# IoT Based Smart Exhaust Fan

Prof Dr Vijay Gaikwad, Niharika Deshmukh, Eshansingh Dixit, Aryan Dongare, Harsh Doshi, Om Durge

*Computer Engineering Department*
*Vishwakarma Institute of Technology , Pune , India*

**Abstract**:- In today's world, ensuring safety and maintaining optimal environmental conditions in residential, commercial, and industrial spaces is of utmost importance. The proposed system develops an IoT-based system to detect gas leaks and control temperature and humidity through an automated exhaust fan, enhancing safety and environmental regulation. Gas, temperature, and humidity sensors provide real-time monitoring, automatically activating the exhaust fan to expel hazardous gases and maintain optimal indoor conditions when necessary.

The system is designed to respond quickly to gas leaks, reducing the risk of accidents, while also controlling temperature and humidity to ensure comfort and protection of equipment or materials. Connected to an IoT platform, it allows for remote monitoring and real-time alerts, enabling timely responses and preventive actions.

By automating these processes, the system minimizes human intervention, ensuring continuous operation for improved safety and environmental control. The solution is cost-effective, scalable, and suitable for homes, offices, and industrial environments where safety and climate control are critical concerns.

The MQ135 sensor has an accuracy of ±3-5 percent in detecting gases such as $CO_2$ and ammonia, while DHT11 proved to have remarkable accuracy, measuring 96.41 percent for temperature and 97.28 percent for humidity.

Keywords: **IoT-based system**, **Gas leakage detection**, **Automated exhaust fan**, **Temperature and humidity control**, **Real-time monitoring**

## I. INTRODUCTION

An urgent need for environmental regulation and safety in residential, commercial, and industrial spaces is addressed by the proposed system "IoT-Based System for Gas Leakage Detection and Environmental Control Using Automated Exhaust Fan.". Using sensors and an automated exhaust fan, the system combines cutting-edge Internet of Things (IoT) technology to monitor and manage temperature, humidity, and gas leaks. This offers a clever and effective way to reduce the dangers of dangerous gas leaks while preserving ideal indoor climate conditions. Gas leaks are among the most hazardous and unpredictable threats in both residential and commercial settings, which is why this system is being designed. If handled slowly, the release of gases such as butane, propane, or methane can result in fires, explosions, or major health risks. Conventional gas detection systems frequently call for human intervention, which raises the risk and slows down response times. Comparably, controlling the humidity and temperature inside a space is essential for both equipment safety and comfort. The proposed system is important because it can reduce response times and human intervention by automating the detection and control of environmental factors and gas leaks. This system uses automation and Internet of Things (IoT) sensors to detect gas leaks in real time, turn on the exhaust fan right away, and notify users through connected devices. In summary, the system combines modern IoT technology with automation to offer a comprehensive solution for gas leakage detection and environmental control. The integration of sensors, automation, and real-time monitoring not only enhances safety but also contributes to improved environmental regulation, making it a valuable innovation for both personal and industrial use.

