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IoT-Enhanced Smart Cold Storage Facility for Horticultural Products

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Abstract

The study proposes a cold storage horticulture monitoring system designed to ensure optimal storage conditions for the horticulture products, thereby preserving quality and extending shelf life. The system integrates rechargeable batteries, a voltage regulator, and MOSFET technology to regulate the data collection and processing through the Arduino and NodeMCU. Environmental parameters like temperature, humidity, and gas levels are monitored using various sensors, while a DC fan regulates airflow for temperature uniformity. The GSM module enables real time monitoring. This system offers a solution for enhancing the quality and shelf life of horticultural products.

Keywords: Horticulture Product, Cold Storage, Gas Detection, Temperature Detection

1. Introduction

Preserving the freshness and quality of plant products during storage is a critical challenge in horticulture[1]. The cold storage horticulture monitoring system addresses this challenge by exactly monitoring and regulating environmental conditions within cold storage facilities. Key components include rechargeable batteries regulated by the 7085 voltage regulators for uninterrupted power, MOSFET technology for efficient power distribution, and microcontrollers (Arduino and Node MCU) for data collection and processing [6]. A GSM module is used for remote monitoring and communication [2], while sophisticated sensors

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(Peltier, temperature, and gas sensors) monitor the critical environmental parameters. A DC fan ensures consistent temperature distribution, thereby fortifying the integrity of the storage environment [4]. This system aims to extend the shelf life and safeguard the quality of horticultural products, contributing significantly to the agricultural sector and food security [8,10].

2. Existing System

Existing cold storage facilities require careful control over temperature, humidity, and air quality to maintain food safety and quality [3], [4]. However, they face inherent risks such as electric current hazards, compressor temperature fluctuations, and potential refrigerant leakage. An IoT-based control (IoT-BC) system equipped with multipurpose sensors can address these challenges by enabling real-time monitoring and risk alerts [5, 6]. This research evaluates the efficiency of deploying an IoT-BC system for remotely monitoring and controlling microclimate parameters and operational conditions within a modified cold storage room (MCSR). Comparative analysis shows that the IoT-BC system manages the MCSR effectively [8], providing reliable data and preserving the superior attributes of stored date fruits, thus enhancing the management of existing cold storage facilities [9,10].

3. Proposed System

The proposed cold storage system integrates advanced technology to revolutionize the preservation of horticulture products. Key components include:

- Rechargeable Battery (3.7v)
- Voltage Regulator (7085)
- MOSFET for efficient current control
- Arduino and Node MCU
- GSM module
- Peltier Module or thermoelectric cooler, temperature sensor, and gas sensor for environmental monitoring
- DC fan for airflow regulation

- IoT for seamless connectivity and data exchange

The system offers real-time monitoring and control, ensuring optimal storage conditions. The rechargeable battery provides reliable backup power, while the regulator ensures stable current output. The GSM module enables remote monitoring, allowing stakeholders to receive alerts regarding temperature fluctuations or anomalies. The sensors monitor temperature, humidity, and gas levels, and the DC fan ensures proper airflow. IoT technology facilitates comprehensive monitoring and analysis, optimizing the preservation of horticulture products and minimizing wastage.

3.1 Proposed Block Diagram

The Figure.1 shows the block diagram of the proposed.

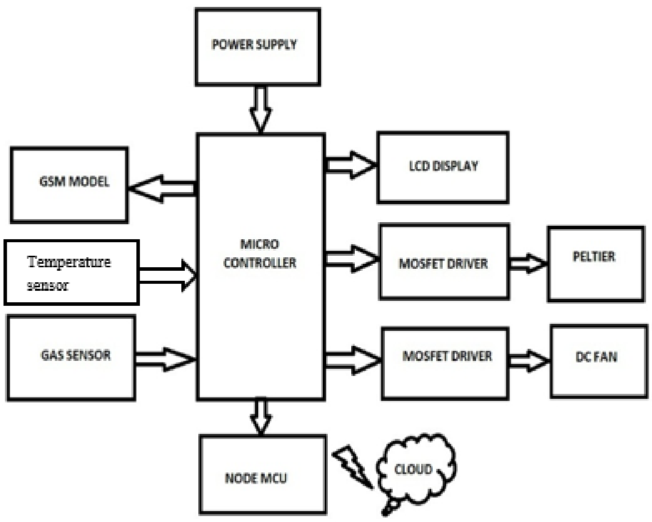

Figure 1. The Block Diagram of the Proposed System

3.2 Components

- NodeMCU: Facilitates communication between components and enables IoT connectivity.
- Arduino Atmega32: Manages specific tasks and interfaces with sensors or actuators.
- Rechargeable Battery (3.7v): Ensures continuous operation.
- Voltage Regulator 7085: Provides stable power supply.
- MOSFET: Controls current flow and enhances efficiency.

