International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

IoT-Enabled Smart Inhaler with GSM and Cloud-Based Health Monitoring System

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Abstract- Asthma is a chronic respiratory condition that affects millions of individuals worldwide and often leads to serious health complications due to missed medication and exposure to environmental triggers. To address this issue, this paper presents the design and development of an IoT-based Smart Inhaler System aimed at improving medication adherence, monitoring environmental conditions, and enabling real-time alerts during critical situations. The system comprises a smart inhaler unit embedded with a usage detection sensor and a wearable smart band equipped with temperature, humidity, and gas sensors to detect potentially harmful surroundings. The collected data is transmitted to a cloud platform via Wi-Fi, while a GSM module provides emergency communication through SMS alerts. This comprehensive solution ensures proactive asthma care by integrating real-time monitoring, data logging, and timely intervention. The implementation demonstrates improved safety, reduced risks, and enhanced healthcare support for asthma patients through a cost-effective and intelligent system.

Keywords— Asthma, Smart Inhaler, IoT, Environmental Monitoring, GSM, ESP8266 Node MCU, ThingSpeak, MQTT, Real-Time Alerting

I. INTRODUCTION

Asthma continues to be one of the most common and dangerous respiratory disorders, often leading to hospitalization and even fatalities if left unmanaged. While inhalers serve as the first line of defense in asthma treatment, studies have shown that many patients forget or ignore prescribed inhaler schedules. In addition, changes in environmental factors such as temperature, humidity, or air quality significantly increase the risk of asthma attacks. These challenges underscore the necessity of an integrated system that can monitor health-related data, detect high-risk conditions, and promote timely medical action.

To address these limitations, the Smart Inhaler System introduces an IoT-enabled approach to asthma management. The system consists of two major units: a smart inhaler embedded with a usage detection sensor and a wearable smart band equipped with DHT11 and MQ-135 sensors. The inhaler unit detects whether the user has taken their prescribed dose, while the wearable band monitors real-time temperature, humidity, and air quality conditions. Sensor data from both units is collected and processed by an ESP8266 NODE MCU microcontroller and uploaded to the cloud using Thing Speak for real-time tracking and record-keeping.

The system also incorporates a SIM800L GSM module to deliver emergency alerts when dangerous conditions or missed medication events are detected. A buzzer or vibration motor provides local notification to the user, ensuring that they are aware of unsafe surroundings or missed inhaler use. The combined implementation of cloud connectivity, local alerts, and mobile communication helps reduce emergency response time and improves the quality of life for asthma patients.

This paper outlines the full design process of the system, including hardware integration, sensor calibration, data transmission, and software implementation. By introducing this Smart Inhaler solution, the aim is to promote proactive health management and minimize asthma-related health risks through an intelligent, cost-effective system.

II. LITERATURE REVIEW

A. Background and Related Work

The increasing global prevalence of asthma has led to extensive research on digital health solutions aimed at improving disease management. Several studies have investigated the use of IoT-based systems for medication adherence, environmental monitoring, and remote health supervision. The integration of embedded electronics and wireless communication has opened up new possibilities in the automation of asthma treatment and real-time response systems.

Patel et al. (2023) proposed an IoT-based smart inhaler system that detects inhaler usage through an airflow sensor and uploads data to the cloud. Their system successfully logs the frequency and timing of inhaler use, but lacks integrated environmental monitoring or emergency alerts. Sharma et al. (2022) introduced a wearable device that monitors temperature and humidity using the DHT11 sensor and alerts the user via local notification. However, the system does not

track inhaler compliance, reducing its effectiveness in preventing asthma attacks caused by skipped medication.

In another study, Alvi et al. (2020) developed a portable air quality monitoring system using the MQ-135 sensor to measure pollutants. Although the system provides real-time detection of poor air conditions, it does not interact with the user's medication habits, thereby limiting its use in asthma management. A related work by Roy et al. (2021) integrated a GSM module to send emergency SMS alerts during respiratory distress, showcasing the importance of immediate communication in asthma emergencies.

Most of the existing systems perform well in isolated areas—either environmental monitoring, inhaler logging, or emergency communication—but fail to integrate all three into a single solution. Furthermore, many systems rely on manual data input, have no cloud storage, or do not provide automated alerts, reducing their practicality in day-to-day asthma care.

