



Smart Air Pro

¹R. Vasantha, ²SK. Chan Basaha, ³P. Tejaswi, ⁴K. Akhila

B.Tech Student, Dept. of EEE, Sir C R Reddy College of Engineering, Eluru, India¹ Associate Professor, Dept. of EEE, Sir C R Reddy College of Engineering, Eluru, India² B.Tech Student, Dept. of EEE, Sir C R Reddy College of Engineering, Eluru, India³

B.Tech Student, Dept. of EEE, Sir C R Reddy College of Engineering, Eluru, India⁴



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ABSTRACT: The issue of air pollution is a significant problem in the cities like the roadside schools and colleges, offices near the industrial areas, residential neighborhoods near the factories and in places of high traffic. The lack of ventilation and constant human presence in these areas contribute to the presence of pollutants, dust, and harmful gases, creating poor living conditions, and health issues (such as respiratory diseases) in vulnerable populations, including children and the elderly. To solve this problem, it is suggested to consider the SMART AIR PRO (SAP) system as an environmentally-friendly air quality monitoring and purification system. The system consists of a transmitter unit that comprises of Arduino Nano, AHT10 temperature and humidity sensor, ZP07- MP503 air quality sensor, HEPA filter, DC fan, and LCD display, and a receiver unit that has a matrix display. The sensors constantly check the temperature, humidity, and harmful gases, and the system automatically cuts purification into action in case of an increase in the level of pollution. It also transmits the real time air quality status (clean, moderate, or poor) to the recipient to monitor the situation easily. In general, SMART AIR PRO is a viable and sustainable solution that could be implemented to enhance the quality of the air and create a healthier environment both at home, school, workplace, and industrial territories.

KEYWORDS: Air Quality Monitoring, Transmitter Unit, Receiver Unit, Environmental Sensors, Gas Detection Sensor, HEPA Filtration Technology, Real-Time Data Monitoring, Automatic Control System, Air Purification Mechanism, Environmental Parameter Monitoring, Sensor Data Acquisition, Digital Display Interface

I.INTRODUCTION

[1] This paper introduces an IoT-based air quality monitoring device that is aimed at monitoring the environmental parameters, including the concentration of gases, temperature, and humidity in real-time. The system employs sensors attached to a microcontroller to gather atmospheric data and send the data to an online platform. This allows users to check the air quality remotely and get alerts when the pollution is above safe levels. The study emphasizes the relevance of inexpensive IoT technology in monitoring the environment. [2] The authors created an air pollution sensors and air purification system combining sensing and purification technologies and based on IoT. The system constantly monitors pollution and can automatically turn on an air purifier when the level of pollution is above a certain point. IoT platforms are also used to transmit data in order to remotely monitor and analyze the data. This combined solution is effective in enhancing indoor air quality. [3] The present paper is devoted to enhancing the indoor air quality of smart homes with the help of an intelligent electrical device. The system proposed identifies the environmental conditions and automatically regulates air purification according to sensor readings. It shows how technologies of smart homes can help to build healthier living conditions by ensuring the right amount of air quality. Automation and energy efficiency is also a priority in the system. [4] The study suggests a smart air cleaner with a



system of air quality monitoring. The purifier is automatically triggered when pollutants and environmental conditions are detected by sensors and the purifier turns on. The system will offer real-time visualization of data and enhance the conditions in the indoor air. The research points out the practicality of intelligent purification systems in the city. [5] This project proposes a solar powered air purifier with an air quality monitoring system. The system is energy efficient as it utilizes renewable solar energy to operate sensors and purification components, and is therefore environmentally friendly. The real-time air quality monitoring will enable the purifier to be turned on and used when needed. The study advocates the sustainable remedies of pollution. [6] This survey paper gives a detailed description of wireless sensor networks (WSNs). It also talks about network architecture and communication protocols as well as uses of sensor networks in environmental monitoring. The article emphasizes the ability of distributed sensors to acquire real-time data about the environment in an efficient way. It is a reference point of numerous IoT-based monitoring systems. [7] The authors offered a low cost IoT-based air quality monitoring system to detect pollutants in the environment. The system consists of low-cost sensors and microcontrollers, which gather air quality data and send them to a Web server. This will allow users to keep track of the pollution levels. The design focuses on being cheap and easily accessible to enable extensive environmental monitoring. [8] The paper introduces an IoT-based air quality monitoring system with cloud computing. The sensor data is sent to cloud platforms where it can be stored, processed and visualized. The system enables users to retrieve environmental data wherever they are through the internet. The study reveals the benefits of cloud technology in making data more accessible and analyzed. [9] This paper presents the Internet of Things (IoT) and how it is applied in the creation of smart cities. It describes how networked sensors and devices could be used to measure the environmental aspects of air quality, traffic, and energy consumption. The paper emphasizes on the significance of IoT in enhancing life in urban areas. It also talks of the issues of scalability and communication networks. [10] The authors suggested the U-Air framework that relies on big data analytics to predict urban air quality. The system uses sensor data, meteorological and machine learning to predict the level of pollution. It can give the correct predictions of air quality even in locations with no direct monitoring stations. The study shows the strength of the data-driven environmental surveillance. [11] The following paper will describe a smart city-based air quality monitoring system that is built on the IoT. The system gathers pollution data using the distributed sensors and sends this data to a central monitoring platform. Real-time analysis is useful in keeping authorities up-to-date with the environmental conditions. The paper shines light on the use of the IoT technology in massive environmental monitoring. [12] The proposed research is an air quality monitoring system in real-time based on wireless sensor networks. Several sensor nodes are used to gather environmental data and send it wirelessly to a central station. The system allows a constant monitoring of the level of air pollution in various places. It shows the effectiveness of WSN technology in sensing the environment.

