

Development of a Cloud-Connected Industrial Temperature and Humidity Monitoring System

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Abstract: *The present study focuses on the design and implementation of an Internet of Things (IoT)-based Industrial Temperature and Humidity Monitoring System utilizing the ESP32 microcontroller and the Blynk cloud platform. The proposed system enables real-time acquisition, processing, and visualization of environmental parameters such as temperature and humidity in industrial environments. Accurate control of these parameters is essential for maintaining product quality, ensuring equipment longevity, and providing a safe workplace.*

The DHT11 sensor is employed to measure temperature and humidity, while the ESP32 microcontroller, equipped with integrated Wi-Fi, processes the acquired data and transmits it to the Blynk cloud. Through the Blynk mobile application, users can remotely monitor live readings, analyze parameter fluctuations, and receive instant alerts when thresholds are exceeded.

The system effectively eliminates the limitations of manual monitoring by providing continuous and automated supervision. Collected data can further support predictive maintenance and performance optimization. Due to its low cost, scalability, and reliability, the proposed system is well-suited for diverse industrial applications, including manufacturing, warehousing, and pharmaceuticals. This research demonstrates an efficient, intelligent, and user-oriented approach for enhancing industrial automation and operational safety through IoT integration..

Keywords: IoT, ESP32, Blynk, Temperature and Humidity Monitoring, DHT11 Sensor, Industrial Automation, Cloud-Based Monitoring

I. INTRODUCTION

In industrial environments, maintaining optimal temperature and humidity levels is crucial for ensuring product quality, protecting sensitive equipment, and providing a safe and comfortable working atmosphere for employees. Fluctuations in these environmental parameters can lead to equipment malfunction, product degradation, or operational inefficiencies, thereby reducing overall productivity. Traditionally, industries have relied on manual monitoring methods involving human supervision, periodic inspection, and manual data logging. However, such conventional approaches are time-consuming, prone to human errors, and incapable of providing real-time data or instant alerts during sudden environmental changes. These limitations often delay corrective actions and increase the risk of system failures or product damage.

To overcome these challenges, the integration of Internet of Things (IoT) technology presents a smart, automated, and efficient solution for industrial environmental monitoring. The proposed IoT-based Industrial Temperature and Humidity Monitoring System employs an ESP32 microcontroller and a DHT11 sensor to continuously measure environmental conditions in real time. The DHT11 sensor records temperature and humidity values, while the ESP32—equipped with inbuilt Wi-Fi capability—processes this data and transmits it to the Blynk cloud platform. This wireless



connectivity eliminates the need for physical monitoring and allows users to remotely observe environmental parameters using the Blynk mobile application.

Through the Blynk interface, users can visualize live readings, analyze historical trends, and define threshold limits for both temperature and humidity. When these thresholds are exceeded, the system automatically sends alert notifications, enabling operators to take timely corrective measures. This functionality enhances industrial safety and prevents potential losses caused by environmental deviations. Additionally, the Blynk cloud facilitates data logging and long-term storage, supporting predictive maintenance and performance optimization.

The ESP32 microcontroller was selected for its low cost, compact architecture, high processing capability, and reliable wireless communication, making it an ideal platform for IoT-based monitoring systems. The proposed system can be deployed across various industrial sectors, including manufacturing plants, warehouses, cold storage facilities, food processing units, and pharmaceutical industries—where maintaining controlled environmental conditions is essential.

In conclusion, the proposed IoT-based Industrial Temperature and Humidity Monitoring System provides an efficient, real-time, and automated approach to monitoring critical environmental parameters. It minimizes manual intervention, enhances operational efficiency, and promotes data-driven decision-making. By integrating IoT, cloud computing, and mobile technology, this system represents a modern, scalable, and sustainable solution for advancing industrial automation and environmental management.

II. LITERATURE SURVEY

Several researchers have contributed to the advancement of IoT-based environmental monitoring systems for industrial and commercial applications. Patel et al. (2024) developed a cloud-connected temperature and humidity monitoring system using Arduino and the Blynk platform. Their system enabled real-time data acquisition and remote accessibility, allowing users to monitor warehouse environmental conditions efficiently. The integration of Blynk provided a simple user interface for data visualization and alert notifications.