The proposed Smart Inhaler System fills these gaps by integrating inhaler usage detection, temperature and humidity monitoring, gas sensing, and GSM-based emergency alerts into one comprehensive IoT platform. This all-in-one solution addresses both preventive and reactive aspects of asthma management by ensuring medication adherence, providing trigger warnings, and facilitating timely caregiver intervention.

III. METHODOLOGY

The proposed IoT-based Smart Inhaler System is designed to assist asthma patients by monitoring their medication usage and environmental conditions while enabling emergency alert mechanisms. The system architecture is divided into two units: the Inhaler Unit and the Wearable Band Unit. Both units are developed using ESP32 microcontrollers programmed through the Arduino IDE.

The **Inhaler Unit** is embedded with a usage detection sensor, typically a pressure or airflow switch, which detects every press of the inhaler. This detection is essential for ensuring medication adherence. The sensor output is read digitally by the ESP32 microcontroller, and each inhaler press event is timestamped and stored for cloud upload. The microcontroller is also interfaced with a SIM800L GSM module to send SMS alerts when usage is missed within a predefined timeframe.

The **Wearable Band Unit** is worn on the wrist and contains a DHT11 sensor to monitor temperature and humidity levels and an MQ-135 gas sensor to detect air pollutants such as carbon monoxide, ammonia, and smoke. These readings help identify environments that can trigger asthma symptoms. The ESP32 continuously reads data from these sensors and uses its built-in Wi-Fi to transmit the information to a Thing Speak cloud platform in real time. This enables healthcare providers and caregivers to remotely access live data and historical logs.

Both units operate on rechargeable lithium batteries regulated to provide safe voltage levels to all components. A buzzer or vibration motor on the wearable unit provides real-time feedback to the user during unsafe conditions. Alerts are generated locally and remotely, ensuring that both the patient and caregiver receive notifications in critical situations.

The entire system was tested under various environmental conditions and usage scenarios to validate sensor accuracy, cloud synchronization, and GSM communication reliability. The methodology ensures seamless integration of health tracking, cloud computing, and emergency alerts, all essential for real-time asthma management.

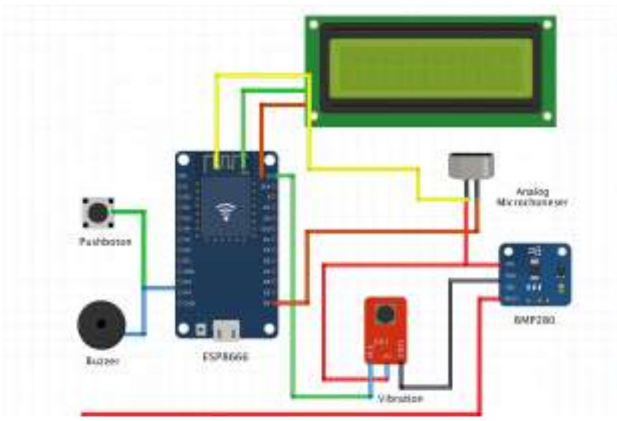


Fig. 2. Inhaler Unit Side Circuit Connections

The proposed IoT-Based Smart Inhaler System comprises two main components: the inhaler-mounted unit and a wearable band. Together, they function as a unified system to monitor the health of asthma patients by logging medication usage, sensing environmental triggers, and providing timely alerts. The design emphasizes portability, automation, and ease of integration into daily life.

The Inhaler Unit is designed to detect medication usage through a pressure sensor attached near the actuator of the inhaler. The ESP32 microcontroller continuously reads the digital output of the sensor. Upon each detected press, the microcontroller logs the event and transmits the data to a cloud server using Wi-Fi. If an expected dose is not administered within a scheduled time window, the system triggers a buzzer on the wearable unit and sends an SMS alert to the registered caregiver via the GSM module. This ensures that both patients and caregivers are immediately informed about missed medication, reducing the risk of emergency conditions.