## II. RELATED WORK

In [1], an IoT-based smart exhaust fan is designed to monitor smoke levels in a room using sensors and Arduino technology. The system automatically activates or deactivates the fan based on real-time data, helping to maintain air quality. By integrating a Wi-Fi module, users can access live smoke levels remotely, offering a practical solution for enhancing indoor air conditions. In [2], the project applies fuzzy logic, using the Mamdani method, to control an exhaust fan based on room air conditions. By integrating a gas and temperature sensor, the system detects harmful gases and adjusts the fan's speed to maintain air quality. Fuzzy logic controls the fan's rotational speed, ensuring optimal airflow for a comfortable and safe indoor environment. In [3] the project proposes a smart ventilation system using wirelessly controllable dampers, powered by a Photon microcontroller, to modulate airflow in homes and commercial buildings. The dampers adjust airflow based on user needs, improving occupant comfort and reducing energy costs. The solution is suitable for both retrofit projects and upgrading existing Variable Air Volume (VAV) systems. In [4] project presents a control system for a mini electric fan in a smart home environment, using an STM32L100 microcontroller for speed control via pulse-width modulation (PWM). The system incorporates a ZigBee module for wireless communication, enabling control through an Android app and integration with other smart devices. Testing confirmed the fan's smooth speed control and reliable wireless operation within a mesh network. In [5] the project aims to develop a cost-effective smart fan for home use, enhancing comfort and reducing electricity costs. Using readily available market components, the prototype serves as a foundation for further smart home appliance development. In [6] the project aims to develop a cost-effective smart fan for home use, enhancing comfort and reducing electricity costs. Using readily available market components, the prototype serves as a foundation for further smart home appliance development. In[7] paper presents the development of an automated exhaust fan for modern kitchens, integrated with an IoT notification system. It aims to improve air ventilation, reduce energy consumption, and lower installation costs by using a temperature-controlled system. The fan automatically adjusts its speed based on temperature changes, sending alerts via the Blynk app when critical thresholds are reached, ensuring efficient energy use and enhanced kitchen comfort.In[8] project develops an IoT-based smart kitchen using NodeMCU ESP8266 to enhance safety by detecting gas leaks, fire, high temperatures, and human activity. It also enables remote monitoring and control of kitchen appliances via a web application. In [9] the paper presents an automated exhaust fan and flushing system that integrates sensors, actuators, and control algorithms to enhance restroom hygiene and air quality. The system automates flushing based on user presence and optimizes exhaust fan operation based on air quality data, improving energy efficiency and reducing resource wastage in modern buildings.In [10] the paper presents an IoT-based energy-conserving smart fan system that automatically adjusts fan speed based on room temperature and human presence. The fan can operate in both manual mode, controlled via a smartphone, and auto mode, using ultrasonic and temperature sensors to optimize energy efficiency and user comfort. The system is designed to reduce energy consumption while providing ease of control. In [11] the paper presents a smart fan system controlled by room temperature and human presence using a DHT11 temperature sensor and PIR sensor. The fan speed adjusts automatically based on temperature, and the system can be monitored remotely via an ESP8266 Wi-Fi module. In [12] the paper focuses on controlling CO2 levels in indoor spaces, specifically detecting CO2 concentrations produced by cigarette smoke using the MQ-2 sensor and Arduino-based exhaust fan control. It highlights the system's effectiveness in maintaining safe CO2 levels under 350 ppm. In [13] the paper proposes a system that uses sensors to detect LPG gas leakage and prevent kitchen accidents by alerting users via GSM and activating an exhaust fan automatically. It also monitors room temperature and gas levels, ensuring safety even when users are not home. In [14] the paper proposes to develop a system that detects LPG gas leakage and monitors the gas level in cylinders, automatically notifying users via SMS and displaying the gas concentration and cylinder weight on an LCD. It also includes a buzzer for accident alerts, ensuring continuous, real-time monitoring and quick response to gas leaks.In [15] the paper presents an IoT-based temperature monitoring and automatic fan control system using an ESP32 module, DHT11 temperature sensor, and a fan. The system adjusts fan speed based on temperature changes to improve energy efficiency and environmental comfort. Controlled via a mobile app, it provides real-time temperature monitoring and remote fan control. The project demonstrates efficient and user-friendly fan automation, with potential for future improvements such as enhanced security, scalability, and integration with other IoT devices. In [16] paper discusses the development of a smart fan using IoT technology, focusing on energy efficiency and user convenience. The fan integrates ESP8266 microcontroller, DHT22, and KY-038 sensors to adjust speed and automate on/off functions based on environmental temperature and user presence. The study highlights the fan's ability to enhance comfort, reduce energy consumption, and provide a modern automated experience.In [17] the paper presents an IoT-based automatic exhaust fan system designed to reduce cooking smoke in home environments. Utilizing sensors to detect smoke, the fan activates automatically to improve air quality and ventilation, ensuring energy efficiency and user convenience. The system also supports real-time monitoring and control through connected devices.In [18] the paper examines the impact of using kitchen exhaust fans during and after cooking on indoor air quality. The study, conducted in research homes in Ottawa, tested different fan flow rates and evaluated pollutant concentrations such as ultrafine particles (UFP), fine particulate matter (PM2.5), and nitrogen oxides (NO, NO2). It found that continuing to run the fan after cooking slightly improves pollutant removal, but the fan's flow rate during cooking has a greater effect on reducing exposure.In [19] the paper investigates the impact of different jet fan arrangements on smoke spread in tunnels during fires. Using a multi-scale coupling method and fire dynamics simulation (FDS) software, the study analyzes smoke behavior under various fan configurations to reduce backlayering and enhance smoke exhaust efficiency. The findings provide valuable insights for the optimal design and operation of jet fans in underground tunnels.In [20] paper investigates the performance of a novel kitchen ventilation system designed to minimize exposure to PM2.5 (fine particulate matter) generated during cooking. The study uses computational fluid dynamics (CFD) simulations and on-site testing to assess the system's efficiency in reducing PM2.5 intake while minimizing energy consumption. The results show significant improvements in air quality and energy savings compared to traditional ventilation systems.

## III. DESIGN METHODOLOGY

In order to improve indoor environmental monitoring and safety, this paper describes the design and development of a smart exhaust fan system based on the Internet of Things. The ESP32 Wroom module functions as the central control unit for the system and provides power. The DHT11 for temperature and humidity monitoring, the MQ2 for flammable gas detection, and the MQ135 for air quality measurement—which includes hazardous gases like carbon dioxide and ammonia—are the three main sensors that are integrated. By continuously providing real-time data, these sensors allow automated fan operation based on pre-established thresholds. The system also has a manual fan on/off control feature that lets users override automatic operation if needed. A complete solution for preserving air quality and safety in a variety of settings is offered by the combination of environmental sensing and manual control.