Table 1.1: Literature survey of some of the existing work :

Sl.No	Author Name	Description	Methodology	Key Findings
1	Selvakumar S., Hemalatha	Proposed an IoT-based air quality monitoring system for real-time pollution tracking.	Sensors connected to microcontroller with IoT data transmission.	Provides real-time monitoring and alerts for unhealthy air conditions.
2	A. Manisekaran, L. S. Kumar	Developed an IoT-enabled air pollution monitoring and purifier system.	Sensors detect pollutants and automatically trigger purification.	Improved indoor air quality using automated purification.



3	A. Ş. Pica, V. Dulea	Smart home device designed to improve indoor air quality.	Intelligent sensors with automated device control.	Demonstrates efficient air management in smart home environments.
4	D. Panicker	Smart air purifier integrated with air quality monitoring.	Environmental sensors purifier control operation.	Automatic purification improves indoor air conditions.
5	S. N. Ahamed et al.	Solar powered air purifier with monitoring system.	Solar energy powers sensors and purifier system.	Provides sustainable and energy-efficient air purification.
6	I. F. Akyildiz et al.	Survey on wireless sensor networks for monitoring applications.	Analysis of WSN architectures and communication protocols.	Shows WSN suitability for environmental monitoring systems.
7	N. Kumar, M. P. Singh	Low-cost IoT air quality monitoring system.	Affordable sensors and IoT connectivity.	Cost-effective solution for pollution monitoring.
8	S. Kumar, A. Jasuja, R. Gupta	IoT air monitoring integrated with cloud computing.	Sensor data uploaded to cloud servers for analysis.	Enables remote monitoring and large data storage.
9	M. Zanella et al.	IoT applications for smart cities including environmental monitoring.	Networked sensors integrated with smart city infrastructure.	IoT improves urban environmental monitoring efficiency.
10	Y. Zheng, F. Liu, H.-P. Hsieh	Urban air quality inference using big data analytics.	Combines sensor data with machine learning algorithms.	Predicts pollution levels even without direct sensors.
11	J. Lee, H. Kim, S. Lee	IoT-based air monitoring system for smart cities.	Distributed sensors with centralized monitoring platform.	Enables large-scale urban pollution monitoring.



12	P. Spachos, K. Plataniotis	Real-time air monitoring using wireless sensor networks.	Multiple sensor nodes transmit environmental data wirelessly.	Efficient real-time monitoring across wide areas.
13	T. Mukherjee, S. Gupta	Smart IoT-based pollution monitoring system.	Microcontroller with gas sensors and internet connectivity.	Enables real-time environmental pollution detection.
14	S. Devarakonda et al.	Mobile sensing for real-time metropolitan air monitoring.	Uses mobile devices and sensors for pollution data collection.	Provides large-scale urban pollution data coverage.
15	A. Kumar, I. P. Singh, S. K. Sud	Energy-efficient air monitoring using wireless sensor networks.	Low-power sensor nodes and optimized communication.	Reduces energy consumption in environmental monitoring.
16	H. Hasenfratz, O. Saukh, L. Thiele	Smartphone-based participatory air pollution monitoring.	Uses smartphone sensors and crowd-sourced data collection.	Enables large-scale community participation in monitoring.
17	M. Mead et al.	Study on electrochemical sensors for urban air monitoring.	Low-cost sensor networks deployed in cities.	Demonstrates accurate pollution measurement using low-cost sensors.
18	A. Al-Ali, I. Zualkernan, F. Aloul	Mobile GPRS-based air pollution monitoring system.	Sensor array connected with GPRS communication module.	Allows remote monitoring of pollution levels via wireless networks.
19	S. Abraham, X. Li	Wireless sensor network for indoor air quality monitoring.	Distributed sensor nodes collect and transmit indoor data.	Provides cost-effective indoor environmental monitoring.