- GSM Module (SIM800L): Enables remote communication.
- Peltier Module (TEC1-12706): Regulates temperature by heating or cooling.
- Temperature sensor (DHT11): Monitors temperature inside the facility.
- Gas Sensor (MQ3): Detects gases that can affect product quality.
- DC Fan: Ensures uniform airflow within the facility.

4. Working of Proposed Method

The proposed IoT-enhanced smart cold storage facility is designed to ensure optimal storage conditions for horticultural products, thereby extending shelf life and preserving quality. The system integrates various components and technologies to monitor, regulate, and maintain the ideal environment within the storage facility.

The rechargeable battery provides power to the entire system. The regulator (7085) ensures a stable current output to avoid fluctuations. Sensors (temperature, gas, Peltier) continuously monitor environmental conditions. Arduino and Node MCU collect data from these sensors and process it for real-time analysis. The Peltier module adjusts the temperature by either heating or cooling, maintaining the optimal temperature range. The temperature sensor ensures the temperature remains consistent. The gas sensor detects any harmful gases and triggers alerts if levels exceed the threshold. The DC fan ensures uniform distribution of air within the storage facility, preventing temperature stratification. The GSM module allows stakeholders to remotely monitor environmental parameters through mobile devices. IoT technology enables real-time data sharing and notifications. Alerts are sent if any parameter deviates from the preset ranges. Data is visualized using Blynk and ThingSpeak, allowing for easy interpretation and timely interventions.

Proactive Measures: The system automatically takes corrective actions based on sensor data, such as adjusting the fan speed or activating the Peltier module. Alerts and notifications prompt users to take manual interventions when necessary. The Figure 2 illustrates the flowchart of the proposed.

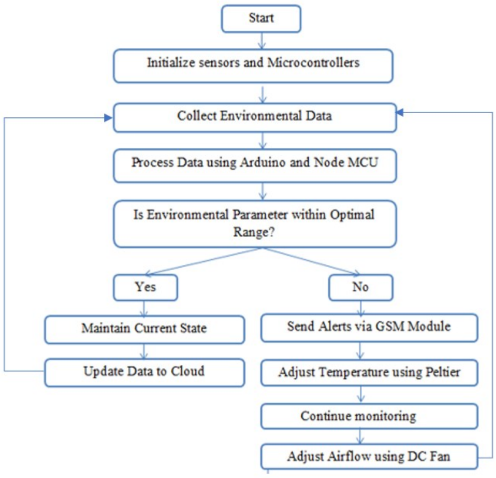

Figure 2. Flowchart of Proposed System

5. Results and Discussion

The implementation of the cold storage system for horticulture products has significantly advanced the preservation of product quality and storage conditions.

5.1 Temperature and Environmental Monitoring

The integration of Peltier module, temperature sensors, and gas sensors provides comprehensive environmental monitoring. Real-time data collection ensures precise temperature control and timely detection of deviations, maintaining the desired storage conditions.

5.2 Remote Monitoring and Control

GSM modules and IoT technology allow stakeholders to access real-time data on environmental parameters from anywhere. Alerts and notifications enhance responsiveness and enable proactive measures to prevent spoilage or quality deterioration.

5.3 Energy Efficiency and Power Management

Rechargeable batteries, the regulator 7085, and MOSFET contribute to energy efficiency and effective power management. This sustainable approach reduces operational costs and enhances the system's reliability and longevity.

5.4 Airflow Regulation

The DC fan ensures uniform distribution of cool air, preventing temperature stratification and maintaining consistent conditions throughout the storage space. This improves product quality and reduces spoilage risks.

