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Wearable Environmental Allergy Monitoring and Alert System for Dust Sensitive Individuals

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Abstract—Air pollution and airborne allergens are major environmental factors that affect respiratory health, particularly for individuals who are sensitive to dust and particulate exposure. Continuous exposure to pollutants such as particulate matter and harmful gases can trigger allergies, breathing discomfort, and other respiratory complications. This paper presents the design of a wearable environmental allergy monitoring and alert system that enables real-time personal air quality monitoring. The proposed system measures particulate matter including PM1, PM2.5, and PM10 along with harmful gases such as nitrogen dioxide (NO_2) and ammonia (NH_3). In addition, environmental parameters such as temperature and humidity are monitored to understand surrounding conditions. The collected sensor data are evaluated using predefined threshold limits to identify unsafe pollution levels. When pollutant concentrations exceed safe limits, the device generates alerts using vibration and visual indicators, allowing users to take preventive action. The wearable design enables continuous monitoring and provides a practical and affordable solution for personal environmental health awareness.

Keywords—Wearable gas sensors, PM monitoring, IoT,Allergy prevention,**Threshold-based alert system,Environmental health,Personal exposure monitoring,Air quality,Low-cost sensors.**

I. INTRODUCTION

The quality of ambient air has a significant impact on human health, especially for individuals who are sensitive to dust and airborne pollutants. Airborne particles and harmful gases such as particulate matter (PM), nitrogen dioxide (NO_2), ammonia, and volatile organic compounds (VOCs) are common environmental pollutants that can trigger respiratory problems and allergic reactions. In urban and industrial environments, these pollutants are often present in varying concentrations, making continuous monitoring important for protecting human health.

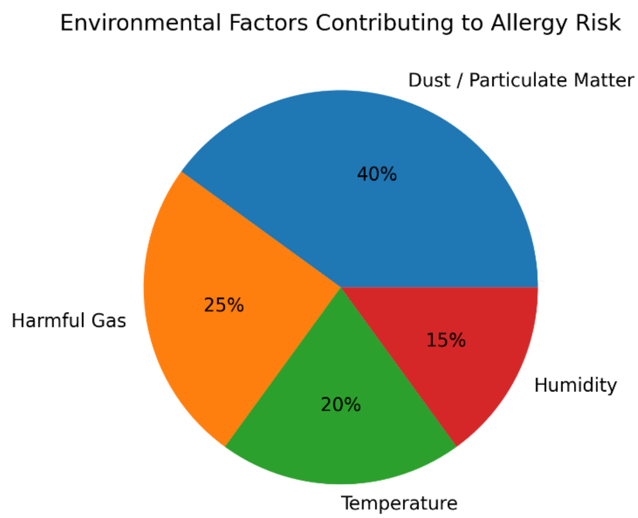

Figure 1: Environmental Factors Contributing to Allergy Risk

Most existing air quality monitoring systems are installed at fixed locations such as government monitoring stations. While these systems provide general information about regional air quality, they do not represent the actual environmental conditions experienced by individuals in their immediate surroundings. Pollution levels can vary significantly depending on location, movement, and environmental conditions. As a result, dust-sensitive individuals may unknowingly remain exposed to harmful pollutants during their daily activities.

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To address this limitation, this work proposes a wearable environmental monitoring and alert system designed for personal air quality assessment. The system integrates particulate matter sensors, gas sensors, and temperature–humidity sensors to monitor environmental parameters such as PM1, PM2.5, PM10, nitrogen dioxide (NO_2), and ammonia (NH_3). The collected sensor data are evaluated using predefined threshold limits to identify unsafe pollution levels. When pollutant concentrations exceed safe limits, the device generates alerts through vibration and visual indicators, enabling users to take preventive action. The proposed wearable system provides a simple, portable, and affordable solution for continuous environmental monitoring and improved respiratory health awareness

II. OVERVIEW OF THE EXISTING SYSTEM

Existing environmental monitoring systems are commonly designed to measure air quality parameters within a fixed location. Many of these systems use low-cost Internet of Things (IoT) devices that combine particulate matter sensors with basic gas sensing modules to monitor pollutants present in the surrounding environment. These devices are typically deployed in homes, offices, or urban monitoring stations to observe general air quality conditions.

In industrial or research environments, more advanced sensing technologies are sometimes used to achieve higher detection sensitivity. However, these systems are often complex, expensive, and designed for laboratory or large-scale environmental monitoring applications rather than for personal use. As a result, such systems are not practical for individuals who require continuous monitoring of their immediate surroundings.

