



SMART SYSTEM FOR MONITORING DEPARTMENTAL ATMOSPHERIC CONDITIONS AND EMERGENCY ALERT

Khushi Shivhare, Chandani Parate, Snehal Raut, Shubhangi jangle,
Mr.D.G.gahane

Department of Electronics and telecommunication Engineering
Priyadarshini College of Engineering, Nagpur, Maharashtra, India

Abstract : This paper presents an IoT-enabled solution, named the Smart System for Monitoring Departmental Atmospheric Conditions and Emergency Alert, for tracking air quality and safety-related conditions in a department, laboratory or comparable indoor space without interruption. A monitoring station gathers data through three sensing elements: an ENS160 with AHT21 module for CO₂ and ambient readings, a CS8811 sensor for air quality, and a sound sensor for detecting abnormal noise levels. An Arduino Nano collects these measurements and sends them through a LoRa radio module to a remote receiving unit based on an ESP32. That unit presents the values on an LCD display, sounds a buzzer when any reading exceeds its set safe limit, and uploads the data to a Firebase cloud database so that it can be viewed through a web page. By combining multi-sensor measurement, low-power long-range communication, cloud access, an LCD display and automatic alarms in one platform, the system cuts down on manual inspection, gives staff a remote view of departmental conditions and enables quicker detection of, and reaction to, unsafe situations.

IndexTerms - IoT, Atmospheric Monitoring, Emergency Alert System, Arduino Nano, ESP32, LoRa, LCD Display, Firebase, Air Quality, CO₂ Monitoring.

I. INTRODUCTION

Indoor spaces such as offices, laboratories and classrooms are affected by many atmospheric factors. Weak ventilation, raised CO₂ concentration, unsuitable temperature or humidity and sudden loud noise can lower comfort and productivity and may endanger occupants. Relying on people to check conditions occasionally, or on instruments that work in isolation, seldom produces an instant warning when something goes wrong. To address this, the Smart System for Monitoring Departmental Atmospheric Conditions and Emergency Alert merges several sensors, microcontrollers, a wireless link and a cloud service into a single automated arrangement.

Sensing takes place at the monitoring station. The ENS160 with AHT21 module supplies CO₂ and ambient data, the CS8811 sensor supplies air-quality data, and a sound sensor reports unusual noise. An Arduino Nano reads each of these outputs, processes them and hands them over for wireless transmission.

A LoRa module links the station with a separate IoT unit, which makes cabling between the two unnecessary while still allowing a fairly long range at low power consumption. This IoT unit is centred on an ESP32 microcontroller. It receives the readings, shows them on an LCD display and, using its inbuilt Internet connectivity, sends them to the Firebase cloud, where they are stored and made available on a web-based interface. As a result, conditions in the department can be viewed remotely and not just at the LCD of the receiving unit.

Emergency alerting is the main highlight. Every measurement is compared continuously with its preset safe limit, and an out-of-range value or an unusual sound level switches on the buzzer so that people close by are warned immediately. The same readings continue to appear on the LCD and on the web interface for staff who are elsewhere. With real-time sensing, wireless transfer, cloud monitoring, LCD display and automatic alarms working together, hazardous conditions can be caught early, which is useful in departments, laboratories, offices, classrooms and industrial areas where regular supervision is needed.

II. LITERATURE REVIEW

Published work on smart environmental monitoring and emergency alerting generally concludes that IoT technology allows indoor conditions to be tracked continuously and raises safety levels in workplaces and educational institutions.

- IoT-based environmental monitoring: Connected sensors take over the job of manual inspection and report temperature, humidity, air quality and gas concentration as they change.
- Air quality and CO₂ monitoring: Research on indoor spaces stresses measuring CO₂ and air-quality indicators to reveal poor ventilation and unhealthy air; using multiple sensors together yields a more complete assessment.
- Wireless sensor networks: Radio links are used to bring readings from monitoring points to remote systems. LoRa suits such work since it combines long range with low power consumption between spread-out stations and a central receiver.
- Microcontroller-based monitoring: Arduino and ESP32 boards are commonly chosen to acquire and process sensor data and operate connected devices. Typically the Arduino performs acquisition, and the ESP32 contributes processing and Internet access.
- Cloud-based data monitoring: Many IoT designs rely on cloud platforms to store, visualize and share data, so users can check readings in a web browser without being on site.
- Local display units: LCD modules are frequently attached to microcontrollers to present sensor values at the point of measurement, so that people there get immediate feedback even without network access.
- Emergency alert mechanisms: Earlier designs add buzzers and comparable alarms that alert users once values exceed set limits, helping staff react promptly to danger.

Overall, the literature points to the value of combining multi-parameter sensing, LoRa communication, ESP32-based IoT connectivity, cloud monitoring, an LCD display and emergency alerts: together they form a more complete answer than any single technique. The proposed system unites these elements in one platform to deliver continuous monitoring, remote data access and prompt warnings.

