Application of IoT in Hydroponics

Project Report submitted in partial fulfillment of the requirements for the Degree of

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND COMMUNICATION ENGINEERING

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Department of **ELECTRONICS AND COMMUNICATION ENGINEERING**

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

FUTURE INSTITUTE OF TECHNOLOGY
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2023

CERTIFICATE

This is to certify that the project work entitled **"Application of IoT in Hydroponics"** submitted by **Soham Chakraborty (34200319016), Sneha Kumari (34200319027), Shatadru Sen (34200319028), Srijoni Das (34200319032), Soumik Dutta (34200319044)** in the partial fulfillment for the award of the degree of Bachelor of Technology in **Electronics and Communication Engineering** at Future Institute of Technology, is a bona fide work done by them.

The matter presented in this thesis has not been submitted for the award of any other degree of this orany other Institute/University.

I wish them all success in life.

Date:

……………………………………………………………

Mr. Amit kumar Majumder
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ACKNOWLEDGEMENTS

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At last, I end up thanking all who helped me in finalizing the project within the limited time frame.

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FINAL YEAR PROJECT REPORT

Title of the Project – Application of IoT in Hydroponics

Objective – To produce a hydroponics system and use pH sensors, temperature sensors to monitor the system and change those values in real-time.

Introduction – The goal of this project is to develop a sensor-based automatic control mobile application to control the entire hydroponics system. The application should be able to automatically control the environment of the hydroponics system via different types of sensors, including water temperature, and pH sensors. It should also be able to provide the functions for planning, managing, as well as harvest data recording, of hydroponic gardening to fulfill the planting demands. The harvest data should be used for hydroponics planning in the next grow. In addition, users should be able to monitor plant growth.

Literature Survey

Design of an Affordable pH module for IOT-Based pH Level Control in Hydroponics Applications – ***Written by Smita Pawar, Shreya Tembe, Sahar Khan***

Hydroponics is a growing technology that is being used to grow plants without the use of soil. Hydroponics systems use different solutions to give plants the nutrients they need. This system is called recirculating hydroponics.

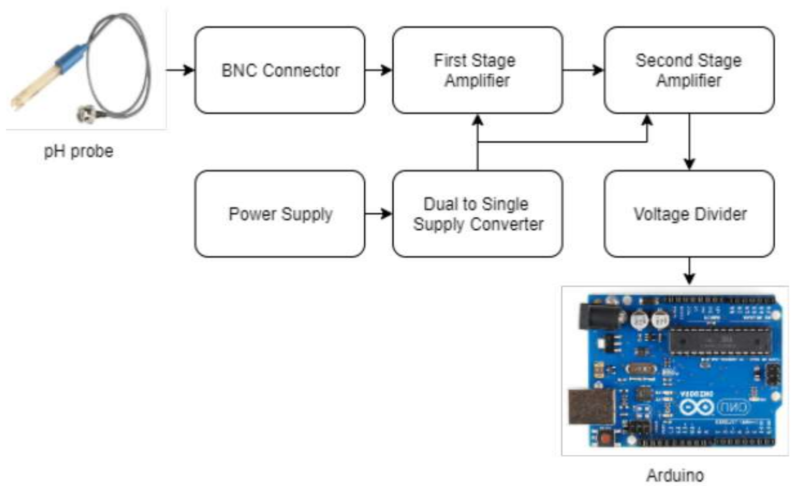
When the pH of the solution is not properly regulated, it can cause problems for the plants. pH probes are used to monitor the pH of the solution and ensure that it is within the correct range. They have an output impedance of 1013 Ω and produce an analog signal. This signal needs to be processed before it can be used.

There are a number of boards that can be used to interface with pH probes. Arduino is one of these boards. Arduino can be used to control the pH probes and output the data onto a display or into a data file. Node MCU is another board that can be used to interface with pH probes. Node MCU can be used to control the pH probes and output the data onto a display or into a data file. Raspberry Pi is also a possible board that can be used to interface with pH probes. Raspberry Pi can be used to control the pH probes and output the data onto a display or into a data file.

The pH probes are used in a lab setting and typically generate an extremely minor current based on the pH level of a solution. The current can be positive or negative, depending on the positive and negative hydrogen ion concentration. It is inadvisable to calculate this current with a multimeter or an analog-to-digital converter (ADC) without proper signal conditioning. We amplify the current to a suitable level using operational amplifiers that have an input impedance equal to the output impedance of the pH probe. These probes are prone to picking up noise voltages other than the potential difference between hydrogen ions. Therefore, using BNC connectors as isolation between the probe and the pH module is mandatory.

pH levels and their voltages represent the equivalent potential difference obtained for each pH level. From observation, we can conclude that output voltage varies inversely concerning the pH levels. The voltage of -414mV.

$$\textbf{pH level} \propto \textbf{(1 / Output Voltage)}$$



Block Diagram of pH module

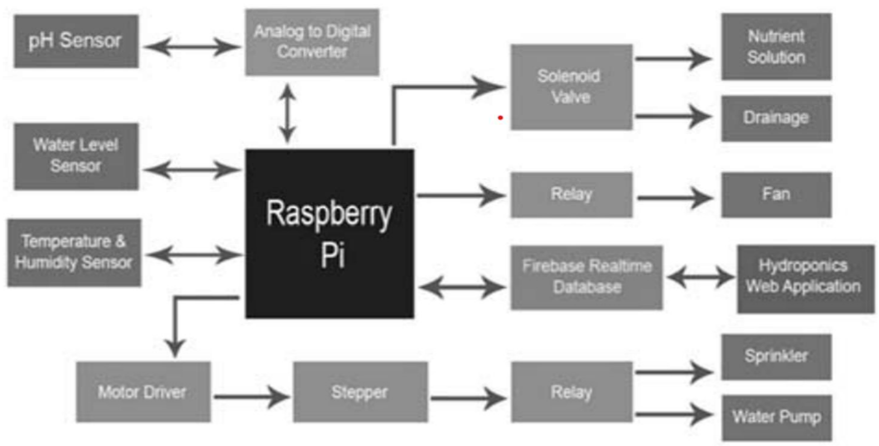
The major downside of this system is the high input impedance OPAamp. The conventional IC 741 can't be used, as the input impedance is not enough for this system. Hence, they opt for IC TL072, TL062, or LMC6001 & LMC6004, all of these matches the specifications. In addition, an ideal pH probe has an impedance between 50M Ω to 500M Ω. TL072 OPAamp is the heart of this system's design. TL072 has an input impedance of 1012 and can handle the maximum peak voltage of ±12V. In addition, low noise is a cherry on top. For current conversion and voltage amplification, two amplifier blocks having high impedance and low drift are essential. Hence, the TL07X series are suitable for pre-amplification applications.

