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Air Monitoring System for Smart Cities

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Abstract: Nitrogen, oxygen, carbon monoxide, and traces of several rare elements are all found in air. Humans require a contaminant-free environment in which to live. This is extremely important for human survival and health. Any change in the natural composition of air could endanger life on the planet. We can control any electrical equipment in homes and businesses using the Internet of Things (IOT). Users can read data from any sensor and analyze it graphically from anywhere in the world with this project. Using Arduino Uno, Wemos D1 R1 and LoRa, users can read the air quality data from the MQ135 air quality sensor and HPMA155S0 Particulate Matter sensor and upload it to a ThingSpeak cloud. Users will be able to read the data collect via the sensor using smart devices.

Keywords: Air, IOT, MQ135, ThingSpeak

1. Introduction

A smart city is one that maximizes its capabilities in a cost-effective and intelligent manner by combining all of its systems and administrations into a single entity and utilizing smart devices for monitoring and control to ensure supportability and effectiveness [1].

In such a metropolis, an effective air monitoring system is essential to ensure the quality of life and promote prosperity for people of all ages. According to the World Health Organization, 9 out of 10 people on the planet breathe air that contains dangerous particles that can cause health problems or even death, with an estimated 7 million people dying each year as a result of air pollution [2]. Pollution has serious health consequences, including stroke, lung cancer, and heart disease.

Furthermore, as evidenced by contemporary global air pollution problems such as ozone depletion, air pollutants have a harmful influence on humans and the earth's ecology.

Internet of Things (IOT) can manage any electrical appliance in homes and companies. IOT also may also examine data from any sensor and analyse it graphically from any location on the earth. Using Arduino Uno and LoRa, users can examine the air quality data from the MQ135[3] air quality sensor and send it to a cloud database. The MQ135 gas sensor feeds data into the air monitoring system, which

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is used to compute the concentrations of hazardous gases such carbon dioxide, carbon monoxide, and propane [5].

1.1 LoRa

LoRa 433 MHz module designed by AI-THINKER, which based on the chip SX1278. The SX1278 RF module is mainly used for long-range spread spectrum communication. It can resist Minimize current consumption. LoRa is a chirp spread range (CSS) innovation-based spread range regulating mechanism. LoRa devices and wireless radio frequency technology are a long-range, low-power wireless platform that has emerged as the de facto Internet of Things technology (IoT). LoRa SX1278 RA-02 is used to send the collected data from the sensor at transmitter circuit to the receiver circuit. LoRa SX1278 RA-02 has a high sensitivity of -148 dBm with a power output of +20 dBm. The LoRa SX1278 RA-02 can achieve 15-20 km communication.

2. Materials and Methods

2.1 Project flowchart

Throughout the project and development of the mobile application, the project flowchart as shown in Figure 1 (a) and (b) are used to represent the overall workflow of the development process.

Figure 1 (a) elaborates the flow of system at the transmitter side. First initial setting such as pin assignments must be done. Then the baud rate and frequency must be set according to the requirement of LoRa. Since system uses serial communication, it must check for the availability of serial pin. If serial pin is available, collect the data from sensor and broadcast the data and check for the gateway. If available, check for acknowledgement form the gateway. If acknowledgement is received successfully, then it indicates communication successful between the transmitter LoRa and receiver LoRa.

