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pH Measurement in Hydroponics System

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Abstract:- In hydroponic systems, precise pH management is crucial for optimizing plant growth and nutrient uptake. This study investigates the methodologies for measuring and maintaining pH levels in hydroponic systems, focusing on the effectiveness of various pH meters and calibration techniques. We assessed the accuracy and reliability of different pH measurement tools, including handheld meters and continuous monitoring systems, in a controlled hydroponic environment. Our results demonstrate how crucial routine pH meter calibration and maintenance are to ensure accurate readings. We also explored the impact of pH fluctuations on plant health and growth rates, providing recommendations for maintaining optimal pH levels to enhance nutrient availability and overall crop performance. The results emphasize the role of rigorous pH monitoring in the successful management of hydroponic systems.

Keywords:- *Hydroponics Systems, ESP32 Microcontroller, Touch Sensor, pH Meter (pH Sensor Probe).*

I. INTRODUCTION

In India, agriculture is the backbone of our economy. The cultivation process requires a wide stretch of geography. Nowadays plant cultivation is being done indoor which reduces a lot of space. But there is a lot of objectives which makes the plant growths low and hard. Some of them are lack of nutrients in water, wastage of water, poor maintenance and monitoring. To overcome these circumstances an automated hydroponic system can be developed. Maintaining sufficient nourishment is crucial for controlling the fertility of hydroponic plants. A farmer can keep an eye on the hydroponic plants more easily by keeping an eye on the flow of nutrients and the pH stability of those nutrients. This makes sure that less wastage of water, moisture monitoring, temperature monitoring, Ph monitoring and automatic actions to reduce any disadvantages are achieved. The temperature is being monitored regularly by the help of an exhaust fan. A constant 3-4hour cycle of light is functioning to ensure photosynthesis. All these parameters make sure to duplicate all the resources needed for a plant growth. This phase of the project contains literature survey of different projects and component assembly of moisture sensor.