Development of an IoT-based Aquaponics Monitoring and Correction System with Temperature-Controlled Greenhouse – ***Written By Lean Karlo S. Tolentino, Edmon O. Fernandez***

This study describes an Internet of Things-based monitoring and automatic correction system for an aquaponics setup in a temperature-controlled greenhouse (IoT). The system involves gathering real-time data information obtained from the ambient temperature and humidity sensor, as well as the light intensity sensor. In addition, it involves keeping an eye on the plant's canopy area as well as the pH and temperature of the recirculating water in the system. The correction devices, which include growing lights, exhaust and inlet fans, an evaporative cooler, an aerator, and a peristaltic buffer device, were automatically triggered by the system to rectify and return to a normal state if the acquired data did not fall within the threshold range. Internet remote access includes the effective wireless transmission and reception of data reports between the system and an Android unit with the Android application in real time.

IoT Hydroponics Management System* – *Written by Chris Jordan G. Aliac', Elmer Maravillas

Hydroponics Management System (HMS) is a hydroponics system that enables users to control certain mechanisms for refilling, sprinkling, draining, and many more through the web application. They can also monitor the pH level, relative humidity, air temperature, and water level, which is data collected from the sensors. As long as there is an internet connection available, the user should be able to monitor and control these anytime and anywhere. Through HMS, hydroponics should become more accessible and available. This will allow busy people to grow their own food while managing and monitoring the system.



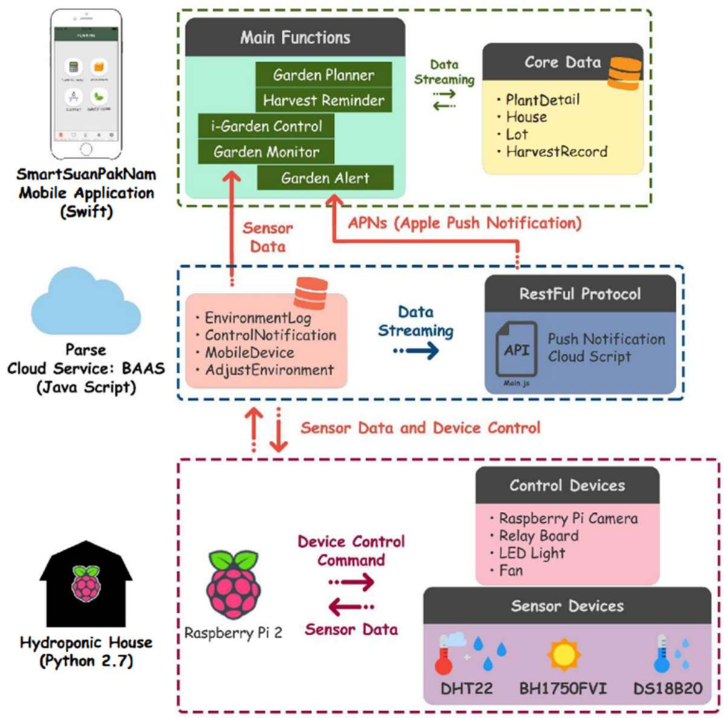
This block diagram shows the flow of data in the hydroponics hardware system.

- The Raspberry Pi is used to control the components in the hydroponics system based on the command that was retrieved from the Google Firebase a real-time sensor logging system cloud service.
- The Raspberry Pi is also used to control the data retrieval from the sensors and the data is then uploaded to Firebase. The data stored from Firebase is shown in the Hydroponics Web Application.

With the use of simple mechanisms, this system provides controlled irrigation of water and nutrient solution intake. Through the data gathered by the sensors and the use of cloud-based technology as the backend, information is stored, managed, applied, and shared via the internet by users.

DIY Sensor-Based Automatic Control Mobile Application for Hydroponics* - *Written By Chanya Peuchpanngarm, Pantita Srinitiworawong, Wannisa Samerjai and Thanwadee Sunetnanta

Hydroponics is a new popular technique for growing plants, especially in urban areas, due to its many advantages over traditional soil-based gardening. A DIY sensor-based automatic control mobile application is used for hydroponics to apply affordable technology for managing and controlling hydroponics gardening. The application enables automatic environmental control for hydroponics via different types of sensors, including water temperature, temperature and humidity, and light intensity. It also consists of the functions for planning, managing, as well as harvest data recording, of hydroponic gardening to fulfill the planting demands. The harvest data will be used for hydroponics planning in the next grow. In addition, users can monitor the plant growing progress remotely.



System Architecture and Functions of the Android Application

- This app composes of functions for planning and monitoring hydroponics gardening. Users will be received the notification when plants are suitable for harvest and the inappropriate environments of the hydroponic system occur. Additionally, this part has a small database on mobile called "Core Data", containing the data of plants, houses, planting targets, and harvest records.
- This hydroponics house is installed with sensors for environment control of hydroponics. There are three main sensors which are temperature and humidity sensors, water temperature sensors, and light intensity sensors. We use raspberry pi version 2 to interface between sensors and cloud service.
- Cloud Services keep all data that we read from the hydroponics house's sensors and perform functions to send notifications automatically to users. For this part, we implement by using Parse Service.

Smart and Sustainable Home Aquaponics System with Feature-Rich Internet of Things Mobile Application* – *Written by R Mahkeswaran, Andrew Keong

The proposed home aquaponics system is designed to be efficient in terms of energy and water usage, as well as space. The system is also designed to be easily scalable so that it can be adapted to different-sized homes. The system comprises various sensors, actuators, and a microcontroller with internet connectivity to continuously monitor, control, and record fish tank water and ambient air quality.

The system is designed to send an early warning to the user in the event of any abnormal system condition via push notification in a feature-rich IoT mobile application. Furthermore, appropriate actuators are automatically operated to rectify abnormalities in a timely manner. Plant grow lights and fish feeders are also automatically controlled to optimize fish and plant growth. All sensor readings and actuator statuses are intuitively displayed to the user in real-time through the IoT mobile application and securely sent to an online spreadsheet for storage and further analysis.

