REMOTE MONITORING FOR AUTOMATED COLD STORAGE FACILITY MANAGEMENT SYSTEM

Submitted

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DECLARATION

We declare that the mini project work contained in this report is original and it has been done by me under the guidance of my project guide.

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CERTIFICATE

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Signature of the Project Guide

Signature of HOD

ACKNOWLEDGMENT

We would like to express our gratitude to all the individuals and organizations who have contributed to the development of our system for utilizing machine learning and the Internet of Things (IoT) to monitor food quality (smart computers). First off, a big thank you to our group. They put a lot of effort into developing and enhancing our system. Without them, it never would have occurred. We also like to thank our mentors and instructors for their guidance and assistance. They were vital to the success of our endeavor and acted as our guides. Organizations donated funds to our project so that we could purchase tools and conduct tests. We appreciate their financial assistance. Thank you also to the individuals and organizations that allowed us to utilize their information and spaces to test.

ABSTRACT

Cold storage is deemed one of the main elements in food safety management to maintain food quality. The temperature, relative humidity (RH), and air quality in cold storage rooms (CSRs) should be carefully controlled to ensure food quality and safety during cold storage. In addition, the components of CSR are exposed to risks caused by the electric current, high temperature surrounding the compressor of the condensing unit, snow and ice accumulation on the evaporator coils, and refrigerant gas leakage. These parameters affect the stored product quality, and the real-time sending of warnings is very important for early preemptive actionability against the risks that may cause damage to the components of the cold storage rooms. The IoT-based control (IoT-BC) with multipurpose sensors in food technologies presents solutions for postharvest quality management of fruits during cold storage. Therefore, this study aimed to design and evaluate a IoT-BC system to remotely control, risk alert, and monitor the microclimate parameters, i.e., RH, temperature, CO_2 , C_2H_4 , and light and some operating parameters, i.e., the temperature of the refrigeration compressor, the electrical current, and the energy consumption for a modified CSR (MCSR). In addition, the impacts of the designed IoT-BC system on date fruit quality during cold storage were investigated compared with a traditional CSR (TCSR) as a case study. The results showed that the designed IoT-BC system precisely controlled the MCSR, provided reliable data about the interior microclimate atmosphere, applied electrical current and energy consumption of the MCSR, and sent the necessary alerts in case of an emergency based on real-time data analytics. There was no significant effect of the storage time on the most important quality attributes for stored date fruit in the MCSR compared with the TCSR. As a result, the MCSR maintained high-quality attributes of date fruits during cold storage. Based on the positive impact of the designed IoT-BC system on the MCSR and stored fruit quality, this modification seems quite suitable for remotely managing cold storage facilities.

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Chapter I:

1.Introduction

1.1.1 In a world driven by rapidly advancing technology and the constant quest for efficiency, one of the most critical aspects of modern commerce is the preservation of perishable goods. Cold storage facilities play an irreplaceable role in the supply chain, ensuring that products ranging from fresh produce and pharmaceuticals to vaccines and specialty chemicals remain at their peak quality. While these storage units are essential, managing them effectively and safeguarding the precious contents within is an ongoing challenge. The task of preserving the integrity and safety of stored items extends far beyond mere temperature control. It encompasses a broad spectrum of environmental parameters, from humidity and gas levels to energy consumption and security. The need for comprehensive, real-time monitoring and management of cold storage facilities is more pressing than ever. This is where the concept of "Remote Monitoring of Cold Storage" comes into play**.**

1.1.2 In the realm of cold storage management, the task is far from simple. It goes beyond fundamental temperature control, evolving into a symphony of environmental parameters, encompassing humidity, gas levels, energy consumption, and security measures. The orchestration of these elements is crucial for ensuring the impeccable safety and quality of stored goods, especially in an era of globalized supply chains where even a minor temperature deviation or an undetected gas leak can send ripples of financial losses, public health concerns, and consumer trust erosion. In response to these challenges, the concept of "Remote Monitoring of Cold Storage" emerges as a transformative solution.