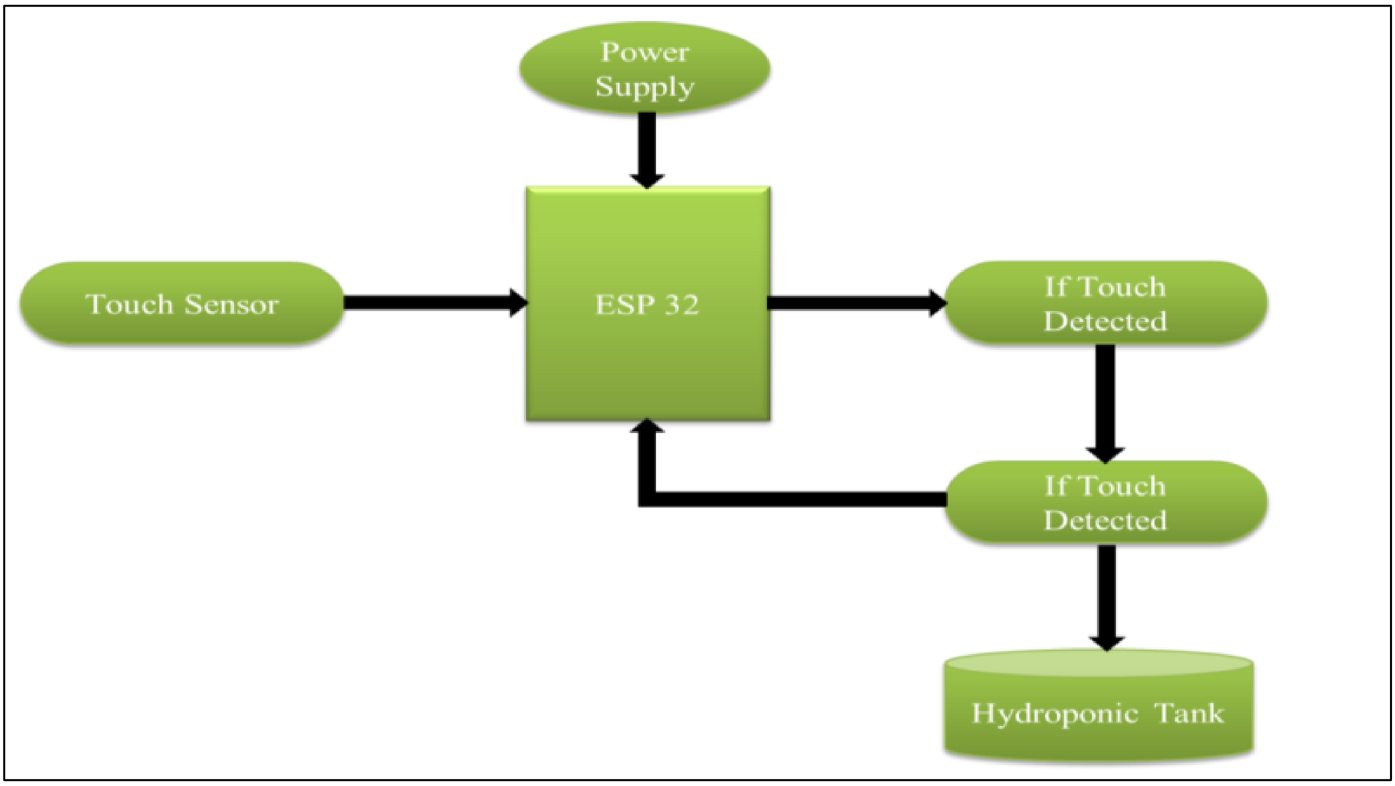

Fig 1: The pH Measurement in Hydroponics System

II. LITERATURE REVIEW

The literature review provides a concept for module design. Numerous studies have been carried out in the field of selecting applications. In order to identify the optimal methodology, a few pioneering works were briefly discussed in the first section. The following is a quick description of related papers that were analyzed and the many procedures that were evaluated using various approaches. The following summarizes the key findings from the study.

Libia I. Trejo - Tellez and Fernando C. Gomez-Merino [1], This paper is the concept of pH as well as effect of nutrients availability was observed and nutrients solutions with electrical conductivity. Also the importance of oxygenation and the temperature emphasization was observed, but there is no proper functionality for the physical layout. The usage of three containers with the three different NPK solution placed across each container. The suction motor acts as a pump. When the pH value is differed, the suction pipe pumps the nutrient solution and again checks for the Ph value. The nutrients are added until the pH is at its ideal level.

Deise Sliva Castro Poltronieri, Maria Christina Marques Fonseca [2], The goal of this paper is to assess the various N:K ratios when combining nutrient solutions for hydroponic vegetable production. The findings shown that the greatest K concentration in the nutrient solution increases the diameter of the yield rather than changing its length. Every yield produced in a hydroponic system has a preset N:K ratio. Effective chemicals are included in the nutrient solution, and the relay serves as a key component of the yield-cultivation system.

Vaibhav Palandea, Adam Zaheera , and Kiran Georgea [3], This paper main objective is the hydroponic system that is completely mechanized. aims to develop an inexpensive, user-friendly hydroponic system that uses Titan Smartponics to maintain ideal growing conditions for plants. Key parameters including pH, electrical conductivity (EC), water temperature, and air temperature/humidity can all be automatically monitored and controlled. Use an Internet of Things (IoT) network to provide remote monitoring and control. using open-source software Ensure the system's reliability by providing notifications of any abnormal parameter values.

Glenn D britto, Safa Hamdare [4], Automate Hydroponic Farming Develop a system that automatically controls water, nutrients, light, and environmental conditions. Improve Plant Growth Enhance growth rates and yields of plants, specifically using Tomato F1 Hybrid Suhyana seeds, by optimizing conditions. Data Collection Gather environmental data such as light, temperature, pH, water level, and nutrition availability to monitor and adjust plant growth by using the AI collecting the information of the plant and to get the notifications to the mobile.