Most existing monitoring systems are also integrated with centralized data processing platforms where environmental data are collected and analysed remotely. While these solutions provide useful environmental information, they are primarily intended for regional monitoring rather than personal exposure assessment.

Therefore, individuals who are sensitive to airborne allergens usually depend on public weather reports or indoor monitoring devices to estimate air quality levels. These tools may not accurately represent the pollution levels experienced within an individual’s immediate breathing zone. Consequently, current monitoring approaches often provide delayed information about air quality conditions rather than enabling proactive protection against harmful environmental exposure.

III. DRAWBACKS IN THE EXISTING SYSTEM

Although existing air quality monitoring systems provide useful environmental information, several limitations reduce their effectiveness for personal health protection. One of the main drawbacks is that many current monitoring solutions are designed as stationary systems that measure pollution levels only within a specific location. As a result, these systems cannot capture variations in air quality that occur as individuals move through different environments during their daily activities.

Another limitation is the lack of portability in conventional monitoring devices. Many advanced sensing systems are expensive and require complex installation, making them unsuitable for continuous personal monitoring. Individuals who are sensitive to dust and airborne pollutants therefore lack access to practical tools that can measure pollution levels in their immediate surroundings.

In addition, several monitoring devices rely on delayed data processing or cloud-based analysis. This means users may receive information about poor air quality only after exposure has already occurred. For people who experience allergies or respiratory irritation due to pollutants such as particulate matter or irritant gases, this delay reduces the ability to take timely preventive action.

Furthermore, environmental conditions such as temperature and humidity can influence sensor readings, which may affect the accuracy of measurements if proper calibration is not implemented. Due to these limitations, existing monitoring systems are often insufficient for providing reliable and immediate alerts for personal environmental health protection.

IV. LITERATURE REVIEW

Recent research in environmental monitoring has focused on improving the detection and analysis of air pollutants that affect human health. Several studies have explored the development of sensor-based systems capable of measuring particulate matter and harmful gases in urban environments. These monitoring systems help researchers understand pollution patterns and evaluate environmental risks associated with poor air quality.

Traditional air quality monitoring stations are widely used by environmental agencies to measure pollutants such as particulate matter, nitrogen dioxide, and other atmospheric gases. While these stations provide accurate data for regional pollution analysis, they are typically installed in fixed locations and therefore cannot capture variations in air quality at the personal exposure level.

To address this limitation, recent developments have focused on portable and wearable monitoring devices that allow individuals to track environmental conditions in their immediate surroundings. These devices integrate compact environmental sensors with embedded electronics to continuously measure pollution levels during daily activities.

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Several research studies have demonstrated that wearable monitoring systems can help individuals better understand their exposure to airborne pollutants. By providing real-time environmental information, these systems allow users to avoid areas with high pollution levels and reduce potential health risks. As a result, wearable air quality monitoring technology has become an important area of research for improving personal environmental health awareness.

V. PROBLEM STATEMENT

Air pollution and airborne allergens remain major environmental factors that contribute to respiratory discomfort and allergic reactions. Pollutants such as particulate matter and harmful gases can cause serious health problems for individuals who are sensitive to dust or suffer from respiratory conditions.

Although environmental monitoring technologies exist, most current systems are designed for large-scale environmental observation rather than personal health protection. Stationary monitoring stations provide regional air quality information but do not accurately represent the pollution levels present in an individual's immediate surroundings.

Additionally, many available monitoring solutions do not provide instant alerts when pollution levels exceed safe limits. This delay can result in prolonged exposure to harmful pollutants before users become aware of the environmental risk.

Therefore, there is a need for a portable and wearable monitoring system capable of continuously measuring air quality conditions and providing real-time alerts. Such a system would enable individuals to monitor their surrounding environment and take preventive action when harmful pollution levels are detected.

VI. PROBLEM SOLUTION

The proposed solution involves the development of a wearable environmental monitoring and alert system designed to measure air pollutants in real time and notify users when unsafe conditions are detected. The system integrates multiple environmental sensors on a compact embedded platform to continuously monitor particulate matter and harmful gases present in the surrounding air.

The device includes sensors capable of measuring particulate matter levels such as PM1, PM2.5, and PM10 along with gas sensors for detecting pollutants including nitrogen dioxide (NO_2) and ammonia (NH_3). Temperature and humidity sensors are also incorporated to monitor environmental conditions that may influence air quality.

