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Cold Track Guardian – Next Gen Warehouse Monitor

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Abstract: Maintaining the conditions, for storing food can be quite a challenge for small warehouses. Wired systems in these setups often come with costs, complex setups and limited flexibility. This study suggests a temperature control system that relies on sensors to tackle these issues and improve food safety and shelf life in smaller warehouses. By getting rid of wiring this system brings down costs significantly. Makes installation simpler causing less disruption to daily operations. The wireless sensors keep track of temperature and humidity constantly allowing control over the storage environment based on food needs. Owners can easily. Monitor their storage conditions through real time data displayed on a website. Moreover, this system is designed to be flexible making it easy to scale up or make changes as needed to adapt to warehouse layouts. With measures in place operations run smoothly without interruptions. Being wireless reduces interference concerns. Makes it easier to move sensors for optimal placement. This study goes into detail about how the system's set up how it works in practice and the potential advantages it offers – such, as improving food safety standards cutting costs and enhancing storage management efficiency for warehouses.

***Keywords*: Includes relevant keywords like "wireless", "sensor-driven", "food safety", "small-scale warehouses", "Web based GUI", "Cost effective" and "Smart Warehouse**

I. INTRODUCTION

Many homes and businesses rely on warehouses to store goods ensuring a constant supply of essentials. However, hidden within these buildings is a danger; inadequate environmental conditions. While temperature changes are known to be harmful, humidity and moisture also present risks affecting the safety and lifespan of stored food products. innovative solutions to mitigate accidents caused by potholes. Picture for instance, a display filled with fresh fruits and vegetables drowning in a pool of excessive water, hence, decaying. Visualize a meal served as condensations of flavors of grains and spices as humidity levels keep changing. What is even sadder is that this kind of situations are not as unique as we would like them to be. In the typical small warehouse where resources and budgets often are lean, the dilemma of maintaining good environmental control is very common. While the traditional wired systems offer temperature control of some level, they are also associated with many shortcomings. Imposing hurdles for installation, maintenance and modifying connections, the unreliability and vulnerability to damage are evident. Along with that, concerns about interference and non- mobility are other factors that also limit their application. Given this imperative, we have started a project to invent an innovative system that will be targeted at small-scale warehouses only. Our wired systems' shortcomings would also be addressed in addition to affordable, efficient, and flexible comfort provisions. The result? A temperature control system based on a sensor driven wireless technology that draws a line between the old-fashioned food preservation and modern storage. The objectives of this project are:

1. Enhanced Food Quality Control: Enable users to monitor and maintain optimal conditions for food products, reducing the risk of spoilage, contamination, or other quality issues.
2. Minimized Food Wastage: Provide retailers with real-time insights into the freshness and condition of their food inventory, allowing for proactive measures to prevent wastage.
3. Improved Operational Efficiency: Streamline day-to-day operations by automating the monitoring process.

In later parts of the chapter, we will discuss the finer points of environmental control that is featured in small-scale warehouses. We shall talk about the exact perils arisen by the humidity and moisture, investigate the restrictions of the traditional wired systems and reveal the novel features as well as benefits of the wireless solution. In the final analysis, we'll illustrate how this technology has the capacity to lead to food storage practice revolution and improved safety, shelf-life extension, as well as costs reduction for small-scale warehouse owners.

Module	**Description**
Temperature sensor	Detect temperature change in warehouse using DHT 11
Gas sensor	Rotten foods emit variety of gas which can be detected by MQ2 sensor
OLED screen	Displays changes in warehouse on 16*2 screen
Website	Deploying server and hosting website for remote accessing warehouse data
ESP32	Controller, Decision making, Collects data from sensor and publish it to website