PriyankaBelhekar, Anuradha Thakare, Payal Budhe, Uday Shinde, Vaishnavi Wagh [5], In these paper hydroponic system is to monitor and control environmental parameters to ensure optimal plant growth. This involves plant growth. This includes controlling factors such as light intensity, humidity, temperature, and nutrient levels using sensors and a microcontroller (Node MCU) to enhance the remote monitoring and control, which can be managed through an Android application. The system is designed to provide necessary and sufficient nutrients to the plants, whose roots are suspended in the water, thus supporting their healthy growth to manage the proper balance of nutrients to plants. To maintain the proper yields of the plants. and get the result as fast compare to soil based method.

Herman, Nico Surantha [6], The proposed system is to Use fuzzy logic and the Internet of Things (IoT) to track and manage the water and nutrient requirements of plants. This system aims to automate the management of hydroponic farming, ensuring optimal conditions for plant growth by continuously monitoring various parameters such as pH, electrical conductivity (EC), water level, and air temperature

Tanabut Changmai, Sethavidh Gertphol, Pariyanuj Chulak [7], The primary goal of the study described in this document is to create and construct an automated hydroponic system that can manipulate various environmental and nutrient parameters to optimize growth and quality of hydroponic plants.This objective is achieved by employing various sensors to measure and control critical parameters, ensuring that the hydroponic system can provide the optimal conditions for plant growth. The proposed system aims to reduce the complexity of hydroponic farming by automating the process, allowing for precise and timely adjustments based on sensor data.

SmitaPawar , ShreyaTembe , SaharKhan[8], The main objective of the study described in the document is to design an affordable pH module that can be integrated with IoT-based systems for monitoring and controlling pH levels in hydroponic applications. The focus is on creating a cost-effective solution that can interface with common microcontroller platforms like Arduino, Node MCU, and Raspberry Pi, enabling accurate and reliable pH measurements essential for maintaining optimal nutrient conditions in soilless agriculture.

Shalini MS, Adya S, Bhavana S, Neha HR, Sonu Shivani[9], The system aims to automate the monitoring and control of key parameters like pH, temperature, humidity, nutrient levels, and light intensity to optimize plant growth. Enhance water usage efficiency and reduce reliance on chemical fertilizers by precisely controlling the growth environment. Provide a sustainable alternative to soil-based farming, addressing issues like soil degradation, water scarcity, and the need for chemical-free food production.

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and up-to-date predictions compared to conventional methods. With faster data processing and analysis, an intelligent weather prediction system can provide early warnings for severe weather events, such as storms or hurricanes, enabling better preparedness and risk mitigation. The accuracy of predictions heavily depends on the quality of the data collected. Calibration issues or inaccuracies in sensor readings may lead to flawed predictions. an intelligent weather prediction system based on IoT holds significant promise in advancing weather forecasting capabilities. However, careful consideration of infrastructure, security, cost, and data quality is required to address any problems and ensure the system's effectiveness and durability.

III. PROPOSED METHODOLOGY

In a system, components play a crucial role in ensuring the system's functionality and performance. Some of the important components are- • Sensors are devices that collect data and send it to the ESP32. Actuators are devices that receive commands from the network and perform physical actions based on those commands. Network Connectivity refers to the various communication technologies and protocols used to connect devices to the internet, such as Wi-Fi, Bluetooth

