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Ozone and Nitrogen Dioxide Pollutants Detection System Based on IoT

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A B S T R A C T

Air pollution is one of the main causes of health problem in urban areas. Vehicles are the major sources of the air pollution in urban cities. To prevent the air pollution situation from increasing, we have developed an advanced outdoor air quality measurement system using an ESP8266 microcontroller and senores. It can be placed at crowded automobile locations to monitor pollutants emitted from vehicles. Ozone gas (O_3) and nitrogen dioxide (NO_2) was measured in this study. The system provides continuous monitoring of vehicle air pollution with a high time accuracy.

Introduction

Ozone gas exists both in the earth's upper atmosphere and at the ground level. It may be good or bad, depending on where it is found. Ozone occurs naturally in the upper atmosphere, called stratospheric ozone; this is good ozone, where it is in the form of a protective layer from the sun's harmful ultraviolet rays. While ozone at ground level is a very harmful air pollutant, it affects people as well as the environment. The chemical reactions between air pollutants from vehicle exhaust and gasoline fumes and other emissions from fuel burning processes will result it. [1]

Nitrogen dioxide gas is a toxic and harmful gas, it results from the combustion of fuel at high temperatures, and can lead to eye and respiratory irritation, while exposure to it in the long term leads to heart, blood vessel and lung diseases. It also has a devastating effect on plants as it reduces their growth and leads to the fall of their leaves. [2] Therefore, there is a need for a dedicated system that can continuously monitor air pollutants from these harmful gases with a high time accuracy.

Internet of Things (IoT) is an open and comprehensive intelligent network, it has the ability to automatically organize and share data. It also assists in dealing with environmental changes and capable of providing a networked infrastructure for all physical items at any moment and connecting anything [3]. The IoT provides a unique identity to all its users. It is possible to say that it is a global network that connects people and things to each of them. IoT now is able to offer many solutions in different sectors, includes healthcare, safety, energy efficiency, comfort and more. [4]

Related Works

Alvear, O., and others in 2016 developed an Eco Sensor to monitor the air pollution. It is deployed with an Arduino platform, low-end sensors and raspberry pi device. Eco Sensor collects air pollution gases using an embedded sensor, then transfers the data to an android device. The levels of air pollution are displayed in ppm in real time. [5]

Gupta, K. and others in 2018 presented an automobile air pollution monitoring module. They detected the vehicles that their pollution emits greater than the standard limit. The data can analyse the sort of vehicle that major contributor of pollution and thus make proper strategies to tackle such vehicle problems. The sensor was arranged in a network form. The output data were passed to Arduino through the analog to digital converter and then passed to the raspberry pi which acts as a hub of information. [6]

Ibrahim, A. and Khidhir, A. in 2022 presented a compensation of inherent errors for the various sensor reading in the Arduino and ESP. They used MQ -135 air quality sensor. The voltages of the ESP and Arduino were measured with the sensor instantaneously, by dropping 6volt from a charged battery, and through a potentiometer; several different readings were obtained from the real voltages measured by voltmeter with the corresponding ESP and Arduino reading voltage. [7]

Mohammed, E. and others use the Internet of Things, they use a Photon; which is a Wi-Fi remote control development group; they monitored the performance of the power plant at the Mosul University. The power factor, supplied voltage and total load current were monitored for each substation within the university area. The system has implemented the safety feature to completely shut down the power station in case of fire, for example, or anything dangerous using thing speak. [8]

Jumaah, H. and others in 2021 proposed a UAV-based air quality monitoring system. Where the temperature, humidity and dust PM2.5 particles were monitored. The system included four sensors; a dust sensor DSM501A, a temperature and humidity sensor DHT11, NEO-6M GPS module and DS3231 real-time module. An Arduino Uno microcontroller is used with Arduino Uno IDE. The system also contains a memory to record data. The study showed that a portable system, in addition to being lightweight, can be used to collect remote sensing data reliably and accurately. [9]

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System Design

The ESP8266 model is used, which implements the IEEE 802.11 b/g/n network protocol. This microcontroller has a built-in Wi-Fi capability, so it is used as a communication and processing unit. MQ131 and MiCS-2714 sensors are connected to it. The system collects data through these sensors to monitor air pollution. This design involves both hardware and software components.