An Arduino Mega 2560 microcontroller is the central processing unit of the home aquaponics system. The microcontroller receives sensor values and sends the values to a NodeMCU Wi-Fi module over a serial connection for internet connectivity. A Grove-Mega shield is also mounted on the microcontroller to lessen connections on the breadboard.

Besides that, a four-channel relay is employed to control the activation of actuators in the event of an abnormal system condition. The relay is triggered when a preset sensor threshold value is exceeded. For instance, a water heater is activated when the water temperature drops below 23°C; a reserve air pump is turned on when the amount of oxygen dissolved in water falls below 5.0 mg/L, and light-emitting diode grow lights are switched on when the ambient light intensity drops below the required level for plant growth of 25000 lux. An automatic fish feeder, which was made of acrylic and a 5V servo is also deployed to dispense fish food based on a user-defined schedule.

The mobile application was designed to be intuitive and user-friendly. Upon installation, the user is prompted to set up a login and password. From here, the user can access a variety of functionality, such as monitoring system status, controlling system parameters, and uploading data to a local server. In addition, the mobile application offers a variety of features that make it convenient for the user to manage the aquaponics system. For example, the user can view real-time sensor readings and actuator statuses through the application, and port forwarding was implemented to allow remote monitoring and control. Overall, this mobile application provides a convenient way for the user to monitor and control the home aquaponics system in real-time.

STUDY OF THE PROJECT

What is Hydroponics?

Hydroponics is a type of horticulture and a subset of hydroculture that involves growing plants, usually crops or medicinal plants, without soil, by using water-based mineral nutrient solutions in aqueous solvents. Terrestrial or aquatic plants may grow with their roots exposed to the nutritious liquid or in addition, the roots may be mechanically supported by an inert medium such as perlite, gravel, or other substrates.

Despite inert media, roots can cause changes in the rhizosphere pH and root exudates can affect rhizosphere biology and the physiological balance of the nutrient solution by secondary metabolites. Transgenic plants grown hydroponically allow the release of pharmaceutical proteins as part of the root exudate into the hydroponic medium.

The nutrients used in hydroponic systems can come from many different organic or inorganic sources, including fish excrement, duck manure, purchased chemical fertilizers, or artificial nutrient solutions.

Plants are commonly grown hydroponically in a greenhouse or contained environment on inert media adapted to the controlled-environment agriculture (CEA) process. Plants commonly grown hydroponically include tomatoes, peppers, cucumbers, strawberries, lettuces, and cannabis, usually for commercial use, and Arabidopsis thaliana, which serves as a model organism in plant science and genetics.

What is Aquaponics?

Aquaponics is a food production system that couples aquaculture (raising aquatic animals such as fish, crayfish, snails, or prawns in tanks) with hydroponics (cultivating plants in water) whereby the nutrient-rich aquaculture water is fed to hydroponically grown plants.

As existing hydroponic and aquaculture farming techniques form the basis of all aquaponic systems, the size, complexity, and types of foods grown in an aquaponic system can vary as much as any system found in either distinct farming discipline.

What is IoT?

The Internet of things (IoT) describes physical objects (or groups of such objects) with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. Internet of things has been considered a misnomer because devices do not need to be connected to the public internet, they only need to be connected to a network and be individually addressable.

The field has evolved due to the convergence of multiple technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems, as well as machine learning. Traditional fields of embedded systems, wireless sensor networks, control systems, and automation (including home and building automation), independently and collectively enable the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", including devices and appliances (such as lighting fixtures, thermostats, home security systems, cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smartphones and smart speakers. IoT is also used in healthcare systems.

Project Summary:

Project Title: Hydroponics Monitoring and pH Control System using Node MCU

Introduction:
We have developed a project utilizing Node MCU, aimed at automating and monitoring a hydroponics system. Hydroponics is a method of cultivating plants without soil, relying on a nutrient-rich water solution. In our project, we have integrated various sensors, including a pH sensor, a DHT11 for temperature monitoring. The system maintains the pH value within a desired range. By integrating temperature and pH sensors with the Node MCU, we provide growers with crucial data to optimize plant growth conditions and ensure successful hydroponic cultivation. Additionally, it provides real-time notifications through Firebase whenever the luminosity or temperature deviates from the predefined thresholds.

Working Process:
Our hydroponics monitoring system offers a detailed working process, focusing on temperature and pH monitoring for effective plant care.

- **Sensor Data Acquisition:**
  The Node MCU collects data from the temperature and pH sensors strategically placed within the hydroponic system. The temperature sensor continually measures the ambient temperature, while the pH sensor monitors the pH value of the water in the hydroponic tank.

- **pH Control:**
  The Node MCU transmits the temperature and pH data to a monitoring interface, allowing users to view real-time measurements. The interface can be a web-based dashboard or a mobile application, providing growers with immediate access to vital information about their hydroponic system's temperature and pH levels.

- **Manual pH Balancing:**
  In the current implementation, if the pH level deviates from the desired range, users manually adjust the pH solution to restore optimal conditions. By monitoring the pH readings, growers can take timely corrective actions and manually add appropriate amounts of acidic or basic solutions to the hydroponic tank to restore the desired pH range.

