Air Pollution Monitoring System Using Nova Pm2.5 SDS011 Sensor

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Abstract: **This paper presents a low-cost, scalable, and reliable air pollution monitoring system using Nova PM2.5 SDS011 sensor, MQ2 gas sensor, MQ7 gas sensor, and NodeMCU microcontroller. The system measures PM2.5 and PM10 concentrations, detects combustible gases and carbon monoxide, and displays real-time data via an IoT platform. The system effectively captures variations in particulate matter and gas concentrations.**

Index Terms- AIR POLLUTION MONITORING , PM 2.5 SENSOR, NOVA SDS011, NODE MCU,MQ2 GAS SENSOR ,MQ7 SENSOR

I. INTRODUCTION

Air pollution has become a serious worldwide concern, negatively affecting human health, environmental quality, and overall living standards. Exposure to pollutants like particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), and other hazardous gases is among the main factors contributing to respiratory and cardiovascular conditions, as indicated by the World Health Organization. Ongoing monitoring of air quality is essential in determining sources of pollution, estimating exposure levels, and facilitating prompt interventions [3], [11]. Despite this, traditional air monitoring stations, although very accurate and reliable, are expensive to install and maintain and have sparse spatial distribution. This makes the implementation of complete monitoring in both urban and rural regions difficult, especially in developing nations where resources are limited [3], [15]. Consequently, researchers have turned their efforts to the development of low-cost, portable, and distributable air quality monitoring systems based on low-cost sensors and IoT-based technologies [2], [4], [7], [12], [16].

Several studies have shown the viability of employing microcontroller boards like Arduino and NodeMCU, coupled with sensors like SDS011, MQ2, MQ7, and MQ135, to measure important air pollutants at a fraction of the expense of conventional systems [1], [6], [8], [13], [14], [17]. These systems have proved capable of particulate matter and toxic gas detection, providing the benefits of easy deployment, real-time data, and flexibility in different environments [9], [10], [18]. Cloud-based platforms and data analytics also improve remote accessibility, visualization, and storage of air quality information, allowing more effective public engagement and decision-making [5], [7], [16], [20].

In spite of these developments, low-cost sensors continue to suffer from calibration issues, measurement accuracy, sensor drift, and environmental sensitivity, which impact their long-term performance and reliability [3], [11], [15], [18]. Hence, ongoing validation and cross-comparison with reference-grade instruments are critical to maintain data quality and system reliability.

In this paper, we introduce the design and implementation of a low-cost, IoT-based air quality monitoring system utilizing low-cost sensors, cloud infrastructure, and wireless connectivity. The system is designed to offer real-time, accurate, and accessible air quality information to enable continuous monitoring and pollution management in various environments. Through overcoming existing limitations, the suggested system provides a cost-effective and scalable solution for improving air quality monitoring capabilities.

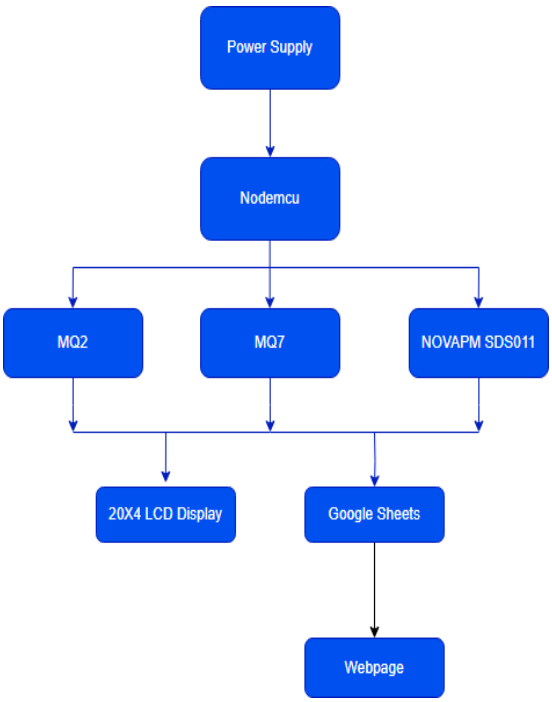
II. DESIGN PROCEDURE

The air quality monitoring system consolidates several environmental sensors into an IoT-capable microcontroller to support real-time, remote air quality monitoring. The system is based on the NodeMCU ESP8266, which was selected due to its onboard Wi-Fi capabilities, ease of programming,

and cloud platform compatibility. The Nova SDS011 sensor assesses particulate matter (PM2.5 and PM10) based on laser scattering technique, whereas the gas pollutants are measured through MQ-2 sensor (for smoke, LPG, and combustible gases) and MQ-7 sensor (for carbon monoxide). Both of these sensors are interfaced to the NodeMCU and, through the implementation of the time-sequential sampling strategy, reliable data measurements from all of these sensors will be ensured with no interference occurring.

Firmware is created with the Arduino IDE using libraries for communication with sensors and network operations. Sensor data are processed to scale raw outputs to meaningful units—PM levels in µg/m³ and gas levels in ppm. Processed data is packaged and sent via Wi-Fi to the Thingspeak cloud platform that offers real-time visualization and logging of data. An optional LED display offers in-situ pollutant level visualization.The system operates on a regulated 5V supply, taking into account sensor stability and thermal management. Routine fault detection and data validation ensure system reliability. The design as a whole is compact, low-cost, and scalable, appropriate for deployment in a variety of environments to effectively monitor important air pollutants.

