DEPARTMENT OF ELECTRICAL ENGINEERING

ASSAM ENGINEERING COLLEGE, GUWAHATI-13

REPORT ON PARTIAL COMPLETION OF FINAL YEAR PROJECT AT THE END OF 7TH SEMESTER ON

IoT-POWERED HYDROPONICS: FARMING THE SMART WAY

Under the Guidance of Dr. Sarmila Patra

Submitted by: **GROUP 18**

Ronil Baruah (210610003065)

Harshanya Darathi (210610003032)

Shreyosi Roy Choudhury (210610003074)

Angsuman Sharma (210610003004)

ABSTRACT

This project focuses on developing a horizontal hydroponics system integrated with IoT technology for real-time monitoring and efficient plant growth. The system incorporates sensors to measure pH, temperature, humidity, and nutrient levels, enabling precise control of plant growth conditions. Using IoT, the data is displayed on an LCD and monitored remotely, ensuring efficient resource use and automation. The project aims to optimize water and nutrient delivery, making it ideal for sustainable and urban farming applications. Current progress includes hardware assembly, motor testing, and sensor simulations, with future work focused on full system integration and real-time monitoring development.

I. INTRODUCTION

Hydroponics is an innovative farming method that allows plants to grow without soil by using nutrient-rich water solutions. This technique is gaining popularity for its ability to conserve resources, optimize plant growth, and enable farming in urban and resource-scarce areas. Integrating Internet of Things (IoT) technology into hydroponics further enhances its potential by enabling real-time monitoring and control of critical parameters such as pH, temperature, humidity, and nutrient levels.

This project aims to design and implement a horizontal hydroponics system equipped with sensors and IoT-based monitoring. The system automates water and nutrient delivery while providing real-time data visualization for efficient crop management. By leveraging IoT, this solution addresses the challenges of traditional farming, promoting sustainable and precise agriculture.

The objectives are:

i. Designing a horizontal hydroponics setup for efficient water and nutrient use.
ii. Integrating IoT for real-time monitoring and remote control of system parameters.
iii. Developing automation features to optimize plant growth conditions.
iv. Creating a sustainable model suitable for urban and indoor farming applications.

II. METHODOLOGY

A. *System Design*

The system uses a horizontal layout, which involves setting up PVC pipes to act as the primary structure for holding hydroponic cups where plants will grow. The horizontal configuration maximizes space efficiency and allows for easy water flow and nutrient distribution. Small holes are drilled into the pipes to securely hold the hydroponic cups. Each cup holds a plant, allowing water and nutrients to flow around the roots without the need for soil. A water pump is used to circulate the nutrient-rich water throughout the system. The water flows through the PVC pipes, delivering nutrients to the roots and ensuring an oxygenated environment for optimal plant growth. The system operates in a closed loop, so excess water is collected and recirculated, reducing waste.

B. *Hardware Selection and Setup*

- **pH Sensor:** Measures the acidity or alkalinity of the nutrient solution. Proper pH levels are essential for nutrient uptake.
- **DHT Sensor:** Records temperature and humidity, as these factors influence plant growth and the environment within the hydroponics system.
- **TDS Sensor:** Measures Total Dissolved Solids, giving an estimate of nutrient concentration in the water. This helps ensure optimal nutrient levels for healthy growth.
- The **Arduino Uno** is the primary control unit, responsible for reading data from the sensors, processing it, and either displaying it on the local LCD or sending it to an IoT platform for remote monitoring. It also controls the water pump based on sensor readings, automating water flow adjustments as needed.
- **LCD Display (20×4):** This display shows real-time data on pH, temperature, humidity, and nutrient concentration locally, allowing users to monitor conditions without external devices.
- **Water Pump:** The pump circulates the nutrient solution through the pipes. It is activated or adjusted based on sensor readings, maintaining a consistent flow and nutrient supply.

Fig.: Growth of Pak-Choi

Fig.: Growth of Spinach

Programming the Arduino: Custom code is written for the Arduino to read data from each sensor, process it, and respond based on predefined thresholds (e.g., activating the pump if water flow needs adjustment). The code also formats the sensor data for display on the LCD and for transmission to the IoT platform.

IoT Integration: A Wi-Fi module (e.g., ESP8266) is connected to enable remote monitoring. The module sends real-time data to a cloud-based IoT platform or a custom web dashboard. Users can access this data remotely to track plant growth parameters and make necessary adjustments, even from a distance. Alerts or notifications can be configured on the platform to notify the user if parameters deviate from optimal ranges.

System Calibration: Calibration involves adjusting sensor readings to ensure accurate measurements. For example, the pH and TDS sensors are calibrated to ensure they match standard values for nutrient-rich water solutions. Tests are conducted in various environmental conditions to ensure that sensors like the DHT can reliably record temperature and humidity data.