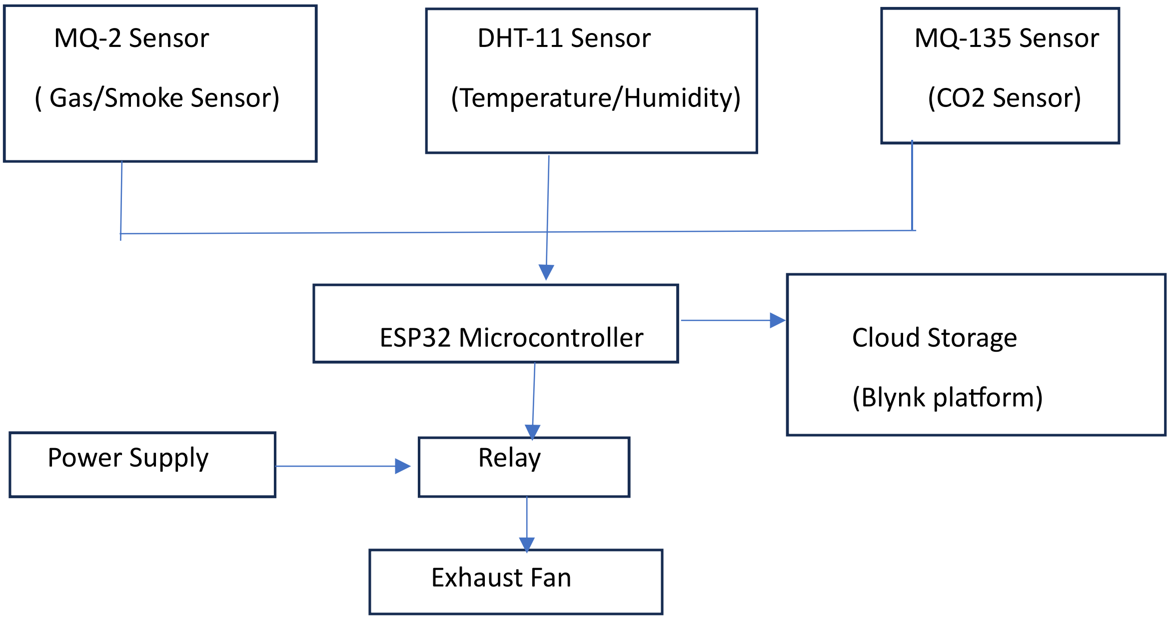


Fig.1 System Architecture for proposed system

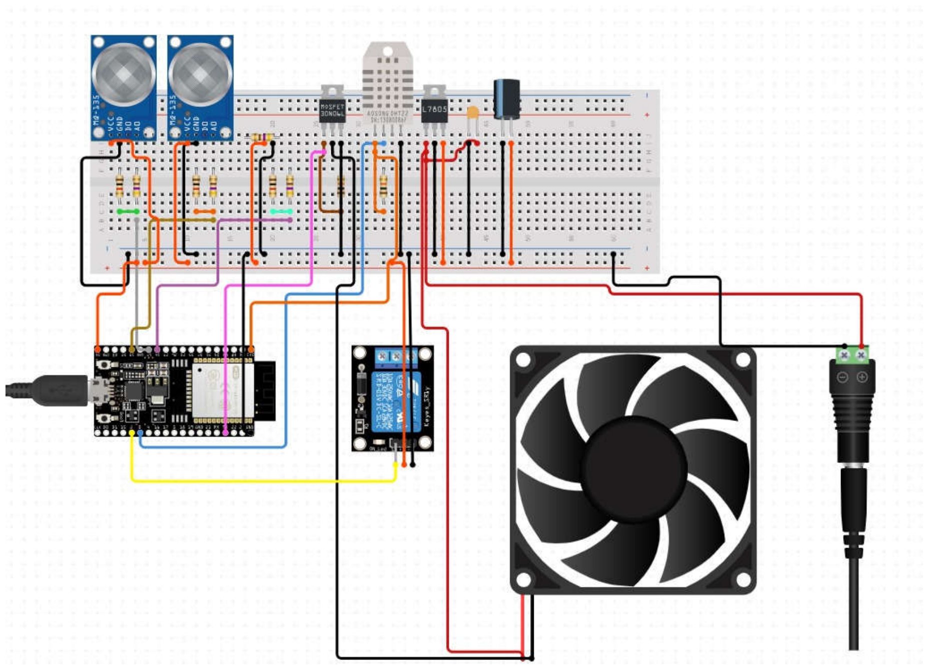

Fig.2 Circuit Design for proposed system

These sensors detect gases like methane, propane, and carbon dioxide. The sensitivity of the gas sensors is defined as the ratio of the sensor's resistance in clean air to its resistance when exposed to the target gas:

$$s = \frac{R_a}{R_g} \quad \text{... (1)}$$

Where $R_a$ is resistance due to air and $R_g$ is resistance due to gas.

The voltage output from the sensor is calculated using the voltage divider equation:

$$v_{out} = v_{CC}\left(\frac{R_L}{R_L + R_s}\right) \quad \text{...(2)}$$

Where $v_{CC}$ is Supply voltage (usually 5V), $R_L$ is Load resistance and $R_s$ is Sensor resistance, which varies based on gas concentration.

Additionally, the current through the heater, essential for sensor operation, is calculated as

$$I_h = \frac{vcc}{R_H} \quad \text{...(3)}$$

Where $R_H$ is the resistance of the heater.

The power consumed by the heater can be derived as:

$$P = v_{cc} * I_h \text{...(4)}$$

This helps estimate the overall energy usage of the sensor.

The sensor resistance, which changes in response to gas concentrations, is determined using the equation:

$$R_s = R\left(\left(\frac{v_{CC}}{v_{out}}\right) - 1\right) \text{....(5)}$$

This formula is fundamental in calculating the gas concentration based on changes in the sensor's resistance.

The DHT11 measures temperature and humidity, ensuring that the exhaust fan operates to maintain comfortable and safe environmental conditions. It operates within a supply voltage of 3.3V to 5.5V, typically using 5V, with a current consumption of approximately 0.5mA during measurement.

The sensor's accuracy, which is critical for ensuring precise control over the environment, is calculated as:

$$\left(1 - \frac{|Actual\ value - error\ |}{Actual\ value}\right) * 100 \ldots(6)$$

In testing, the DHT11 demonstrated an accuracy of 96.41% for temperature and 97.28% for humidity, making it a reliable component for this application.

The sensor's resistance in air (ambient conditions) is represented by $R_0$ . The sensor resistance $R_s$ is calculated based on the analog reading and reference resistor. For both MQ2 and MQ135 sensors:

$$R_s = \left(\frac{4095}{analogValue} - 1\right)^{*} R_0 \ldots(7)$$

The ppm concentration is derived based on empirical formulas that relate the $\frac{R_S}{R_0}$ ratio to gas concentration:

$$ppm = 10^{\left(\frac{log_{10}\left(\frac{R_S}{R_0}\right) - B}{m}\right)} \ldots.(8)$$

Where:

B is an intercept constant based on sensor calibration,

m is the slope of the gas sensitivity curve (determined by the type of gas).