The collected sensor data are processed by a microcontroller and compared with predefined threshold values representing safe environmental limits. When the detected pollution levels exceed these limits, the system activates an alert mechanism.

In addition to local alerts such as vibration and LED indicators, the system also sends notifications to a mobile application through wireless communication. The mobile application allows users to view real-time environmental data and receive warnings when pollution levels become unsafe. This integrated approach enables continuous monitoring and helps users avoid exposure to harmful environmental conditions.

VII. HANDLED METHODOLOGY

The proposed wearable environmental monitoring system is designed to continuously measure air quality parameters in the user's surrounding environment and provide real-time alerts through a mobile application. The methodology of the system involves multiple stages including environmental sensing, data processing, wireless communication, and user notification.

A. Environmental Data Collection

The first stage of the system involves collecting environmental data using multiple sensors integrated into the wearable device. The particulate matter sensor is used to measure airborne dust particles such as PM1, PM2.5, and PM10, which are considered major contributors to respiratory health problems. In addition to particulate matter detection, a gas sensor is used to monitor the presence of harmful gases that may affect air quality.

A temperature and humidity sensor is also included to measure environmental conditions, as these parameters can influence pollutant concentration and respiratory comfort. All sensors continuously collect real-time environmental data from the surrounding air.

B. Data Processing

The collected sensor data is transmitted to a microcontroller, which acts as the central processing unit of the system. The microcontroller reads the sensor values at regular intervals and processes the data to determine the air quality conditions.

Predefined threshold values are used to evaluate whether the detected pollutant levels are within safe limits. If the measured particulate matter or gas concentration exceeds the predefined threshold levels, the system identifies the environment as potentially harmful for the user.

C. Wireless Data Transmission

After processing the sensor data, the microcontroller transmits the information wirelessly to a mobile application using a communication module such as Wi-Fi or Bluetooth. This allows the environmental data to be monitored remotely through the mobile device.

The wireless communication enables real-time data transfer between the wearable device and the mobile application, ensuring that users receive up-to-date information about their surrounding air quality conditions.

D. Mobile Application Monitoring

The mobile application serves as the user interface for monitoring environmental conditions. The application receives the transmitted sensor data and displays the air quality parameters such as particulate matter levels, gas concentration, temperature, and humidity.

The mobile application allows users to continuously monitor the environmental conditions in their immediate surroundings through a simple and accessible interface.

E. Alert and Notification System

An alert system is implemented to warn users when pollutant levels exceed safe limits. If the air quality parameters cross predefined threshold values, the system automatically generates notifications in the mobile application.

These notifications help users become aware of potentially harmful environmental conditions. Based on the alert, users can take preventive actions such as leaving the polluted area, wearing protective masks, or avoiding prolonged exposure to polluted environments.

F. System Workflow

The overall workflow of the proposed system can be summarized as follows:

1) Environmental sensors continuously measure particulate matter, gas concentration, temperature, and humidity.
2) The sensor data is collected and processed by the microcontroller.
3) The system compares sensor readings with predefined safety threshold values.
4) The processed data is transmitted wirelessly to the mobile application.
5) The mobile application displays real-time environmental information.
6) If pollutant levels exceed safe limits, alert notifications are sent to the user.

Through this methodology, the system provides continuous environmental monitoring and early warning alerts, enabling individuals to take timely preventive measures against exposure to harmful air pollutants.

VIII. SYSTEM ARCHITECTURE

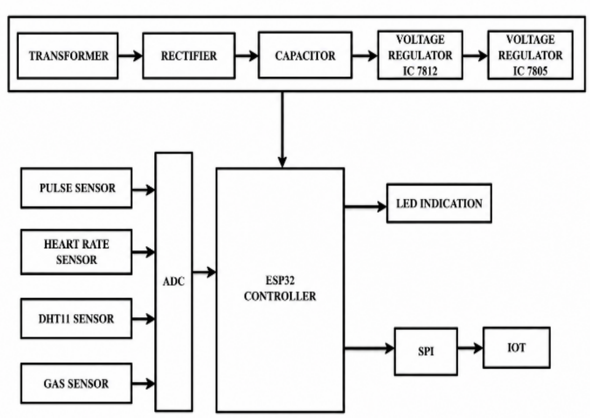

Figure 2: Overall System Architecture of the Proposed Wearable Environmental Monitoring System

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The proposed wearable environmental allergy monitoring system is designed to continuously monitor environmental parameters that may trigger allergic reactions in dust-sensitive individuals. The overall architecture consists of five major modules: sensing module, data acquisition module, processing module, alert module, and IoT communication module. These modules work together to collect environmental data, analyse pollutant levels, and generate real-time alerts when unsafe conditions are detected.