The Wearable Band Unit includes a DHT11 sensor to measure temperature and humidity, and an MQ-135 gas sensor to detect harmful gases and pollutants. These sensors are selected based on their compact size, affordability, and suitability for continuous, wearable applications. Sensor values are read periodically and uploaded to the Thing Speak cloud server using the ESP32's Wi-Fi connectivity. In the case of hazardous environmental conditions—such as

high humidity or pollutant levels—a local alert is generated using a buzzer or vibration motor, and a remote alert is sent via SMS.

The two units communicate wirelessly where necessary and operate independently for specific tasks. Sensor readings are structured into data packets and pushed to the cloud for logging and visualization. The Thing Speak dashboard provides real-time graphs and historical trends, which can be accessed remotely by doctors or caregivers through a web or mobile interface. The integration of cloud-based visualization supports predictive care and early intervention.

Power to both units is supplied using rechargeable lithium batteries (3.7V) with onboard voltage regulators to maintain 3.3V and 5V levels as required by the components. The hardware and software are designed for low-power operation to support extended daily usage without frequent recharging.

The combination of real-time inhaler usage logging, environmental sensing, local and remote alerting, and cloud connectivity creates a reliable and intelligent system for asthma care. This proposed scheme offers a comprehensive, cost-effective solution tailored to improve the quality of life for asthma patients through proactive health monitoring.

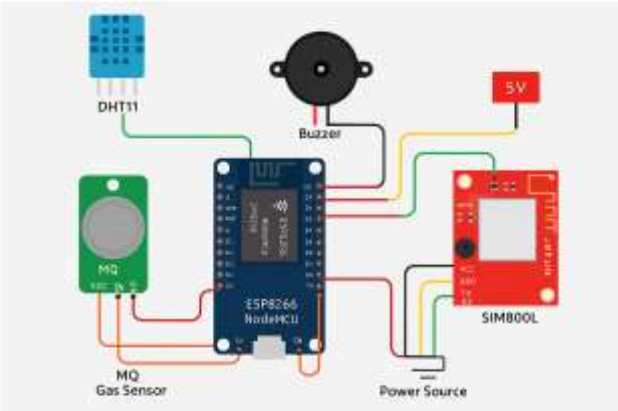


Fig. 3. Band Unit Side Circuit Connections

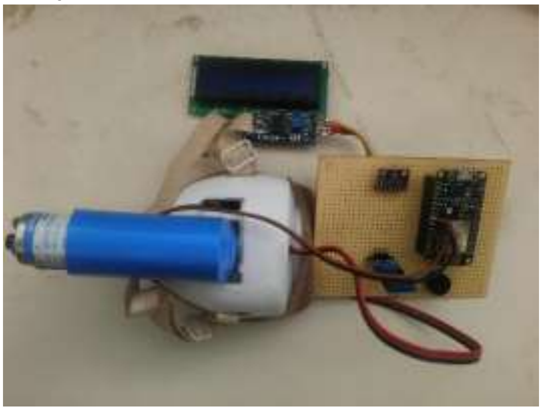
The implementation of the IoT-based Smart Inhaler System was carried out using a functional prototype model comprising ESP8266-based inhaler and wearable units. Each module—usage detection, environmental monitoring, GSM communication, and cloud transmission—was integrated and tested for stability and accuracy. The inhaler unit was mounted with a pressure sensor to detect medication use, while the wearable band included DHT11 and MQ-135 sensors to assess environmental conditions. Initial diagnostics confirmed successful sensor calibration and microcontroller initialization.

During performance evaluation, the system accurately detected each press of the inhaler through the pressure sensor, with timestamped data being successfully uploaded to Thing Speak. If a scheduled dosage was missed, the system activated the local buzzer and automatically sent an emergency SMS to a predefined caregiver's number via the SIM800L GSM module. This ensured prompt awareness and intervention.

In environmental simulations, the wearable band effectively captured real-time temperature, humidity, and gas levels. When the ambient gas concentration exceeded the safety threshold, the buzzer on the wearable unit was triggered, and a remote alert was sent. The DHT11 sensor displayed accurate temperature and humidity values throughout the trials, confirming environmental condition tracking reliability.