For CO2 approximation:

$$ppm = 10^{\left(\frac{log_{10}\left(\frac{R_S}{R_0}\right) - 1.3}{-0.47}\right)} \ldots(9)$$

B=1.3 and m=−0.47 approximate the CO2 sensitivity curve.

For MQ135 gas approximation (e.g., NH3 or similar gases):

$$ppm = 10^{\left(\frac{log_{10}\left(\frac{R_S}{R_0}\right)-1.3}{-0.38}\right)} \quad ...(10)$$

B=1.3 and m=−0.38 align with the MQ135’s sensitivity for gases like NH3.

The system uses a control algorithm that activates the exhaust fan when gas concentrations exceed predefined safety levels or when the temperature and humidity surpass the threshold values. The ESP32 module, which serves as the central controller, is connected to an IoT platform, enabling real-time monitoring and remote control. Data from the sensors, such as gas concentration, temperature, and humidity, is sent to the IoT platform where users can monitor the system and receive alerts in case of anomalies.

## IV. RESULTS & DISCUSSIONS

The proposed system successfully demonstrated its effectiveness in real-time gas monitoring, temperature, and humidity regulation. Tests conducted in controlled environments showed that the MQ-2 and MQ-135 sensors accurately detected gas concentrations at low levels, triggering the exhaust fan promptly when gas levels exceeded the safety threshold. The fan activation times were notably fast, minimizing gas build-up and enhancing safety. The DHT11 sensor performed with high accuracy, maintaining an average error margin of only 3.59% for temperature and 2.72% for humidity, ensuring reliable environmental control. Integration with the IoT platform enabled seamless real-time data access and remote control capabilities. Alerts were delivered promptly, allowing users to respond immediately to hazardous conditions.

**MQ -2 sensor(Gas/smoke sensor)**

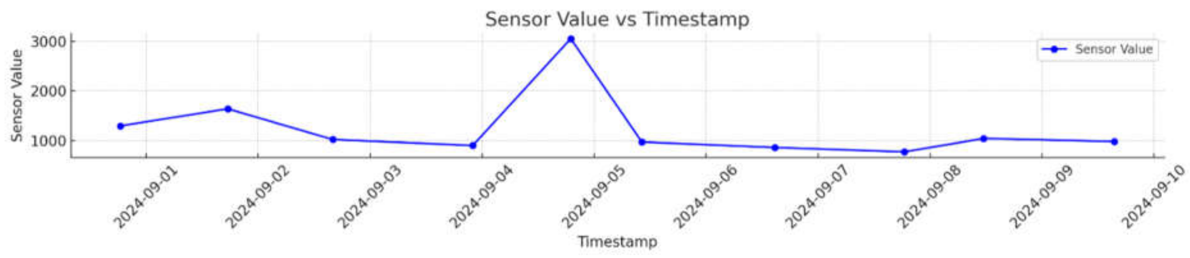


**Fig. 3** Sensor value over time

Fig. 3 illustrates the variation in sensor readings over time, showing higher values on specific dates like September 4th, which indicates the presence of external influences such as the "Perfume" condition. Fluctuations in sensor values may reflect different environmental conditions, with peaks and troughs corresponding to events like smoky or normal air quality conditions.

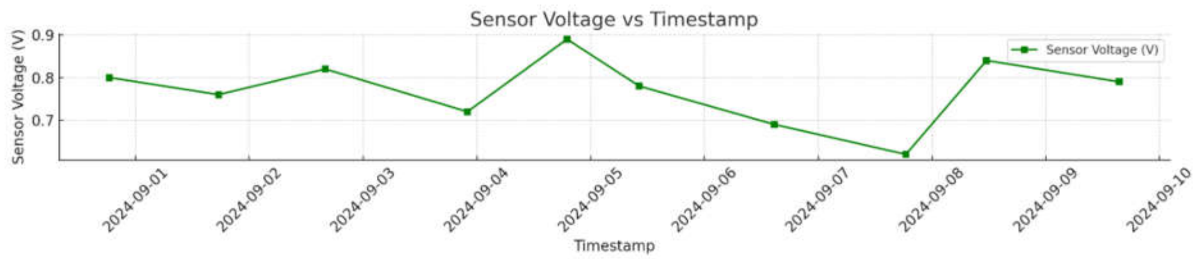


**Fig. 4** Sensor Voltage over time

Fig.4 shows how voltage levels vary in parallel with sensor conditions. Generally, voltage values stay within a narrow range but exhibit slight changes that could correspond to sensor sensitivity shifts due to different gas concentrations or conditions, like the increase noted during the perfume detection event.

