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Design and Development of Low Power and Low Cost Air Quality Monitoring System through IoT

Saritha Chappidi[1], Suneetha Uppala[2], Ramanath V[3], Sukanya V[4]

[1,2,3]Department of ECE, SVIT, Anantapuramu, Andhra Pradesh, India.

[4]Department of Electronics, SSBN Degree College, Anantapuramu, Andhra Pradesh, India.

Abstract:

This paper presents the design and development of a cost-effective air quality monitoring system utilizing Internet of Things (IoT) technology. The system combines multiple components to deliver real-time data on various air pollutants and environmental conditions. Central to the design is the Node MCU microcontroller, which serves as the system's core processing unit and facilitates Wi-Fi connectivity for data transmission. The DHT22 sensor is employed for measuring temperature and humidity, while the MQ135 and MQ2 sensors are used to detect a range of gases including carbon dioxide, ammonia, and volatile organic compounds. Additionally, the PM10 sensor monitors particulate matter concentrations in the air. The system's design emphasizes affordability and accessibility, making it suitable for widespread use in both urban and rural settings. Data collected by the sensors is transmitted to a cloud platform (ThingSpeak) for analysis and visualization, enabling users to monitor air quality in real-time and make informed decisions. This IoT-based monitoring solution aims to provide a practical tool for improving air quality awareness and contributing to public health initiatives.

Key words: *Air Quality, Arduino IDE, Internet of Things (IoT), Node MCU, Thing Speak etc.*

1. Introduction

In today's environment, air pollution has increasingly dire consequences, significantly impacting both natural ecosystems and human health. The proliferation of industrial emissions, vehicle exhaust, and the burning of fossil fuels has led to elevated levels of pollutants such as particulate matter, nitrogen oxides, and volatile organic compounds. These contaminants contribute to smog formation, which not only reduces visibility but also exacerbates respiratory and cardiovascular diseases in populations. Moreover, air pollution accelerates climate change by increasing greenhouse gas concentrations, leading to more extreme weather events and altering global weather patterns. This environmental degradation disrupts agricultural productivity, threatens wildlife habitats, and intensifies the frequency and severity of natural disasters. As a result, addressing air pollution is critical for safeguarding public health, protecting ecosystems, and ensuring a sustainable future for all.

1.1. Problem Statement

To design and develop a low power and low cost air quality monitoring system through IoT and alerts the user.

1.2. Previous work

Previous work on air quality measurement systems has focused on expensive, power-hungry solutions that limit deployment. There is a gap in developing IoT-based systems that are both cost-effective and energy-efficient for broader use.

1.3. Purpose

The purpose of designing and developing a low-power, low-cost IoT-based air quality measurement system is to provide affordable, scalable, and real-time monitoring of air quality in various environments, enhancing accessibility and enabling proactive measures for public health and environmental management.

1.4. Contribution of the Paper

The proposed system is integrated with the cloud service ThinkSpeak.com, allowing for real-time monitoring of pollutant levels at specified time intervals. Data is stored in an XL sheet for future comparison, with updates occurring after each data collection. The final output includes a line graph that visualizes pollutant levels over time and alerts the user.

2. Block diagram of the proposed system and its working

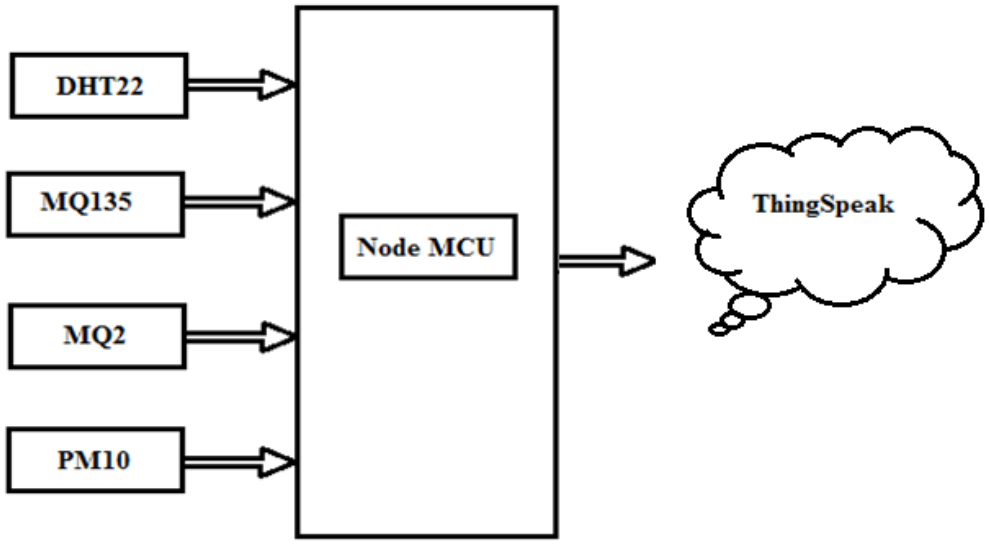


Fig. 1. Block diagram of the system

This paper aims to design and develop a low power and low cost air quality monitoring system through IoT by using NodeMCU as the central processing unit[1]. The speciality of NodeMCU is energy efficient and cost-effective. It operates in various power saving modes, which helps to reduce power consumption. This feature makes it suitable for battery powered and Internet of Things (IoT) applications. In this project NodeMCU is connected with DHT22 (Temperature and Humidity sensor), MQ135 (Air Quality sensor), MQ2 (LPG, Methane) and PM10 (Particulate Matter) sensors. All these sensor probes collect the various harmful gases

present in the air and give their output to the NodeMCU. NodeMCU process the sensed data and the resultant information is sent to the cloud (ThingSpeak) through its in-built Wi-Fi module[2]. ThingSpeak is a cloud service that stores sensor data, which is plotted as a line chart for each execution. The x-axis represents the time of execution, while the y-axis shows the pollution levels for each time slot, allowing users to view the resulting line graph in a browser. It can also send alerts to the user via messages regarding the status of air quality, providing real-time notifications when certain thresholds are met.