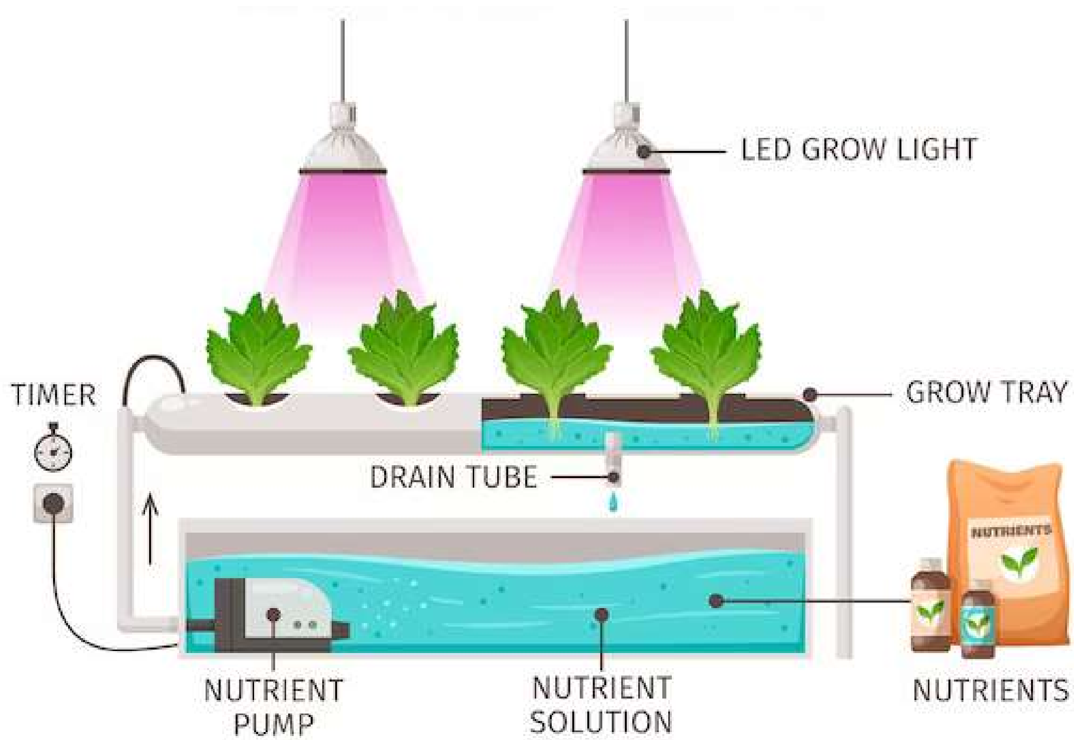
- **Temperature Control:**
  The DHT11 sensor measures the temperature in the hydroponics system. If the temperature exceeds the desired value, indicating potential stress to the plants, the Node MCU activates another relay connected to a fan. The fan is turned on to provide adequate ventilation and cooling, preventing overheating and maintaining optimal temperature conditions.

- **Data Logging and Cloud Connectivity:**
  To ensure data integrity and accessibility, the Node MCU sends sensor data to Firebase every hour. This data includes pH values, temperature levels. Firebase provides a secure and scalable cloud infrastructure for storing and retrieving sensor data, facilitating analysis and historical monitoring of the hydroponic system's performance.

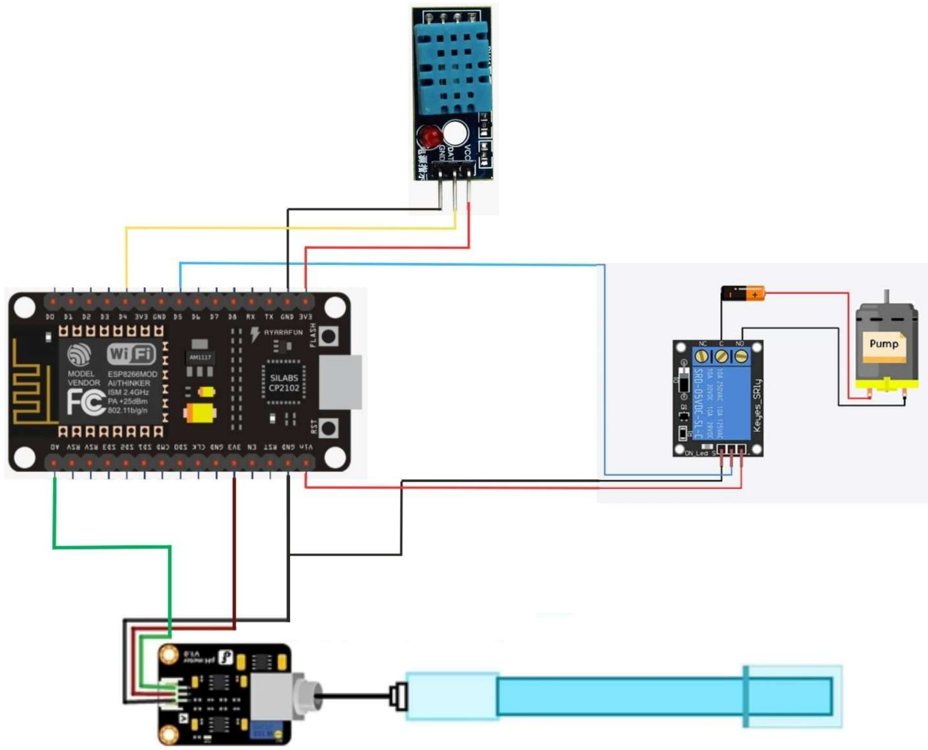
Summary:

Our hydroponics monitoring system, implemented with Node MCU, provides growers with comprehensive insights into the temperature and pH levels of their hydroponic system. By continuously monitoring these crucial parameters, users can optimize plant growth conditions and manually adjust the pH solution when required. The proposed future enhancement of automating the pH balancing process using peristaltic pumps showcases the potential for increased efficiency and automation in hydroponic systems, enabling growers to achieve more precise pH control and enhance the overall success of their hydroponic cultivation.

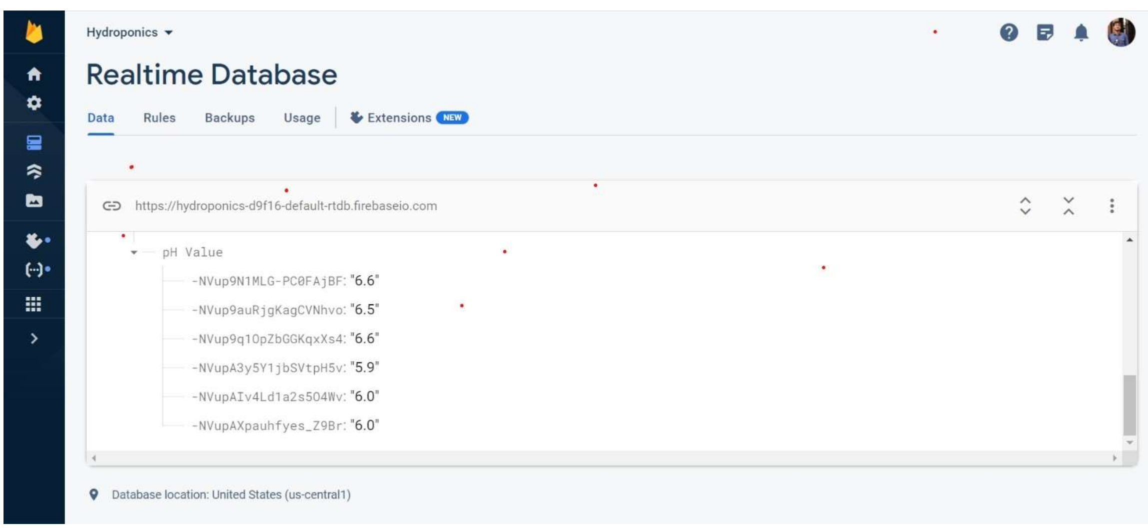
Our project demonstrates the potential of IoT in creating an automated and intelligent hydroponics system.