1.1.3 This concept hinges on the fusion of cutting-edge sensor technologies, data analytics, and secure communication channels, transcending the limitations of conventional manual monitoring. Cold storage facilities, armed with strategically positioned sensors, become sentient entities capable of instantaneously detecting and reacting to environmental deviations. At the heart of this innovation lies the central control hub, a digital sentinel tirelessly processing incoming data. When a sensor registers a deviation from the ideal storage conditions, the system springs into action, autonomously adjusting temperature, activating alarms, and notifying designated personnel in real-time. This technology's significance extends well beyond the storage unit's walls, impacting diverse industries, enhancing product quality and safety, reducing the impact of human error, and offering a groundbreaking opportunity to minimize product loss and wastage, ultimately contributing to a more sustainable future. In a world that demands the highest standards of quality, safety, and efficiency, "Remote Monitoring of Cold Storage" represents a quantum leap forward, embodying technology's transformative power in securing supply chains, elevating quality assurance, and fostering responsible resource stewardship on a global scale. As our world evolves, technology's role in safeguarding our most vital resources has never been more prominent.

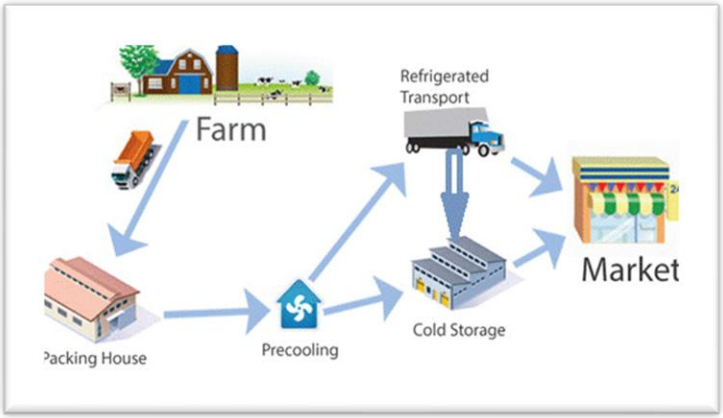

Fig.3 Analog out in Arduino IDE Complier

1.1.4 However, the management of these facilities is no simple task. While temperature control remains a fundamental factor, the complexities of cold storage management extend far beyond that. It's a symphony of environmental parameters that includes humidity, gas levels, energy consumption, and security measures. The harmonious orchestration of these elements is essential to guaranteeing the unblemished safety and quality of stored goods, In the age of globalization and interconnected supply chains, the stakes are higher than ever. A minor deviation in temperature or an undetected gas leak can reverberate through the entire ecosystem, resulting in financial losses, jeopardizing public health, and undermining the trust of consumers. In this context, the concept of "Remote Monitoring of Cold Storage" emerges as a transformative solution.

1.1.5 In a world that demands the highest standards of quality, safety, and efficiency, the concept of "Remote Monitoring of Cold Storage" represents a quantum leap forward. It is the embodiment of technology's transformative power, securing our supply chains, enhancing quality assurance, and contributing to the responsible stewardship of resources on a global scale. As the world continues to evolve, the role of technology in safeguarding our most vital resources has never been more pronounced.

1.2 OBJECTIVES

- To Develop the Real-Time Monitoring System for food storage
- To Implement of IOT-Based Decision Support for risk monitoring

Chapter II:
LITERATURE REVIEW

2.1Smart Cold Storage and Inventory Monitoring System:

2.1.1The perishable goods are often required to travel thousands of miles by land, air,water transport facilities to reach their final destination. It creates a lot of pressure on tracking the companies using the cold storage supporters for the distribution of the food and maintain a certain temperature during the entire journey, Our system enables endless real time monitoring. It helps in controlling the losses which occur for business. As per the research India has 7645 cold storage facilities, out of these about 68% is used to store vegetables. And remaining 32% is used for storing other commodities, The proposed cold storage system Temperature and Humidity sensor, Ultrasonic sensor, Wi-Fi enabled microcontroller board and Mobile application are used.