III. PROBLEM STATEMENT AND SIGNIFICANCE

This work responds to the need for continuous, dependable supervision of atmospheric and safety conditions in departments, laboratories, offices and other enclosed work areas. Usually, temperature, humidity, CO₂, air quality and noise are measured manually or with devices that operate separately, which leaves gaps in the record and makes sudden or abnormal changes hard to catch. Where readings can be viewed only on site, those responsible cannot follow conditions when they are away, and the lack of an integrated alarm can slow the reaction to a problem.

Addressing this problem is important because workplace conditions have a direct bearing on comfort, health, productivity and safety. By bringing together multi-parameter sensing, LoRa communication, IoT monitoring, an on-site LCD display and emergency alerts in a single platform, the proposed system allows problems to be found sooner, lowers the manual monitoring effort, and offers a scalable option for offices, laboratories, classrooms, industrial departments and other smart spaces.

IV. OBJECTIVES

- To keep continuous watch over CO₂ concentration, air quality, temperature, humidity and sound level in a department or similar enclosed space.
- To design an automated sensing arrangement in which multiple sensors supply an Arduino Nano that collects and processes real-time environmental readings.
- To establish dependable wireless transfer of sensor data from the monitoring station to the IoT unit through LoRa.
- To offer remote monitoring and data storage with an ESP32-based IoT unit connected to the Firebase cloud.
- To make readings available instantly on site through an LCD display and remotely through a web-based interface.
- To trigger a buzzer alarm at once when any sensor value exceeds its safe limit or an abnormal condition is detected.

V. SYSTEM DESIGN AND METHODOLOGY

A. System Architecture

Two functional units make up the system: the main monitoring station and the IoT receiving unit. The station holds the environmental sensors, the Arduino Nano and a LoRa transmitter module, and is responsible for sensing and local processing. The receiving unit holds a LoRa receiver, an ESP32 microcontroller, an LCD display and a buzzer; it accepts the incoming data, displays it, uploads it to the Firebase cloud and generates the emergency alerts. Table 1 lists the main hardware and the role of each item.

Table 1: Hardware Components and Their Function

Component	Function
ENS160 + AHT21	Measures CO2 and ambient conditions
CS8811	Measures air quality
Sound sensor	Senses abnormal or excessive noise
Arduino Nano	Reads the sensors and processes data locally
LoRa module (Tx/Rx)	Long-range, low-power wireless link between the units
ESP32	Handles IoT processing and Internet access
Firebase cloud	Cloud storage and web-based display of readings
LCD display	Shows readings on site at the receiving unit
Buzzer	Local audible alarm for emergencies

B. Working Methodology

- 1) **Environmental Data Collection:** The sensors given in Table 1 observe the atmospheric and safety conditions of the department without a break and provide up-to-date information about the area around the monitoring station.
- 2) **Data Acquisition and Processing:** The Arduino Nano, to which the sensor outputs are connected, acts as the central acquisition and processing element. At regular intervals it reads each sensor, processes the values and arranges the measurements ready for transmission.
- 3) **Abnormal Condition Detection:** The processed values are checked against preset safe limits for CO2 concentration, air quality, temperature, humidity and sound level. A value above its limit is treated as a warning or emergency, which initiates the alert response.
- 4) **Wireless Data Transmission Using LoRa:** The processed data pass from the Arduino Nano to the LoRa transmitter module, which radios them to the receiving unit. No wired connection is therefore required, and the units can be placed at a convenient distance from each other.
- 5) **IoT Connectivity and Cloud Monitoring:** At the receiving unit, the ESP32 takes the data from the LoRa receiver, processes it and shows it on the LCD display, and then uses its Internet connection to upload the readings to the Firebase cloud. Authorized users can open the stored data on a web-based interface and monitor conditions from a distance.
- 6) **Emergency Alert and Continuous Monitoring:** The received data are assessed without pause, and the buzzer is switched on the moment an abnormal condition is found. It warns those near the receiving unit, while the LCD display and web interface present the related readings so that on-site and remote staff can both see what is happening. In this way the method gives continuous sensing, processing, wireless transfer, LCD display, cloud monitoring and rapid emergency indication in a single system.