1- ESP8266 Microcontroller

ESP8266, shown in figure (1), is an open source platform. It can connect many objects and transfer data over the Wi-Fi protocol. The general characteristics of the ESP8266 are it is simple to use, it can function as an access point or station, it

has an internal antenna, and it contains 13 GPIO pins, 10 PWM channels, I2C, SPI, ADC, and UART. [10]

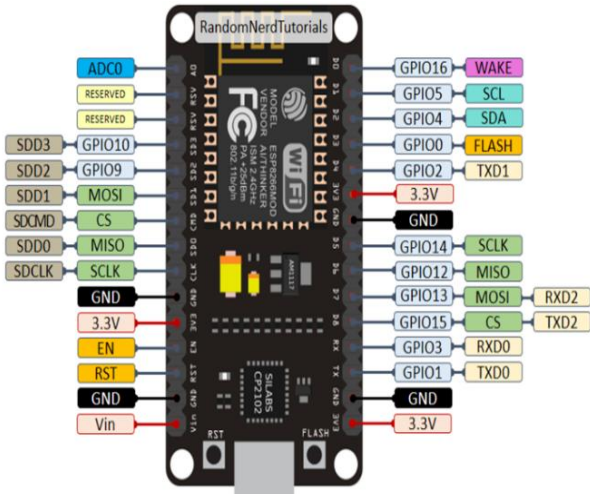

Figure (1) ESP8266 Model

2- MQ-131 Ozone Gas Sensor

The MQ-131 ozone gas sensor, shown in Figure (2), has a high sensitivity to ozone gas in a wide range, has a long life, low cost and simple drive circuit. When ozone gas is present, the conductivity of the sensor decreases as the gas concentration rises. The change of conductivity to match the output signal of the gas concentration can be converted through a simple circuit [11].

Figure (2) MQ131 Ozone Gas Sensor

The basic test circuit of the MQ-131 sensor is shown in Figure (3). This sensor requires two input voltages, circuit voltage (VC) and heater voltage (VH) that are used to supply the sensor with standard working temperature. It can depend on DC or AC power. Whereas VRL is the load resistance voltage (RL). VC provides detection voltage to RL and must adopt DC power.

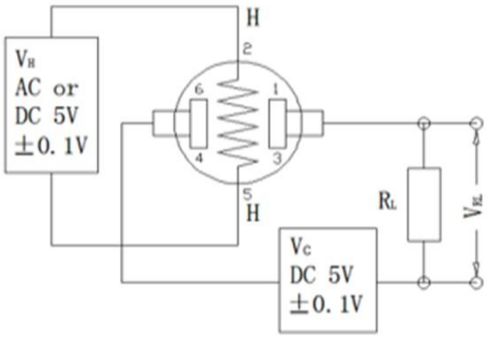

Figure (3) Basic Test Circuit of MQ-131 Sensor

3- MiCS-2714 Sensor

The MiCS-2714 sensor model, shown in Figure (4), has a single sensor chip and is equipped with an independent heater and sensitive layer. This sensor has a wide detection and temperature range, high sensitivity, short pre-heating time, and low heating current. The recommended operating mode is constant power on each sensor. The nominal power of the PH sensor is about (43) mW. The temperature generated by the sensing layer is (220°C) in the air at about 20°C. The pollution gases are detected by measuring the sensing resistance of the sensor. The resistance of the sensor increases in the presence of NO_2.[12]

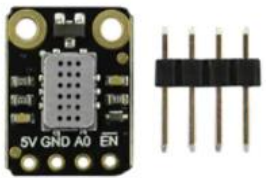

Figure (4) MiCS-2714 Sensor

System Implementation

The connection between MQ-131 sensor and the ESP8266 microcontroller is shown in figure (5). The VCC of the MQ-131 sensor is connect to the VCC of ESP8266, GND with GND, and the data pin of MQ-131 is connected to the D0 pin of the ESP8266.

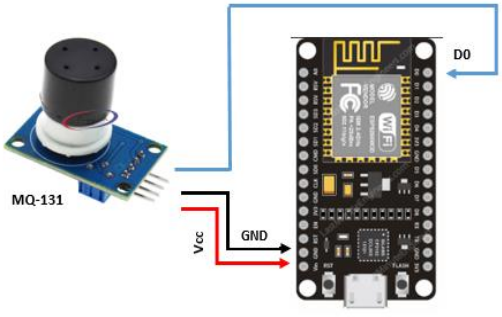

Figure (5) Connection between MQ-131 and ESP8266

MiCS-2714 sensor has four pins, EN witch is connecting to the D0 pin of the ESP8266, VCC to VCC, GND to GND, and the data pin of MiCS-2714 to the D5 of the ESP8266. Figure (6) declare the connection.