2.1.2 The implementation of an IoT -based cold storage and Inventory monitoring system leads to the optimum utilization of space and resources. It helps to track the usage pattern and power consumption of devices, minimize wastage, detect anomalies within the facility, and monitor and control the intensity of light as per the changes in daylight. An IoT -enabled monitoring solution brings terrific value to businesses and enhances profitability. To know more about how IoT -enabled cold storage and inventory monitoring helps to increase your ROI, please talk to our experts. Integrating IoT, Node MCU, and IBM Watson IOT for Real-time Monitoring, Control, and Alerts for Cold Storage Management System.

2.2Automated food grain monitoring system for warehouse using IOT:

2.2.1 One of the most significant sources of income in a developing nation like India is agriculture. Good food storage is essential for ensuring food security, which is impacted by both food loss and wastage. If any of the sensors in this parameter falls below or above the threshold value, the control action will be initiated. The data from the sensors is collected by the PIC microcontroller, which then sends it to the cloud via the Global System for Mobile Communications (GSM) module. Multiple sensor nodes will be deployed throughout of the warehouse, and each of which provides information on the warehouse environment via Short Message Service (SMS) and mobile application.

2.2.2 The data from the sensors is displayed in the dashboard, where a user can view real-time data findings from anywhere and at any time. This approach encourages the modernization, Remote Monitoring and Control System for Cold Storage Using Peripheral Interface Microcontroller (PIC) and MPLAB X IDE Data is transferred Using GSM, the study doesn't mention how the proposed system integrates with existing warehouse management systems.

2.3 Design of a Smart IOT-Based Control System For Remotely Managing Cold Storage Facilities:

2.3.1Cold storage is deemed one of the main elements in food safety management to maintain food quality. The temperature, relative humidity (RH), CO2, C2H4, and Luminosity cold storage rooms (CSRs) should be carefully controlled to ensure food quality and safety during cold storage. These parameters affect the stored product quality, and the real-time sending of warnings is very important for early preemptive actionability against the risks that may cause damage to the components of the cold storage rooms. This research aimed to design and evaluate a IoT-BC system to remotely control, risk alert, and monitor the microclimate parameters, i.e., RH, temperature, CO2, C2H4, and light and some operating parameters.

2.3.2 Maintaining high quality and ensuring food safety are extremely important. The present study presented a smart IoT-BC system that connects sensors, actuators, and related cold storage equipment for remote controlling, monitoring, and risk alerting to maintain food quality and components of cold storage facilities. This research recommends IoT-BC technology to manage cold storage facilities to maintain the high quality and safety of the stored food due to its positive impacts on the characteristics of stored fruits and the potential of remote control and monitoring of cold storage facilities.

Chapter III:

DESIGN AND IMPLEMENTATION OF PROPOSED WORK

3.1 METHODOLOGY

3.1.1The project aims to develop a comprehensive system for the remote monitoring of cold storage facilities. The system utilizes a range of sensors, including the DHT11 for temperature and humidity monitoring and the MQ-3 for gas detection. An ESP32 microcontroller is employed for data collection and transmission, along with a GSM module for real-time alerting. Data is visualized using the ThingSpeak cloud platform. The primary objective is to ensure the preservation of perishable goods within the cold storage unit by providing continuous monitoring and instant notifications in case of temperature or gas threshold breaches.

3.1.2In the comprehensive methodology devised for the "Remote Monitoring of Cold Storage" project, each step is intricately planned to ensure the successful execution of this innovative system. It begins with the connection and calibration of critical sensors, including the DHT11 for temperature and humidity monitoring and the MQ-3 gas sensor. Proper sensor wiring and power supply are meticulously addressed to establish a reliable data source. Calibrating the sensors is of utmost importance to guarantee the precision of temperature, humidity, and gas concentration readings. The process is followed by the implementation of code to enable regular data collection from the DHT11 and MQ-3 sensors, laying the foundation for real-time environmental monitoring.

3.1.3 As the project unfolds, data collection and processing take center stage. The ESP32 microcontroller serves as the central hub for gathering information from the connected sensors at regular intervals. The collected data, comprising temperature, humidity, and gas concentration, undergoes careful processing to prepare it for transmission and analysis. A continuous monitoring system is established to scrutinize the data against predefined threshold values, ensuring immediate detection of any deviations that could jeopardize the safety and quality of stored products.