**DHT-11 sensor(Temperature and Humidity sensor)**

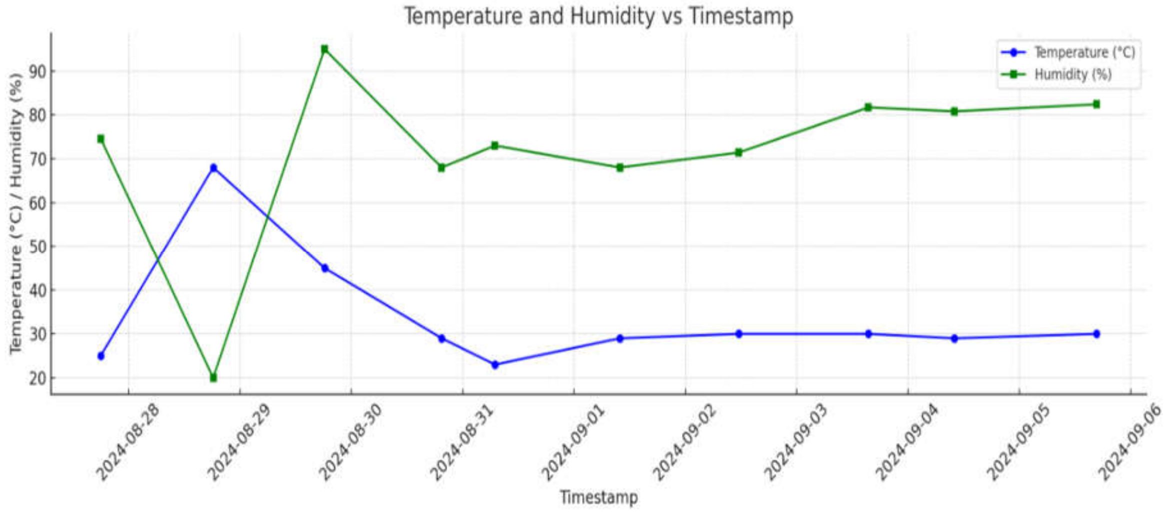


**Fig.5** Temperature and humidity over time

Fig.5 shows temperature and humidity readings over time. Temperature variations are notable with spikes for specific conditions (e.g., “Fire” showing higher temperature). Humidity levels fluctuate, with higher readings during "Water Vapour" and generally stable levels during "Normal" conditions.

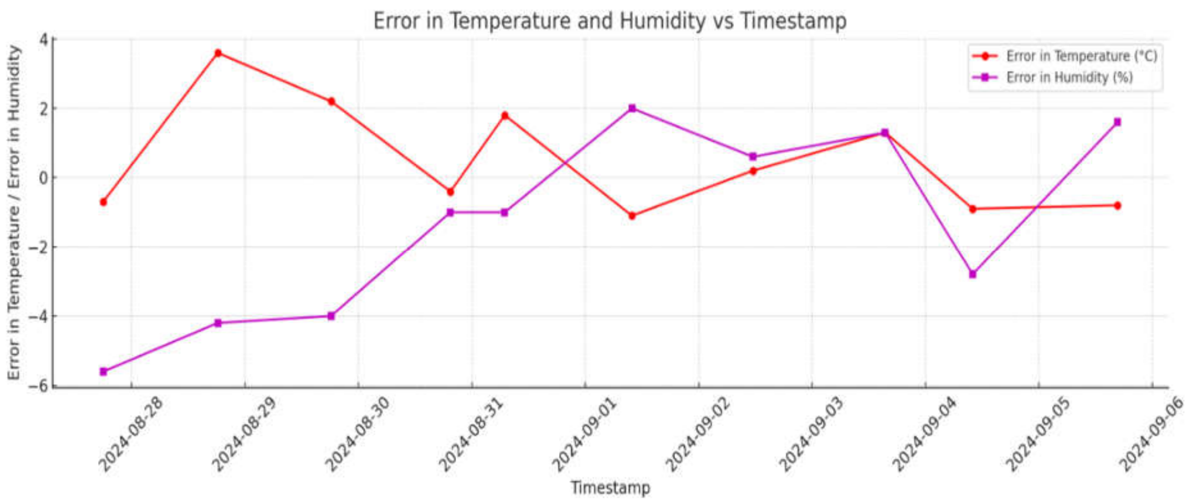


**Fig. 6** Timestamp Vs error in temperature and humidity

Fig.6 presents the error in temperature and humidity compared to actual values. Positive and negative fluctuations indicate deviations, with more pronounced error spikes during unusual conditions like "Fire" and "Water Vapour," while errors remain relatively small during "Normal" conditions.

