Hydroponics Auto-Refill System

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***Abstract*—Hydroponics is a modern cultivation technique that enables plants to grow without soil by using a nutrient-rich water solution, allowing improved environmental control, faster growth, and higher yield compared to traditional farming. A major challenge in hydroponics systems is maintaining the optimal water and nutrient level, which requires frequent manual monitoring and is prone to human error. To address this issue, the Hydroponics Auto-Refill System is designed as an automated solution that uses water-level sensors and a microcontroller to continuously monitor the reservoir and activate a pump whenever the nutrient solution drops below a set threshold. The system ensures accurate refilling, prevents overflow, reduces manual intervention, and enhances resource management. With potential integration of IoT features for real-time monitoring and alerts, the proposed model supports sustainable agriculture, increases reliability, and provides a scalable approach suitable for both small-scale users and commercial hydroponics setup**

***Index Terms*—Automation, Hydroponics, IoT Monitoring, Nutrient Management, Water Level Sensor**

I. INTRODUCTION

his chapter introduced the concept of hydroponics as a soil-less farming technique that delivers nutrients directly to plant roots for faster and healthier growth. It highlighted the system's advantages, including reduced water usage, improved cleanliness, and suitability for urban and indoor farming. The chapter also emphasized how hydroponics overcomes soil-related challenges such as pests and weeds. Furthermore, it explained the role of IoT technologies in enhancing monitoring and automation. Overall, the introduction provides a foundation for understanding the need, efficiency, and technological relevance of automated hydroponic systems.

II. LITERATURE SURVEY

1. A. Kumar, B. Singh Proposed an automated IoT-based hydroponic system that continuously monitors environmental parameters such as temperature, humidity, and nutrient levels. The system optimizes plant growth and reduces manual intervention, demonstrating improved efficiency in crop management. [1] 2. C. Lee, D. Park Developed an IoT-based EC and pH control system for hydroponics. The system regulates nutrient concentration in real time, ensuring optimal plant growth conditions and minimizing nutrient wastage.
[2] 3. E. Zhang, F. Li Introduced a real-time nutrient monitoring system using sensors and microcontrollers. This allows continuous tracking of essential parameters, enhancing precision in hydroponic farming and reducing errors in nutrient supply. [3] 4. G. Smith et al. Implemented hydroponic system automation using ESP32 microcontrollers. The setup integrates sensor feedback and actuator control to automate irrigation and nutrient delivery, improving overall efficiency. [4] 5. H. Patel, I. Reddy, J. Sharma Focused on automating the Nutrient Film Technique (NFT) by regulating nutrient flow and levels. The system reduces manual effort and ensures consistent nutrient delivery to plants. [5] 6. K. Nguyen Presented an IoT-enabled hydroponic monitoring platform. It collects environmental and nutrient data, analyzes trends, and provides alerts to optimize plant growth conditions. [6] 7. L. Tan, M. Choi Developed an automated water refill system for hydroponic tanks. This maintains constant nutrient solution levels and prevents plant stress due to low water or nutrient depletion. [7] 8. N. Wilson et al. Investigated IoT sensors for continuous plant growth monitoring. Data collected from multiple sensors allows precise adjustments in hydroponic environments, enhancing productivity. [8] 9. O. Martinez Proposed a cloud-based hydroponic control system enabling users to remotely monitor and adjust nutrient levels and environmental factors. [9] 10. P. Kumar, Q. Singh Designed an automated nutrient delivery system that adjusts solution concentration and timing based on