3.1.4 The integration of a GSM module adds a critical layer of functionality. The module is connected to the ESP32, enabling SMS alerts to be sent to registered mobile number in real-time when temperature or gas thresholds are breached. To reduce redundancy, an intelligent system is put in place to ensure that SMS alerts are dispatched only once when a threshold breach occurs. The project recognizes the paramount importance of data visualization and storage. To achieve this, the Thing Speak cloud-based IoT platform is leveraged, allowing the collected data to be stored securely while also providing dashboards for real-time data visualization. Security measures are implemented to protect the data and restrict access exclusively to authorized users.

3.1.5 The methodology also underscores the critical aspect of threshold monitoring, where specific safe values are defined for temperature, humidity, and gas levels within the cold storage unit. The system vigilantly monitors the sensor data against these predefined thresholds and stands ready to activate the GSM module for immediate SMS alerts in the event of a breach. In parallel, rigorous testing and validation n processes are carried out to ensure the system's reliability. This involves simulating temperature and gas threshold breaches and verifying the promptness of SMS alerts, as well as the accuracy of data visualization on Thing Speak. Adjustments and refinements are made based on the test results, ensuring the system's robustness.

3.2 WORKING AND IMPLEMENTATION

3.2.1 Sensor Setup and Calibration:

3.2.1.1 DHT11 Sensor (Temperature and Humidity):

The DHT11 sensor is securely connected to the ESP32 microcontroller, ensuring proper wiring and power supply. This connection allows for the accurate measurement of temperature and humidity within the cold storage unit. Calibration procedures are conducted to fine-tune the sensor and ensure precise temperature and humidity readings. Software code is implemented to regularly query and collect data from the DHT11 sensor at defined intervals. This collected data is then processed and prepared for transmission.

3.2.1.2 MQ-2 Gas Sensor:

The MQ-2 gas sensor is connected to the ESP32 according to the manufacturer's specifications, ensuring stable operation. The sensor undergoes a calibration process, taking into account variations in gas concentration levels to deliver accurate readings. Custom software code is developed to continuously monitor gas levels and provide readings in parts per million (PPM) for real-time assessment.

3.2.2Data Collection and Processing:

3.2.2.1 The ESP32 microcontroller serves as the central hub for data collection. It periodically retrieves data from the connected sensors, including temperature, humidity, and gas concentration. The collected data is subjected to processing to ensure its compatibility with the transmission and analysis stages of the system. The system's software is designed to perform constant checks for deviations in the collected data against predefined threshold values. These thresholds are determined based on safe storage conditions within the cold storage unit.

3.2.3 GSM Module Integration

3.2.3.1 A GSM module is seamlessly integrated with the ESP32 microcontroller to enable SMS alert functionality. This integration involves setting up the appropriate connections and configuration. Custom code is developed to trigger SMS alerts sent to a registered mobile number in real-time when temperature or gas thresholds are breached. To minimize redundancy, an intelligent system is put in place to ensure that SMS alerts are sent only once when a threshold breach is detected, reducing unnecessary notifications.

3.2.4 Data Visualization and Storage

3.2.4.1Data collected from the sensors, including temperature, humidity, and gas levels, is stored and visualized using the Thing Speak cloud-based IoT platform. ThingSpeak channels are established for each parameter to create user-friendly dashboards that display real-time data, making it accessible for authorized users.Robust security measures are implemented to protect the stored data and restrict access to authorized personnel