Integration Testing: Once all hardware and software are functional individually, they are integrated, and the full system is tested. Data from the sensors are validated against manual readings, and the automation system is tested to confirm that the pump and other components respond correctly.

Iterative Optimization: Following testing, the system may need adjustments to fine-tune performance. For example, pump flow rates or nutrient concentration levels might be optimized based on plant response.

C. *Simulation*

Initial Testing of the sensors(pH, Water Level, DHT) have been performed in the Proteus Pro Software to ensure the functionality and accuracy.

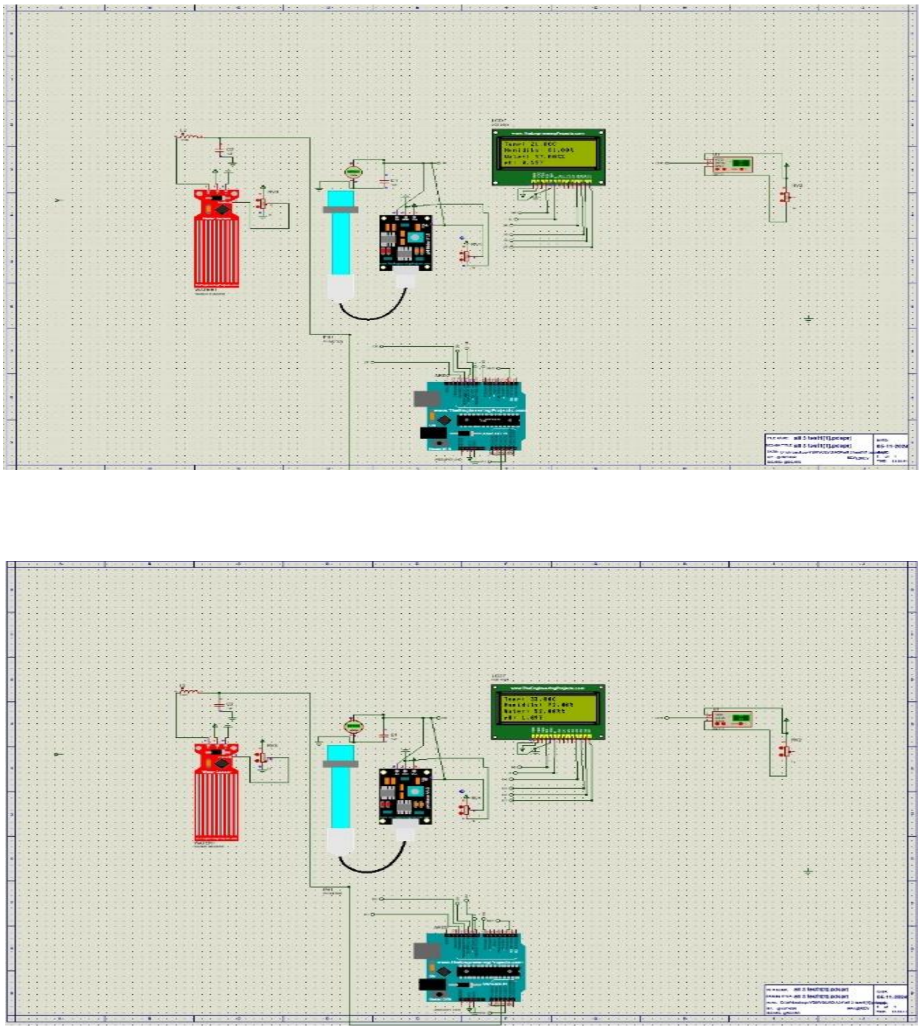

Fig.: Simulation of Sensors

III. SYSTEM ARCHITECTURE

Block Diagram Overview : The block diagram for this hydroponics system shows the major components and how they interact. It consists of three primary layers:

i) Sensor Layer: Collects real-time environmental and nutrient data.
ii) Processing and Control Layer: Manages data processing, control, and decision-making.
iii) Communication and Display Layer: Facilitates IoT-based data transmission and local display.

These three layers collectively form a robust architecture that enables your hydroponics system to function autonomously while offering real-time data accessibility. The modularity of this design also allows for scalability, such as adding more sensors or enhancing control mechanisms in the future.

Each layer interacts to achieve automated monitoring and nutrient control, as illustrated below:

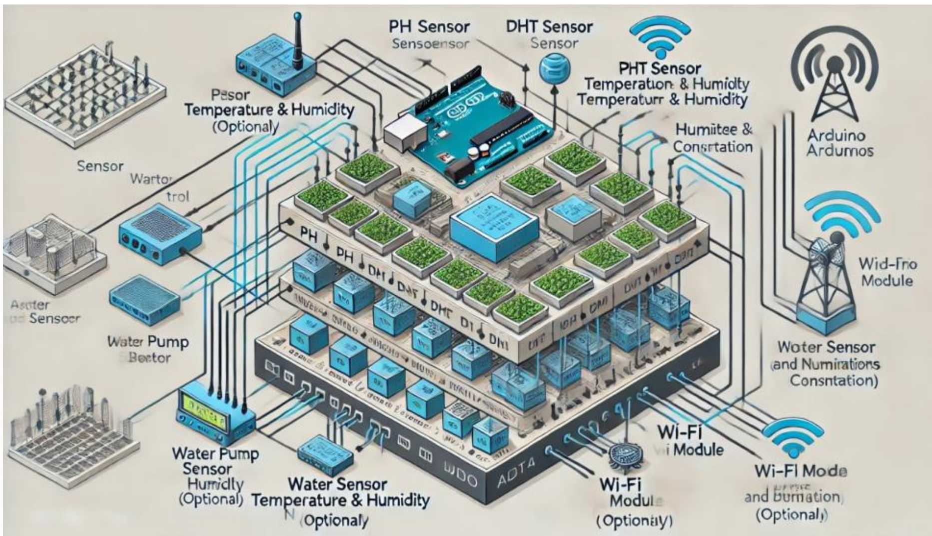

Fig.: Block Diagram of the project

IV. FUTURE WORK

1. Assemble and integrate sensors (pH, TDS, DHT) with the hardware setup: The next step involves physically integrating the pH, TDS, and DHT sensors into the hydroponics system by means of PCB. This will require ensuring that the sensors are properly positioned in the system to measure water quality and environmental conditions effectively. The wiring and connections will also need to be secured to avoid any interference with the system's operation.

2. Program the microcontroller for data collection and system control: Once the sensors are integrated, the Arduino Uno needs to be programmed to collect data from the sensors. The code will be written to handle real-time readings of the pH, TDS, and DHT sensors, process the data, and make decisions for system control (such as activating the pump or adjusting nutrient levels).

3. Develop and implement the IoT-based real-time monitoring system: The system will be connected to the Internet through a WiFi Module to enable real-time monitoring via a mobile or web application. The app will be developed to display real-time data on plant health, nutrient levels, and environmental conditions, allowing users to remotely monitor and control the system.

4. Test, calibrate, and complete the final project setup: In this phase, the entire system will be tested for functionality and accuracy. The sensors will be calibrated to ensure they provide precise readings. Any necessary adjustments will be made to the hardware, software, or IoT system to improve performance. Once all tests are complete, the final project setup will be ready for demonstration, showcasing a fully integrated and automated hydroponics system.

V. Challenges Faced

1. Simulating all sensors (pH, TDS, DHT) together

Integrating multiple sensors for monitoring various parameters was a challenging task. Each sensor required precise calibration and testing to ensure accurate readings. Compatibility issues between sensors and the microcontroller had to be resolved, and combining their outputs in a unified system demanded meticulous coding and synchronization.

2. Gradual nutrient addition for plant absorption

Adding nutrients to the water in appropriate amounts proved to be critical for plant health. When nutrients were introduced too quickly, the plants struggled to absorb them effectively, leading to inefficiencies in growth. This required careful monitoring of nutrient levels and implementing a controlled method for gradual mixing to maintain an optimal balance.

3. Aligning and sealing the U-shaped pipe assembly

The construction of the U-shaped pipe assembly posed significant challenges in ensuring smooth water flow without any blockages or turbulence. Achieving a leak-proof design required precise alignment of joints and thorough sealing of connections. Any misalignment or leakage could disrupt the water flow, affecting the system's overall efficiency and functionality.

VI. CONCLUSION

The assembly of the hydroponics system hardware has been successfully completed, including the setup of PVC pipes, hydroponic cups, and the water pump. Sensor simulations have been carried out, and preparations are underway for the integration of pH, TDS, and DHT sensors. With these foundational steps completed, the project is on track to proceed with IoT-based monitoring and control, ensuring efficient plant growth and management in the upcoming phases.

The IoT simulation successfully demonstrated real-time monitoring and control capabilities for essential hydroponic parameters (such as pH, nutrient levels, and water temperature). Sensor data could be tracked and managed remotely, allowing for adjustments to be made as needed, showcasing the system's potential for automation and ease of use. The hardware model constructed with PVC pipes facilitated continuous water flow, essential for nutrient circulation and oxygenation of plants. The design proved efficient, with minimal leakage and effective distribution of nutrient solution across the plant bed. The flow system maintained nutrient-rich water circulation, which is crucial for plant growth in a hydroponic system. The combined IoT-hydroponic system allowed for seamless data transfer from sensors to a control unit, enabling real-time adjustments based on plant requirements. The model demonstrated effective automated regulation of nutrient levels, providing a sustainable environment for plant growth with minimal manual intervention. Early testing showed that plants grown in this controlled environment exhibited consistent growth, suggesting a promising application for stable crop yields. The automation contributed to maintaining optimal conditions, potentially reducing growth time compared to traditional methods.

VII. REFERENCES

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