3. Hardware details

3.1. NodeMCU

Node MCU is an open-source development board based on the ESP8266 Wi-Fi module. It combines a microcontroller with integrated Wi-Fi, making it ideal for Internet of Things (IoT) projects. The board is compact, cost-effective, and can be programmed using the Arduino IDE or Lua script, offering ease of use for both beginners and advanced developers. Its low power consumption and extensive connectivity options make it suitable for a wide range of applications, from home automation to environmental monitoring.

3.2. DHT22

The DHT22 is a versatile digital sensor used for measuring temperature and humidity. It provides accurate readings over a broad range, with temperatures from -40°C to 80°C and humidity levels from 0% to 100% RH. The sensor delivers data via a single-wire digital interface, making it easy to integrate with microcontrollers like Arduino and NodeMCU. Its reliability and ease of use make it a popular choice for various environmental monitoring and automation applications.

3.3. MQ135

The MQ135 is a gas sensor used to detect a range of gases, including carbon dioxide (CO2), ammonia (NH3), benzene (C6H6), and smoke. It operates by measuring changes in resistance caused by the presence of these gases, providing analog output that correlates with gas concentration levels. The sensor is widely used in air quality monitoring systems and environmental sensing applications due to its sensitivity and ability to detect multiple gas types. Its versatility and affordability make it a popular choice for various projects requiring air quality measurement.

3.4. MQ2

The MQ2 is a gas sensor designed to detect a range of gases, including carbon monoxide (CO), methane (CH4), propane (C3H8), and smoke. It operates by measuring changes in resistance in its sensing material when exposed to these gases, providing an analog output proportional to their concentration. The MQ2 is commonly used in air quality monitoring systems, gas leakage detection, and safety applications due to its sensitivity, reliability, and affordability. Its versatility makes it suitable for various environmental and industrial applications.

3.5. PM10

PM10 represents particulate matter with diameters of 10 micrometers or less, which are small enough to be inhaled into the lungs. These particles include dust, pollen, and soot, and their presence in the air can have

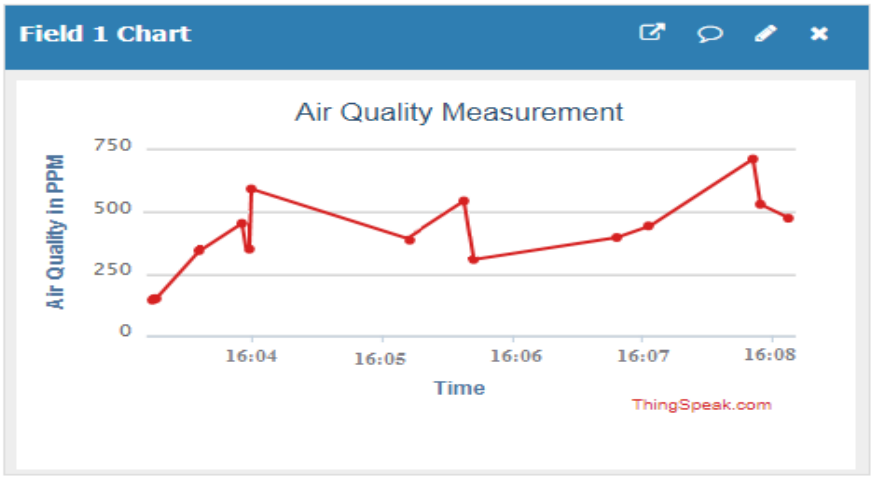
significant health impacts, particularly on respiratory and cardiovascular systems. Monitoring PM10 levels is essential for assessing air quality and managing pollution, as high concentrations are linked to various health problems and environmental concerns.

4. Software details (Arduino IDE with ThingSpeak)

The Arduino IDE is a powerful, open-source development environment used for writing and uploading code to Arduino and NodeMCU. When combined with ThingSpeak, it allows users to effortlessly send sensor data to the ThingSpeak cloud platform[3]. The integration is facilitated through the ThingSpeak library, which simplifies the process of connecting to and interacting with ThingSpeak's APIs. This setup enables real-time data monitoring and visualization, leveraging the IDE's user-friendly interface and extensive library support to streamline the development of IoT applications[4].

5. Results

The system successfully measured and transmitted temperature, humidity, and levels of various pollutants, including CO, SO2, and PM10, to ThingSpeak every minute. The data was visually represented in graphs on ThingSpeak, allowing users to easily track and analyze air quality trends. Additionally, the system provided timely alerts via messages when pollutant levels exceeded set thresholds, ensuring prompt user notifications and enhancing environmental monitoring.



6. Conclusion

The design and development of the low-power, low-cost air quality monitoring system featuring NodeMCU, DHT22, MQ135, MQ2, and PM10 sensors, along with ThingSpeak cloud integration, offers a practical solution for real-time air quality monitoring. The system's advantages include its affordability, energy efficiency, and the ability to provide comprehensive data visualization and instant notifications. However, it faces limitations such as potential sensor accuracy issues and reliance on stable internet connectivity. The system is well-suited for applications in urban air quality monitoring, indoor environment management, and personal health tracking. Future enhancements could focus on improving sensor precision, exploring alternative power sources, and

expanding functionality to monitor additional environmental parameters, thereby increasing the system's versatility and deployment potential.

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