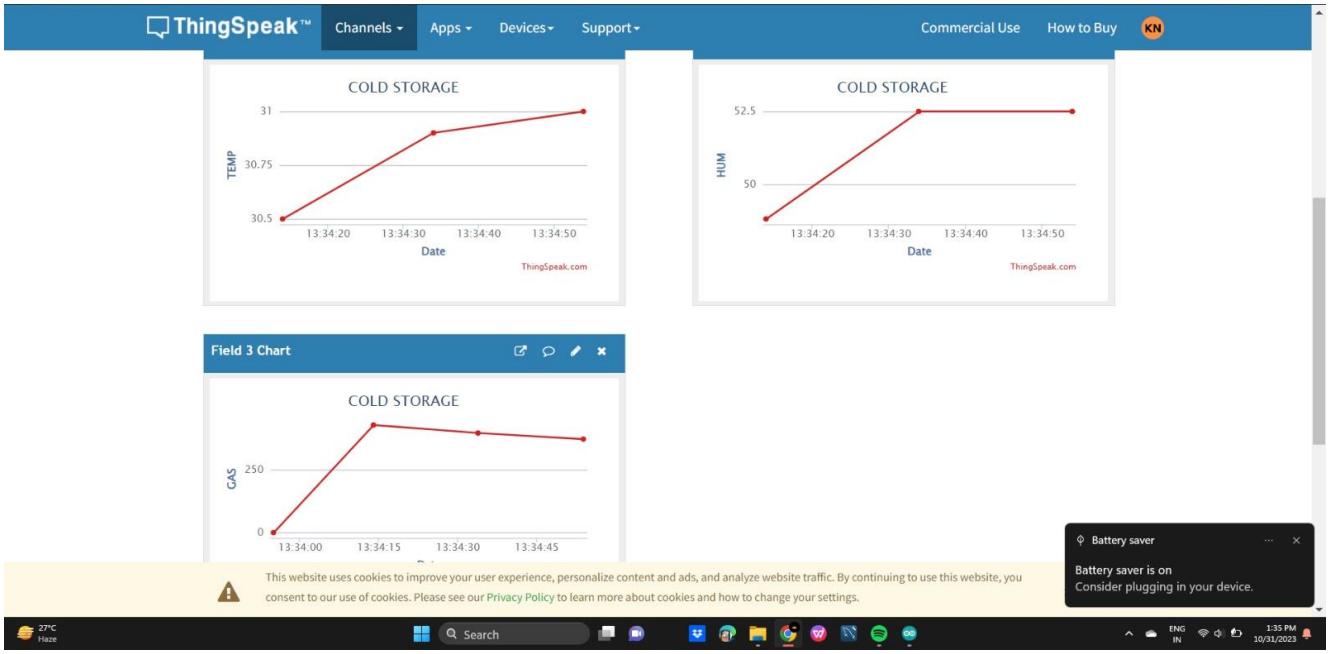

Fig 2 Dashboard of Varying Temperature and Gas values

3.2.5 Threshold Monitoring:

3.2.5.1Threshold values for temperature, humidity, and gas levels, considered safe for cold storage, are defined within the system. The system continuously monitors sensor data against these predefined thresholds to ensure that the storage conditions remain within acceptable limits. If a deviation is detected and a threshold is breached, the system promptly activates the GSM module, which sends an SMS alert to the registered mobile number.