20	K. Dutta, S. Chowdhury, A. Roy	Arduino-based IoT air quality monitoring system.	Sensors connected to Arduino with IoT communication.	Provides low-cost real-time monitoring solution.
21	R. Kumar, M. Kumar	Design and implementation of IoT pollution monitoring system.	Microcontroller-based sensors with internet data upload.	Enables remote environmental monitoring.
22	S. Bhattacharya, A. Sridevi, S. Pitchiah	Indoor air quality monitoring using WSN technology.	Wireless sensor nodes deployed inside buildings.	Improves indoor environmental monitoring accuracy.
23	J. Li, J. Sun, Q. Li	IoT-based air monitoring and forecasting system.	Combines sensors with predictive analytics models.	Helps forecast future pollution levels.



24	M. H. Rehmani et al.	Survey on communication networks for smart systems.	Analysis of software-defined networking in smart grids.	Provides insights for efficient data communication in IoT systems.
25	L. Yu, J. Wang, K. Chen	Air monitoring system based on wireless sensor networks.	Sensor nodes deployed for environmental data collection.	Demonstrates reliable large-scale pollution monitoring.

II. PROBLEM STATEMENT

The toxic gases, dust, and particulate matter are increasing air pollution in urban areas and even in the villages as a result of increased use of transportation and impacts air conditioning with other mode of operation like factories, schools and offices. The lack of fresh air and circulation leads to increased exposure to these dangerous factors. Long-term exposure to polluted air not only leads to breathing diseases but also to the suppression of the protective system of the whole body, particularly in predisposed populations. The existing solutions usually do not possess the two-fold ability of purification and constant monitoring of the environment. To guarantee the better quality of air and secure people in highly populated regions, a sustainable and intelligent system is most needed.

III. METHODOLOGY

The Smart Air Pro system will be created to detect changes in air quality and temperature and humidity and issue warnings and control ventilation under the influence of a higher level of pollution. The system consists of two major parts; transmitter part and receiver part. Environmental data are gathered in the transmitter area through sensors and analyzed by an Arduino Nano microcontroller. This digitized information is then shown locally and also transmitted to receiver part via serial communication.

Two sensors are employed in the transmitter side to measure the environmental conditions. The ZP07-MP503 air sensor is a device that measures the amount of air pollution and harmful gases within the local area. Meanwhile, AHT10 Temperature and Humidity Sensor measures the temperature and humidity of the air. These sensors constantly provide their readings to the Arduino Nano which interprets the data and decides whether the air quality is clean or contaminated. The sensor data is processed and the Arduino Nano transmits the data to various output devices. The real time values of air quality, temperature and humidity are displayed on a 16×2 LCD monitor so that the user can easily monitor the environment. The system also has a buzzer that sounds an alarm to alert when the pollution is beyond a predetermined safe limit. It also has a manual switch to enable the user to have manual control of the ventilation system when necessary. The system has a fan control to enhance the quality of the air when pollution is observed. The Arduino Nano drives the fan using

an L293D Motor Driver IC which is an interface between the microcontroller and the DC motor. The motor driver magnifies the signal and drives the DC fan since the Arduino is unable to provide current sufficient to directly drive the motor. As the air pollution level increases, the fan will automatically switch on to distribute fresh air and minimize contamination.

The transmitter and receiver parts use serial communication via the TX and RX pins. The information measured and computed by the transmitter Arduino Nano is transmitted to another Arduino Nano in the receiver part. The incoming data is processed by the receiver and presented on a MAX7219 LED Matrix Display Module that has scrolling messages with information on air quality. The results of the monitoring can be observed at a distance with this display,

which makes this system appropriate in smart environments and monitoring of the population.