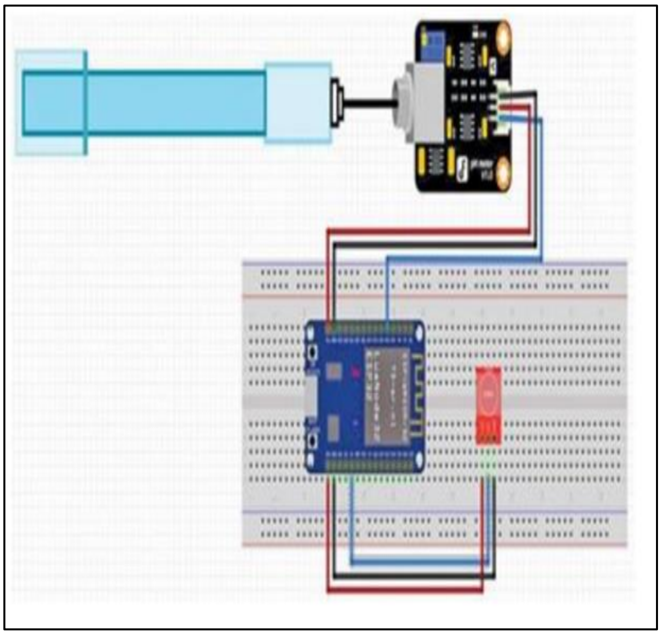

Fig 2: Hardware Connection

IV. IMPLEMENTATION

The ESP32-WROOM-32 is a highly integrated microcontroller module from Espressif Systems, featuring robust wireless communication capabilities, powerful processing, and a wide range of peripheral interfaces. At its core, the module houses the ESP32-D0WDQ6 chip, which includes a Tensilica Xtensa LX6 microprocessor with two or one core and a maximum clock speed of 240 MHz. This high processing power makes it suitable for demanding applications that require real-time performance and multitasking.