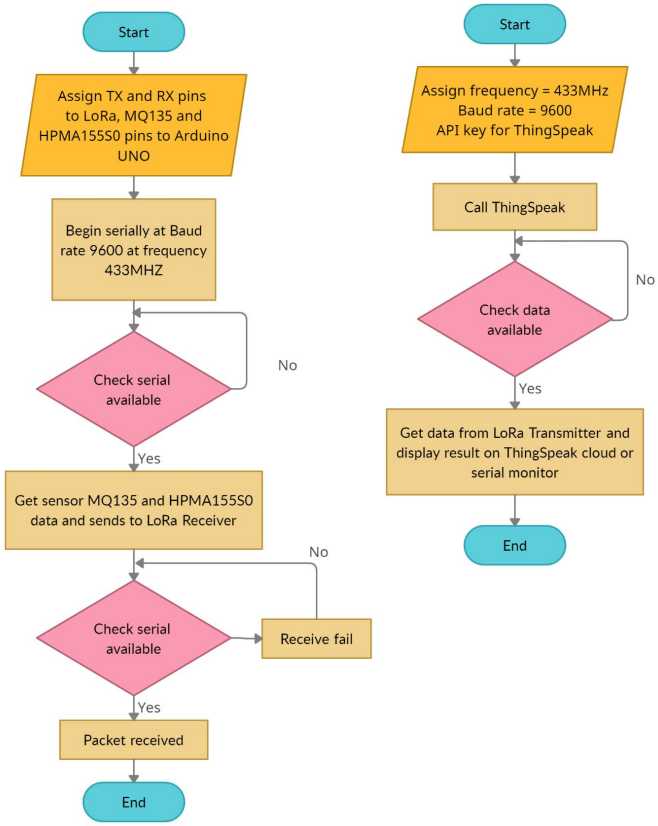

Figure 1: (a) Flowchart for transmitter; (b) Flowchart for receiver

Initially the baud rate and frequency have to be set with the API key obtain from the cloud account. Continuously check or the data at the set frequency. If available, get the data and display it on the cloud as well as on the serial monitor.

2.2 Hardware

I. Arduino UNO

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

II. Wemos D1 R1

WEMOS D1 is a WIFI development board based on ESP8266 12E. The functioning is similar to that of NODEMCU, except that the hardware is built resembling Arduino UNO. The D1 board can be configured to work on Arduino environment using BOARDS MANAGER.

III. MQ135 Gas Sensor

MQ135 Gas Sensor. Air quality click is suitable for detecting ammonia (NH3), nitrogen oxides (NOx) benzene, smoke, CO2 and other harmful or poisonous gases that impact air quality. The MQ-135 sensor unit has a sensor layer made of tin dioxide (SnO2), an inorganic compound which has lower conductivity in clean air than when polluting gases are present. To calibrate Air quality, use the on-board potentiometer to adjust the load resistance on the sensor circuit.

IV. HPMA155S0 Particulate Matter Sensor

HPMA115S0 is a HPM series PM2.5 particle sensor with UART output. The HPM series particle sensor is a laser-based sensor which uses light scattering method to detect and count particles in concentration range of 0μg/m3 to 1000 μg/m3 in an environment.

V. LoRa SX1278 RA-02

LoRA SX1278 RA-02 is a wireless transmission module-based on SEMTECH's SX1278 wireless transceiver. It can be covering thousands of people in the district environment, particularly suitable for meter reading, smart home, burglar alarm equipment

2.3 Software

i. Aduino IDE

Arduino IDE is an open-source software that is use to write code and upload to Arduino boards. This software can be use with any Arduino Board.

ii. Thing Speak

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts

2.4 Hardware Transmitter

Figure 9 and 10 is showing the front view and the top view of the Transmitter. At the front view have 3 holes for the MQ135 sensor, HPMA155S0 Particulate Matter sensor and the LoRa transmitter antenna.

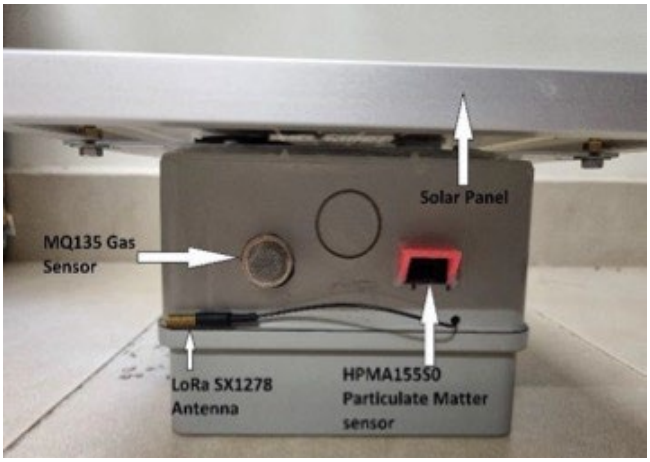

Figure 2: Front view of Transmitter

Figure 3: Top view of Transmitter

Figure 4 show the inside components of the transmitter circuit which consists of the microcontroller (Arduino UNO), the battery charger board, MQ135 sensor, HPMA155S0 sensor and the LoRa SX1278 transmitter module. All of the components are powered by the battery which is charged by the solar panel.