table no 1.1. Description of the modules

II. LITERATURE REVIEW

Today's interconnected global industry faces a complex challenge in optimizing the flow of shipments from factories to consumers' doorsteps. Central to this challenge is supply chain management, which oversees the movement of various products, including clothing, medicine, and food, through physical distribution channels. The purpose of this essay is to examine the fundamentals of supply chain management, specifically as they relate to the logistics of distributing tangible items. It will clarify the idea of product logistics while examining the complete process, from obtaining the required parts to delivering the finished product. Additionally, the need of keeping cold deliver chains can be underlined, emphasizing the precise control of temperature, humidity, and mild that perishable items require. Nonetheless, it's vital to recognize the weaknesses built into this complicated community. There is probably interruptions in the products drift at many factors, from little delays on the road to serious injuries regarding the loss or wrong garage of merchandise that are touchy to temperature. Supply chain managers may also guarantee greater reliable and seamless shipping by means of proactively figuring out and lowering those dangers. [3] Environmental variations in feed loss during storage present many issues Central Warehousing Corporation (CWC) Traditional methods such as chemical handling or on-site monitoring. It may not provide current or up-todate information. For this reason, Doritos Warehouse Control is exploring modern strategies, specifically using Internet of Things (IoT) technology. The system can notify operators when environmental conditions exceed safety limits by using sensors to track variables such as temperature and humidity. This allows for early intervention. By implementing system automation, CWC has the opportunity to increase productivity and reduce losses. The logistics and operations teams will be able to manage operations more effectively if the shift to this data-driven approach is successful, which will need effective communication and employee training. [1]. This study explores an Internet of Things (IoT)- based system for monitoring the environmental state of warehouses in order to guarantee the best possible storage conditions for commodities. The system is organized into four layers, each of which performs a distinct purpose. First, there is sensing. Wireless sensor nodes send real-time data via the ZigBee protocol while keeping an eye on temperature, humidity, and smoke. After processing, the data is structured to make it easier for higher-level programmed to use. Subsequently, the communication layer stores processed data in the server database and sends out instructions as needed to enable data transmission and interaction between producers and consumers. Ultimately, the application layer offers a convenient interface for system access and control, with features like mobile apps, webbased interfaces, and integrated monitoring. By collecting, processing, and communicating environmental data, the system empowers managers to make informed decisions, streamline

operations, and minimize inventory losses, paving the way for intelligent and datadriven warehouse management. [2]

III. METHODOLOGY

Think of a smart sentinel system as a silent watch that patrols your food storage. This is the gist of the wireless sensor-driven temperature control system which is developed to sustain excellent conditions in the small warehousing facilities. Let's clutter deeper into it. Micro, agreement ally small sensor nodes on a regular basis are monitoring temperature and gas level within the warehouse. The particular DHT11 temperature sensor is one of the most accurate with its readings within the food storing temperature range being accurate. Moreover, the sensors secondarily depend on the types of food are stored, as gas sensors like MQ-2 sense spoilage gases, which can be a early warning system. Each user Node MCU functioning as a data micro powerhouse, powered by a sensor node. It processes raw sensor data, runs simple arithmetic and transmits anything that needs to be communicated from one side to the other wirelessly to a central hub, usually it is a computer which serves as the interface module. This takes place due to the strong protocols planned in a way that uses minimal energy and ensures the reliability of the data. The CPU (Central Processing Unit) as the brain of the system Data is received by it from all nodes, processed into useful charts, and data history is stored for trend analysis. For instance, imagine a webpage or a mobile app that maps the temperature in real-time and marks hotspot areas. It would highlight high gas sensor readings over safety levels. This way, you could be warned if there are dangerous air quality conditions. In accordance with user-defined settings as well as intelligent algorithms, the system itself is in charge of adjusting the surrounding environment. It could be the fans or the coolers being switched on to match the target, or getting the alarms on to act immediately manually. Imagine an unseen force improving the environment everywhere in the world. Your dinner is being served by this unseen hand.

IV. HARDWARE DESCRIPTION

4.1 ESP32 Module

Since its launch in September 2016, Espressif Systems' ESP32 microcontroller and systemon-a-chip (SoC) has gained significant traction. With a dual-core Tensilica Xtensa LX6 CPU capable of reaching speeds of up to 240 MHz, this scalable platform can handle a wide range of applications quickly Built-in Bluetooth v4.2/BLE and Wi-Fi 802.11 b /g/n connections The ESP32's networked and Its extensive peripheral interface that can be easily integrated into wireless communications environments allows communication with a wide range of sensors, actuators and displays. It has GPIO pins, UART, SPI, I2C, I2S, ADC, and more. The ESP32's low-energy design is one of its major advantages; That makes it perfect for battery-powered products. In addition, the chip has strong security capabilities that ensure data integrity and security in IoT and connected device. Such as secure boot, flash encryption, cryptographic acceleration as well as compatibility with many development environments, such as ESP-1. IDF is compatible with Arduino IDE, making the development easier process and fast for users – Possibly leverage extensive libraries and tools for application deployment and prototyping The ESP32 finds broad applications in consumer electronics, wearable technology, industrial automation and Internet of Things devices.