The sensing module includes multiple sensors such as a gas sensor, DHT11 temperature and humidity sensor, pulse sensor, and heart rate sensor. These sensors measure environmental conditions and physiological parameters that may indicate potential allergic exposure. The sensor outputs are processed through an Analog-to-Digital Converter (ADC), which converts analog sensor signals into digital data suitable for microcontroller processing.

The ESP32 microcontroller acts as the central processing unit of the system. It continuously reads sensor data, performs threshold-based analysis, and determines whether the environmental conditions exceed predefined safety limits. If abnormal pollutant levels are detected, the system activates the alert module, which provides visual notification through LED indicators.

Additionally, the ESP32 uses its built-in Wi-Fi capability to transmit environmental data to an IoT platform such as Blynk for remote monitoring. This enables users to track environmental conditions through a mobile application and receive timely notifications. The integrated architecture ensures real-time monitoring, early detection of harmful environmental exposure, and improved respiratory health protection for dust-sensitive individuals.

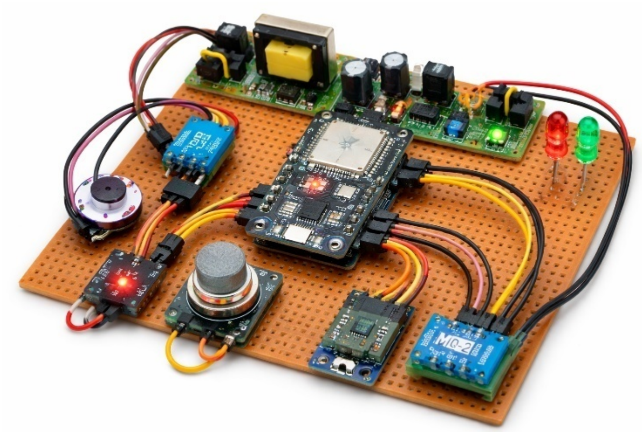

Figure 3: Hardware prototype implementation

IX. EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results demonstrate the effectiveness of the proposed wearable environmental monitoring system in detecting variations in environmental parameters. The gas concentration levels increased significantly after 15 minutes, exceeding the predefined threshold limit of 300 ppm, which triggered the alert mechanism. Temperature and humidity levels also showed gradual variation during the monitoring period, indicating the influence of environmental conditions on airborne allergen concentration. These results confirm that the proposed system is capable of continuously monitoring environmental parameters and providing timely alerts when unsafe conditions are detected.

Time (min)	Gas Concentration (ppm)	Temperature (°C)	Humidity (%)
0	180	30	60
5	200	31	62
10	240	32	65
15	310	33	68
20	330	34	70
25	290	33	69
30	260	32	67

Table 1: Environmental Sensor Readings Collected During Monitoring

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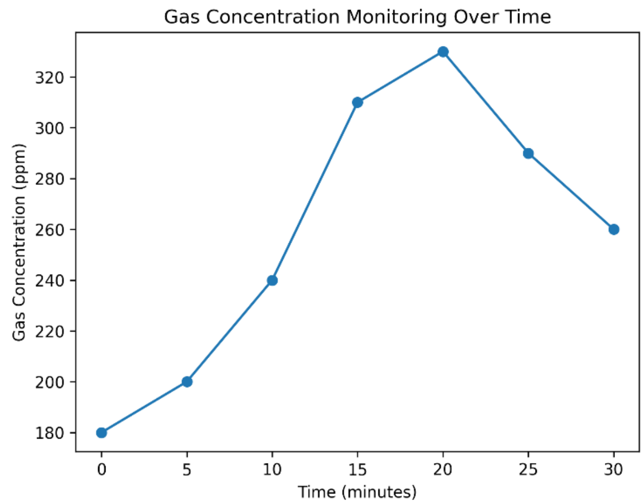

Figure 4: Gas Concentration Variation During Environmental Monitoring

The developed environmental allergy monitoring system transmits real-time sensor data to a mobile application using IoT connectivity. The dashboard interface displays various environmental and physiological parameters including heart rate, oxygen saturation (SpO2), temperature, humidity, and dust sensitivity levels. These parameters are continuously monitored and visualized through gauge-based indicators in the mobile application.

