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SMART AIR QUALITY INDEX

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ABSTRACT:

The Smart Air Quality Index (SAQI) is an innovative IoT-based system designed to provide real-time monitoring and visualization of air quality data. Equipped with advanced sensors, SAQI measures key environmental parameters such as carbon monoxide (CO),methane,dust-particles, ozone levels, temperature, and humidity, using a DHT11 sensor. This data is processed to calculate an Air Quality Index (AQI), which is displayed on an LED board for easy accessibility and immediate awareness.

The system also features an alert mechanism that notifies users during adverse air quality conditions, ensuring timely actions can be taken to mitigate health risks. Additionally, SAQI incorporates predictive modeling to forecast pollution trends, enabling authorities and citizens to adopt proactive measures for environmental and public health safety.

Keywords: Smart Air Quality Index (SAQI), IoT Air Quality Monitoring, Real-Time Air Pollution Monitoring, Carbon Monoxide Sensor (CO), Methane Sensor, Dust Sensor, Ozone Sensor, DHT11 Sensor (Temperature and Humidity), LED Display Board, Predictive Analytics, Environmental Monitoring, Public Health Awareness, Smart City Infrastructure.

I. INTRODUCTION

Air pollution is one of the most critical environmental challenges affecting human health and ecosystem balance. With rapid urbanization, industrialization,and increasing vehicular emissions, air quality has significantly deteriorated, leading to severe health risks such as respiratory diseases, cardiovascular problems, and environmental degradation.

The Air Quality Index (AQI) is a standardized measure used to assess air pollution levels based on key environmental parameters. Traditional air quality monitoring systems are often expensive, stationary, and not accessible for localized monitoring. To address these limitations, this paper presents a Smart Air Quality Index (SAQI) system, which provides real-time air quality data using an Arduino Uno and various environmental sensors, an LED display board, and a GSM 900A module for remote alerts.

The system continuously measures temperature, humidity, carbon monoxide (CO), particulate matter (PM10 & PM2.5), methane (CH_4), and ozone (O_3) to evaluate air quality. The collected data is displayed on an LED board for easy visibility, while the GSM module sends automated SMS alerts to a predefined phone number when pollutant levels exceed safety thresholds. This enables timely responses and preventive actions, making it ideal for smart city applications, industrial areas, and residential monitoring.

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II. LITERATURE SURVEY: SMART AIR QUALITY INDEX (SAQI) SYSTEM:

1) Air Quality Index A Comparative Study for Assessing the Status of Air Quality:

Shivam et al carried out a comparative study, wherein the various formulas and methodologies used in the computation of AQI were assessed. The study included an analysis of five different techniques to determine the most precise calculation methodology to provide accurate results for further scrutinization.

2) Forecasting of Air Quality in Delhi Using

Principal Component Regression Technique: Anikender et al proposed a forecasting model to predict the AQI value which implemented the technique of Multiple Linear Regression and Principal Component Regression model. This research model included the usage of the past days' AQI values. These values were computed using the EPA, 1999 formula.

3) A Review on Air Quality Indexing System:

Kanchan et al calculated and compared AQI values. The AQI value is defined with respect to five main air pollutants: carbon monoxide (CO), ozone (O3), Sulphur dioxide (SO2), nitrogen dioxide (NO2), and particulate matter (PM10 and PM2.5)[6]. The major differences among these indices were aggregation function, type of pollutants, number of index classes (and their associated colors) and related descriptive terms.

4) Impact Analysis of Air Pollutants on the Air Quality Index in Jinan Winter:

Song studied the effect of air pollutants on the Air Quality Index by using correlation analysis and path analysis. The correlation values revealed the direct effect of pollutants on AQI with a positive value indicating a direct proportionality and a negative value representing indirect proportionality. The path analysis revealed a more in-depth dependency of AQI on the pollutants by giving both the direct and the indirect dependency (ie; changes in concentration due to other pollutants' concentration).