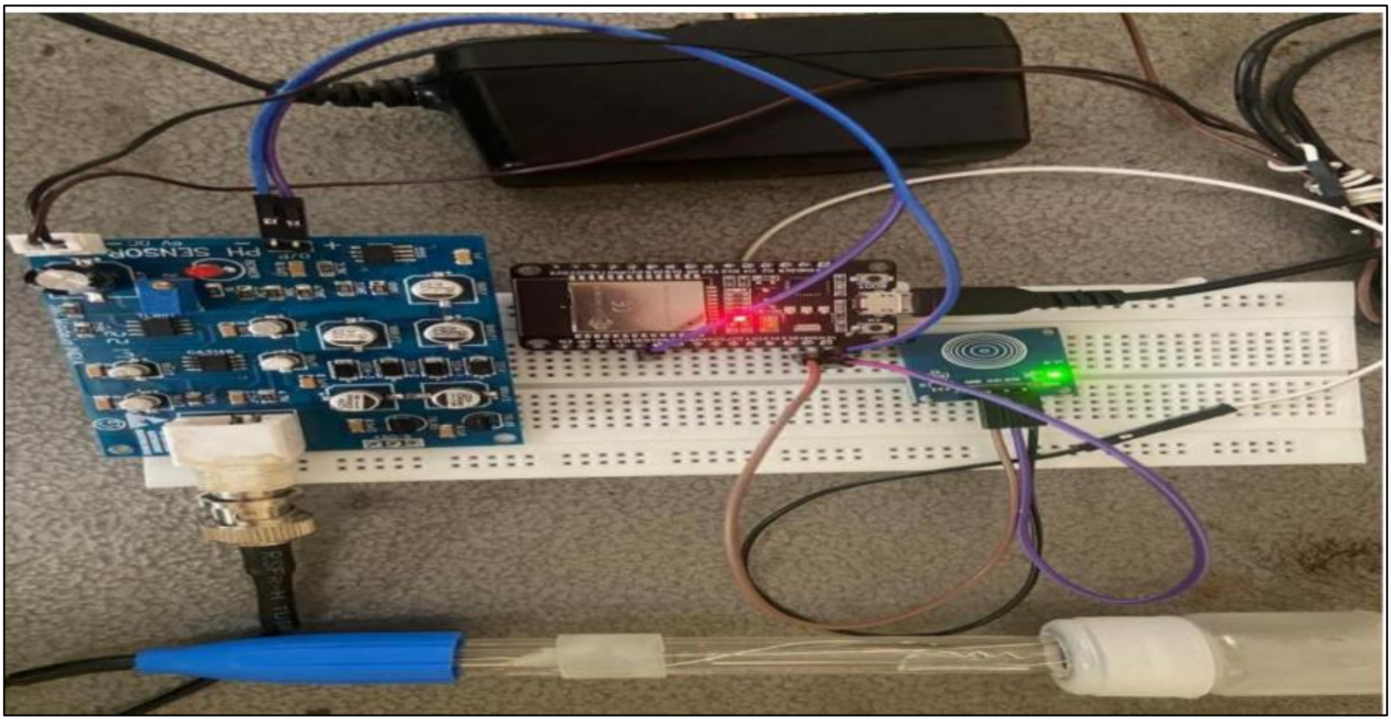

Fig 3: Circuit Implementation

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The ESP32-WROOM-32 module peripherals, including multiple ADC, DAC, and PWM interfaces. These peripherals make it highly adaptable to various sensor and actuator integrations, such as pH sensors, temperature sensors, pumps, and LED grow lights in hydroponic systems. The dual 12-bit ADCs provide precise analog input readings, essential for accurately monitoring environmental conditions. pH measurement in hydroponics system Dept. ECE, VIT 12 2023-24 In terms of memory, the ESP32-WROOM-32 includes 4 MB of flash memory, which is ample for storing firmware and application code. The module's power management features are designed to optimize energy consumption, with a number of power-saving settings like light and deep sleep, and hibernation. This is particularly advantageous for battery-operated devices and systems where energy efficiency is paramount. The ESP32-WROOM-32 is also supported by a robust development ecosystem, including the widely-used Arduino IDE, Espressif own ESP-IDF, and other development frameworks. This wide range of tools simplifies the development process, from prototyping to production. The module is also compatible with a variety of cloud platforms, allowing for seamless integration with cloud-based monitoring and control systems. Overall, the ESP32-WROOM-32 microcontroller is a powerful, versatile, and costeffective solution for building smart, connected devices. Its combination of high processing power, extensive peripheral options, and robust wireless connectivity makes it particularly well-suited for sophisticated applications such as automated hydroponic systems, where reliable performance and connectivity are essential.

Table 1: NPK Ratio Table

Plant Name	Nutrient	NPK Ratio
Tomato	NPK, Calcium & Magnesium	7:9:5
Lettuce	NPK, Copper, Iron & Manganese	5:10:15
Strawberry	NPK, Calcium, Magnesium & Sulfur	Urea (96:0:0), Ammonium nitrate (33:0:0)
Cucumber	NPK, fertilizer	2:3:6
Basil	Potassium, Calcium	1:1

V. RESULTS

A system with cultivated plants with low power and water consumption. • Development of system which detects the pH value in the nutrient solution and automates the water supply. • Healthier and fast plant growth in very less space. • Vertical farming and compact space. • Monitoring through pH sensor using ESP32. • Hydroponic systems can provide a closed, controlled growing environment that can help reduce the risk of pest infestations and diseases. Hardware Setup and Import To set up a pH measurement system for a hydroponic system using an ESP32, connect the pH sensor module's VCC pin to the ESP32's 3.3V or 5V, GND pin to the ESP32's GND, and Analog Output (AOUT) pin to an analog input pin on the ESP32 (e.g., GPIO 34). For the touch sensor, connect its VCC to the ESP32's 3.3V or 5V, GND to the GND of the ESP32, and OUT or Signal to a digital input pin (e.g., GPIO 0). Ensure all connections are secure, then power the ESP32 through a stable source. Verify connections by uploading a test sketch to the ESP32, and calibrate the pH sensor using standard buffer solutions to ensure accurate readings. The below fig.5.3.1 shows the figure of hardware connection and fig.5.3.2 shows the figure of circuit implementation. 1. The USB cable is connected to ESP32. 2. The ESP32is connected SIG. 3. The Touch sensor is connected to ESP32. 4. The pH meter output +ve is connected to ESP32 and –veisconnected.

