

# **AUTOMATIC MONITORING SYSTEM FOR HYDROPONICS**

## **A Project Report Phase – II**

Submitted in partial fulfillment of the requirements for the award of  
Bachelor of Engineering degree in Electronics and Communication Engineering

by

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**  
**SCHOOL OF ELECTRICAL AND ELECTRONICS**

# **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC**

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**APRIL - 2023**





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## **BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of PRADHEEPA P (39130353) and RENUGA S (39130371) who carried out the project entitled "AUTOMATIC MONITORING SYSTEM FOR HYDROPONICS" under our supervision from November 2022 to April 2023.

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19.04.2023

Submitted for Viva voce Examination held on

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## DECLARATION

We Pradheepa.P (39130353) and Renuga.S (39130371) hereby declare that the Project Report entitled “**Automatic Monitoring system for Hydroponics**” done by us under the guidance of Dr. P. Kavipriya., M.E, Ph.D., Associate professor, Dept. of Electronics and Communication Engineering, SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

**DATE:** 19.04.2023

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**SIGNATURES OF THE CANDIDATE**

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## **ABSTRACT**

Hydroponics is the cultivation of plants without using soil. Hydroponic systems work by allowing minute control over environmental conditions like temperature and pH balance and maximized exposure to nutrients and water. We developed a sensor based automatic control mobile application for hydroponics to managing and controlling hydroponics gardening. First part of this application allows users to plan the growing area and define area requirements and supports users to create a year plan for their gardening. The application enables automatic environmental control for hydroponics via different types of sensors like water temperature sensor, temperature and humidity sensor, and light intensity sensor.

Hydroponics can be adapted to many situations from outdoor farming to greenhouse and now in-home gardening. The main objective of hydroponics is to supply the ideal nutritional environment for optimum plant performance. Plant performance may be further optimized by controlling the climate and lighting. Advances in technology in lighting, nutrient delivery, and environmental control, will further improve plant productivity and performance. Since hydroponic systems reduce water and nutrient stress to the plants, they grow faster and can be grown closer together without starving each other. Healthier plants also produce higher yields.

The main function of this application is planning, managing, as well as harvest data recording, of hydroponic gardening to fulfill the planting demands. Using this project users can monitor the plant growing progress remotely. Finally, Harvest data will be used for hydroponics planning in the next growth.

## TABLE OF CONTENTS

| Chapter No. | TITLE                                | Page No. |
|-------------|--------------------------------------|----------|
|             | <b>ABSTRACT</b>                      | V        |
|             | <b>LIST OF FIGURES</b>               | Viii     |
|             | <b>LIST OF TABLES</b>                | Xi       |
|             | <b>LIST OF ABBREVIATIONS</b>         | X        |
| <b>1</b>    | <b>INTRODUCTION</b>                  |          |
|             | 1.1 Hydroponics                      | 1        |
|             | 1.2 Internet of Things               | 3        |
|             | 1.3 Problem Statement                | 4        |
|             | 1.4 Objective                        | 5        |
| <b>2</b>    | <b>LITERATURE SURVEY</b>             |          |
|             | 2.1 Literature Survey                | 6        |
|             | 2.2 Problems in Existing System      | 10       |
| <b>3</b>    | <b>HARDWARE DESCRIPTION</b>          |          |
|             | 3.1 Existing system                  | 11       |
|             | 3.2 Proposed system                  | 13       |
|             | 3.3 Block Diagram of Proposed System | 16       |
|             | 3.4 Hydroponics systems Installation | 18       |
|             | 3.5 Components Required              | 23       |

|          |                                         |    |
|----------|-----------------------------------------|----|
| <b>4</b> | <b>METHODOLOGY</b>                      |    |
|          | 4.1 Working Methodology                 | 31 |
|          | 4.2 Software Required                   | 36 |
|          | 4.3 Advantages of Proposed System       | 39 |
| <b>5</b> | <b>RESULTS AND DISCUSSION</b>           |    |
|          | 5.1 Results                             | 40 |
|          | 5.2 Hardware Connection                 | 43 |
|          | 5.3 Data visualization using Thingspeak | 45 |
| <b>6</b> | <b>CONCLUSION AND FUTURE WORK</b>       |    |
|          | 6.1 Conclusion                          | 47 |
|          | 6.2 Future work                         | 47 |
|          | <b>REFERENCES</b>                       | 48 |
|          | <b>APPENDIX</b>                         |    |
|          | <b>SOURCE CODE</b>                      | 51 |