Sharma and Lee (2024) designed a multi-sensor IoT framework that combined DHT22 and gas sensors to enhance safety and environmental supervision in industrial settings. Their approach demonstrated how multi-parameter sensing could improve accuracy and provide a more comprehensive assessment of workplace conditions.

Chen (2023) proposed a Wi-Fi-enabled IoT system for temperature regulation in food storage facilities. The system offered continuous monitoring, automated data collection, and real-time alert notifications to prevent spoilage, ensuring compliance with food safety standards.

Kumar et al. (2023) implemented an ESP8266-based industrial monitoring system that featured data logging and mobile notifications. The system improved the reliability of environmental supervision by providing immediate alerts during critical fluctuations in temperature and humidity, thereby ensuring timely preventive actions.

Garcia and Martinez (2023) explored IoT-based temperature and humidity monitoring using Raspberry Pi and MQTT communication protocols. Their study emphasized data reliability, scalability, and seamless communication between edge devices and cloud servers, making it suitable for smart factory implementations.

Wang et al. (2022) focused on the development of cloud visualization dashboards that provided real-time monitoring, historical data analysis, and performance tracking. Their work highlighted the importance of cloud computing and data analytics in enhancing industrial process efficiency and decision-making.

Collectively, these studies demonstrate the growing significance of IoT, cloud connectivity, and smart sensing technologies in industrial automation. They also highlight the trend toward developing low-cost, reliable, and user-friendly solutions that can be remotely managed through mobile and cloud platforms.

Table1: Comparative review of smart temperature controlled fan system..

Paper / Project	System Architecture	Cost	Ease of Implimentation	Performance	User Experience	Limitations
Patel et al. (2024)	Arduino + DHT11 Sensor +	Low	Easy	Good real-time monitoring	Simple mobile dashboard	Limited scalability and



	Blynk Cloud					data storage
Sharma and Lee (2024)	DHT22 + Gas Sensors + IoT Gateway	Moderate	Moderate	High accuracy and safety alerts	Enhanced multi-sensor integration	Increased complexity and cost
Chen (2023)	ESP32 + Wi-Fi + Cloud Dashboard	Low	Easy	Fast real-time response	User-friendly interface with alerts	Limited to small-scale applications
Kumar et al. (2023)	ESP8266 + Cloud Server + Mobile App	Low	Easy	Reliable data logging and alerts	Accessible via mobile notifications	Limited to small-scale applications
Garcia and Martinez (2023)	Raspberry Pi + MQTT Protocol + Cloud	Moderate	moderate	Stable and scalable performance	Interactive visualization via cloud	Higher power consumption

III. PROPOSED METHODOLOGY

The proposed IoT-Based Industrial Temperature and Humidity Monitoring System is designed to measure, process, and visualize environmental parameters in real time. The methodology consists of both hardware and software components that work together to ensure reliable data collection, cloud transmission, and user accessibility.

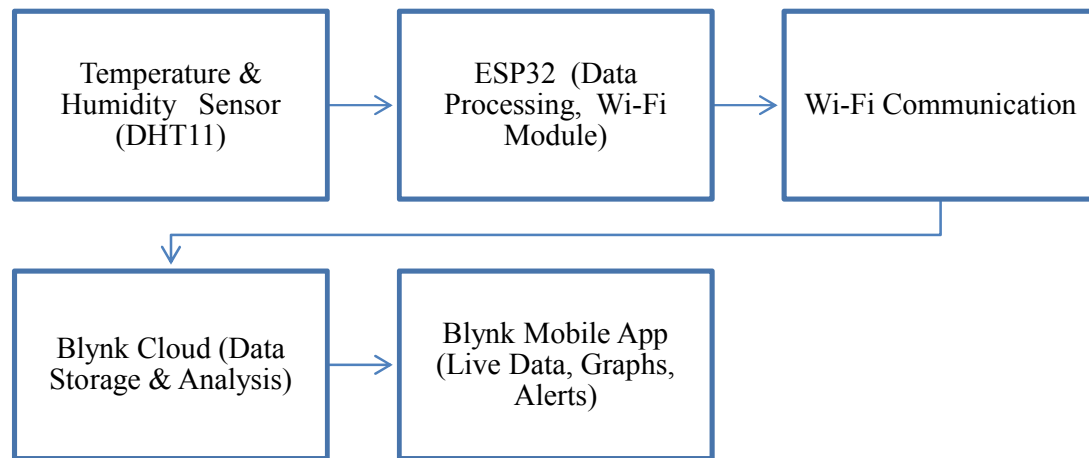


Figure1: Block Diagram of Cloud-Connected Industrial Temperature and Humidity Monitoring System

Figure 1 shows the system architecture of the proposed IoT-based temperature and humidity monitoring system. The DHT11 sensor measures environmental parameters and sends data to the ESP32 microcontroller. The ESP32 processes the data and transmits it via Wi-Fi to the Blynk cloud, where the readings are visualized on a mobile application for real-time monitoring and alert notifications.