From the obtained results, the system recorded a heart rate value of 17 BPM, an SpO2 level of 99%, an environmental temperature of 34°C, and humidity of 40%. The dust sensitivity index was measured at a value of 29, indicating the presence of environmental particulate exposure. The graphical dashboard allows users to easily monitor environmental conditions in real time and receive alerts when any parameter exceeds the predefined safety thresholds. This IoT-based monitoring interface improves user awareness and supports early preventive actions for dust-sensitive individuals.

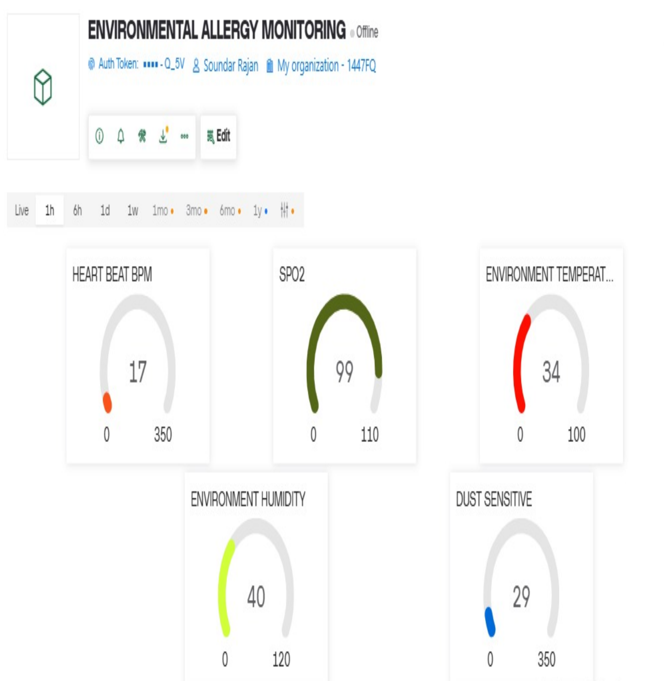

Figure 5: Real-time environmental and physiological monitoring results displayed on the IoT mobile application dashboard

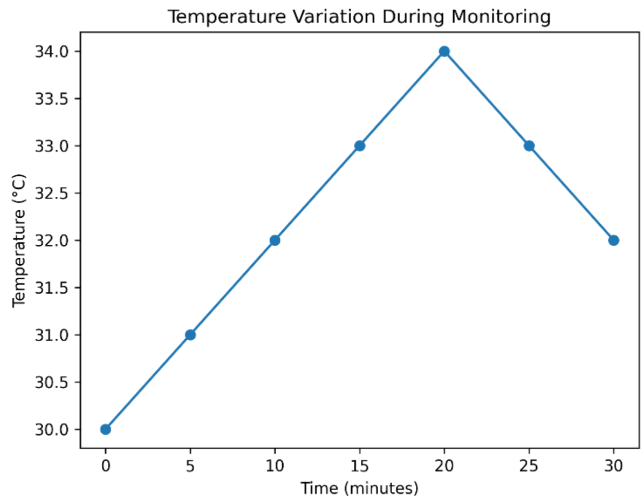

Figure 6: Temperature Variation Recorded by the Monitoring System

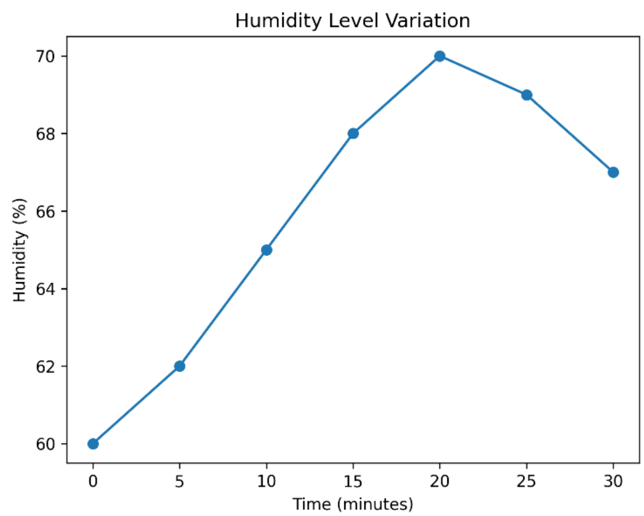

Figure 7: Humidity Level Changes During Monitoring

X. CONCLUSION

This paper presented the design and development of a wearable environmental monitoring system aimed at improving personal health awareness in polluted environments. The proposed system integrates multiple sensors to continuously monitor environmental parameters such as gas concentration, temperature, humidity, and particulate matter levels. The collected sensor data is processed using an ESP32 microcontroller, which evaluates environmental conditions based on predefined safety thresholds.