The communication between the inhaler and wearable units, as well as their cloud synchronization, was achieved through stable Wi-Fi connections. Across multiple trials, the system exhibited consistent performance and responded to both usage events and environmental changes with minimal latency. Power was supplied through regulated lithium-ion cells, providing uninterrupted operation during field testing.

These results validate the system's capability for real-time asthma management, offering medication tracking, environmental alerts, and emergency communication in a compact, wearable format. The project proves effective as a cost-efficient and scalable solution for improving the daily safety and health of asthma patients.



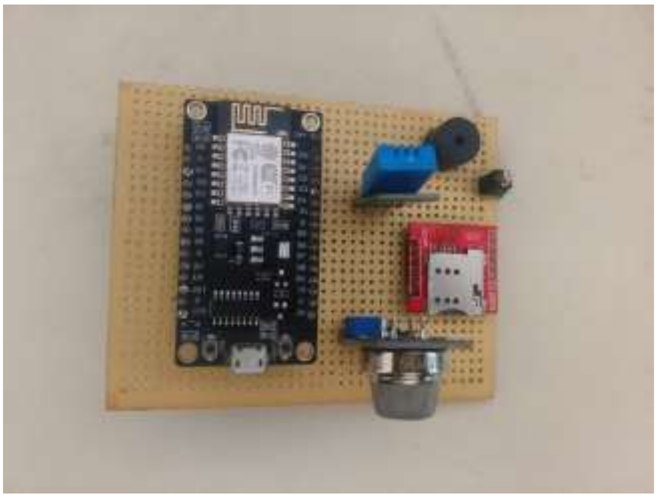


Fig. 5. Smart inhaler prototype

The current implementation of the Smart Inhaler System provides a robust foundation for enhancing asthma care through digital health solutions. However, several potential upgrades can further improve its effectiveness and user interaction. One major enhancement would be the integration of voice assistance, which could deliver real-time audio alerts for missed medication schedules or exposure to harmful environmental conditions. This feature would help ensure that the patient receives instant, hands-free feedback, improving adherence and safety without the need for screen-based interaction.

Another promising development is the incorporation of GPS functionality. By integrating a GPS module, the system can transmit the user's real-time location during emergency alerts. This would not only improve the response time of caregivers or emergency services but also enable route history tracking for identifying environmental hotspots or exposure-prone zones. Such insights can be valuable for medical professionals and caregivers in providing personalized care strategies.

Cloud storage and mobile application integration could also significantly extend the system's capabilities. With cloud-based data logging, long-term trends in inhaler usage and environmental exposure can be visualized and analyzed. A connected mobile app can offer real-time dashboards, schedule reminders, and push notifications to both users and caregivers, making the system more interactive and responsive.

Finally, future versions of the system can include predictive analytics using AI/ML models to detect patterns of missed medication or hazardous exposure and generate early warnings. These innovations would transform the Smart Inhaler System into a comprehensive, intelligent health monitoring tool, capable of offering both preventive care and real-time support to asthma patients.

VI. CONCLUSION

This project successfully presents the development of an IoT-based Smart Inhaler System designed to improve asthma care through real-time health monitoring and intelligent alert mechanisms. The system emphasizes preventive healthcare by ensuring inhaler usage compliance and detecting harmful environmental triggers. It begins by verifying medication adherence using a pressure sensor embedded in the inhaler, while the wearable band continuously monitors temperature, humidity, and air quality through DHT11 and MQ-135 sensors. Upon detecting missed medication or unsafe environmental conditions, the system immediately activates a buzzer for local alerts and employs a GSM module to send SMS notifications to caregivers or emergency contacts. These features ensure timely intervention and reduce the risk of severe asthma episodes.

Additionally, the system leverages ThingSpeak cloud connectivity to store and visualize sensor data in real time, allowing caregivers and medical professionals to analyze trends and make informed decisions. Wireless data transmission using the ESP32 microcontroller ensures seamless integration between system components, enabling a compact, efficient, and portable design.

In conclusion, the Smart Inhaler System demonstrates how IoT technologies can be applied effectively in chronic disease management. By integrating multiple sensors, cloud services, and communication modules, the project offers a scalable, cost-effective solution for real-time asthma monitoring and response. Its successful implementation lays the groundwork for future innovations in smart healthcare and patient-centric medical systems.

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