1. System Design

The system architecture comprises an ESP32 microcontroller, a DHT11 sensor, and the Blynk IoT platform. The ESP32 is selected as the central processing unit because of its built-in Wi-Fi and Bluetooth capabilities, low cost, and high processing efficiency. The DHT11 sensor measures ambient temperature and humidity, providing digital data output compatible with the ESP32. The design emphasizes modularity and scalability, enabling additional sensors such as air-quality or gas detectors to be integrated in the future.



2. Hardware Implementation

The DHT11 sensor is interfaced with the ESP32 using digital input pins and powered through a 3.3V regulated supply. The assembled circuit is compact and energy-efficient, allowing continuous operation through USB or an adapter. The connections are verified for stability to ensure accurate data sensing and minimal noise interference.

3. Software Development

The software implementation is carried out using the Arduino IDE. Required libraries, including *WiFi.h*, *DHT.h*, and *BlynkSimpleEsp32.h*, are integrated into the code. The Wi-Fi credentials and Blynk authentication token are configured to establish a secure connection between the ESP32 and the Blynk cloud server. The microcontroller is programmed to acquire temperature and humidity readings periodically and transmit them to the cloud platform in real time.

4. Cloud Connectivity and Data Visualization

Once connected, the ESP32 continuously uploads the sensor data to the Blynk cloud. The Blynk mobile application displays live readings through user-friendly widgets such as gauges and charts. Users can monitor environmental conditions remotely and set predefined

threshold values for both temperature and humidity. If these thresholds are exceeded, the system automatically sends notifications to the user, prompting immediate corrective actions.

5. Testing and Validation

The system is tested under varying environmental conditions to evaluate its accuracy, response time, and Wi-Fi stability. Data readings are compared with standard reference instruments to verify precision. The results confirm that the system provides consistent real-time updates and accurate environmental monitoring suitable for industrial applications.

6. System Advantages

The proposed system is low-cost, portable, and easy to implement. It reduces manual effort, minimizes human error, and enables predictive maintenance through continuous monitoring. The cloud integration ensures data accessibility from anywhere, supporting informed decision-making and improved process efficiency.

The methodology integrates IoT, sensor technology, and cloud computing to build a reliable, real-time monitoring system. Using ESP32 and Blynk ensures seamless data collection, visualization, and alerting, offering an efficient and scalable solution for industrial environmental management.

IV. RESULTS AND DISCUSSION

The IoT-based Industrial Temperature and Humidity Monitoring System was successfully implemented and tested using the ESP32 microcontroller, DHT11 sensor, and Blynk cloud platform. The system continuously monitored temperature and humidity values in real time and transmitted the data to the Blynk mobile application through Wi-Fi. During testing, the system demonstrated stable connectivity, quick data refresh rates, and accurate sensor readings under varying environmental conditions.

Table 1 presents the observed temperature and humidity readings recorded during the experimental phase. The DHT11 sensor provided consistent results, with an average accuracy deviation of $\pm 1^\circ\text{C}$ for temperature and $\pm 3\%$ for humidity compared to a standard reference hygrometer.

