ANNDATA: AN IOT-BASED ENVIRONMENTAL MONITORING SYSTEM FOR COLD STORAGE UNIT

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ABSTRACT

Demand for effective cold storage management is rapidly increasing, especially in the food, pharmaceutical and biomedical domains. This paper proposes an IoT-based system "Ann Data" to monitor and control parameters in cold storage units, such as temperature, humidity, compressor status (ON/OFF), door lock status, and gas leakage. The system continually monitors and controls the cold storage units to ensure their perishable goods maintain the optimum quality of freshness by providing real-time data, alerts/alarms and automated control actions. The system uses sensors, microcontrollers and cloud analytics which can be then scaled and have reliability in the monitoring solution. The hardware and software architecture, design and performance evaluation of the prototype demonstrates its promise for industrial use is documented in this paper.

KEYWORDS: *Cold Storage, IoT, Environmental Monitoring, Temperature Control, Humidity Sensor, Leakage Detection, Web page monitoring*

1. Introduction

Food storage represents a significant consideration when assessing food security, minimizing post-harvest losses, and maintaining the quality of agricultural, horticultural, and aquacultural produce. In agriculture, adequate storage systems ensure that staple crops and grains stay fresh with limited spoilage and loss from pests, moisture, and/or microbial contamination. For horticulture, adequate storage will permit perishable fruits and vegetables to have a more extended shelf life, preserve nutritional product quality and marketability. For aquaculture, cold storage is necessary to preserve the harvested fish while inhibiting bacterial growth. Controlling environmental conditions, which may encourage growth, is an essential component to effective food storage. Model not only leads to decay but also can produce mycotoxins, which have serious health implications and economic losses. Hence, knowledge of the environmental conditions under which proliferation humidity, temperature, and ventilation takes place is critical to the design of efficient storage systems. This research paper delves into the significance of food storage in these industries and analysis the environmental conditions development within storage facilities.

Cold stores play a crucial role in maintaining the quality of temperature-sensitive items. Conventional monitoring systems are usually manual and response-based, leading to potential spoilage or hazard through a reaction delay.To counterbalance this, Ann Data came into play which uses real time remote monitoring and logging of eles of importance environmental parameters. At the heart of it is the use of IoT technology to not only make operations efficient but also minimize human error and allow for predictive maintenance strategies.

The following paper is designed to meet the challenge of ineffective monitoring in rural cold storage buildings for perishables. It initiates with the overview of currently existing cold chain problems, after which an IoT-based system model for real-time monitoring of temperature, humidity, door opening access, and power status is detailed. The sections that follow outline system architecture, data

visualization, alerting methods, predictive maintenance capabilities, power efficiency, and deployment viability with a focus on advantages for farmers and rural supply chain participants.

2. Literature Review

Earlier studies have addressed various cold storage monitoring methods. The systems were proposed for tracking temperature variations using i2c module. ESP32 and Raspberry Pi based systems through IoT have proven beneficial in the implementation of sensors in real-time alerting most of the systems do not have door open/close status and gas leakage that are critical in efficiency and safety aspects. Ann Data bridges this gap by combining environmental monitoring, access and Hazard control. They are sensing humidity, Temperature, cooling, leakage, door / open Close status and have an auto cooling function.

3. Components & Materials

Components are mounted & emulate in Ann Data project:

- Outer side of plastic closure box mounted the 16x2 LCD Display with I2C module (PCF8574T) / CPU Cooling shows temperature, humidity, and system status.
- I2C address can be set using jumpers.
- Button (Tactile Button) for input or resetting.
- LEDs (Bright white) used to show system status (e.g., power, start OK/error).
- Set resistor with LEDs and the transistor base or pull-down setup.
- Buck meter (voltage adjusting mainly utilized as a variable resistor)
- Battery Pack of 3 (18650 Li-ion cells Can be utilized as a portable power. total voltage ~11.1V (3.7V x 3).
- Plastic enclosure Box Utilized for framing the circuit securely.
- DHT11 Sensor Since temperature and humidity readings are displayed on the LCD is highly likely utilized.
- Microcontroller (Node MCU) and small component, it exists to read sensor information and drive the LCD and LEDs and acting similar to heart in the organisms.
- Electronic lock for automatic lock and also shown status of open and door close on web page.
- Moisture sensor for leakage detection of the cold storage, the platform is modular and consists of sensor nodes that are connected to a central microcontroller.
- Sensor readings are transmitted to a cloud server at specified intervals. It also includes a user interface for real-time monitoring and an alert system upon occurrence of threshold violations (e.g., high temperatures or gas alerts)