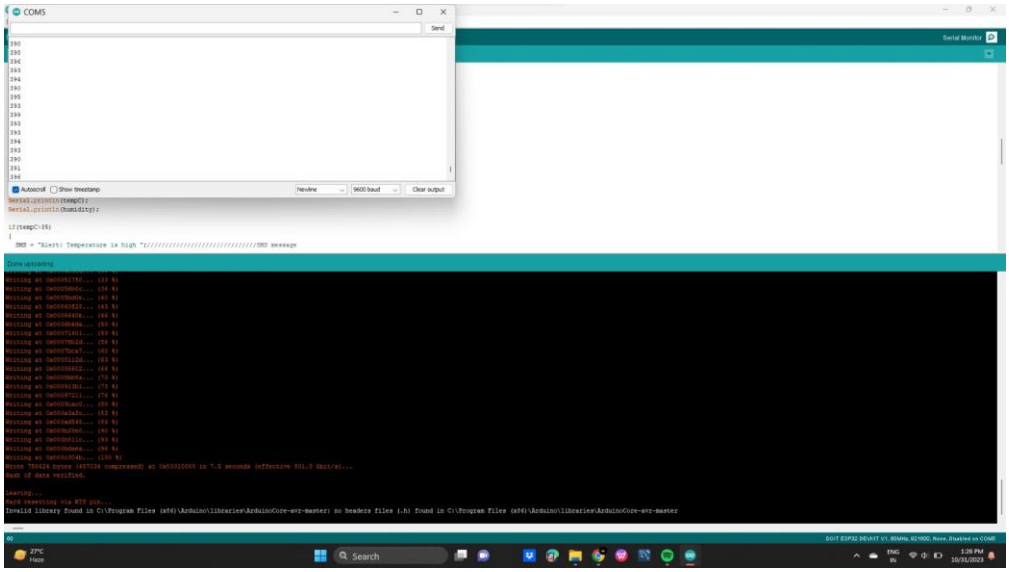

Fig.3 Analog out in Arduino IDE Complier

3.2.6 Testing and Validation:

3.2.6.1The project undergoes rigorous testing to validate its performance. Simulated temperature and gas threshold breaches are used to verify the promptness of SMS alerts. Data visualization on Thing Speak is closely scrutinized to ensure that the displayed information is accurate. Necessary adjustments and refinements are made to the system based on the results of these tests, guaranteeing its reliability and functionality.

Fig 4 SMS Alert sent by GSM module

CHAPTER IV

4.1RESULTS

4.1.1 The "Remote Monitoring of Cold Storage" project has been implemented successfully, resulting in a robust and reliable system for monitoring and safeguarding cold storage environments. Throughout the project, key sensors such as the DHT11 and MQ-2 have consistently provided accurate temperature, humidity, and gas concentration readings. Calibration procedures have fine-tuned these sensors, ensuring the precision of data collection. The ESP32 microcontroller, serving as the central data hub, has proven efficient in collecting, processing, and preparing data for transmission. The system's vigilance in detecting deviations from predefined threshold values, especially regarding temperature, humidity, and gas levels, has been a vital component in ensuring the safety and quality of stored products.

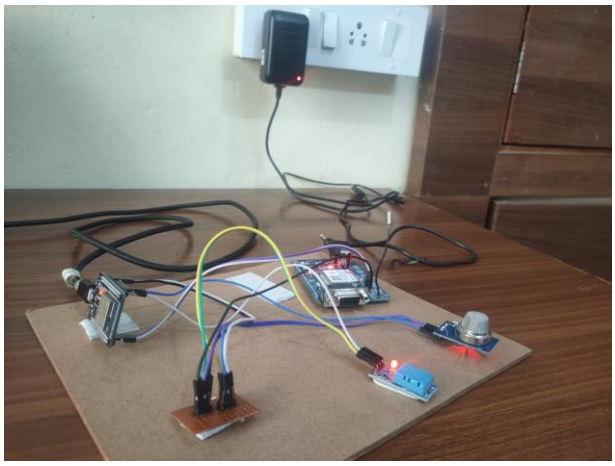

Fig 5.1 Circuit(Side View)

4.1.2 The integration of a GSM module has enabled the system to send SMS alerts promptly when temperature or gas thresholds are breached, demonstrating its effectiveness in notifying stakeholders and facilitating a swift response to potential risks. Notably, the system has also displayed intelligence by avoiding the delivery of redundant SMS alerts upon threshold breaches, enhancing user experience. The utilization of ThingSpeak as a cloud-based IoT platform has further bolstered the project's functionality, providing user-friendly dashboards for real-time data visualization and storage. Rigorous security measures have been put in place to safeguard the data and limit access to authorized personnel.

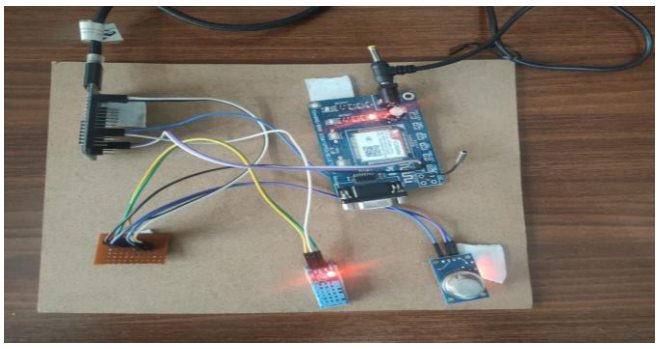

Fig 5.2 Circuit(Top View)