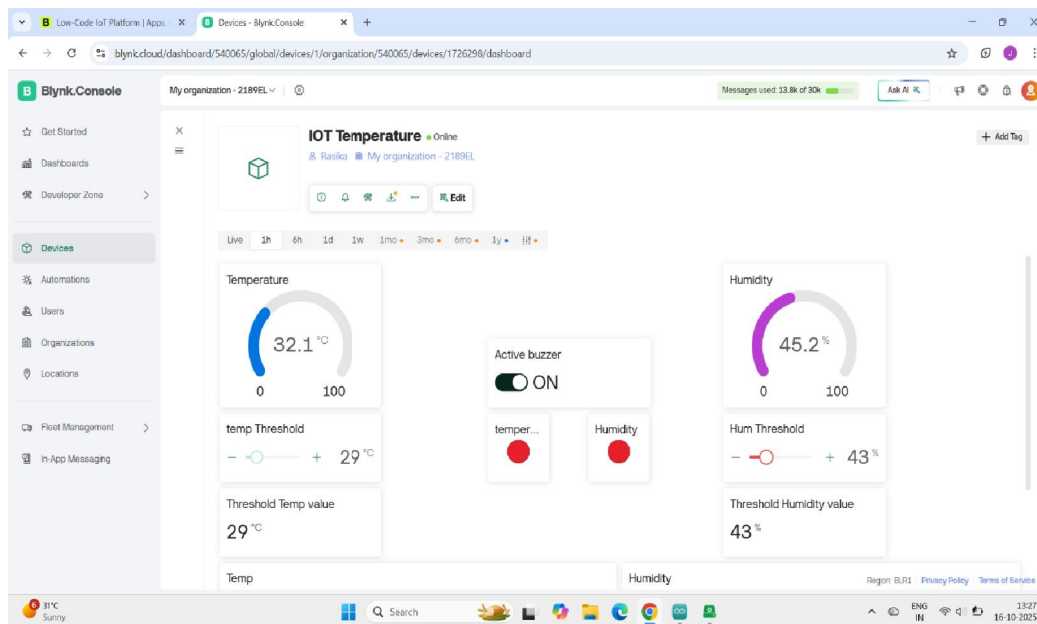
Time (HH:MM)	Temperature ($^\circ\text{C}$)	Humidity (%)	Condition
10:00	28.4	64.1	Normal
10:00	29.2	66.3	Slight increase
10:00	31.0	71.0	Threshold reach
11:30	33.6	72.4	Alert triggered
12:00	30.6	69.2	Normalized



When temperature or humidity exceeded predefined limits, the system immediately sent a notification through the Blynk app, verifying the successful operation of the alert mechanism. The average response time for data updates and alerts was found to be less than two seconds, confirming real-time communication efficiency.

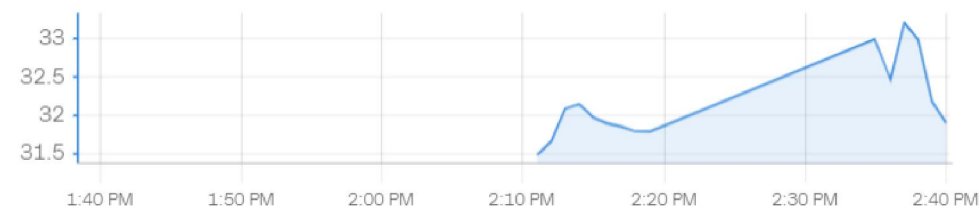
he graphical representation on the Blynk dashboard allowed users to visualize variations in environmental conditions over time, aiding in better decision-making. The system remained stable during long-duration tests, showing no significant data loss or Wi-Fi disconnection issues.

Overall, the proposed system achieved reliable and continuous monitoring performance. It proved to be cost-effective, easy to implement, and suitable for scalable industrial environments. The results validate that IoT integration using ESP32 and Blynk provides an efficient solution for industrial automation, predictive maintenance, and environmental safety.



