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Hydroponic Farming using IoT

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Abstract: *This paper presents an automated hydroponic farming system powered by the ESP32 microcontroller, designed to optimize plant growth in controlled environments without soil. Leveraging IoT technologies and embedded systems, the setup integrates environmental sensors (EC, temperature, humidity, and light) to monitor key parameters in real-time. Python, Arduino IDE, and cloud-based data platforms are used to analyze data and enable remote control and monitoring. The system includes automated nutrient dosing, water circulation, and lighting control, all coordinated through the ESP32. Furthermore, the platform supports wireless connectivity for mobile alerts and dashboard visualization. By combining automation, wireless communication, and precision agriculture principles, this prototype offers an efficient, scalable, and sustainable solution for modern soilless farming.*

Keywords*:* Hydroponics, Smart Farming, ESP32, IoT, Sensor Automation, Precision Agriculture, Nutrient Monitoring, Sustainable Farming, Soil-less Cultivation

I. INTRODUCTION

As the global demand for sustainable agriculture rises, hydroponic farming is emerging as a viable alternative to traditional soil-based cultivation. This project, titled *"Smart Hydroponic Farming Using ESP32"*, aims to automate and optimize plant growth by monitoring and controlling environmental parameters in real time. Utilizing the ESP32 microcontroller, the system integrates various sensors to measure pH, electrical conductivity (EC), temperature, humidity, and light intensity.This approach not only enhances farming efficiency but also makes precision agriculture more accessible to urban growers.

II. LITERATURE REVIEW

Reshma R. Patil and Dr. S. R. Patil [1] have proposed an automated hydroponic system using Internet of Things (IoT), focusing on reducing manual labor in modern agriculture. In this work, the authors utilized sensors for measuring water pH, temperature, humidity, and nutrient levels. These sensor values were sent to the cloud via Wi-Fi modules, enabling remote monitoring and control. The system automatically controlled water pumps and nutrient supply using predefined thresholds, thus optimizing plant growth. The study shows how hydroponic systems can be made smarter and more efficient using automation.

Aniket S. Patil and Aarti G. Mahajan [2] have discussed the implementation of a smart hydroponics setup using Arduino and sensor modules. This paper highlights the importance of soilless farming in urban and resource-limited settings. Using sensors like DHT11 (temperature/humidity), pH sensors, and TDS sensors, they ensured optimal plant growth conditions. The project also included automated water circulation and LED lighting controlled through a microcontroller. This helps reduce human involvement while improving productivity and water usage efficiency.

K. L. Sailaja and S. Vani [3] proposed an IoT-based vertical hydroponics farming system that enables real-time environmental data monitoring. The system incorporates wireless communication and cloud data storage for scalability. It aims to provide solutions for food security and sustainable urban farming. The model is integrated with mobile notifications for user alerts, and the system can be controlled manually or automatically. This project offers a reliable and energy-efficient approach to vertical farming and aims to make agriculture smarter and more accessible in cities.