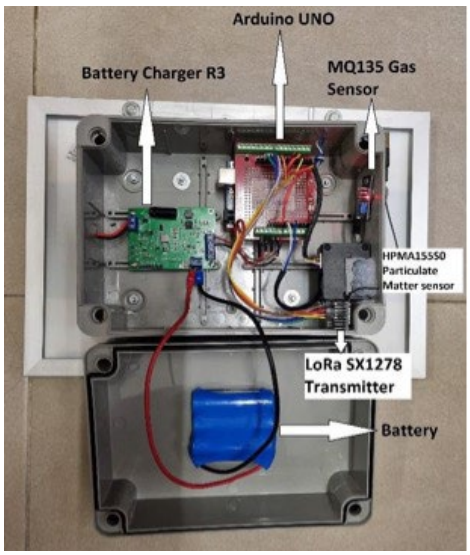

Figure 4: Inside view of Transmitter

2.5 Hardware receiver

Figure 5 and 6 is showing the top view and the inside view of the receiver. At the top view have a hole for the LoRa receiver antenna. Figure 6 shows the inside components of the receiver circuit which consists of the microcontroller (Arduino WMOS D1 R1 and the LoRa SX1278 receiver module. All of the components are powered by the USB connecter which will be connected to a 5V power supply.

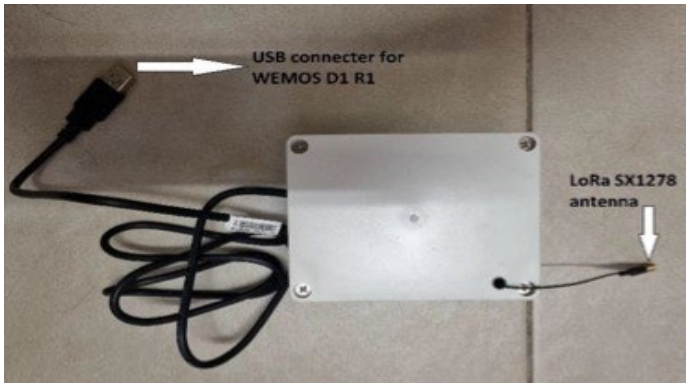

Figure 5: Top view of Receiver

Figure 6: Inside view of Receiver

2.6 Block Diagram

Figure 7 shows the sensors use in this project, which are MQ135 Gas Sensor and HoneyWell HPMA155S0 Particulate Matter sensor. The MQ135 sensor is a sensor which detect harmful gases such as carbon monoxide and carbon dioxide. This sensor comes with digital pin that makes this sensor to operate even without microcontroller. The MQ135 also have analog pin which is uses to measure PPM level of the air quality. The analog pin is TTL driven and works on 5V. The HoneyWell HPMA155S0 Particulate Matter sensor is a calibrated sensor with digital output via UART protocol. This sensor can determine PM2.5 and PM10 in concentration up to 1000 $\mu g/m^3$ with an accuracy of ±15.00 %.

The microcontrollers use in this project is Arduino UNO and Wemos D1 R1. The Arduino UNO is used to control the sensors and the transmitter LoRa SX1278. The MQ135 gas sensor is connected to the analog in pin and to the 5 V supply form the Arduino. The HoneyWell HPMA155S0 particulate matter sensor is connected to the TX and RX pin on the arduino and the supply for the sensor is connected to the V on the Arduino board.

The communication use in this project is the LoRa SX1278 RA-02 and the ESp8266 WiFi module (on Wemos D1 R1). The LoRa SX1278 RA-02 is used to send the collected data from the sensor at transmitter circuit to the receiver circuit. LoRa SX1278 RA-02 has a high sensitivity of -148 dBm

with a power output of +20dBm. The LoRa SX1278 RA-02 can achieve a distance of 15-20 km communication.