5) A Comparative Study of Air Quality Index Based on Factor Analysis and US-EPA Methods for an Urban Environment:

Bishoi et al posited the EPA method for the computation of AQI (EPAQI). This technique involved the calculation other index value for each pollutant (SO2, NO2, carbon monoxide, Ozone, Particulate Matter). The EPAQI was then evaluated by determining the maximum index value of the single pollutant which provided a rough estimate of the impact on the quality of air on human health. Furthermore, the research involved the Factor Analysis method to calculate the New AQI (NAQI) encompassing the Principal Component Analysis (PCA) [3], which was used to ascertain whether their quality has worsened or improved over the months.

III. BLOCK DIAGRAM & COMPONENTS:

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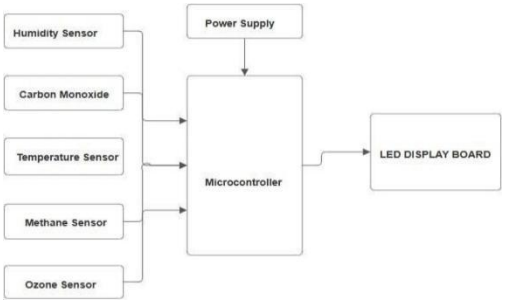

Fig.No.1.Block Diagram

To achieve real-time air quality monitoring and alerting, the Smart Air Quality Index (SAQI) system is designed using Arduino Uno, environmental sensors, an LED display, and a GSM 900A module. This section provides an in- depth overview of the key system components and their functions.

i. Parameters Measured

The system continuously tracks critical air quality indicators:

- Temperature& Humidity(DHT11/DHT22)
  - Affects the dispersion of pollutants and human comfort levels.
- Carbon Monoxide(CO)(MQ-3 Sensor)
  - A toxic gas produced by vehicle emissions and combustion processes.
- Particulate Matter (PM10 & PM2.5) (PMS5003 Sensor)
  - Fine airborne particles that pose severe respiratory health risks.
- Methane (CH_4) (MQ-6 Sensor)
  - A greenhouse gas from landfills, agriculture, and industrial activities.
- Ozone (O_3) (MQ-131 Sensor)
  - A pollutant harmful to human lungs, formed due to chemical reactions in the atmosphere.

Each of these pollutants is measured and compared against predefined safety thresholds to determine the overall air quality status.

ii. Hardware Components

The SAQI system consists of the following key components:

- Arduino Uno:The microcontroller processes sensor data and controls the LED display and GSM module.
- Air Quality Sensors: Detect environmental parameters and send data to the Arduino.
- LED Display: Shows real-time air quality readings, making the information easily accessible.
- GSM 900A Module: Sends SMS alerts when pollution levels exceed safe limits.
- Power Supply: A 5V-12V power source ensures continuous operation of the system.

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These components work together to provide an effi