4. Methodology

The architecture is equipped with sensors and modules along with it for the Conditioning of environment to transfer data for Upkeep.

Sensor Calibration: Sensors are calibrated for accuracy. Microcontroller Programming: ESP32 is programmed using Arduino IDE. Transmission of Data: Sensor data gets uploaded using MQTT or HTTP protocol. Integration of Cloud: stores the data. Alert Generation and Notifications: SMS or mail notifications get activated through Chrome page (192.168.1,1). testing and Validation: Prototype testing is done by emulating the environmental changes.

4.1 System Architecture

The system is client-server based. ESP32 is the client, sending sensor data to the cloud. The cloud server is the backend, providing storage, processing, and user access. A web/mobile interface reads data from the cloud to display and control.

4.2 Hardware Setup and Software Design

Hardware:

- ESP32 with GPIO pins connected to sensor, Voltage divider circuits for safe operation of sensor, Relay modules on compressor lines Software:
- NODE MCU code controls sensor reading and Wi-Fi connection, Cloud API integration for logging data
- HTML/CSS/JavaScript dashboard for visualization

Fig 1: In this figure shown enclosure plastic box where all components are simulate.

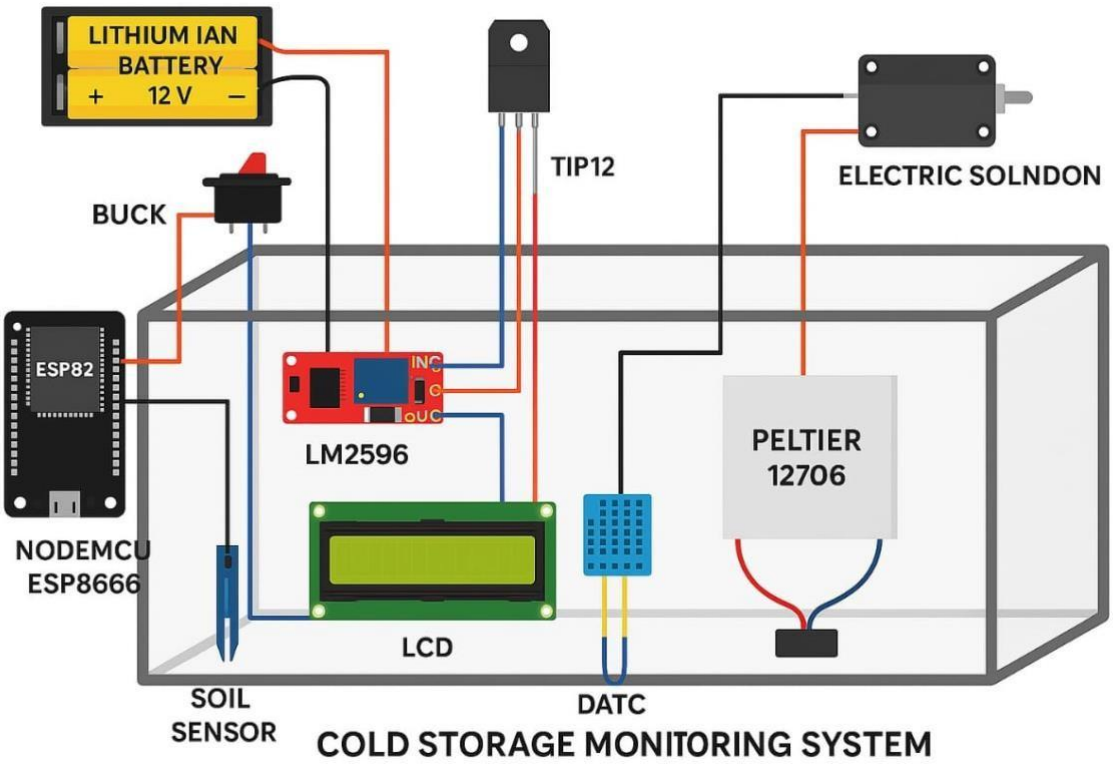


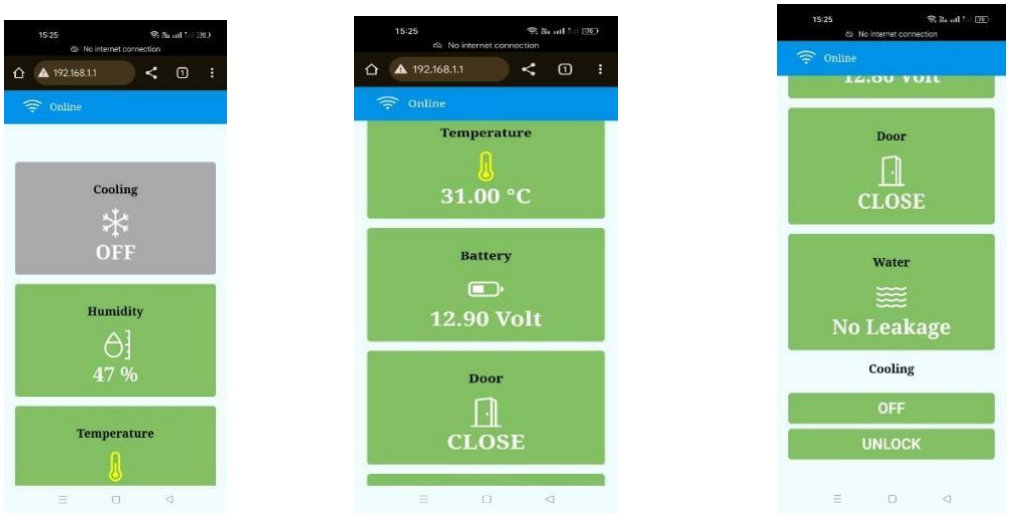
Fig 2: Circuit Diagram of Ann Data

5. Results and Discussion

In summary, the suggested IoT-based cold storage monitoring system tackles key issues confronting rural and semi-urban storage facilities through ensuring real-time monitoring of environmental conditions and equipment performance. With automated notification, predictive maintenance, and visualization, the system reduces product loss and improves