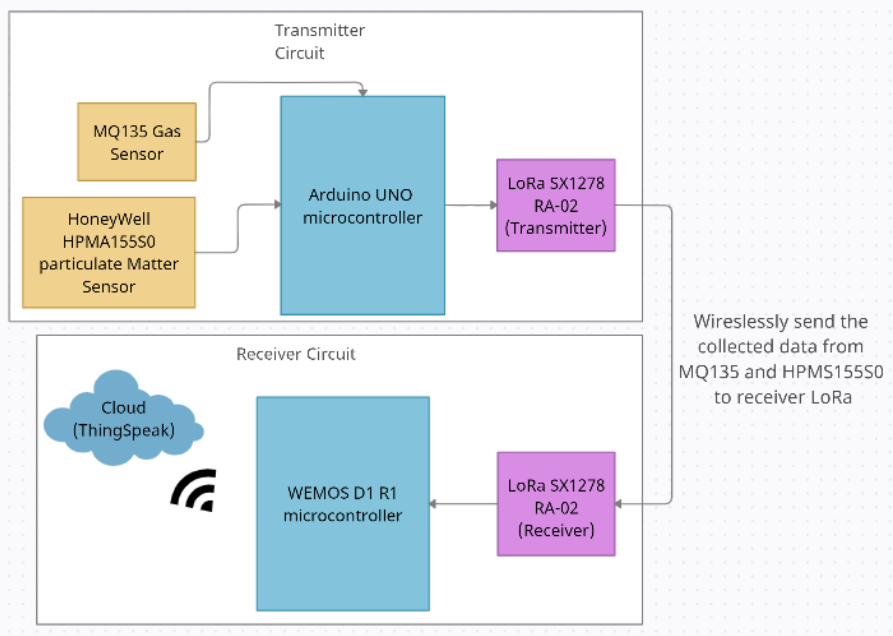

Figure 7: Block Diagram for Air Monitoring System

3. Results and Discussion

3.1 Normal condition

Referring to Figure 8,9 and 10, the graph shows the reading for MQ135 and HPMA155S0 sensors at normal condition. At normal condition the reading for MQ135 is between the range of 20-30 PPM. For the reading of HPMA155S0 sensor at normal condition is between the range of 2.00 - 11.00 for PM 2.5 and 3.00 – 13.00 form PM10.