BLOCK DIAGRAM:



III. IMPLEMENTED DESIGN

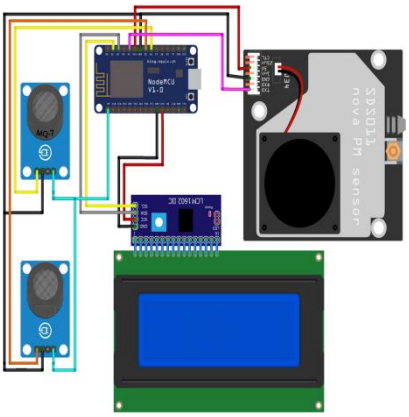


Fig 1.Hardware implementation setup

The designed air pollution monitoring system employs the Nova PM2.5 SDS011 sensor and MQ2 and MQ7 gas sensors, all connected to a NodeMCU microcontroller. The SDS011 detects PM2.5 and PM10 particles, MQ2 detects smoke and LPG, and MQ7 detects carbon monoxide. The NodeMCU reads the data and displays real-time air quality on an OLED and LCD screen.

The system offers precise air pollutant monitoring and can be extended for IoT purposes with Wi-Fi. The entire circuit diagram and code indicate how the sensors and displays are interfaced and how data is processed and displayed effectively.

The air pollution monitoring system features cloud integration for real-time remote access and data logging via Wi-Fi, enabling long-term analysis and alerts. Power-saving measures make it suitable for continuous outdoor use, while its modular design allows easy addition of sensors to enhance monitoring accuracy.

IV. RESULTS AND DISCUSSIONS

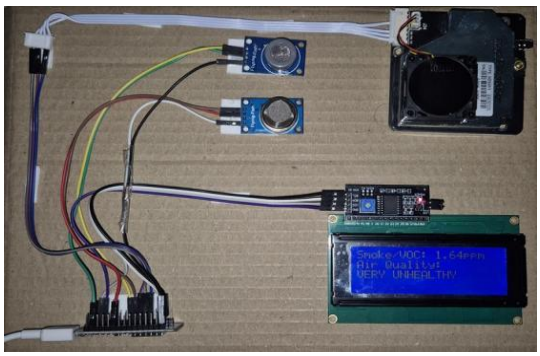


Fig 2.initializing and connecting wifi

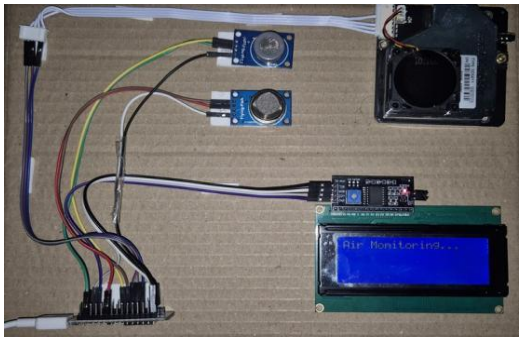


Fig 3. Displaying values and data uploaded

1. LCD Display (Offline Mode):
The 20x4 LCD indicates real-time readings of sensors if no internet is available. It indicates PM2.5 and PM10 particulate matter concentration from the SDS011 sensor and CO (Carbon Monoxide) and CH4 (Methane) gas concentration from the MQ7 and MQ2 sensors. Other information such as Smoke/VOC concentration is also indicated. It cycles through these readings every few seconds and notifies if any value exceeds safe levels, allowing users to have important air quality data at hand even without WiFi.

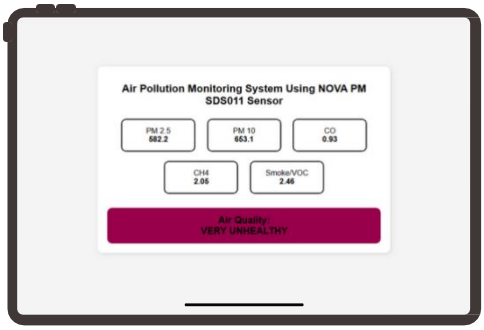


Fig 4.Desktop webpage monitorin

2. Webpage Monitoring (Live View):
The project also includes a live website with HTML, CSS, and JavaScript. It fetches data from Google Sheets and displays it dynamically. Every pollutant is displayed within a sensor box with real-time updates, color-coded based on severity. For instance, "GOOD" (green) if AQI is less than 50, or "UNHEALTHY" (red) if greater than 150, making it easy to visually understand even for non-technical users.

IV. CONCLUSION

This paper illustrates a low-cost, IoT-driven air pollution monitoring system that accurately senses PM2.5, PM10, carbon monoxide, and flammable gases through the SDS011, MQ-2, and MQ-7 sensors coupled with a NodeMCU microcontroller. Real-time data transfer and visualization are possible using cloud platforms, offering easy and reliable air quality data. Its modularity, scalability, and use of open-source solutions make it ideal for a variety of environments. Future development will center on broadening sensor capability, rolling out multi-node networks, and integrating predictive analytics to enhance air quality Monitoring and public health management.

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