**MQ-135 sensor**

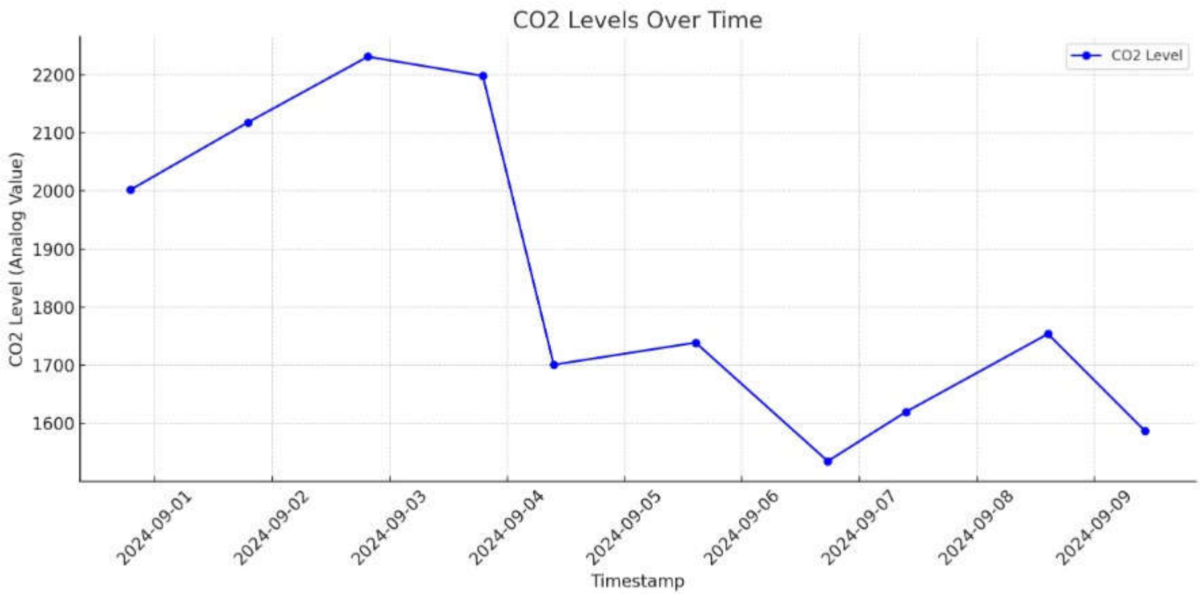


**Fig. 7** CO2 level over time

Fig. 7 shows the CO2 level over time. The x-axis represents the time stamps, and the y-axis represents the CO2 level. The graph shows that the CO2 level generally increases over time, with some fluctuations. There are also some spikes in the CO2 level, which may be due to various factors such as burning incense sticks or other activities.

The papers specified that the sensor's accuracy is ±10% to ±15% depending on the gas and environmental conditions. It's Sensitivity Range is 10 ppm to 1000 ppm for harmful gases. Response Time is 10 to 30 seconds. Recovery Time ≤ 60 seconds and Operating Voltage is generally 5V.

The Blynk app was chosen for this IoT-based system due to its user-friendly interface and extensive features that facilitate remote monitoring and control and improves user experience. Blynk enables seamless integration with various sensors, allowing users to visualize real-time data on gas levels, temperature, and humidity from anywhere using their smartphones. The app also supports customizable alerts and notifications, ensuring timely responses to critical environmental changes or gas leaks. Additionally, Blynk's scalability allows the system to grow alongside user needs, making it an ideal choice for homes, offices, and industrial applications. Its robust community support and easy-to-use dashboard empower users to efficiently manage their safety and environmental conditions.