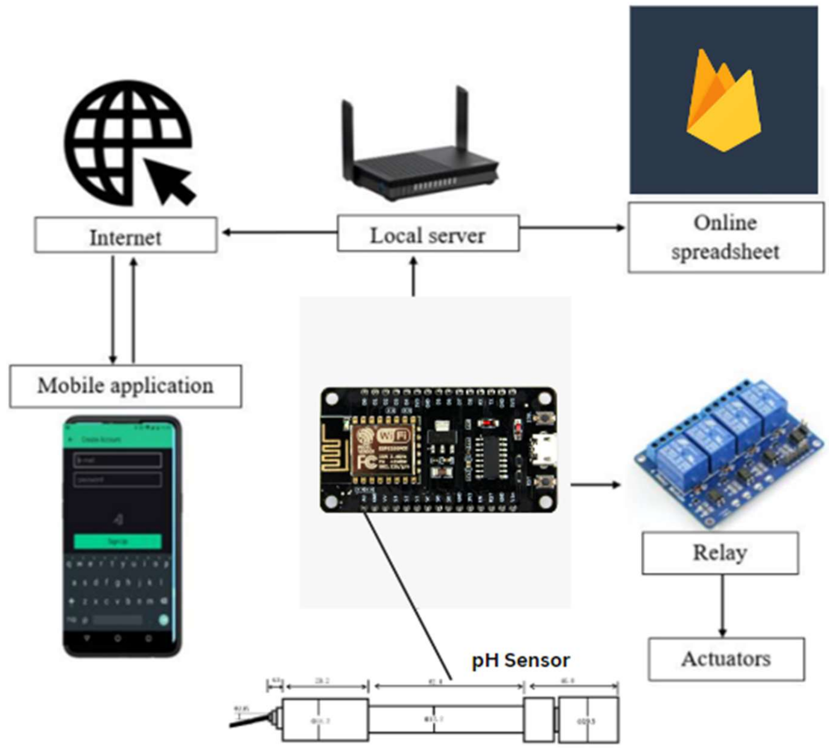
Hydroponics Model



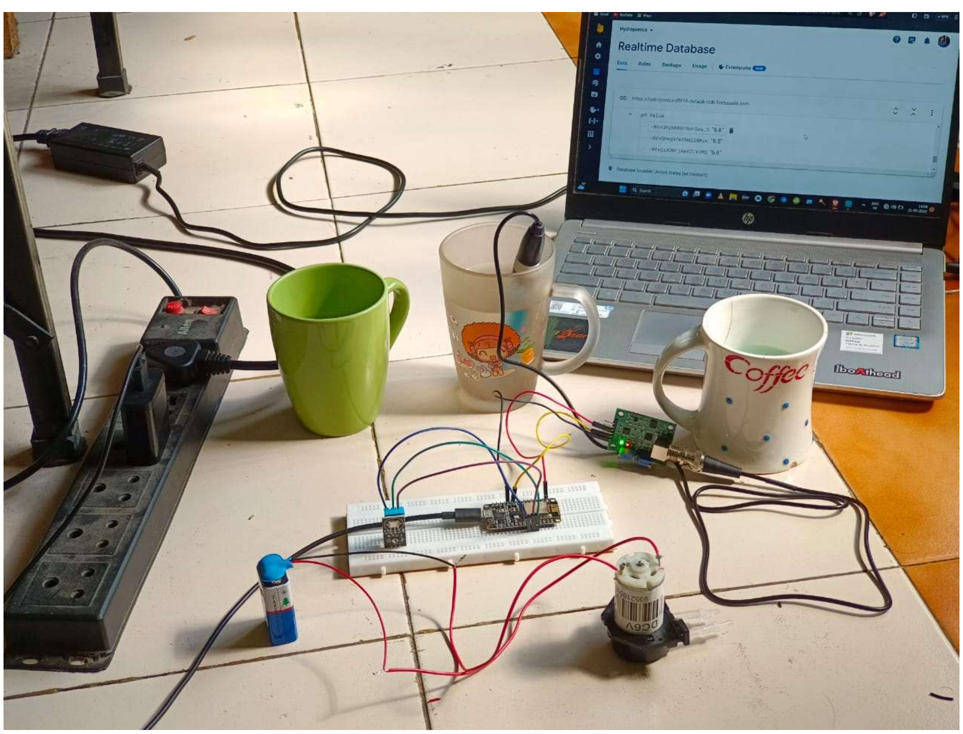
<u>Circuit Diagram</u>



<u>Firebase Value Screenshots</u>



Block Diagram



Prototype of our model

Based on the data table, the pH values of the water in the hydroponic system were recorded on two different occasions: May 19th at 7:23 pm and May 20th at 8 am.

On May 19th at 7:23 pm, the pH value of the water was measured to be 6.6, with a tolerance of plus or minus. This indicates that the water was slightly acidic but still within an acceptable range for the hydroponic system.

However, on May 20th at 8 am, the pH value of the water was found to be slightly lower, around 6. This decrease in pH can be attributed to the presence of waste from the fishes in the hydroponic system. Fish waste contains organic compounds that can contribute to increased acidity in the water.

It is important to note that maintaining a stable pH level is crucial for the optimal growth of plants in a hydroponic system. Monitoring the pH regularly and taking corrective actions, such as adjusting the pH solution, can help maintain a suitable pH range and ensure a healthy growing environment for the plants.

Based on the data provided, it is recommended to monitor the pH closely and take appropriate measures, such as adjusting the pH solution or implementing filtration methods, to prevent further fluctuations and maintain a stable pH level in the hydroponic system.