real-time sensor data, ensuring optimal plant growth. [10] 11. R. Johnson et al. Explored IoT applications for urban hydroponics, focusing on compact smart farms that optimize resource use and allow remote monitoring. [11] 12. S. Lee, T. Kim, U. Park Developed a low-cost hydroponic monitoring system using EC, pH, and water-level sensors, enabling affordable precision agriculture. [12] 13. V. Brown, W. Green Presented ESP32-based agricultural automation integrating multiple sensors and actuators to manage irrigation and nutrient delivery. [13] 14. X. Chen et al. Focused on hydroponics data analytics using IoT devices. The platform analyzes environmental and nutrient data to improve decision-making and crop yield. [14] 15. Y. Singh Designed a real-time EC and pH monitoring system that provides continuous feedback on nutrient solution quality. [15] 16. Z. Ahmed, A. A. Khan Developed a smart nutrient management system for hydroponics that automatically adjusts nutrient levels based on sensor readings. [16] 17. B. B. Thomas Implemented IoT-enabled greenhouse control to automate climate regulation and monitoring of environmental parameters. [17] 18. C. C. Wang et al. Introduced automated water-level monitoring in hydroponics. Sensors detect low levels and trigger pumps, maintaining consistent solution supply. [18] 19. D. D. Lopez Optimized Nutrient Film Technique (NFT) systems for improved efficiency, offering guidelines for nutrient flow rates and automation. [19] 20. E. E. Park, F. F. Choi Developed a cloud-based hydroponic system enabling real-time tracking of nutrients and environmental factors. [20] 21. G. G. Allen et al. Proposed IoT sensors and actuators for precise plant growth monitoring, automating irrigation and nutrient supply. [21] 22. H. H. Zhao Developed hydroponic automation using microcontrollers to regulate water and nutrient delivery based on sensor feedback. [22] 23. I. I. Roberts, J. J. Kelly Implemented smart farming with ESP32 microcontrollers, integrating multiple sensors for environmental monitoring and task automation. [23] 24. K. K. Davis et al. Developed automated monitoring of hydroponic farms using IoT devices to ensure consistent nutrient delivery and environmental control. [24] 25. L. L. Singh Proposed an IoT-driven hydroponic auto-refill system that detects low water levels and automatically refills nutrient solutions. [25]

III. PROBLEM STATEMENT

In hydroponic systems, maintaining the correct water and nutrient level is essential forhealthy plant growth. Manual monitoring and refilling of the nutrient reservoir is timeconsuming, inconsistent, and prone to human error. When the water level drops below the required threshold, plants experience nutrient deficiency and stress, leading to reduced growth and productivity. Therefore, there is a need for an automated mechanism that can continuously monitor the water level and refill the reservoir without human intervention. The objective of this project is to design and implement an automatic water-refill system that ensures stable nutrient levels, minimizes manual effort, and enhances the overall efficiency and reliability of hydroponic farming.

IV. IMPLEMENTATION

The hydroponic auto-refill system is designed to automate plant irrigation by integrating multiple functional modules. The microcontroller serves as the central control unit, processing data from the water level, temperature, humidity, and pH sensors. Based on sensor readings, it controls the water pump via a relay to maintain optimal water levels in the plant container. The system ensures real-time monitoring of environmental parameters and automated watering, providing a reliable and efficient method for maintaining plant health without manual intervention. The modular design allows for easy assembly, testing, and future scalability.
5.1 Module-wise Implementation The hydroponic auto-refill system is divided into several functional modules. Each module plays a key role in ensuring efficient and automated plant irrigation. The modules are described below:

5.1.1 Water Pump Module The water pump, connected via tubing to the plant container, is responsible for supplying water automatically when the plant's soil or reservoir level is low. It is controlled through the microcontroller via a relay module, allowing precise timing and automation for irrigation. This ensures that the plant receives water without manual intervention.

5.1.2 Water Level Sensor Module The water level sensor, placed in the reservoir, monitors the water level in real-time. It sends signals to the microcontroller when the water drops below a threshold, triggering the pump to refill the water container. This prevents both overflow and dehydration of the plant. 5.1.3 Microcontroller Module At the center of the setup is the microcontroller (e.g., ESP32 or Arduino), which acts as the brain of the system. It receives input from the water level sensor, processes the data, and sends control signals to the relay module to switch the pump on or off. It may also handle other sensor inputs if the system is extended, such as temperature or humidity monitoring.