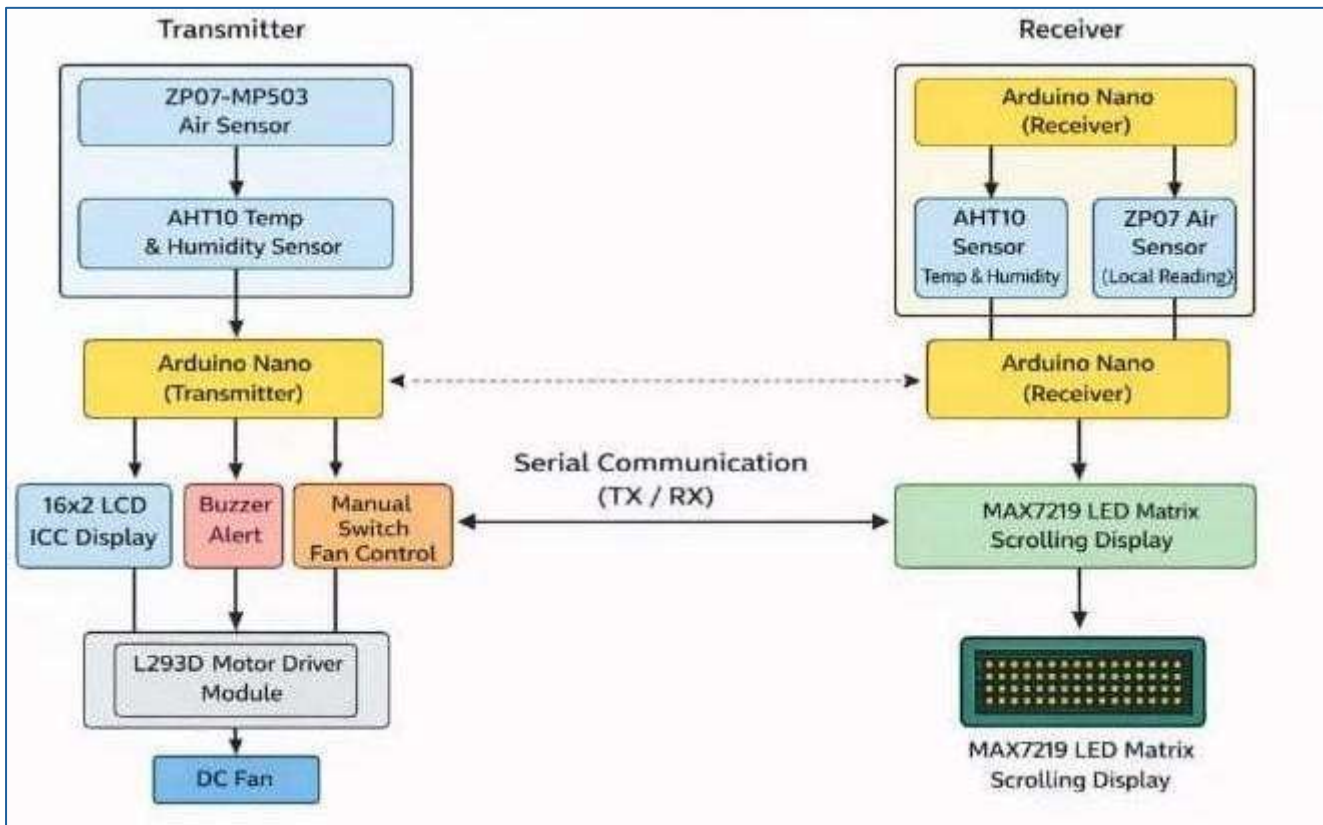


Figure 3.1: Block diagram of system

The figure 3.1 shows a wireless air quality monitoring and control system which comprises two main components; a transmitter unit and a receiver unit. The construction of both units is based on the Arduino Nano microcontroller. The transmitter unit will monitor the environmental conditions (temperature, humidity, and air quality) and the receiver unit will show the received data and give a visual output through a display module. The system assists in keeping track of air conditions and automatic operations of devices such as a fan in case of a rise in pollution.

IV. SYSTEM DESIGN AND IMPLEMENTATION

The connection diagram and flowchart together explain the overall design and working of the proposed system.

A. HARDWARE INTERFACING:

Environmental data are gathered in the transmitter part by sensors. The AHT10 Temperature and Humidity Sensor will measure the temperature and humidity around the device, and the ZP07-MP503 Air Quality Sensor will be used to monitor the presence of harmful gases in the air. These sensors transmit the readings to the Arduino Nano which interprets the data and establishes the air quality status. The transmitter is also fitted with a buzzer and DC fan attached to it by a motor driver to provide warnings and ventilation in case pollution is beyond a certain limit.