## LIST OF FIGURES

| FIGURE NO | TITLE                                         | PAGE NO |
|-----------|-----------------------------------------------|---------|
| 1.1       | Hydroponics                                   | 1       |
| 3.1.      | Existing Hydroponics monitoring system        | 10      |
| 3.2       | Internet of things technology process         | 16      |
| 3.3       | Block diagram of proposed system              | 15      |
| 3.4       | Hydroponics initial setup                     | 17      |
| 3.5       | Nutrients                                     | 20      |
| 3.6       | Wifi Module                                   | 22      |
| 3.7       | TDS Sensor                                    | 24      |
| 3.8       | Temperature sensor                            | 27      |
| 3.9       | OLED Display                                  | 30      |
| 4.1       | NFT Method of Hydroponics                     | 30      |
| 5.1       | Type of decoration plant on Hydroponic System | 40      |
| 5.2       | Tomato plant growth with water                | 41      |
| 5.3       | Hardware connection                           | 41      |
| 5.4       | Plant parameters on OLED Display              | 42      |
| 5.5       | TDS visualization                             | 43      |
| 5.6       | Temperature visualization                     | 44      |
| 5.7       | Ph value output                               | 45      |
| 5.8       | Motor state                                   | 45      |

## LIST OF TABLES

| TABLE NO | TITLE                              | PAGE NO |
|----------|------------------------------------|---------|
| 3.1      | Ph and Tds value for plants        | 22      |
| 4.1      | Readings about the plant condition | 36      |

## LIST OF ABBREVIATIONS

|      |   |                                    |
|------|---|------------------------------------|
| IOT  | - | Internet of things                 |
| MQTT | - | Message Query Telemetry Transport  |
| NFT  | - | Nutrient Film Technique            |
| DWT  | - | Deep Water Technique               |
| API  | - | Application Programming Interface  |
| PPM  | - | Parts Per Million                  |
| OLED | - | Organic Light Emitting Diode       |
| TDS  | - | Total Dissolved solids             |
| GPIO | - | General Input and Output Pins      |
| SPI  | - | Serial Peripheral Interface        |
| IDE  | - | Integrated Development Environment |
| SOC  | - | System on Chip                     |
| LED  | - | Light Emitting Diode               |

# CHAPTER 1

## INTRODUCTION

### 1.1 HYDROPONICS

Hydroponics is the science of growing healthy plants in a medium, other than soil, using mixtures of the essential plant nutrient elements, dissolved in water, as plant food. Utilizing this technology, the roots absorb a balanced nutrient solution dissolved in water that meets all the plants developmental requirements.



***Fig:1.1 Hydroponics System***

Hydroponics farming becomes more intelligent and seen to be the future of agriculture. Farms with an automated system, produces higher quality of crops by sensing its controlling parameters. This project presents an automated system for farming of hydroponic style. Objective is to atomize the crop monitoring during growth process using the network of sensors and actuators. This network helps in monitoring and control of various physical events at farms such as water level, pH, electrical conductivity, water temperature, and relative humidity. These physical events are controlled by providing decisions through messaging system. From the experimental results, it is observed that, the proposed system shows minimum fluctuations in sensor values which helps in automatic control. This work mainly gathers data about ecological elements from remote sensors and using remote conventions send it to the database. A system results in appropriate decisions about various nutrient values and inform to the farmer through

messaging system. A prototype is developed which results in sending accurate decisions to the end-users.

The extreme outside weather could cause some disease for plants. Very few species of plants thrive in such situations and are often not used as a food source. In this project, we created a system that can grow common plants and vegetables and can operate without depending on the outside climate. We achieved this by using a technique called Hydroponics. Hydroponics is a method of growing plants without using soil.

Agriculture is the cornerstone of human civilization and is responsible for the production of quality food for the human population. To ensure the availability of inexpensive and quality products to meet the increasing food demand, intensification of the growing practices is necessary. By definition, hydroponics is subset of hydro culture, the method of growing plants without the use of soil, using mineral nutrient solutions in a water solvent.

Hydroponics or soilless cultivation has been widely used in different countries because of its feasibility and environmental safety. This technique can be considered as the best alternative in areas where serious soil and water problems like soil born pests and diseases, soil and water salinity, chemical residues in soil and water, shortage of water etc. exist. In hydroponics, plants are grown by directly supplying optimum amount of nutrients in water. Composition of nutrient solution, electrical conductivity, pH and oxygen concentration have direct influence on the yield and quality of crops grown under hydroponics. If any of these factors are non-optimal, crops expresses stress symptoms.