The system also includes a wireless communication mechanism that transmits the processed data to a mobile application, enabling users to monitor environmental conditions in real time. In addition, an alert mechanism is implemented to notify users whenever the detected parameters exceed safe limits, allowing them to take preventive measures.

The experimental implementation demonstrates that the proposed system can effectively monitor environmental conditions and provide timely alerts to the user. Due to its compact design and low-cost components, the system can be used as a practical solution for individuals who are sensitive to polluted environments. Overall, the proposed system contributes toward improving personal environmental monitoring and supporting proactive health protection.

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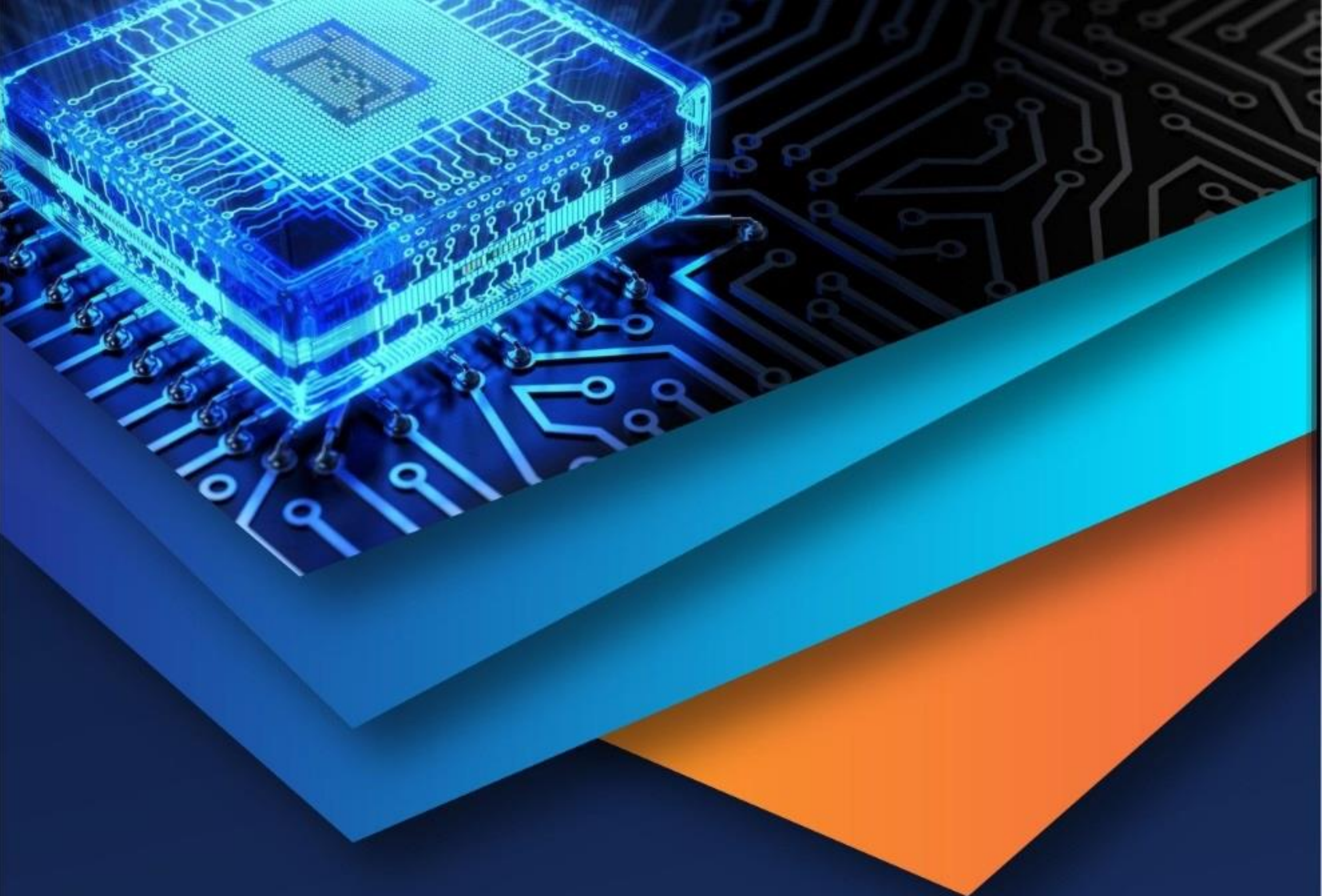

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