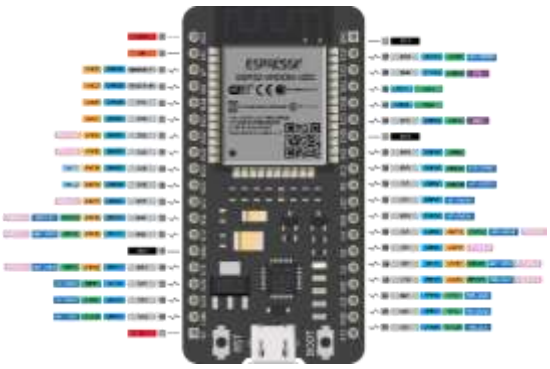

fig no 4.1. ESP32 pinout diagram

Engineers, enthusiasts, and experts alike love the ESP32's adaptability, connectivity possibilities, and ease of development—whether it's for industrial monitoring systems, wearable devices, smart home devices, or multimedia equipment. Its versatility, coupled with low-cost and featurerich capabilities underscores its position as an industry leader in embedded systems.

4.2 DHT Sensor

fig no 4.2. Temperature sensor DHT11

A popular and affordable digital temperature and humidity sensor, DHT11 is used in a wide range of applications. It has a thermistor for measuring temperature and a capacitive humidity sensor that gives reliable readings with a comparatively simple interface. The DHT11 is preferred for applications ranging from home automation to HVAC control to weather station environmental monitoring systems due to its affordability and user-friendliness Wide voltage range operation and digital output capability allow this sensor to search the outdoors for the novice and specialist electronics enthusiasts Because this fits DHT11 is a common feature of many do-it-yourself commercial projects that require temperature and humidity detection due to reliable operation and simplicity

4.3 MQ Gas Sensor

fig no 4.3.1 Gas sensor

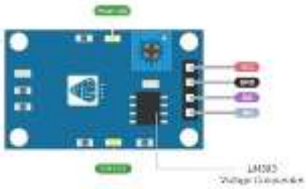

fig no 4.3.1 Back of Gas sensor MQ2

It can be used as a monitoring tool for contamination of indicators in food storage situations, the MQ-2 sensor is important for flammable gases When exposed to large amounts of gases, this sensor based these chemical resistance surfaces exhibit changes in electrical resistance. A popular part for detecting various gases such as carbon monoxide, alcohol, butane, propane and methane is the MQ2 gas sensor. The MQ2 uses a semiconductor sensing element to detect changes in conductivity upon contact with a target gas. It then generates an analog voltage proportional to the air volume. It is a well-loved choice for security alarm, air quality monitoring, and gas leak detection systems due to its size, cost-effectiveness, and ease of integration It can adjust its functionality to meet application requirements specific solutions.

4.4 OLED Screen

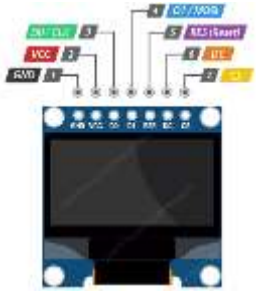

fig no 4.4 OLED pinout diagram

The small display technology with wide aperture, low power consumption and good contrast is the OLED (Organic Light Emitting Diode) module. OLED displays provide brighter colors and deeper blacks than conventional LCD displays because they do not require backlighting but produce instantaneous light when power is applied Easily installed in electronic devices, OLED modules consists of OLED panels, control circuits and interfaces. OLED modules are very versatile and thinprofile, making them ideal for a wide range of applications, including digital cameras, automobile dashboards, wearable technology, and smartphones. OLED displays are perfect for both indoor and outdoor applications because they have quick response times and superior visibility in both bright and dark conditions. Being a flexible display option