Temp

● Temperature

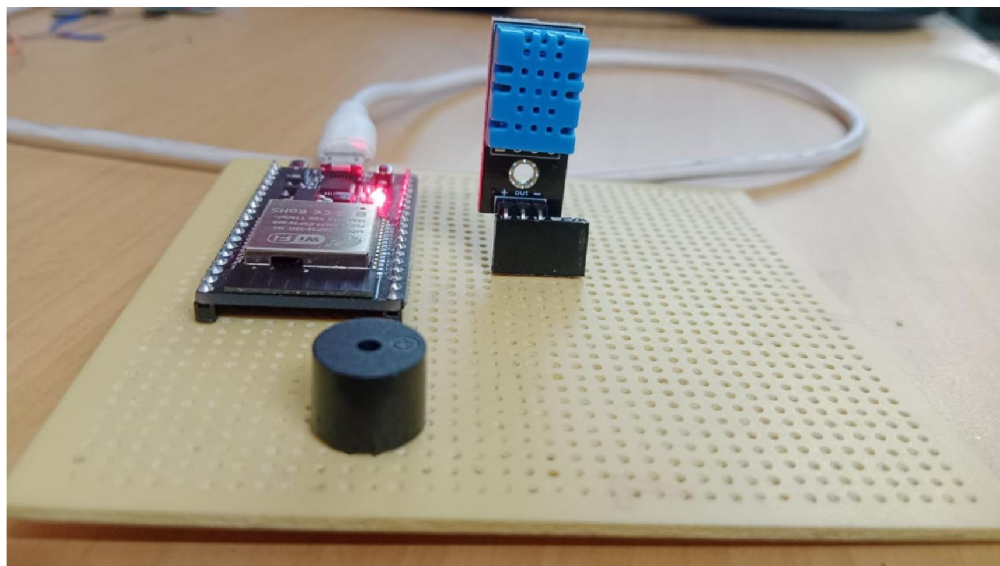
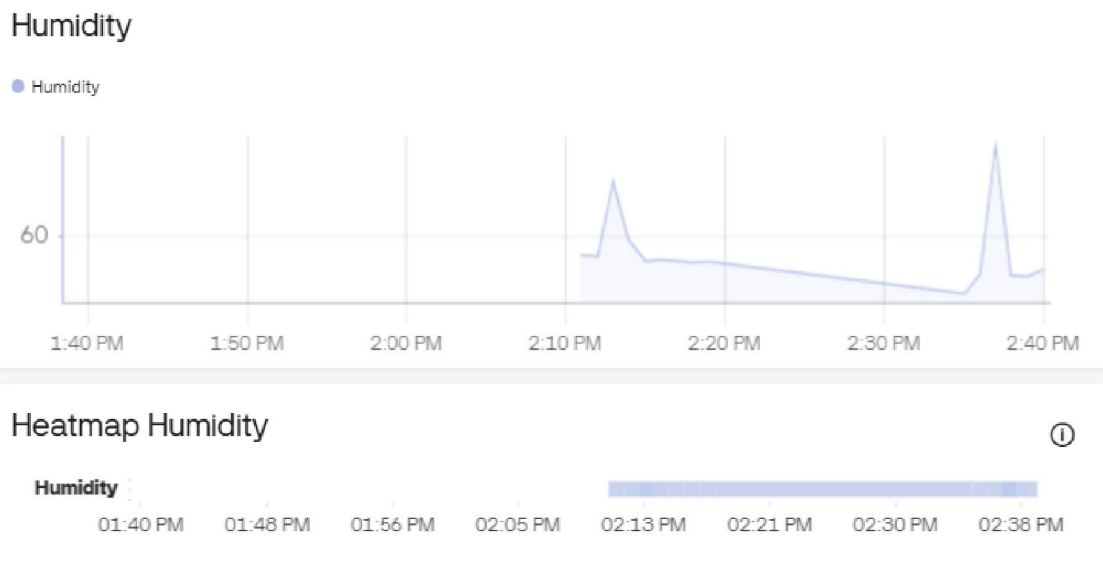


Heatmap Temperature

Temperature

01:40 PM 01:48 PM 01:56 PM 02:05 PM 02:13 PM 02:21 PM 02:30 PM 02:38 PM





V. CONCLUSION

The proposed IoT-based Industrial Temperature and Humidity Monitoring System using ESP32 and Blynk successfully demonstrates an efficient, low-cost, and real-time solution for environmental monitoring in industrial applications. The system integrates the DHT11 sensor with the ESP32 microcontroller to continuously measure temperature and humidity, while the Blynk platform enables cloud-based visualization and remote access.

Experimental results confirmed that the system delivers accurate and stable readings with minimal latency. The alert mechanism effectively notifies users when environmental parameters exceed predefined thresholds, ensuring timely corrective action and enhanced operational safety. The use of Wi-Fi-enabled ESP32 eliminates the need for external communication modules, simplifying the hardware design and reducing overall cost.



This system offers high scalability and flexibility, allowing additional sensors such as gas, pressure, or air-quality modules to be incorporated for comprehensive environmental monitoring. The results indicate that IoT-based automation can significantly improve process control, reduce manual intervention, and support data-driven decision-making in industrial environments.

Future enhancements may include the integration of advanced analytics, AI-based predictive maintenance, and improved cloud security features to further optimize system performance and reliability.

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