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III. WORKING

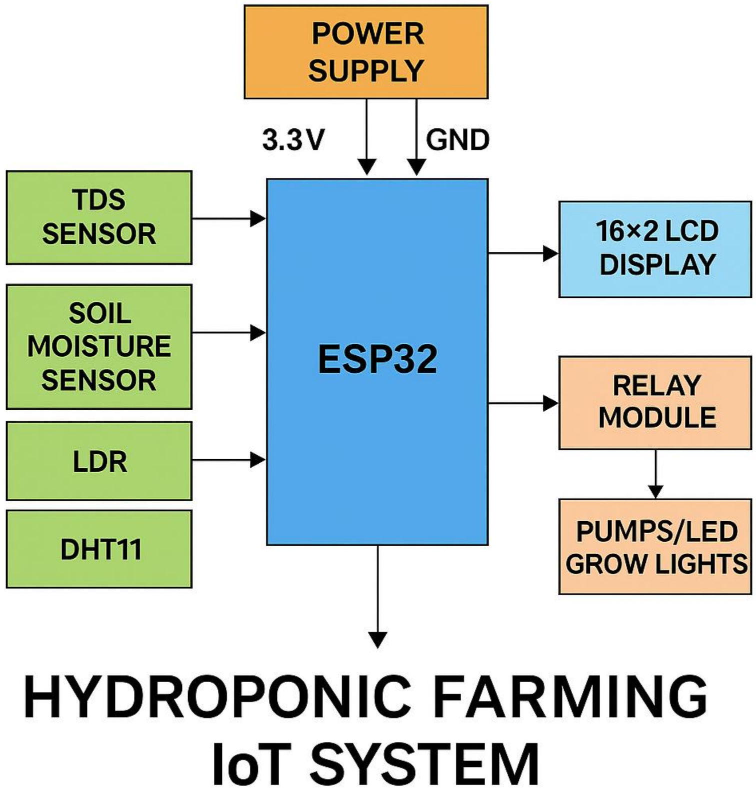

Fig: Block diagram

"Hydroponic farming using IOT An ESP32microcontroller acts as the central brain, powered by a Power Supply. It gathers data from essential sensors: a TDS sensor (for nutrient strength), a Soil Moisture **Sensor** (for growing medium hydration), an LDR (for light intensity), and a DHT11sensor (for temperature and humidity). The ESP32 processes this information to make decisions. It displays real-time readings on a 16x2LCD **Display** and controls Pumps/LED **Grow** Lights via a **Relay Module** to maintain optimal growing conditions. The IoT aspect, facilitated by the ESP32's Wi-Fi, enables remote monitoring and control, making hydroponic farming more efficient and automated.

"Hydroponic Farming IoT System with ESP32," showcasing the interconnectedness of various components. At its core lies the **ESP32 Dev Board**, powered by an external **Power Supply**, acting as the central processing unit. The ESP32 is responsible for collecting data from multiple environmental sensors. These include a **7x2 Sensor** (likely a placeholder or a less common specific sensor, potentially related to pH or conductivity, common in hydroponics), a **Soil Moisture Sensor 1 (Analog)**, which measures the moisture content of the growing medium, and an **LDR (Light Sensor)**, which detects ambient light levels. Additionally, a **DHT11 (Digital) Sensor** is incorporated to provide crucial temperature and humidity readings of the environment. Noticeable are the 10 kΩ pull-up resistors, which are typically used to ensure stable digital readings from sensors.

For output and control, the system features a **16x2 LCD** display, directly connected to the ESP32, providing real-time data visualization to the user. Critical for automation is the **4-Channel Relay Module**, which interfaces with the ESP32's digital output pins. This module enables the ESP32 to safely switch on and off higher-power devices such as **Pumps** (and implicitly, other hydroponic actuators like LED grow lights, as seen in the block diagram). The comprehensive wiring diagram, color-coded for signal, 3.3V power, and ground (GND), outlines how these components are interconnected, forming a functional system for automated hydroponic management with inherent IoT capabilities via the ESP32's wireless features.

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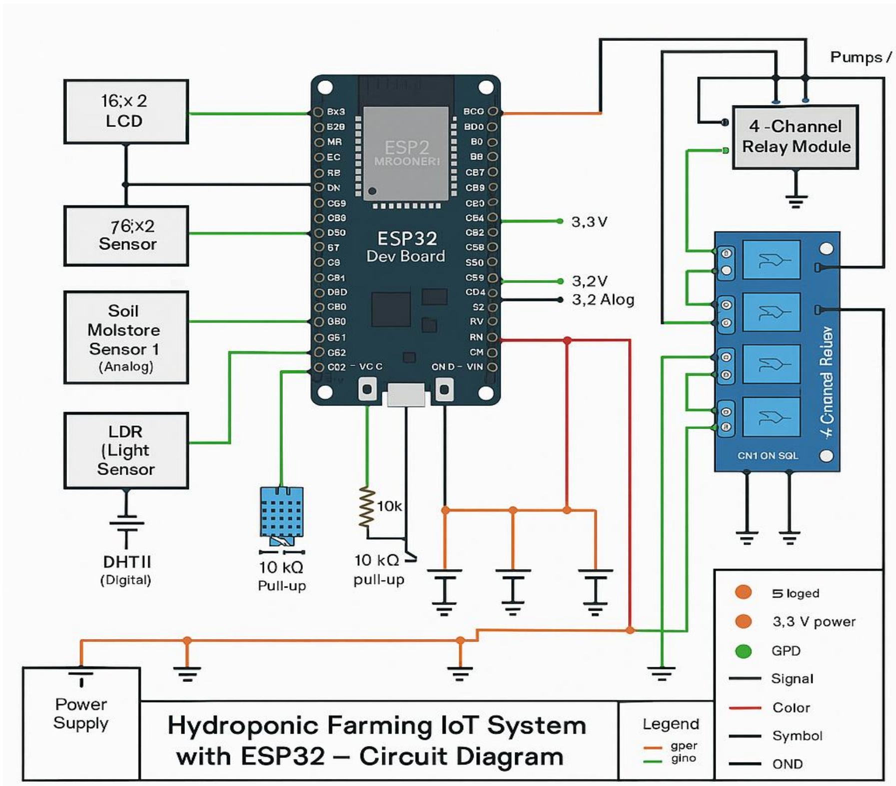