A 16x2 I2C LCD Display is attached to the microcontroller of the transmitter to show the readings of the environment locally. The LCD displays information like air status, temperature, humidity and fan status. The system has the capability of automatically switching on the fan operated by L293D Motor Driver when poor air quality is sensed to circulate fresh air. It also has a manual switch that regulates the running of the fan in case it is necessary.

The data is transmitted to the receiver unit which displays it to be monitored remotely. It also uses another Arduino Nano which processes the incoming data from the transmitter. This information is then shown on a MAX7219 LED

Matrix Display which gives the air quality information in scrolling or digital display. This enables users to keep track of the environmental conditions elsewhere.

Generally, the system offers an effective way of real-time environmental monitoring and automatic air quality control. The combination of sensors, microcontrollers, and display modules into the setup assists in identifying harmful gases and ensuring safer air conditions. These systems may be beneficial in residential and laboratory settings as well as industrial settings where it is critical to monitor air quality to avoid health and safety issues. The transmitter section incorporates the use of various sensors in collecting the environmental information. The AHT10 Temperature and Humidity Sensor is sensitive to detect the temperature and humidity of the surrounding area, whereas the ZP07-MP503 Air Quality Sensor can be used to detect the presence of harmful gases in the air. This sensor data is transmitted to the Arduino Nano, which analyzes the information to determine the status of air quality. The transmitter unit has a buzzer and a DC fan linked by L293D Motor Driver IC, which can be utilized to give warning as well as enhances ventilation when the pollution level exceeds the limit that has been set.

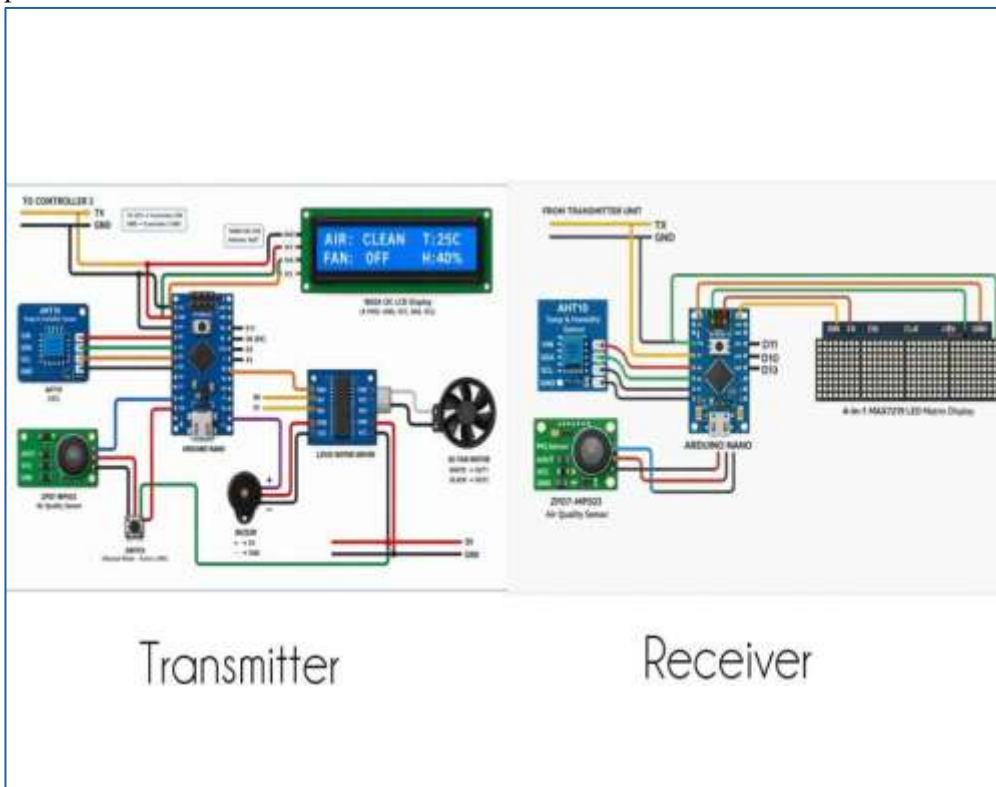


Figure 4.1: Schematic diagram

The above figure 4.1 shows the microcontroller of the transmitter is connected to a 16X2 I2C LCD display to show the collected environmental data in the local area. This interface presents valuable data like air quality status, temperature, humidity and fan operating status. The Arduino is programmed to automatically turn on the fan using the motor driver when the system monitors that the air quality is poor and force fresh air into the system to lower the pollution levels. Moreover, it has a manual switch which means that the user can manually turn on the fan when it is necessary. Environmental parameters are constantly checked in the transmitter unit with the help of the sensor that is attached to the Arduino Nano microcontroller. The AHT10 Temperature and Humidity Sensor is applied to check the temperature and humidity of the atmosphere around, and the ZP07-MP503 Air Quality Sensor is used to check the concentration of harmful gases in the air.