Date	Time	pH Value
19.05.2023	7:23:34 pm	6.6
19.05.2023	7:23:36 pm	6.5
19.05.2023	7:23:38 pm	6.6
20.05.2023	8:18:11 am	5.9
20.05.2023	8:18.13 am	6.0
20.05.2023	8:18:15 am	6.0

pH Value Monitoring Table

Components to be used for the project:

Node MCU:

Node MCU is an open-source development board that combines the capabilities of an ESP8266 Wi-Fi module with a Lua-based firmware. Designed as an IoT (Internet of Things) platform, Node MCU provides a user-friendly and cost-effective solution for building and prototyping connected devices. The board itself is compact and lightweight, making it ideal for embedded applications and projects with space constraints.

One of the key features of Node MCU is its built-in Wi-Fi functionality. The ESP8266 module on the board enables seamless wireless connectivity, allowing devices to connect to local networks or even communicate directly with cloud services. This feature is crucial for IoT applications, as it enables remote control, data logging, and real-time monitoring. The Wi-Fi connectivity can be easily programmed and configured using the Lua scripting language, making it accessible for developers of all skill levels.

In addition to Wi-Fi, Node MCU offers a range of general-purpose input/output (GPIO) pins, which provide a flexible interface for connecting various electronic components and sensors. These pins can be used to read digital or analog inputs, control output signals, or communicate with other devices using protocols such as I2C or SPI. This versatility allows developers to create complex projects and integrate multiple sensors or actuators seamlessly.

Another notable feature of Node MCU is its support for the Lua programming language. Lua is a lightweight and powerful scripting language that is easy to learn and use. It offers a simple syntax and a wide range of built-in functions and libraries, making it suitable for rapid prototyping and development.

The Lua firmware that comes pre-installed on Node MCU provides an interactive development environment, allowing developers to write and execute code directly on the board. This feature simplifies the development process and eliminates the need for external programming tools.

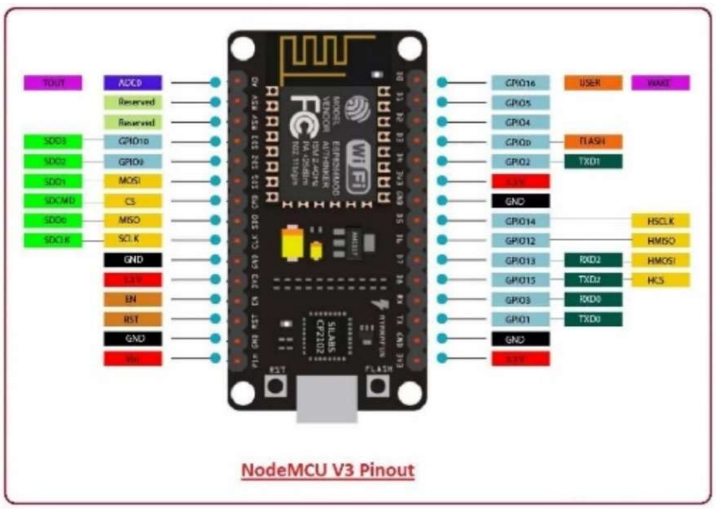
Overall, Node MCU is a versatile and feature-rich development board that empowers developers to create IoT devices and prototypes efficiently. With its integrated Wi-Fi, GPIO pins, and support for the Lua programming language, Node MCU offers a seamless and accessible platform for building connected projects. Whether you are a beginner or an experienced developer, Node MCU provides the tools and capabilities needed to bring your IoT ideas to life.

- ***Node MCU Specifications***
    - **Microcontroller:** ESP8266
    - **Processor:** Tensilica L106 32-bit RISC microcontroller
    - **Clock Speed:** 80 MHz
    - **Flash Memory:** 4MB
    - **Wi-Fi Standards:** IEEE 802.11 b/g/n
    - **GPIO Pins:** 11
    - **Analog Input Pins:** 1 (10-bit resolution)
    - **USB Interface:** Micro USB
    - **Power Supply:** 3.3V
    - **Firmware:** Lua-based
    - **IDE Compatibility:** Arduino IDE, ESPlorer IDE, Node MCU Firmware Programmer
    - **Operating Voltage:** 3.3V
    - **Dimensions:** Approximately 49mm x 24mm
    - **Open-Source Platform**

- ***Compatible with Cloud Services:***

Node MCU supports the following cloud services:

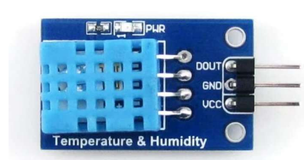
- Amazon Web Services (AWS)
- Microsoft Azure
- Google Cloud Platform (GCP)
- IBM Cloud
- Blynk
- Adafruit IO
- Thingspeak
- Ubidots
- MQTT (Message Queuing Telemetry Transport)
- Firebase



Temperature Sensor (DHT11): The DHT11 is a digital temperature and humidity sensor widely used in various applications requiring environmental monitoring. It provides reliable and accurate measurements of temperature within a range of 0 to 50 degrees Celsius, and humidity within a range of 20% to 90%. With its low cost and simple interface, the DHT11 is an accessible choice for projects involving temperature and humidity sensing. The sensor communicates using a one-wire digital protocol, making it compatible with a wide range of microcontrollers and development boards such as NodeMCU.

Here are the features and specifications of the DHT11 sensor:

- **Type:** Digital temperature and humidity sensor
- **Temperature Range:** 0 to 50 degrees Celsius
- **Humidity Range:** 20% to 90%
- **Voltage Supply:** 3.3V to 5V
- **Interface:** One-wire digital protocol
- **Accuracy:** ±2°C (temperature), ±5% (humidity)



- **Response Time:** 2 seconds (temperature and humidity)
- **Sampling Rate:** 1 Hz (1 measurement per second)
- **Dimensions:** 15.5mm x 12mm x 5.5mm
- **Compatibility:** Suitable for various microcontrollers and development boards.

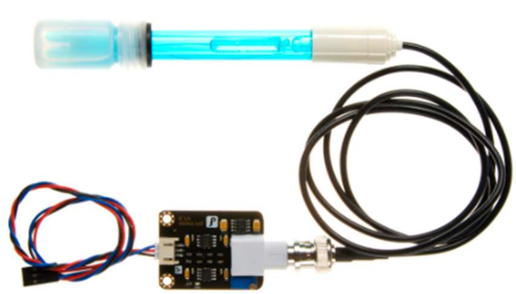
Other Similar Sensors **----**

Indicators	LM35	TMP36	DHT11
Maximum measurement error	0.5° C	2° C	2° C
Operating temperature range	-55 ... +150°C	-40 ... +125°C	0 ... +50°C
Non-linearity	+/-0.18	+/-0.5	+/-1
Maximum electric current intensity, µA	60	50	150
Low level heating	+	+	+
Voltage level	4-30 V	2.7-5.5 V	3-55 V
Price	$1.23	$1.77	$1.09

pH Sensor: The pH sensor is a simple device that measures the amount of alkalinity or acidity present in the water and sends the data to a specific device or to a cloud service.
A pH meter measures the hydrogen-ion activity in water-based solutions, indicating its acidity or basicity expressed as pH. pH level is an important indicator in many scenarios, especially in monitoring soil conditions and water quality. A pH sensor is widely used in farming, gardening, hydroponics, aquaponics, swimming pools and spas, sewage treatment, education, environmental monitoring, and many other applications.