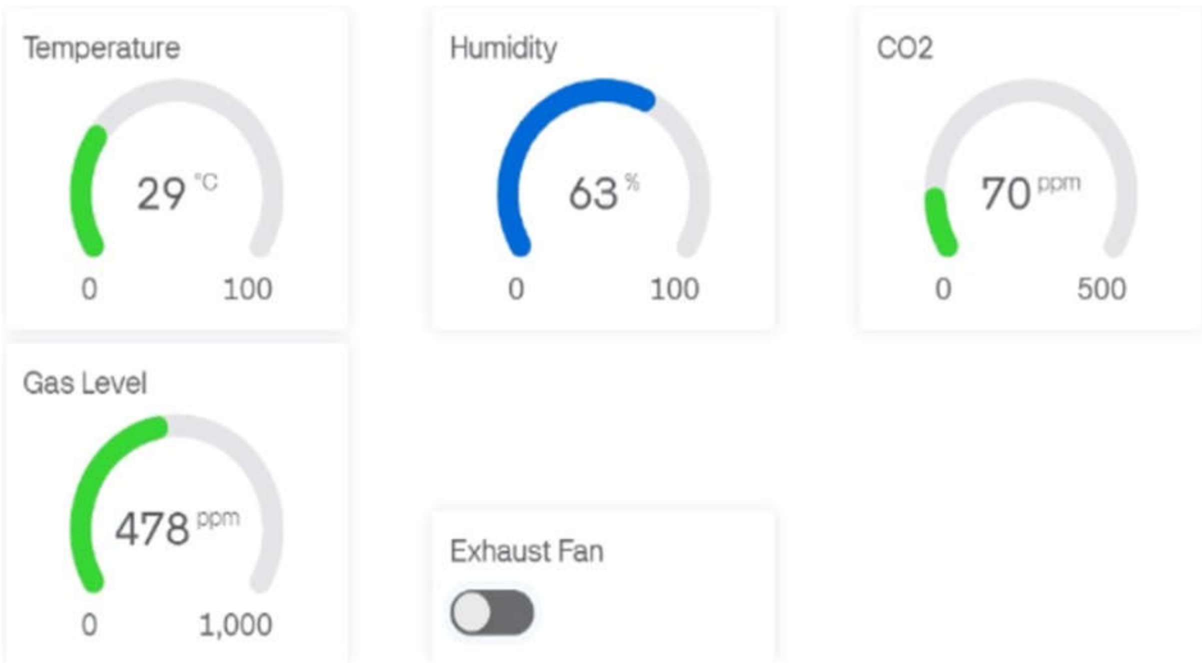


**Fig .8** Blynk Interface for normal condition with exhaust fan off

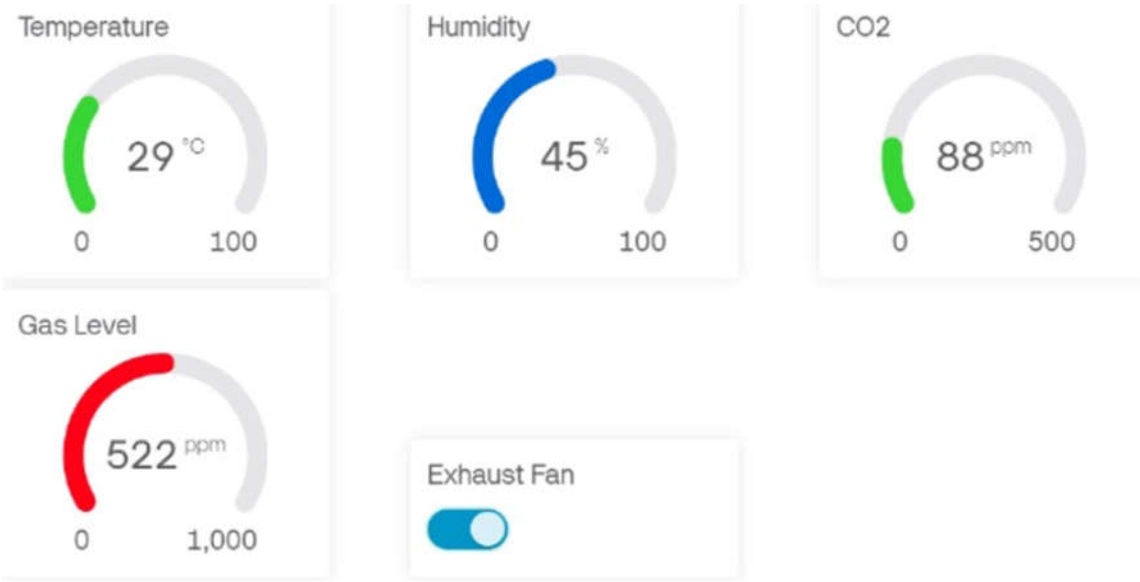


**Fig.9** Blynk Interface for normal condition and manually turning on exhaust fan

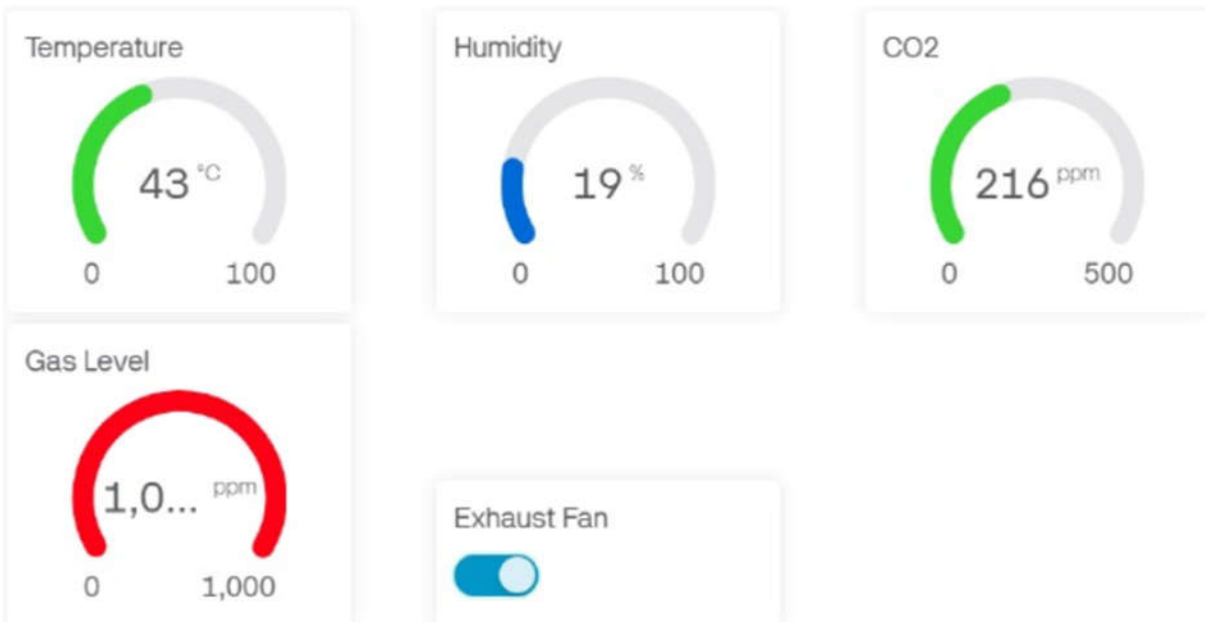


**Fig. 10** Blynk Interface for critical condition

**Table 1.** Changes in Temperature, Humidity and CO2 over Time

| TIME | TEMPERATURE | HUMIDITY | CO2 |
|---|---|---|---|
| 0 Min | 45 | 38 | 208 |
| 1 Min | 41 | 43 | 180 |
| 2 Min | 36 | 46 | 155 |
| 3 Min | 30 | 50 | 120 |
| 4 Min | 29 | 53 | 115 |
| 5 Min | 28 | 59 | 107 |