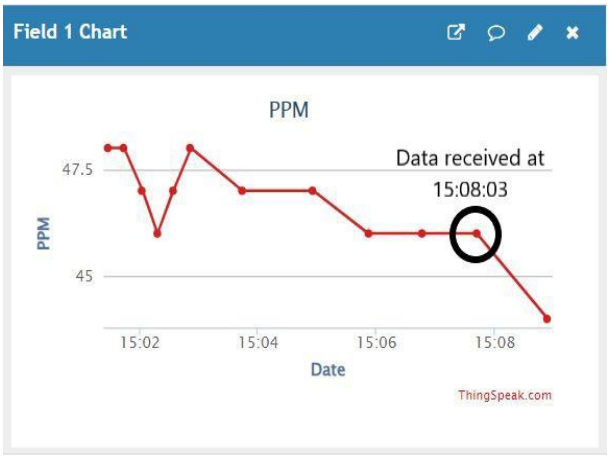

Figure 8: PPM reading for Normal Condition

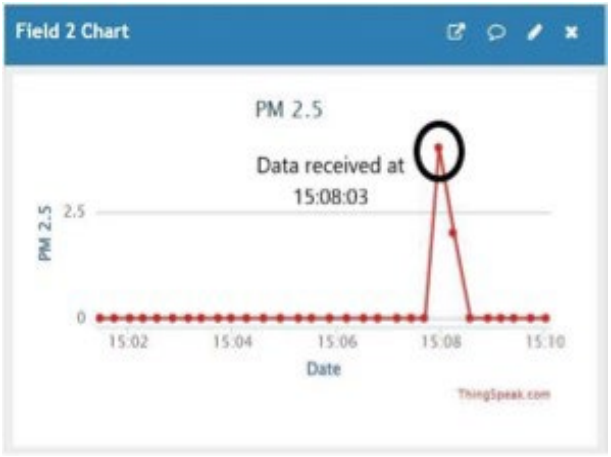

Figure 9: PM 2.5 reading for Normal Condition

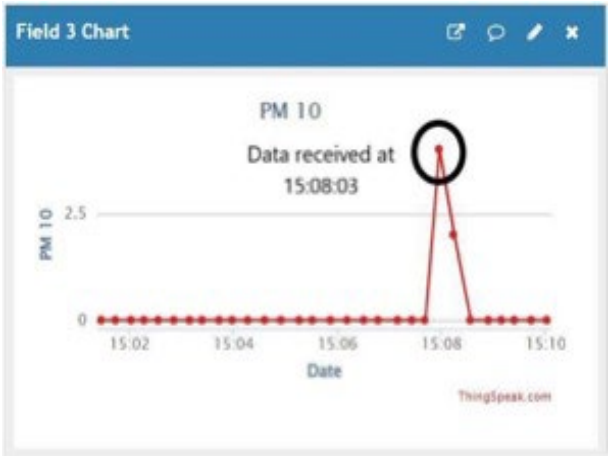

Figure 10: PM 10 reading for Normal Condition

3.2 Polluted condition

Referring to Figure 11, 12 and 13, the graph shows the reading for MQ135 and HPMA155S0 sensors at polluted condition. At polluted condition the reading for MQ135 is between the range of 53-63 PPM. For the reading of HPMA155S0 sensor at normal condition is between the range of 300.00 - 1000.00 for PM 2.5 and 305.00 – 1013.00 form PM10.

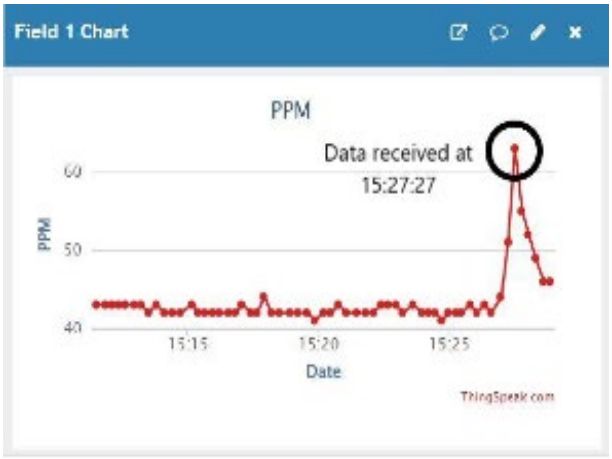

Figure 11: PPM reading for Polluted Condition

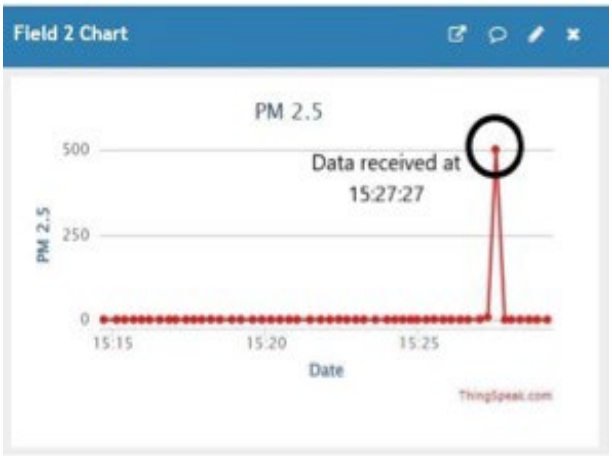

Figure 12: PM 2.5 reading for Polluted Condition

Figure 13: PM 10 reading for Polluted Condition

3.3. Comparison of Testing Result with API standards

Table 1 show the comparison between the Ambient Air Quality Standards and the result obtain from testing.

Table 1: Comparison of Standard with result

	National Ambient Air Quality Standards	Result
PPM	Good = 0-50 Moderate = 51-100 Unhealthy = 101-200 Very unhealthy = 201-300 Hazardous = 301-500	Normal condition = 20-30 Polluted condition = 53-63
PM 2.5	Good = 0-12.0 Moderate = 12.1-35.4 Unhealthy = 35.5-150.4 Very unhealthy = 150.5-250.4 Hazardous = < 250.5	Normal condition = 2.00-11.00 Polluted condition = 300.00-1000.00
PM 10	Good = 0-54.0 Moderate = 55.0-154.0 Unhealthy = 154.0-354.0 Very unhealthy = 354.0-424.0 Hazardous = < 425.0	Normal condition = 3.00-13.00 Polluted condition = 305.00-1013.00

4. Conclusion

The objective of the Air Quality Monitoring System for Smart Cities is achieved. The MQ135 sensor of Air Quality Monitoring System for Smart Cities is able to detect the PPI level of harmful gases. The LoRa is able to communicate and send the collected data from the sensor at the transmitter circuit to the receiver circuit. From the receiver circuit the data is send to ThingSpeak cloud via ESP8266 WEMOS module. The user can see the collected data using their smart devices.

Acknowledgement

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