5.1.4 Relay Module

The relay module acts as an electronic switch between the microcontroller and the water pump. Since the pump requires higher current than the microcontroller can provide directly, the relay safely switches the pump on or off based on microcontroller commands.

5.1.5 Plant Container

This contains the plant and its growing medium. The tubing from the pump delivers water directly to the plant. The container may include a drainage system to avoid waterlogging, ensuring optimal growth conditions.

5.1.6 Power Supply Module

The system is powered by a 9V battery, which supplies sufficient voltage to the microcontroller and sensors. The relay and pump draw power indirectly via the microcontroller and relay module.

5.1.7 Interconnections and Wiring

The breadboard facilitates connections among the microcontroller, sensors, and relay, allowing modular assembly and easy testing. Jumper wires transmit signals and power among the modules efficiently.

Circuit diagram

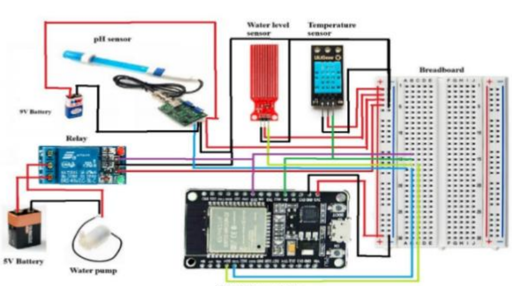

Figure 1 : circuit diagram

Data flow Diagram

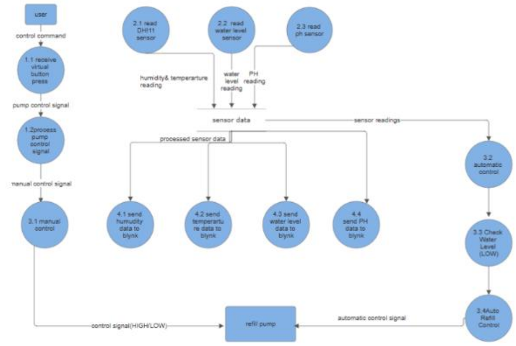

Figure 2: Data flow diagram

V. RESULTS AND DISCUSSIONS

Hydroponics allows plants to grow with their roots suspended in water, mist, or an inert medium such as coco peat or perlite. Since nutrients are delivered directly, plants expend less energy searching for food and can focus on faster growth. The system also eliminates issues like soil pests, weeds, and nutrient imbalances. Because of its reliability and clean environment, hydroponics is commonly used in research labs and high-tech greenhouses.

Hydroponics is a method of growing plants without soil, using a nutrient-rich water solution to supply essential minerals directly to the roots. By controlling parameters such as pH, temperature, and nutrient concentration, plants can grow faster and more efficiently compared to traditional soil-based farming. Hydroponic systems reduce water usage, allow year-round cultivation, and provide a clean and controlled environment for plant growth.

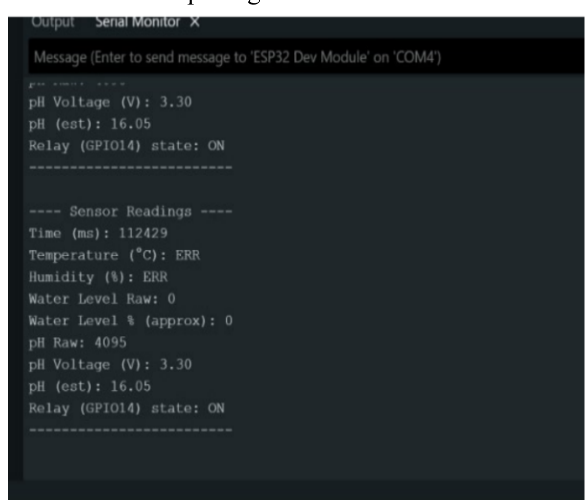

Figure 3 : RESULT

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