This pH sensor ***(S-pH-01A)*** is designed with industry standards. It adopts international advanced solid dielectric and large-area polytetrafluoroethylene liquid junction, which is not easy to block and convenient for maintenance. It's designed with ATC (automatic temperature compensation), making sure the data is accurate regardless of the temperature changes. This pH Sensor is IP65 rated, waterproof in a tight seal, and capable of withstanding long-term constant use in professional application scenarios.

This pH Sensor comes with a **MODBUS-RTU RS485** serial communications protocol or 4~20mA current output. It can be easily connected to and integrated with other devices such as data loggers, controllers, displays, etc. This cost-effective pH sensor features low-power consumption, compact size, portability, and high integration, making it widely applicable in both indoor and outdoor environments.
Example - Gravity Analog pH sensor.

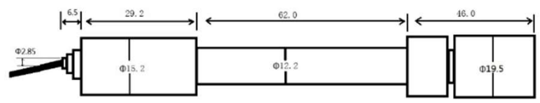


Specifications

- Module Power: 5.00V
- Module size: 43mm×32mm
- Measuring Range:0-14PH
- Measuring Temperature :0-60 ℃
- Accuracy : ± 0.1pH (25 ℃)
- Response Time: ≤ 1min
- High performance: high accuracy, fast response, good repeatability
- Universal protocol: MODBUS RS-485 or 4~20mA current
- Wide-range power supply: 3.6V ~ 30V

- Robustness: suitable to be immersed in soil or water for a long time
- Maintainance-Free: advanced junction design, no clogging
- Durable: anti-corrosion, automatic temperature compensation
- User-friendly: Easy to install and integrate
- pH Sensor with BNC 3-footer
- pH2.0 Interface (3-foot patch)
- Gain Adjustment Potentiometer
- Power Indicator LED

pH Electrode Size



Peristaltic pump:

A positive displacement pump used to pump a variety of fluids is called a peristaltic pump, also referred to as a roller pump. A flexible tube that is inserted inside the circumference of the pump casing houses the fluid. Although linear peristaltic pumps have also been created, rotating motion is how most peristaltic pumps operate. The flexible tube is compressed while the rotor rotates by several "wipers" or "rollers" that are attached to its outside circumference. The compressed portion of the tube is sealed, forcing the fluid to pass through it. More fluid is sucked into the tube when it opens to its original state after the rollers pass. This process is called peristalsis and is used in many biological systems such as the gastrointestinal tract. Typically, there will be two or more rollers compressing the tube, trapping a body of fluid between them. The body of fluid is transported through the tube, toward the pump outlet. Peristaltic pumps may run continuously, or they may be indexed through partial revolutions to deliver smaller amounts of fluid.

- ***Peristaltic Dosing Pump Features***
  - Settable flow rate of 19~100 mL/min.
  - Flow rate is settable by turning a thumb wheel.
  - Low cost.
  - Changeable flow direction.
  - Compact attractive design.
  - 15 Failsafe timed outputs or continuous operation

- ***Specifications***:

• Brand	• Robocraze
• Model	• NKP-DC-S06
• Operating Voltage (VDC)	• 12
• Operating Current (A)	• 0.25
• Operating Temperature (C)	• 0 to 40
• Flow Rate (ml/min)	• 100ml/min
• Noise Level (dB)	• <40
• Length (mm)	• 67
• Width (mm)	• 55
• Height (mm)	• 41
• Weight (gm)	• 100

***Relay Module*:**

An electronic relay module is a compact and versatile device that integrates one or more relays with supporting components to enable efficient control and switching of electrical loads in electronic circuits. With features like rapid switching, low power consumption, and enhanced reliability, these modules offer significant advantages over traditional electromechanical relays. Designed with built-in protection circuits, they ensure optimal performance and longevity. Suitable for automation, robotics, IoT applications, and more, electronic relay modules provide convenient interfaces for seamless integration with control systems, making them essential components in modern electrical control and automation projects.
We will be using Relay Module in this project to power up our peristaltic pump and fan.

Features:

- Compact and modular design for easy integration
- Multiple relay options (single relay or multi-channel)
- Fast switching times for quick response
- Low power consumption for energy efficiency
- Built-in protection circuits (e.g., flyback diodes, transient voltage suppression)
- Opto isolators or transistor drivers for input/output interfaces
- Logic-level or voltage-level control signals
- LED indicators for relay status
- Screw terminals or plug-in connectors for easy wiring
- Wide voltage compatibility (e.g., 5V, 12V, 24V)

Specifications:

- Maximum switching voltage and current rating per relay
- Contact configuration (e.g., normally open, normally closed)
- Coil voltage for relay activation
- Operating temperature range
- Dimensions and mounting options
- Maximum input control voltage and current
- Response time and release time of relays
- Electrical isolation between control and load circuits
- Contact material for reliability and durability (e.g., silver alloy)
- Longevity rating (e.g., number of switching cycles)

***Hydroponics tank*:**

Hydroponic tanks hold and circulate water and our hydroponic nutrient solution. Hydroponic reservoirs also house water pumps and air stones or diffusers. They normally utilize a lid or cover to prevent contaminants from getting into our nutrient solution.

***Firebase (Database)*:**

Google Firebase is a Google-backed application development software that enables developers to develop iOS, Android, and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, and creating marketing and product experiment.

Advantages:

- **Real-time monitoring:** The system provides real-time monitoring of temperature and pH levels in the hydroponic system, allowing growers to quickly identify any fluctuations or deviations from the optimal range.

- **Optimal plant growth conditions:** By continuously monitoring temperature and pH, growers can ensure that the hydroponic environment remains conducive to plant growth, maximizing yield and quality.