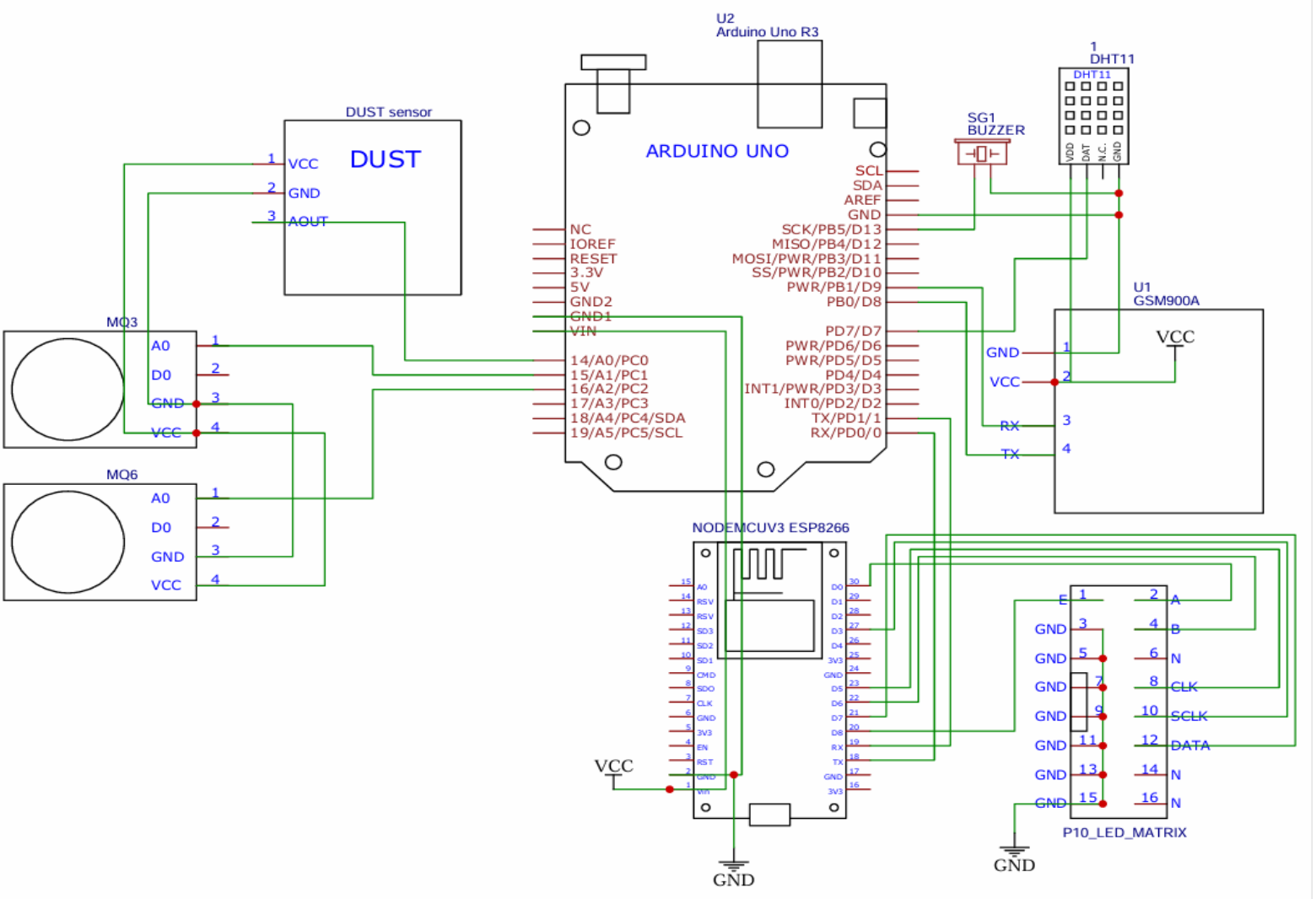

Fig.No.2.Schematic Diagram

cient and cost-effective solution for air quality monitoring.

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IV. METHODOLOGIES

The SAQI system collects data from a variety of sensors to measure specific air pollutants and environmental conditions. Each sensor's raw output is processed and transformed to calculate a real-time Air Quality Index (AQI) that represents the overall air quality.

1. Carbon Monoxide (CO) Sensor:-

A Carbon Monoxide (CO) sensor is a device used to detect the concentration of CO gas in the air. CO is a colorless, odorless, and highly toxic gas produced by incomplete combustion of carbon-based fuels. These sensors play a critical role in safety and environmental monitoring systems.

Applications:-

a) Safety and Security:

b) CO alarms and detectors in homes and workplaces.

c) Monitoring in parking garages, tunnels, and confined spaces.

d) Environmental Monitoring:

e) Smart air quality systems (e.g., your project).

f) Urban air pollution monitoring.

g) Industrial Applications:

h) Combustion process control.

i) Gas leak detection in manufacturing plants.

j) Automotive:

k) Monitoring emissions from vehicle exhaust systems.

Fig.No.3.MQ-3(CO) Sensor

2. Humidity and Temperature Sensor:

Humidity and Temperature Sensors are devices used to measure the moisture content in the air (humidity) and ambient temperature. These sensors are essential in air quality monitoring as humidity and temperature influence the behavior of air pollutants and the accuracy of gas sensors.

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The DHT11 sensor is a basic, low-cost digital sensor used to measure temperature and humidity. It is widely used in hobbyist projects and simple applications due to its affordability and ease of use.

Fig.No.4.DHT-11 Sensor

3. Dust Sensor:

A dust sensor is an electronic device designed to measure the concentration of dust and particulate matter (PM) in the air. These sensors are widely used in air quality monitoring systems, industrial automation, and environmental monitoring.

Fig.No.5.DUST SENSOR

Organizations like the World Health Organization (WHO) and Environmental Protection Agency (EPA) provide guidelines:

PM2.5:

Annual average: ≤10 µg/m³ (WHO) or ≤12 µg/m³ (EPA).