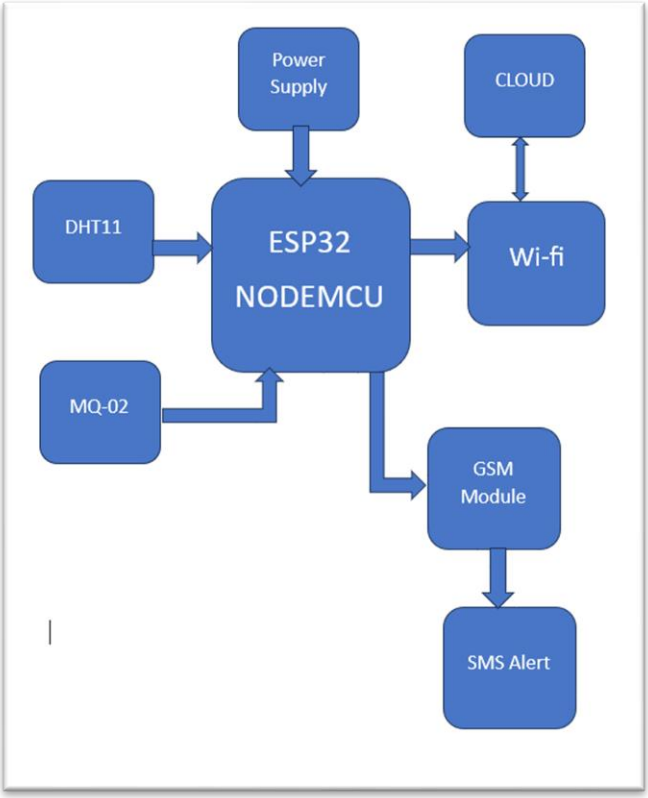

Fig 6 Block Diagram

4.1.3 Thorough testing and validation procedures have verified the system's reliability and effectiveness. Simulated temperature and gas threshold breaches have confirmed the promptness of SMS alerts and the accuracy of data visualization on ThingSpeak. Adjustments and refinements made during testing have fine-tuned the system, enhancing its readiness for real-world scenarios. User documentation and training have equipped end-users with the knowledge and skills required to interpret system alerts effectively, making the system user-friendly and accessible. Lastly, the project's comprehensive documentation and report serve as invaluable resources for understanding the system's operation and significance. The project is forward-looking, with identified opportunities for future enhancements, including remote control of storage conditions, predictive maintenance, and integration with other IoT devices, thus ensuring its adaptability to the dynamic demands of modern cold storage management.

CHAPTER-V

5.1 CONCLUSION

5.1.1 The "Remote Monitoring of Automated Cold Storage Facility Management system" project has been successfully conceived and implemented, through a rigorous and systematic approach, this project has offered profound insights and conclusive outcomes that underscore its significance in preserving the integrity and safety of stored goods.

5.1.2 The project's core components, including the DHT11 and MQ-2 sensors, have demonstrated remarkable accuracy in monitoring critical environmental parameters within the cold storage unit. Calibration processes have fine-tuned these sensors to ensure precise data collection, laying the foundation for reliable and real-time monitoring. The ESP32 microcontroller, as the central data hub, has consistently collected, processed, and prepared data for transmission, showcasing its efficiency and readiness for large-scale deployment.

5.1.3 The vigilance embedded in the system, continuously checking for deviations from predefined threshold values, has been a critical element in ensuring the safety and quality of stored products. The integration of a GSM module for SMS alerts has proven highly effective in notifying stakeholders promptly when temperature or gas thresholds are breached, facilitating swift response to potential risks. The system's ability to prevent redundant SMS alerts has further improved user experience, minimizing unnecessary notifications.

5.1.4 The project has leveraged ThingSpeak, a cloud-based IoT platform, to offer accessible and user-friendly data visualization and storage. Security measures have been robustly implemented to protect data integrity and restrict access to authorized users, ensuring data confidentiality and protection. Thorough testing and validation procedures have confirmed the system's reliability and effectiveness. End-users have been well-equipped through comprehensive user documentation and training, empowering them to interpret alerts and make informed decisions.

CHAPTER-VI

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