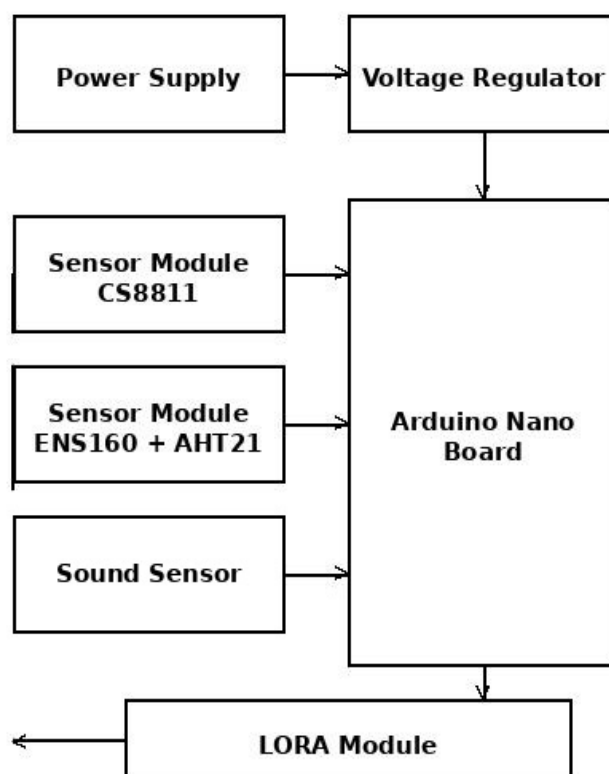


Fig.1. Block diagram of the main monitoring station (transmitter side)

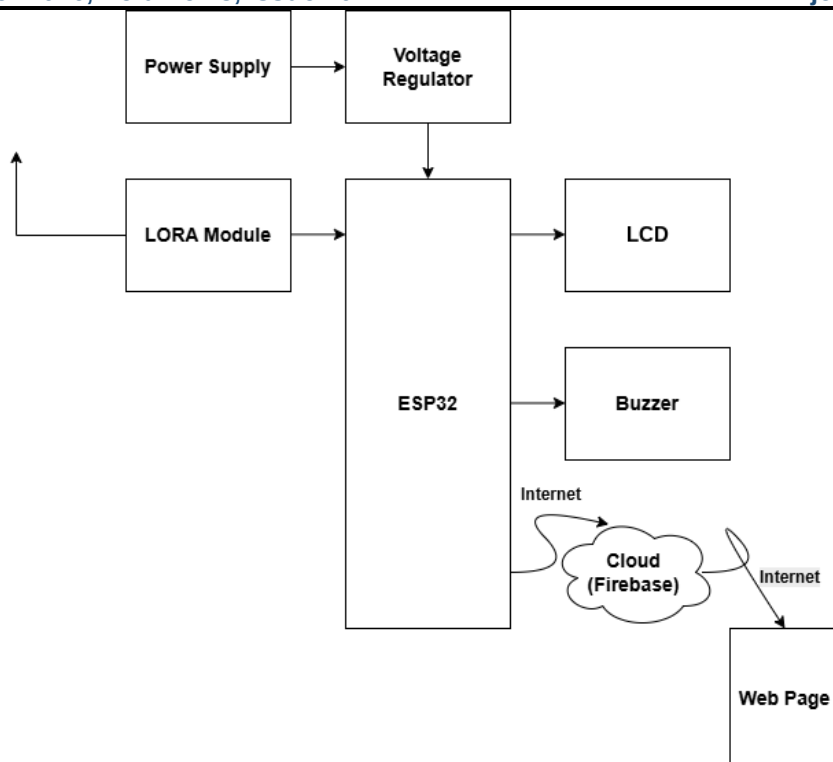


Fig.2. Block diagram of the IoT receiving unit (receiver side)

VI. RESULTS AND DISCUSSION

The project is at the design and development stage, so the results described are expected ones. The monitoring station should capture CO₂, air-quality, temperature, humidity and sound-level data continuously with little delay. The LoRa link should deliver this data dependably over the intended indoor distance to the ESP32-based receiving unit while consuming less power than Wi-Fi-based alternatives, since LoRa is built for long-range, low-power communication. At the receiving unit, the ESP32 should present the incoming readings on its LCD display and upload them to the Firebase cloud database, from which a web dashboard can show them anywhere that has Internet access, fulfilling the remote-monitoring objective. If a simulated or real parameter passes its safe threshold, the buzzer should sound immediately, and the abnormal value should stay visible on the LCD display and web interface, confirming that local alerting and remote visibility complement each other.

In conclusion, the design indicates that multi-parameter sensing, LoRa communication, ESP32-based cloud connectivity, an LCD display and buzzer alerts can together provide continuous, reliable and remotely accessible supervision of departmental atmospheric and safety conditions, lessen the dependence on manual checks and support faster responses to unsafe situations.

VII. CONCLUSION AND FUTURE SCOPE

The Smart System for Monitoring Departmental Atmospheric Conditions and Emergency Alert provides a combined approach to watching over safety and environmental conditions in a department. Using an Arduino Nano, an ESP32, LoRa communication, environmental sensors, an LCD display, Firebase cloud storage and buzzer alerts, it enables continuous collection of data, wireless transmission, remote monitoring and quick recognition of abnormal conditions. It is applicable to departments, laboratories, offices, classrooms, industrial areas and any other location where air quality and environmental conditions must be checked regularly, and it offers a sound basis for a smarter, more connected and more responsive monitoring infrastructure.

Future work may add mobile push notifications and SMS alerts, machine-learning prediction of abnormal conditions ahead of time, further sensors for gases such as CO and LPG, solar-powered operation for efficient deployment, and integration with building-wide fire and access-control systems, so that the design grows into a wider smart-building safety platform.

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