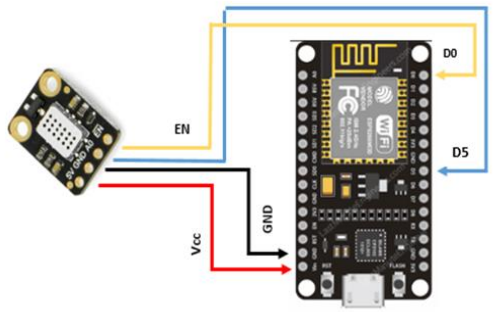

Figure (6): Connection between MiCS-2714 and ESP8266

Results

To test the effectiveness of the proposed system, a realistic experiment was conducted on one of a vehicle. The percentage of ozone gas (O_3) in a part per million (ppm) and a part per billion (ppb) was read. The amount of result ozone near the vehicle exhaust in a high temperature is shown in figure (7). While the amount of ozone in clean air is shown in figure (8).

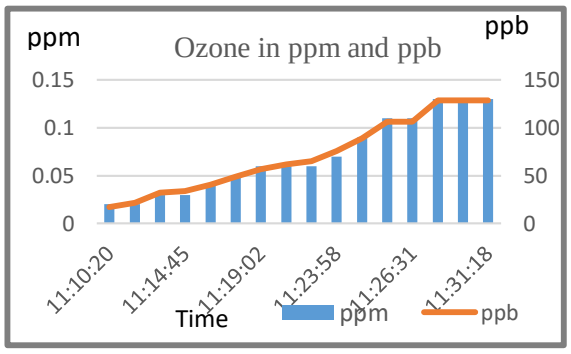

Figure (7) Ozone Level Near the Vehicle

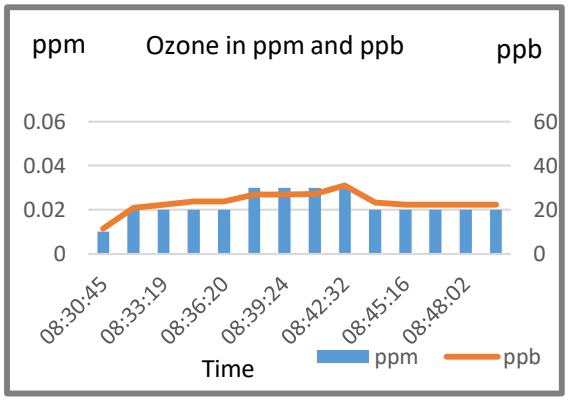

Figure (8) Ozone Level in a Clean Air

Also, the proportion of nitrogen dioxide (NO_2) gas was measured near a vehicle. The gas level in ppm was shown in Figure (9), while no amount of nitrogen dioxide was produced in the clean air.

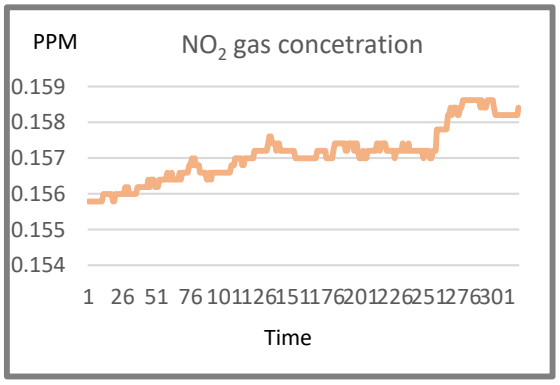

Figure (9) NO_2 Gas Level Near a Vehicle

Conclusions

Due to the danger of exposure to high levels of ozone (O_3) and nitrogen dioxide (NO_2) for a long time, and to avoid the harmful effects that result from exposure to these two gases, a real time monitoring system has been developed. This system records and monitors the amount of these harmful gases as a part per million (ppm). MQ-131 sensor was used to measure ozone gas. While MiCS-2714 sensor was used to measure nitrogen dioxide gas. These sensors were connected to the ESP8266 microcontroller, and its ppm was uploaded to an IoT platform through Wi-Fi. This system provides a low cost, low power and will help to make real-time efficacy in the event of air pollution.

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