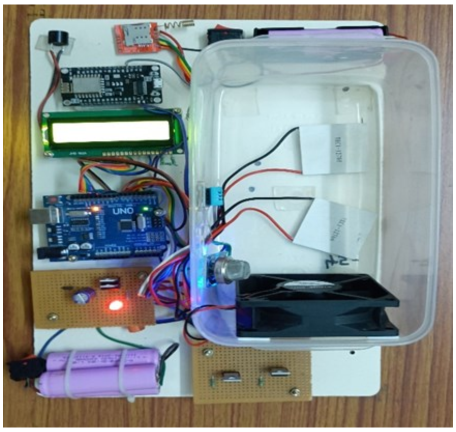

Figure 3. Hardware of Proposed System

Hardware setup of the proposed cold storage system, including the sensors, microcontrollers, GSM module, rechargeable batteries, and other components necessary for the system's operation are shown in Figure.3

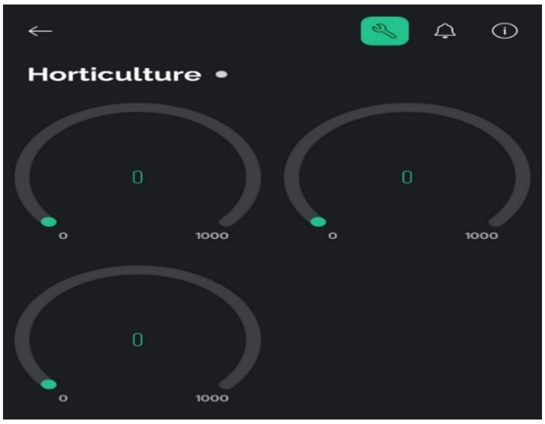

Figure 4. Monitoring of Cold Storage Value in Blynk APP

In Figure.4 the real-time monitoring of cold storage conditions through the Blynk app is shown. It illustrates how environmental parameters such as temperature and humidity are tracked and visualized on a smartphone for remote access.

Figure 5. Monitoring of Gas Level in ThingSpeak

The gas level data collected from the cold storage system is visualized on the ThingSpeak platform, as shown in Figure .5. It demonstrates how gas concentrations are monitored and recorded to ensure optimal storage conditions.

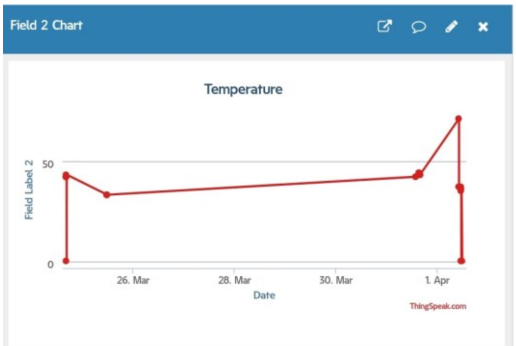

Figure 6. Monitoring of Temperature Level in ThingSpeak

The temperature data from the cold storage system is displayed on the ThingSpeak platform, as shown in Figure.6. It shows the real-time tracking and logging of temperature levels to maintain the required conditions for horticultural product preservation.

Figure 7. Monitoring of Humidity Level in ThingSpeak

The humidity data from the cold storage system is visualized on the ThingSpeak platform, as shown in Figure.7. It highlights the system's capability to monitor and control humidity levels, important for maintain the quality of stored products.

5.5 Software Integration and Use in the Proposed Work

Arduino IDE is used for coding the microcontrollers to interface with sensors and other components.

Blynk App is used for real-time remote monitoring and control through a smartphone.

ThingSpeak is used for storing and visualizing data collected from the sensors.

Fritzing and Proteus are used for the purpose of designing and simulating the electronic components, ensuring they work correctly before physical assembly.

6. Conclusion

The development of a specialized cold storage system for horticulture products marks a significant advancement in preserving perishable goods. The system integrates rechargeable batteries, regulators, sensors, GSM modules, and IoT technology to maintain optimal storage conditions. Real-time monitoring, remote accessibility, and energy-efficient functionality mitigate spoilage risks and preserve product integrity. By providing the users with heightened control and monitoring capabilities, the system enhances cold storage facilities' operational efficiency and contributes to reducing food wastage and improving product standards. This successful implementation sets the stage for further innovations in preserving perishable goods and optimizing storage facility management in horticulture.

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Author's biography

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