B. SYSTEM FLOWCHART :

The flowchart shows how the smart air quality monitoring and purification system works. It starts with the Start stage, during which the system starts all of the necessary hardware parts, including the Arduino Nano, environmental sensors, LCD display, and LED matrix. In the initializing phase, the microcontroller readies up the sensors and display modules to enable them to start gathering and displaying environmental information.

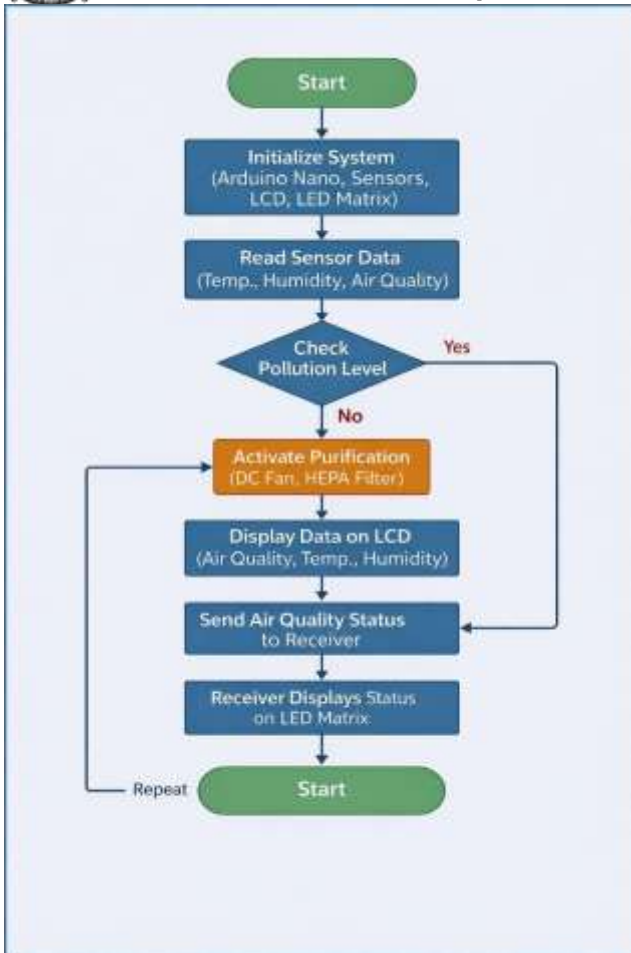


Figure 4.2: Workflow diagram

This figure 4.2 illustrates that installation is to guarantee that everything is operating correctly and that the system begins to monitor the air quality. Once it has been initialized, the system will then read sensor data of the temperature, humidity, and air quality levels of the sensors connected. The data then gathered is analyzed in the level of pollution checking phase. At this decision point, the system, based on the air pollution level, decides whether there is an overflow of air pollution over a predefined threshold. In case the amount of pollution is within the safe margin, the system notifies the receiver of the air quality status and keeps on monitoring. But when the pollution level is high, then the system automatically switches on the air purification system. When high pollution is sensed, the system turns on the purification unit made of DC fan and HEPA filter to filter the air off harmful particles.

Simultaneously, the values of air quality, temperature, and humidity are shown on the LCD to monitor the situation locally. The air quality status is also sent to a receiver module, where the data is shown on an LED matrix to be visually seen remotely. Once this is done, the process will continue repeatedly, and, as a result, the system will be able to track air conditions and ensure cleaner air at any time.

V. RESULTS AND DISCUSSION CASE-1 OVERALL SAP RESULT

The below figure-5.1 represents a smart environmental monitoring and control system using Arduino. The system is comprised of several Arduino Nano which serves as the prime controllers, which are attached to a host of sensors that include temperature, humidity, and gas sensors so as to constantly check the environmental conditions. The data obtained is manipulated by the Arduino and presented in real time on a 16×2 LCD screen, and an LED matrix display to represent alert messages such as FAN ON. A fan is controlled by a motor driver module (L298N) to automatically activate when the gas level rises beyond a set point, allowing air quality to be improved. This system is real time, automated and safe, which means that it combines sensing, processing, and output actions, which are appropriate in such applications as air pollution detection and smart ventilation control.