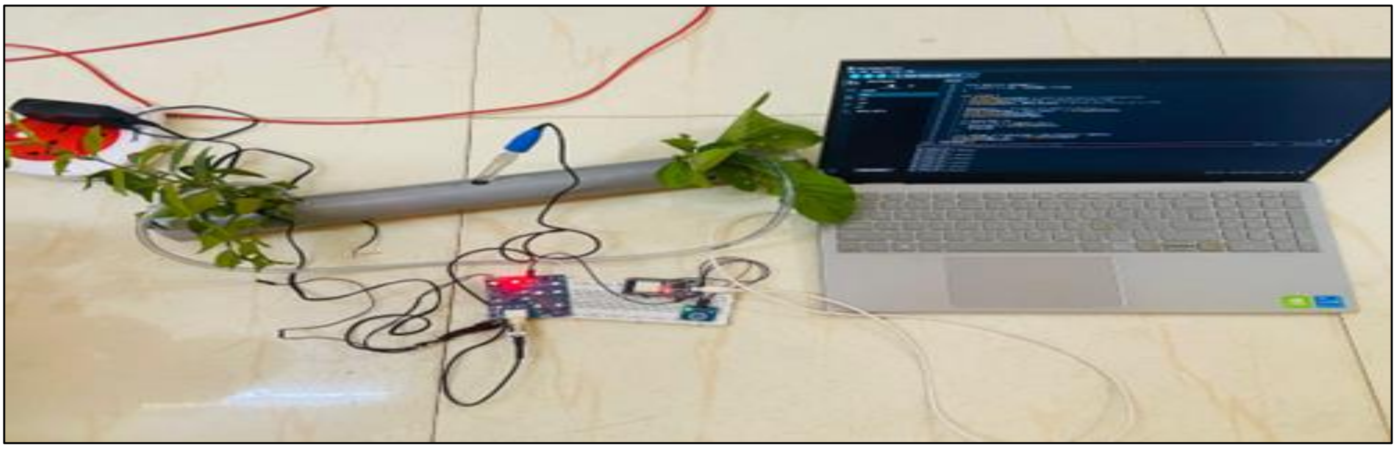

Fig 4: Overview of the System

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VI. CONCLUSION

The automatic hydroponic system is designed which detects pH value in plants, nutrients in water, promotes irrigation without soil and consumes very less space. The sensor is used to detect the pH value with 24/7 monitoring. The data sensed by the sensors can be monitored live on a serial monitor and altered consistently. In future we can add Bluetooth connection and get the message or updates in mobile we get the notifications about the plants and we can also add solar panel for water supply. The device can be installed incompact places such as indoor spaces at home, workspace, hospitals, schools etc. It consumes less power as devices switch off after the plants get the optimal need Operation of moisture detection and nutrients monitoring is the main function of the water dependent irrigation system. The design of the physical layout must have a steady water supply canals/pipes to ensure the water reaching all the plant sections. An additional water pump acts as a backup water supply during the even to flow moisture content. The idea of pH level monitoring is a technique which control's the NPK ratio to meet the essential nutrients needed for the plants.

In the Arduino ecosystem, C++ serves as the foundational programming language, providing a robust framework for developing embedded applications. The Arduino environment simplifies many aspects of C++ to make it accessible to beginners while still leveraging the power and flexibility of the language for more experienced users. The setup() and loop() procedures are the two primary components of a typical Arduino program. When the board first boots up, the setup() method initializes the hardware and settings, whereas the loop() function contains the code that runs repeatedly during the board's operation. This structure makes it easy to manage the flow of an embedded application. Serial communication is another critical aspect of C++ programming in Arduino. Functions such as Serial.begin(), Serial.print(), and Serial.read() enable interaction with other devices and computers, facilitating debugging and data exchange. This feature is crucial for developing and testing Arduino projects, allowing developers to monitor and control their applications effectively. Overall, C++ in the Arduino environment combines simplicity with powerful features, enabling both novice and experienced developers to create a wide range of embedded applications. The language's versatility and the Arduino IDE's user-friendly approach make it an excellent choice for developing interactive and efficient hardware projects.

To set up a pH measurement system for a hydroponic system using an ESP32, connect the pH sensor module's Connect the Analog Output pin to an analog input pin on the ESP32 , the VCC pin to the 3.3V or 5V ESP32, and the GND pin to the ESP32's GND. Attach the touch sensor VCC of the ESP32, GND to the ESP32's GND, and OUT or Signal to a digital input pin. Make sure every link is safe then power the ESP32 through a stable source. Verify connections by uploading a test sketch to the ESP32, and calibrate the pH sensor using standard buffer solutions to ensure accurate readings. The below fig.5.3.1 shows the figure of hardware connection and fig.5.3.2 shows the figure of circuit implementation. precipitation.

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