To apply the benefit usages of mobile devices and application in the digital age, we aim to design and develop a hydroponic smart farming system using the IFD, and to evaluate the effectiveness of the hydroponic farming system. Nowadays, the health care has become more important concerns about organic foods. The consumer demand for organics is likely to increase while supplies may decrease due to unpredictable circumstances such as flood, drought, and disease.

The proposed system here is an automated smart hydroponics system, whereby this system will be able to add and implement Internet of Things concept and functionality to the current existing hydroponics system.

Moreover, with the use of Internet of things the system can be monitored and controlled from anywhere via the internet, therefore parameters such as water, pH level, room temperature, nutrient rich water-based solution temperature and room humidity parameters can be viewed in real time. One of the key features of this system is the ability to make decision and send command from a friendly user interface based on the shown real time parameters.

## **1.2 INTERNET OF THINGS**

To monitor and control the Hydroponics system Internet of things technology is used. The internet of things (IoT) is a set of technologies that uses sensors and actuators to inform us about the status of everyday items such as vehicles, tools and even living beings. It allows us to interact with them, enabling connectivity with platforms in the cloud that receive and process information for posterior analysis. This analyzed data is then used to make decisions.

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another.

The devices do most of the work without human intervention, although people can interact with the devices for instance, to set them up, give them instructions or access the data. The Internet of Things (IOT) is a method for connecting and controlling any device online. An IOT platform connects things and gadgets with built-in sensors, integrating all the valuable data from various gadgets and utilising analytics to share the most crucial data with specific applications. Important decisions, recommendations, and the early detection of patterns and potential issues can all be made using this information.

### **1.3 PROBLEM STATEMENT**

Nowadays, people's interest in how their food is produced has increased greatly. More consumers want safe food that's been produced with sustainable, mindful growing practices and is free from pesticide residues. As a result, more consumers are choosing to grow their own food and many are exploring hydroponics for doing so. Instead of pulling mineral nutrients needed for growth from the ground, plants get all of their nutrition through a nutrient solution supplied to their roots.

But hydroponics system requires constant monitoring and maintenance. hydroponically grown plants are grown in water instead of soil, waterborne diseases are considerably higher. With the water circulating continuously through the system, infections can spread quickly throughout the growing system as a whole, affecting the whole collection of plants. In extreme cases, a waterborne disease can kill all the plants in a hydroponics system within hours.

So, This automation system is helpful to monitor the hydroponics plants and it is used to detect the Problems affected in the plants quickly by analyzing all conditions of the plants using various sensors.

### **1.4 OBJECTIVE**

Vegetables available in urban India are usually highly contaminated with pesticides wrecking our health and the cultivating land instead. Organic Farming as an alternative is not very feasible due to its exorbitant prices. Hydroponics along with our designed system offers a new way of cultivation which promotes all aspects of sustainable agriculture thereby providing an alternative to organic farming.

A hydroponic system was designed in this project which ensures higher growth rate with controlled environment. The main function of our hydroponic system is to monitor and to control parameters with the help of actuators present in the system to produce plants and exotic vegetables at a faster rate and by revoking the necessity of the arduous activities generally associated with farming.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 LITERATURE SURVEY

Many people done projects on Hydroponics using different ways. Here we have collected some references and we came up with a project which monitor Hydroponics system using WIFI module and sensor with IOT technology. Here we listed some of the references related to Hydroponics system.

##### **Vaibhav Palande, Adam Zaheer, and Kiran George (2018) –**

In this research the process goes as follows: create a nutrient solution based on the plant being grown, apply this solution to a bed of water, place a germinated plant into the water such that the exposed roots are touching the solution. If the parameters are maintained within optimum levels, the plant should grow faster and healthier than its natural growth.

The system uses two Arduinos which are programmed using Arduino IDE software to operate the sensor . A Raspberry Pi is used to run an open source automation software called Domoticz. Once the Raspberry Pi receives the input data, it updates the server. The system also uses a mobile app to enable monitoring and control from iOS or Android devices . Because the system is relatively small (smaller than a mini refrigerator), it can fit into a small office space or a nook in the home.

The complete automation and size are different from other hydroponic systems. Part of the analysis for this project was through the comparison of a plant within the system and a plant outside the system.

The status of both plants was monitored over the period of four weeks. Pictures were taken 3 times per week to show the difference in growth. Firebase is designed to be API and Cloud Storage for real time Application and it supports multiple platforms, including IOS App, Android App, and Web App.