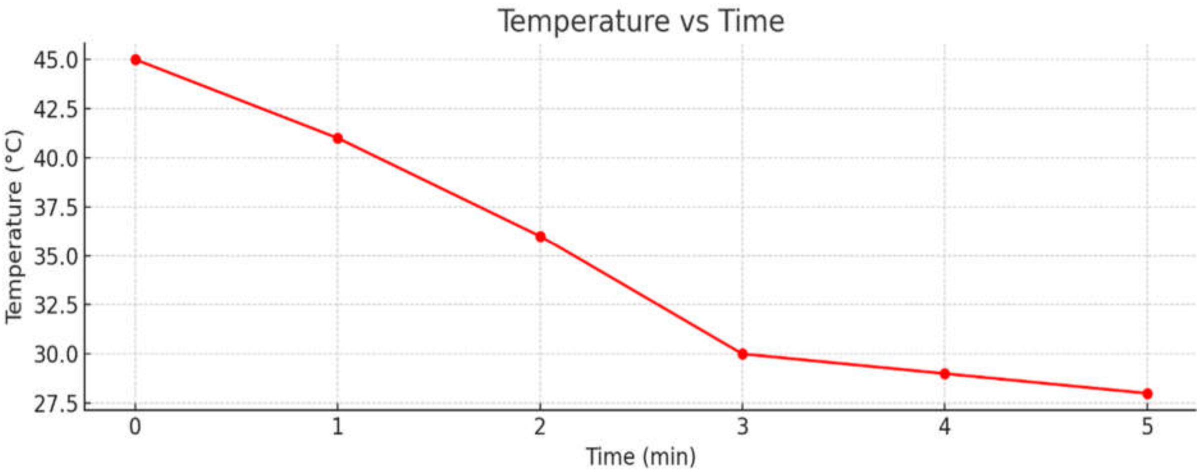


**Fig.11** Temperature Vs Time graph

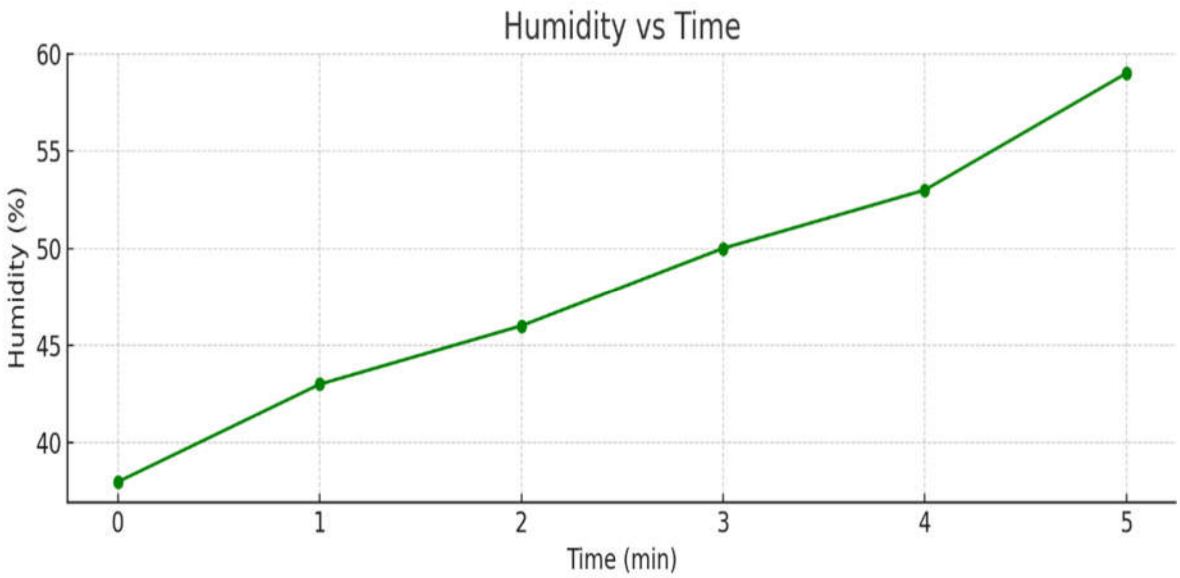


**Fig. 12** Humidity Vs Time graph

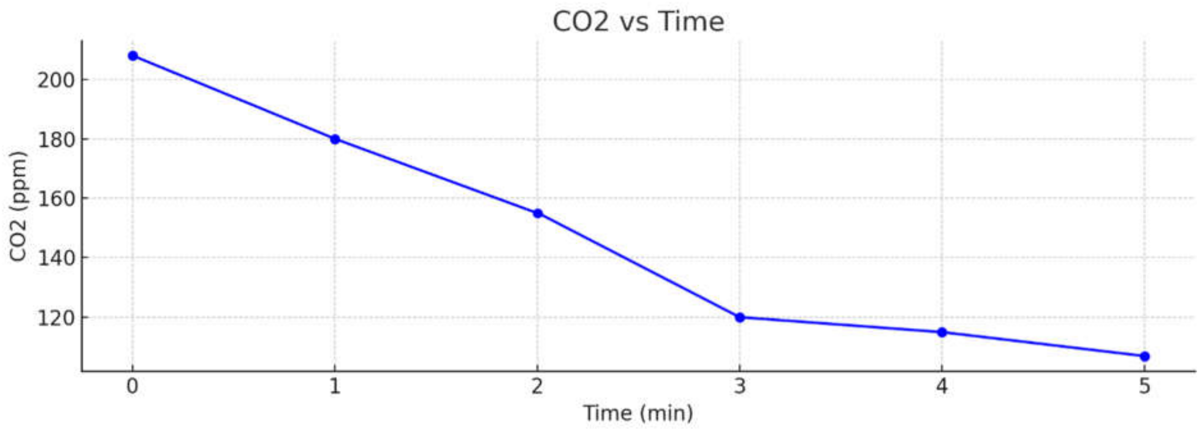


**Fig. 13** CO2 Vs Time graph

## V. CONCLUSION

A comprehensive solution for guaranteeing safety and upholding ideal indoor conditions in commercial, industrial, and residential settings is provided by the Internet of Things (IoT)-based smart exhaust fan system. The system automates responses to hazardous gases and environmental changes by integrating key sensors like the DHT11 for temperature and humidity monitoring and the MQ2 and MQ135 for gas detection. The MQ135 sensor has an accuracy of ±3-5 percent in detecting gases such as $CO_2$ and ammonia, while the MQ2 sensor has a sensitivity range of 200 to 10,000 ppm. In this system the DHT11 sensor—which is essential for climate control—showed remarkable accuracy, measuring 96.41 percent for temperature and 97.28 percent for humidity. When dangerous gas concentrations are detected, or when temperature and humidity levels deviate from ideal ranges, the system automatically turns on the exhaust fan to maintain a comfortable and safe atmosphere. This solution lowers the need for human intervention while increasing operational efficiency thanks to real-time monitoring, remote control via IoT platforms, and quick reaction times. Its scalable and affordable design makes it appropriate for use in workplaces, homes, and other locations where temperature control and safety are vital.

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