4.5 Block Diagram of Proposed System

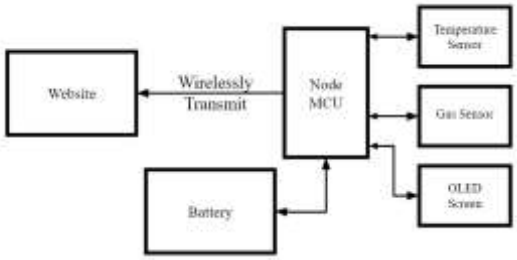

fig no 4.5 Block Diagram of proposed solution

A wireless sensor-driven temperature control system intended for small-scale food storage is shown in this block diagram. Imagine minuscule sentinels, every one of them sporting a temperature sensor, watching over the surroundings all the time. The MCU, a central processing unit, receives data from these sensors, transforms it, and sends it wirelessly. An interface device collects data from various sensors on the receiving end to create a comprehensive picture of the storage conditions. This central hub allows for user interactivity in addition to displaying historical data and realtime temperature readings. Using an intuitive user interface, such as a web app or mobile app, you can set temperature requirements, receive notifications when conditions change, and monitor normal system performance LEDs provide visual indicators of connection status , power and any possible warnings . Recall that the basic structure is shown in this figure. Depending on the specific food being stored, gas sensors can be installed to detect food spoilage indicators such as ammonia or ethylene. Furthermore, the operational specifications of each phase may vary depending on the materials selected and design decisions. For smaller warehouses, this technology provides a scalable and costeffective solution that provides optimal food storage conditions and reduces waste. Finally, user interface (UI) development begins, if necessary, to make it an easy-to-use interface for system design and analysis. Together, these software components make up the system, ensuring efficiency and reliability.

V. ADVANTAGES DISADVANTAGES OF PROPOSED SYSTEM

Advantages	**Disadvantages**
Unprecedented Visibility	Initial investment in hardware, software, and sensors can be significant
Smarter Savings	Technical glitches or hardware failures can disrupt temperature control and impact food quality
Extended Shelf Life	Data security concerns arise due to the collection and transmission of sensitive data
Data-Driven Decisions	Limited scope of data collected by sensors may result in blind spots in large or complex warehouse
User-Friendly Interface	System functionality may be impacted by disruptions in internet connectivity
Cost-Effective Solution	Regular maintenance is essential for optimal performance

table no 5.1 Advantage and Disadvantage of the system

VI. RESULTS

Our system will turn your physical warehouse into a virtual one that you can access through your fingertips. The easy-to-use web-based GUI features real-time temperature readings along with historical data visualization for analytical quality analysis. Another gesture of authenticity; Fully noticeable warmth on fingertips. Forget rigid schedules. Define your best temperature for food storage, our product does the rest. If the temperature exceeds a set threshold, it will receive warnings to act quickly. Regular temperature control is the key to longevity. We do this by mitigating the harmful fluctuations and providing the optimal environment that assures your food stays fresher for a longer period and this could help minimize food waste and maximize your profits

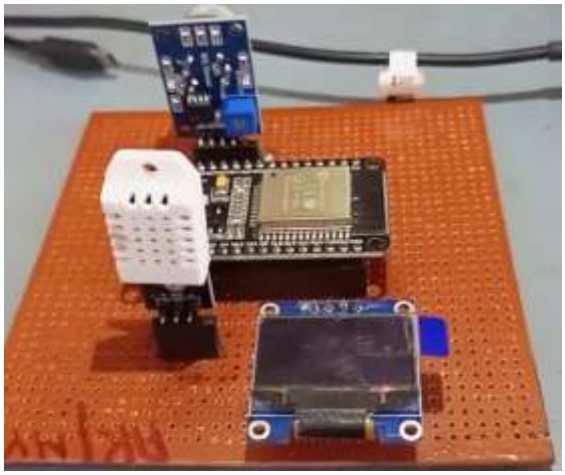

fig no 6.1 PCB of proposed solution

fig no 6.2 Website that display data published

VI. Conclusion

Sensor technology integration improves quality and safety monitoring in food storage warehouses. A real-time monitoring system is established by sensors that track temperature, humidity, and gas levels, guaranteeing compliance and operational effectiveness. By identifying hazards like contamination or spoiling, ongoing data collecting protects the integrity of food. Transparency for stakeholders is enabled by integration with an intuitive online interface, allowing for remote data access. Accountability is encouraged and inventory management decision-making is informed by this transparency. Additionally, the online platform makes predictive analytics for resource efficiency and maintenance possible. All things considered, this initiative uses dynamic, data-driven methods to transform food storage management.

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