- **Manual pH adjustment:** The ability to manually balance the pH solution allows growers to address pH imbalances promptly, ensuring the plants receive the optimal nutrient absorption and preventing nutrient deficiencies or toxicities.

- **Data-driven decision making:** The system provides growers with accurate and reliable data, enabling informed decision-making regarding adjustments to temperature, pH levels, and nutrient solutions.

- **Future automation potential:** The proposed future enhancement of automating pH balancing with peristaltic pumps offers the potential for increased efficiency and reduced manual intervention, allowing for precise and consistent pH control.

Disadvantages:

- **Manual pH adjustment:** The current implementation requires growers to manually adjust the pH solution when imbalances occur, which can be time-consuming and may introduce the possibility of human error.

- **Limited automation:** The system, as currently designed, does not automate pH balancing or other control actions beyond real-time monitoring. This may require growers to closely monitor and manually intervene in the system, which can be demanding for large-scale or busy operations.

- **Dependency on Node MCU:** The system relies on the proper functioning of the Node MCU microcontroller. Any technical issues or malfunctions with the Node MCU could impact the system's functionality and data collection.

- **Limited monitoring parameters:** The system focuses primarily on temperature and pH monitoring, excluding other crucial parameters like humidity, nutrient levels, and CO2 levels. Monitoring a broader range of parameters could provide a more comprehensive understanding of the hydroponic system's conditions.

- **Cost and complexity:** The implementation of the system, including the sensors, Node MCU, and monitoring interface, may involve costs and require technical expertise for setup and maintenance, potentially limiting accessibility for some growers.

It's important to consider these advantages and disadvantages when evaluating the suitability of the hydroponics monitoring system for specific applications and requirements.

Future Scopes:

Our Hydroponics Monitoring System using Node MCU has several potential future scopes for further development and enhancement:

- **Automation of pH balancing:** As mentioned earlier, the system's future scope involves automating the pH balancing process using peristaltic pumps. Integrating two peristaltic pumps, each containing acidic and basic solutions, would allow the system to automatically adjust the pH level without manual intervention. This would enhance the efficiency and accuracy of pH control, reducing the need for constant monitoring and manual adjustments.

- **Expansion of monitoring parameters:** The project can be expanded to include additional monitoring parameters such as humidity, nutrient levels, CO2 levels, and light intensity. This broader range of monitoring would provide a more comprehensive understanding of the hydroponic system's conditions, allowing growers to make data-driven decisions and further optimize plant growth.

- **Integration with a smart irrigation system:** The system can be integrated with a smart irrigation system to automate the watering process based on sensor readings. This would allow for precise control over nutrient delivery and water management, optimizing resource usage and plant health.

- **Mobile application integration:** Developing a dedicated mobile application for the monitoring system would provide growers with more convenient access to real-time data, notifications, and control functions. The application could offer additional features such as historical data analysis, remote control, and customizable alerts.

- **Integration with data analytics and machine learning:** By integrating the monitoring system with data analytics and machine learning algorithms, growers can gain deeper insights into the hydroponic system's performance. This can enable predictive analysis, anomaly detection, and optimization recommendations based on historical data patterns.

- **Integration with environmental control systems:** Integrating the hydroponics monitoring system with environmental control systems such as ventilation, lighting control, and CO2 injection systems would create a comprehensive automated environment management solution. This integration would further optimize plant growth conditions and increase overall system efficiency.

These future scopes can enhance the functionality, automation, and control capabilities of the hydroponics monitoring system, making it more robust, efficient, and user-friendly for growers.

Result Discussion:

The credibility of the pH sensor was evaluated by conducting several test measurements using distilled water, edible vinegar, and a baking soda solution. The purpose of these tests was to verify the accuracy and consistency of the pH sensor readings.

In the first test, distilled water was used as a neutral reference. The pH sensor measured a pH value of 7, which is expected for neutral solutions. This result indicates that the pH sensor was functioning correctly and providing accurate readings.

Date	Time	pH Value
19.05.2023	6:02:23	7
19.05.2023	6:02:25	7
19.05.2023	6:02:27	7

pH Value Test Table with Distilled Water

Next, the pH sensor was tested with edible vinegar, which is known to have an acidic pH. The pH values obtained were 2.4, 2.4, and 2.6, respectively. These readings align with the expected acidic pH range of vinegar and demonstrate the sensor's ability to accurately detect and measure acidity.

Date	Time	pH Value
19.05.2023	6:18:46	2.4
19.05.2023	6:18:48	2.4
19.05.2023	6:18:50	2.6

pH Value Test Table with Vinegar Solution

Finally, the pH sensor was tested with a baking soda solution, which is alkaline in nature. The pH values obtained were consistent at 9.3 for all three measurements. This confirms the pH sensor's capability to accurately measure alkaline pH levels.

Date	Time	pH Value
19.05.2023	6:37:11	9.3
19.05.2023	6:37:13	9.3
19.05.2023	6:37:15	9.3

pH Value Test Table with Baking Soda Solution

Based on the test results, the pH sensor demonstrated credibility and reliability in providing accurate pH measurements. The readings obtained were consistent with the known pH properties of the tested solutions, indicating that the sensor can effectively detect and quantify pH variations in different substances.

These findings instill confidence in the pH sensor's performance and validate its suitability for monitoring and controlling the pH levels in the hydroponic system, ensuring optimal conditions for plant growth.

Conclusion - Hydroponic plants produce a greater yield of fruits and vegetables because in hydroponic system plants are more densely spaced together compared to the size of land that would be needed to grow the same number of plants. Also, in a hydroponic system many of the elements that can enhance plant growth — such as the pH level of the water, nutrient content of the water, amount and type of light, etc. — can be better controlled.

These systems use less water — as much as 10 times less water — than traditional **field crop watering methods** because the water in a hydroponic system is captured and reused, rather than allowed to run off and drain to the environment.

Indoor hydroponic systems allow plants to grow almost anywhere all year round.

In this era of **land scarcity** Hydroponic systems come in a variety of designs including vertical stacking systems that take up a small amount of space. These systems can be a remedy for deforestation and a very good option for food production.

In our project, we are trying to implement the idea of maintaining the environment of such a hydroponic system using IoT, so this system can come in handy to a normal person.

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Budget

Component	Market Price
Relay	40
DHT11	50
pH Sensor	1600
Peristaltic Pump	950
Node MCU	250
Jumpers	100
Bread Board	150
Total	**3140**