Fig: Circuit Diagram of Hydroponic farming using IOT

An **16x2 LCD** is wired to the ESP32 to display real-time sensor readings locally. For automated control, a **4-Channel Relay Module** is connected. This allows the ESP32 to switch higher-power devices like **Pumps** (and implicitly, LED Grow Lights, as indicated in the previous block diagram) on or off based on programmed logic derived from sensor data. The presence of 10 kΩ pull-up resistors suggests proper signal conditioning for digital sensors. The IoT functionality, inherent to the ESP32's Wi-Fi, enables remote data access and control, making it a smart system for efficient hydroponic management.

III. SYSTEM REQUIREMENT

The system requirements for the Hydroponic Farming setup encompass essential hardware and software components required to enable automated, soilless plant cultivation using nutrient-rich water. This system is designed to monitor and control environmental factors such as water quality, temperature, humidity, and light using IoT-enabled hardware and intelligent software algorithms. The project aims to ensure optimum growth conditions, reduce manual intervention, and provide real-time monitoring through a cloud-based interface.

IV. HARDWARE REQUIREMENT

The hardware system of the IoT-based hydroponic farming project is designed for efficiency, modularity, and scalability to suit various farming environments. The central component of the system is the ESP32 microcontroller, chosen for its dual-core performance, built-in Wi-Fi, and Bluetooth connectivity. The ESP32 collects sensor data and communicates with the cloud platform in real time. Key sensors used include the DHT11 or DHT22 for temperature and humidity, TDS (Total Dissolved Solids) sensor for monitoring nutrient levels, and pH sensor to regulate the acidity of the water. A water pump and air pump are controlled using relay modules to circulate and oxygenate the nutrient solution, while a submersible water level sensor ensures appropriate water levels. Artificial lighting is provided using LED grow lights, which can be scheduled or automatically adjusted based on environmental readings. All components are mounted securely on a vertical frame or plant tray system, and powered using a 5V/2A adapter for the ESP32 and an external 12V DC power source for motors and pumps.

V. SOFTWARE REQUIREMENT

Logic, and user interaction. Core programming is done using Arduino IDE for firmware upload to the ESP32. Sensor data is collected and transmitted to the cloud using the MQTT protocol via platforms like ThingSpeak or Blynk, which provide real-time dashboards for remote monitoring. Data logging and analysis are handled through Python-based scripts running on Jupyter Notebook, which visualize trends in pH, temperature, and nutrient levels. The software integrates automated decision-making for controlling water and light schedules using predefined threshold values. For machine learning-based prediction or optimization (optional), libraries like NumPy, Pandas, and scikit-learn are employed. The overall system provides a user-friendly interface, alerts for abnormal conditions, and the flexibility to scale to multiple plant zones.

VI. CONCLUSION

The hydroponic farming project demonstrates a sustainable and efficient method of growing plants without soil by leveraging IoT and automation technologies. Through the integration of environmental sensors, ESP32 microcontroller, and cloud connectivity, the system provides precise control over plant growing conditions. The automated management of pH, temperature, and nutrient concentration ensures better crop yield with less water usage. With real-time monitoring and remote access, users can maintain optimal growth even in indoor or urban setups. The modular design allows for easy scalability and customization. Experimental results showed consistent pH levels and temperature regulation with minimal deviation, validating the system's effectiveness. Future improvements may include AI-based nutrient prediction, solar-powered components, and integration with mobile apps for enhanced accessibility. Overall, the system offers a reliable and low-maintenance alternative to traditional agriculture, suitable for educational, commercial, and personal use.

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REFERENCES

[1] Kumar, R., & Singh, M. (2020). IoT-Based Smart Hydroponic System. *International Journal of Engineering Research & Technology (IJERT)*, Vol. 9 Issue 06.

[2] Sharma, A., & Yadav, P. (2021). Design and Implementation of Smart Hydroponics System Using Arduino and IoT. *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 10, Issue 5.

[3] Patel, H., & Solanki, N. (2019). Real-Time Hydroponic System using IoT. *International Journal of Scientific & Engineering Research*, Volume 10, Issue 4.

[4] Das, B., & Senapati, A. (2018). IoT Based Automated Hydroponic System using pH and TDS Sensors. *International Journal of Recent Technology and Engineering (IJRTE)*, Volume-7 Issue-6.