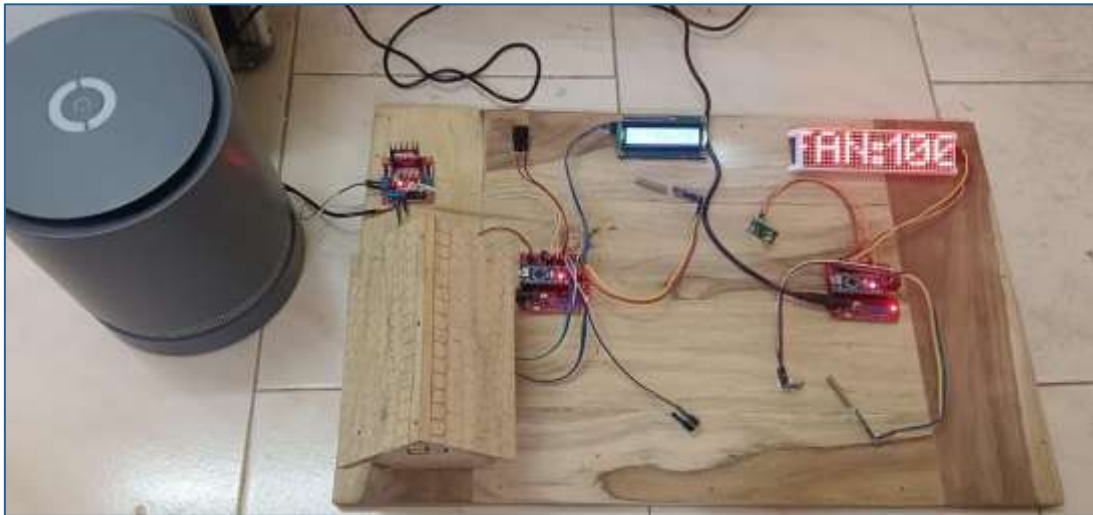


Figure 5.1: Smart Air Pro Result

The project is an intelligent environmental monitoring and automatic controller to enhance the safety and air quality in the indoor areas. It provides several Arduino Nano microcontrollers to manage sensing, processing and output functions effectively. The system gathers real-time information on sensors like temperature, humidity and gas sensors (like MQ series) that sense dangerous gases like CO₂ or smoke. The Arduino constantly analyzes these sensor values and the output is shown on a 16×2 LCD so that it can be easily monitored. Moreover, an LED matrix display will give visual cues or notifications (i.e. FAN ON or a warning symbol) which will make the system more interactive.

The gas level is sensed in this circuit and when it reaches a designated level, the Arduino triggers a signal to the motor driver (L298N) and a fan is turned on to remove the polluted air and introduce fresh air into the room. This demonstrates the principle of automation, in which the system reacts without the intervention of human beings. Distributed processing is also indicated by the use of multiple controllers, making the system more efficient, and enabling system expansion. The application of this project can be implemented in residential, industrial, laboratories, and outdoor areas to monitor pollution and implement safety measures. It is an excellent illustration of an embedded system integrating sensors, microcontrollers, displays, and actuators into a solution of an intelligent and responsive environment control.

CASE-2 TRANSMITTER RESULT

The Arduino program in the above fig.5.2 connected to a ZP07 air quality sensor, an AHT10 temperature and humidity sensor, an LCD display, a fan (through a motor driver), a buzzer and a manual switch to make a smart air quality monitoring and fan control system.. Upon turning on, the LCD displays a welcome message of SMART AIR PRO and SENSOR WARMUP (approximately 5 seconds) to stabilize the sensors. The system will commence with continuous monitoring after this warm-up.



Figure 5.2: Transmitter Result

The system reads the temperature and humidity on the sensor AHT10 and air quality signals on the sensor ZP07. According to digital outputs of the ZP07, the air quality is divided into four categories: CLEAN, LOW, MID and POOR. The values are shown on the LCD and real-time temperature (o C) and humidity percentage. Depending on these conditions, the fan speed is automatically controlled. It stays OFF when clean, switches to LOW, MEDIUM or HIGH with increasing pollution and temperature and operates at full speed when air quality is poor, temperature is very high, or it is set to the manual switch.