operational efficiency. With high energy efficiency and scalability, it's well-positioned for distributed use remote. This solution has immense opportunity to benefit farmers, food processors, and members of the supply chain by providing product quality and reducing economic loss. The system correctly monitored environmental conditions, and accurately represented the anomalies that had been detected. Alerts were sent at defined thresholds, and secure logging of data to the cloud was achieved. The prototype has been validated through variations in temperature and humidity with durations of over 72 hours with over 95% accuracy in the data and a 100% success rate for the delivery of alerts.

(a) (b)

Fig 3 (a & b): Working model of Ann Data



(a) (b) (c)

Fig 4 (a, b, c) : Web page result for observing the environmental condition of cold storage units

6. Conclusion and Future Work

AnnData brings a cutting-edge solution to the table for monitoring environmental conditions in cold storage warehouses. With real-time sensing capabilities, it tracks various parameters like temperature, humidity, door access, and power usage. The cloud-based application makes it super easy to access data whenever you need it, and it sends notifications to keep you informed, making it a great fit for monitoring in rural and remote areas. Looking ahead, future upgrades will leverage machine learning for predictive maintenance, boosting efficiency and minimizing downtime. Plus, its solar-powered operation means it can work off the grid, and integrating with ERP systems will streamline supply chain and inventory management. All these innovations will transform Ann Data into a fully integrated and scalable cold storage monitoring system.

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