowd level of the bus.

In this project, there are two independent variable parameters to test which are carbon dioxide gas and butane gas. Fig. 7 shows the testing method to measure the presence of carbon dioxide gas by using the MQ-2 gas sensor on smoke from a burnt paper. It has a small amount of carbon dioxide gas. This process is called combustion. The release of smoke can be incredibly harmful or irritating. Therefore, it is important to monitor and detect this smoke immediately.

![Image of IoT bus tracker components]

**Figure 7.** The carbon dioxide gas testing.

In this process, the oxygen in the air merges with carbon and hydrogen when the paper is burned, turning it into carbon dioxide gas in the smoke. It leaves the solid ash unconsumed lighter than the original paper. This is one of the ways or procedures to measure one of the hazardous gases in the surrounding. The most dangerous part of tobacco smoke originates from the burning of paper and the smoke likewise darkens perceptibility. This makes it hard to evacuate from a fire.

Fig. 8 shows the test for measuring butane gas in the surrounding. This test must be done shortly after exposure. Butane exposure should always be minimized. Butane combustion can also lead to hazard as it exhausts harmful substances like nitrogen dioxide. Butane is a gas commonly used in lighters and as a propellant in aerosol sprays.
5. Results and discussion

5.1 Results of air quality

The result of air quality of good environment is below than 100, based on air quality index (AQI), which was recorded and measured through tests in the building environment. It was measured by the MQ-2 gas sensor, DHT22 temperature and humidity sensor. For the hazardous air quality, the reading is higher than 200 AQI and all the condition was set up on the range by simulating the Arduino IDE software. All the sensors were working very well because the reading obtained was very accurate and due to fast response time by the air pollution monitoring system. It tested the quality of air in good environment and hazardous environment when the gases or odour was released into the air causing great harm to both human and the environment.

Fig. 9 shows the green LED was illuminated signalling good air quality. This was because the reading was below than 100 AQI; in a range that was set up to indicate that there were no hazardous gases detected in the surroundings. The users can always monitor the air pollution system through the real-time notification via a mobile phone by the using Internet of Things (IoT). If there was no carbon dioxide gas or butane gas detected, the red LED would lit off. The detection of hazardous gas was due to the high sensitivity of MQ-2 gas sensor within the building environment, although a tiny, low quantity of smoke was exposed to the air.
Fig. 10 shows the measurement of carbon dioxide gas, respectively. As can be seen, the red LED was illuminated signalling hazardous air quality. This was because the reading had exceeded to 200 AQI; in a range that was set up to indicate there was hazardous gases exposed to the surrounding. The exposure of hazardous gases can cause suffocation, loss of consciousness and increase breathing rate. Thus, resulting in dangerous hazard to individuals particularly patients and students within the environment.

![Figure 10. The carbon dioxide gas detected from the paper burn.](image)

When the carbon dioxide gas or butane gas was detected, the green LED was lit off. Fig. 11 shows the measurement of butane gas respectively. As can be seen, the red LED was illuminated signalling hazardous air quality. This was because the reading had exceeded to 200 AQI; in a range that was set up to indicate there is hazardous gases detected in the surrounding.

![Figure 11. The butane gas detected from the lighter.](image)

5.2 Results of ThingSpeak application monitoring

All parameters of carbon dioxide gas and butane gas (AQI), temperature (Celsius) and humidity (percentage) were displayed through ThingSpeak application. It is important for the users to ensure air quality is always a good in the environment. Fig. 12 shows the results of good air quality environment from air pollution monitoring system which were displayed and monitored through the ThingSpeak application.
The three graphs depict humidity, hazardous gas and temperature. The data were displayed and updated after being detected by the sensors for every 15 seconds. The reading of the gas level was 86 AQI in a good air quality environment. The gas gauge level was ranged from 0 to 500 and the green indicator started from 0 to 100, which clearly showed the air quality was good. Fig. 13 shows the results from the air pollution monitoring system which were displayed and monitored through the ThingSpeak application in hazardous air quality environment.

The reading of the hazardous gas level was 405 AQI when the carbon dioxide and butane gases were detected by the MQ-2 gas sensor. The red indicator started from 200 to 500; that showed the air quality was hazardous and every 15 seconds the interval gas level was updated. The yellow indicator started from 100 to 200 indicating the unhealthy air quality for sensitive group. Therefore, the red LED was illuminated, and the green LED was lit off.

Figure 12. (a) Humidity (b) Temperature (c) Hazardous gas (d) AQI.

Figure 13. (a) Humidity (b) Temperature (c) Hazardous gas (d) AQI.
5.3 Results of Blynk application monitoring

Fig. 14 shows the results of good air quality environment from the air pollution monitoring system which were displayed and monitored through the Blynk application. There are three-gauge levels were displayed which were humidity, gas level and temperature. The data were displayed and updated after been detected by the sensors every one second. The reading of the gas level was 12 AQI and the gas gauge level was ranged from 0 to 1000.

![Image of Blynk application interface showing good air quality](image)

**Figure 14.** The air quality through Blynk application.

Fig. 15 shows the result of air pollution monitoring system were displayed and monitored through the Blynk application in hazardous air quality environment. The reading of the hazardous gas level was 400 AQI. Therefore, the Blynk application sent a notification as (“Hazardous gas detected”) to the users, as the hazardous gases were detected such as butane and carbon dioxide gases, immediately via a mobile phone application. There was no indicator setting at the gauge block diagram to set the gas level range compared to ThingSpeak application to differentiate between hazardous gases and no hazardous gases when detected.

This application was designed to achieve all the objectives, which are to detect the temperature, humidity and hazardous gases. It is very valuable to be recommended for building environment with the IoT system reliability. When hazardous gas is detected, the red LED was illuminated, and a notification was displayed through Blynk application via a mobile phone. It has the potential to be available in the market.
Figure 15. The hazardous air quality through Blynk application.

6. Conclusion
The IoT based air pollution monitoring system consists of Q-2 gas sensor, ESP8266 Wi-Fi module, and DHT22 temperature and humidity sensors is successfully designed. The air pollution was measured by the MQ-2 gas sensor and the DHT22 temperature sensor. The results showed that the AQI of less than 100 for good air quality and more than 200 AQI for the hazardous air quality are measured. Meanwhile, the green LED was illuminated under a good air quality while the red LED was illuminated to indicate hazardous gas. In addition, all data are able to be monitored in a real-time through ThingSpeak for every 15 seconds. Finally, the notification of hazardous gas is notified the users in a mobile phone app.

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