24-hour average: ≤25 µg/m³ (WHO) or ≤35 µg/m³ (EPA).

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PM10:
Annual average: ≤20 µg/m³ (WHO) or ≤50 µg/m³ (EPA).

24-hour average: ≤50 µg/m³ (WHO) or ≤150 µg/m³ (EPA).

4. Ozone Sensor:

An ozone (O_3) sensor is a device used to detect the concentration of ozone gas in the air. Ozone is a reactive gas that occurs naturally in the Earth's stratosphere (the ozone layer) but is also found at ground level, where it can be harmful to human health and the environment, especially when produced by pollution.

Low-cost, sensitive to ozone concentrations. Operates in the range of 10 ppb to 1000 ppb. Simple to interface with microcontrollers like Arduino.
Ozone sensors are critical for monitoring air quality and ensuring safety in both indoor and outdoor environments.

Fig.No.6.MQ-6(Methane) Sensor

They provide valuable
data about harmful levels of ozone that can affect health and contribute to air pollution.

V. Working of the Smart AQI System:

The Smart Air Quality Index (SAQI) system operates by continuously collecting environmental data, processing it, and displaying real-time air quality readings on an LED board while sending SMS alerts via the GSM 900A module when pollution levels exceed predefined thresholds. The working process can be divided into the following steps:

- **Data Collection**
  - The system uses multiple sensors to measure temperature, humidity, CO, PM10 & PM2.5, methane, and ozone at regular intervals.
  - These sensors are interfaced with the Arduino which reads the raw data from each sensor.
- **Data Processing & AQI Calculation**
  - The Arduino Uno processes the raw sensor data and converts it into meaningful values based on standard Air Quality Index (AQI) calculations.
  - Each pollutant's measured value is compared against predefined threshold limits to determine the severity of pollution.
- **Displaying Data on LED Board**
  - The processed data is sent to the LED display, which continuously updates and shows the latest air quality

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readings.

- The display ensures that nearby individuals can visually check the air quality in real time.

- **Threshold Detection & SMS Alerts via GSM 900A**
  - If any pollutant exceeds its predefined safety threshold, the Arduino triggers an alert system.
  - The GSM 900A module sends an SMS notification to a predefined phone number, warning about the pollution level.
  - This feature enables remote monitoring and timely action.
- **User Notification & Response**
  - The system ensures that both local and remote users stay informed about air quality conditions.
  - Based on the received alerts, authorities, industrial workers, or individuals can take preventive measures such as wearing masks, improving ventilation, or reducing emissions.
- **Power Supply & System Connectivity**
  - The system is powered by a 5V-12V power source, ensuring stable operation.
  - The Arduino Uno communicates with sensors and peripherals via digital and analog interfaces.

VI. CONCLUSION:

The Smart Air Quality Index (AQI) project effectively combines simplicity, cost- efficiency, and reliability to provide real-time air quality monitoring and timely alerts. By leveraging sensors, LCD displays, and GSM technology, the system eliminates the dependence on cloud infrastructure, making it suitable for a wide range of environments, including areas with limited connectivity.

This project not only raises awareness of air pollution but also empowers users to take immediate action to protect their health. Its offline capabilities, user-friendly design, and focus on practical implementation ensure that it serves as a valuable tool for improving environmental awareness and promoting healthier lifestyles.

Fig.No.7.Assembling Of Components

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Fig.No.8.Components Used

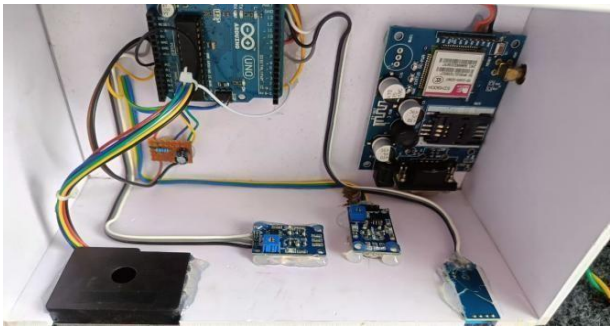

Fig.No.9.PROJECT PHOTO

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