An alert system is implemented via a buzzer that activates when the air quality becomes medium or poor and notifies the user of unsafe conditions and deactivates when the air quality becomes better. Also, the system transmits the information at a certain time interval (one second) via the Serial Monitor in the format of air quality grade, temperature, humidity, which allows the communication with another controller. The system, in general, is a fully automated unit that keeps track of environmental conditions and presents them in a readable fashion, has a fan that can be controlled effectively, sends alerts when needed and can be overridden manually.

CASE-3 RECEIVER RESULT

The result of receiver is displayed in the above display [figure-5.3]. This arduino code is used to run a LED matrix display system, which displays remote and local environmental measurements. Upon switching on, the LED matrix will boot up and will show the message READY briefly, within 2 seconds. Then, it begins to scroll a welcome message WELCOME to SMART AIR PRO across the display meaning that the system is being used and is ready to receive and process data.



Figure 5.3: Receiver Result

The system will then constantly monitor the incoming serial data into it by another controller (Controller 1). These data will be anticipated in CSV format as PPM, Temperature, Humidity. The program then retrieved these values and stored them as remote air quality, temperature and humidity measurements. Meanwhile, the system also gathers local data with its own AHT10 sensor to measure the temperature and humidity, and a ZP07 Analog sensor to measure the



air quality.

The LED matrix display is a dynamically updated scrolling message displaying a combined message of both the remote and the local reading. For example, it displays text like: “REMOTE > AQ:2 T:35C H:60% | LOCAL > AQ:450 T:34C H:58%”. This forms a real time comparison of two environments.

CASE-4 FAN SPEED MODES

Modes of Operation of Fan in SMART AIR PRO System
The fan in the SMART AIR PRO system is significant in ensuring that there is clean and healthy air. It combines with the HEPA filter and air quality sensors to clean the air and surroundings. The system is smart in controlling the fan according to real-time information that has been gathered through sensor devices like AHT10 (temperature, humidity sensor) and ZP07-MP503 (air quality sensor).

1.(Standby Mode) is the first mode.

With this mode, when the surrounding air quality is detected as clean, the fan is off or runs at very low speed. ZP07-MP503 sensor is used to constantly check the availability of harmful gases and pollutants in the air. The system will not activate the purification process in case the level of pollution is not too high. This can be used to conserve power and extend the life of system units.

2. Moderate Purification Mode

Once the sensors detect the medium concentration of the pollutants or minimal air quality degradation, the fan begins working at a medium speed. Air is then drawn through the HEPA filter in this mode and this filter eliminates dust particles, pollutants as well as any other contaminants present in the air. The system balances airflow to enhance slowly the air quality without using too much energy. The transmitter also transmits the status of the air quality to the receiver which is viewed on the LCD1602A display.

3. High Purification Mode

When the air quality sensor records high rate of pollutants, harmful gases, or bad air conditions, the system switches on the fan to the maximum speed. At this point, a fan is used to move contaminated air past the HEPA filter at a high rate to eliminate the harmful particles in a short period of time. This mode is guaranteed to purify polluted air quickly, particularly when there is a high population in an area, in the industrial environment or high traffic spots where pollution can unexpectedly rise.

VI. CONCLUSION

A coordinated combination of the transmitter and receiver codes makes up a full smart air monitoring and control system which operates in a synchronized way. Environmental data (air quality, temperature, humidity) is collected in the transmitter unit with the help of sensors (ZP07 and AHT10). It interprets this data, and shows it locally on an LCD, and smartly manages a fan and a buzzer according to the real-time conditions. This provides rapid action to unhealthy air quality or elevated temperature, enhancing environmental security.

This system is supplemented by the receiver unit that is the data visualization and comparison module. It takes the transmitted data over serial communication and fuses it with its own sensor data locally measured. It also allows the comparison of the environmental conditions of two places in a user-friendly manner with the LED matrix display clearly scrolling and showing remote and local readings in a continuous format. The two systems are effective in real-time communication and automation. The transmitter is specialized in sensing, decision-making, and actuation (fan and buzzer control) whereas the receiver is specialized in improved display and monitoring. Such a separation of functions enhances effectiveness and enables the system to be scaled to bigger applications like a smart home, a classroom, or an industrial setting.



Finally, the project is able to incorporate sensing, processing, communication, and display into a single smart system. Not only does it keep track of environmental conditions, but also reacts automatically and presents easy-to-use outputs. The system will be an effective and convenient way of ensuring quality and comfort in the air and environment with such features as an automatic fan control, alert systems, dual-location tracking, and manual override.

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