## **Kunyanuth Kularbphettong, Udomlux Ampant, and Nutthaphol Kongrodj ( 2019)**

In this paper, Arduino WeMos D1 is used to connect sensor device, WIFI and database .Developers can code a program to connect electronic devices USB cable, websites, and run an application over the Internet. Relay Module is the electrical switch of mains voltage to turn on or off or let the current go through or not and it is used to connect with Arduino board .Ultrasonic Sensor Module used to detect the height of water and to determine the flow of nutrition.

Automation will be done by using Arduino and WIFI module , and MQTT client server architecture is used to transmit the data. this can be easily achieved by integrating the hydroponic system with the IoT. Cloud database acts as the hub for the whole automation process, this database contains all the information on the hydroponic system that is it has the information on the data that has been retrieved from the crops and the water tank.

Sensors and actuators are used in order to automate the hydroponic system, these sensor values are sent to the cloud database from which the user is updated with the real time information about crops condition. The user can also adjust the configuration of the sensors and actuators from the developed mobile application. Edge Computing is a new trend that it may be replacing the traditional cloud architecture and, unlike traditional cloud infrastructures, edge computing pushes the burden of processing data to peripheral devices in the network. This reduces the amount of information required to be sent from Edge to the cloud.

MQTT protocol is suitable to be used with a sensor device that has a small processor on a remote network with low power consumption and very limited bandwidth. MQTT is a Client-Server architecture with hub-and-spoke topology and the destination sensor acts as a client that creates a TCP connection to a server called Broker, which is responsible for transmitting data between messages that are both Publisher and Subscriber The system can check and refill the nutrient by self-regulating and displays the graphic user interface to easy manage and control it. However, the system is divided

into two parts: the automatic part, the manual part, which allows the user to control the measurement of light, temperature and humidity

### **Chanya Peuchpanagarm, Pantita Srinitiworawong, Wannisa Samejai-**

Mobile application 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. Automation will be done by using Arduino , Raspberry pi and MQTT client server architecture is used to transmit the data.

The mobile application has all the specification about the hydroponic system, the user must have a unique login ID. The user name and the password are registered with the cloud database, by this the user can operate with his crop field without any interruptions. Through this mobile application the user can select which seed are to be planted in the crop bed, the water flow can also be controlled with the help of this mobile application. The user can control the flow of water from one tank to other tank with water level sensors and solenoids.

### **Ravi Lakshmanan, Mohamed Djama, Sathish Kumar Selvaperumal, Raed Abdulla(2020) -**

A system that transfers the data using ZigBee from sensor node has been proposed, thus a raspberry pi connected with ZigBee module receives the data from the sensor node and passes it to the PC node whereby data is received and processed. This work uses four type of sensors to detect rainfall, temperature, moisture and light then sends to Thingspeak which is a paid cloud that receives data via MQTT protocol.

Commonly most of the researchers have proposed systems that utilizes ZigBee as communication medium and without any cloud infrastructure to analyze and process data and control actuators in real time . Researchers implemented hydroponics using electronic circuit, nutrients and water to be automatically monitored which led to higher productivity. NodeRed is a visual tool for wiring the Internet of Things

NodeRed visual tool is used for wiring the Internet of Things, It is a tool for wiring together hardware devices, APIs and online services in new and interesting ways. Hence after deploying the NodeRed server, authenticating is done to secure the access to the server and password is encrypted to ensure the maximum amount of security

**Aatif Hussain, Kaiser Iqbal, Showket Aziem, Prasanto Mahato, A.K. Negi**

**Grow Media Perlite** The most common types of media used in containerized systems of soilless culture are perlite (Boodley & Sheldrake, 1977). Perlite granules are very light and originate from a silicone mineral that forms in volcanoes. This medium is available from merchants in small to large bags for addition to growing mediums to increase drainage and aeration in the soil. **Coconut Coir** It is known by various trade names like Ultrapeat, Cocopeat and Coco-tek. It combines the water retention of vermiculite with the air retention of perlite. It is a completely organic medium made from shredded coconut husks. The coconut husk serves its seed two purposes: 2. Protection from sun and salt while floating in the ocean; 3. A hormone-rich and fungus free medium to speed germination and rooting upon landfall. Finely shredded and steam sterilized, coconut coir offers plants an ideal rooting medium that also offers protection against root diseases and fungus. And unlike peat moss, which is rapidly becoming depleted from overuse, coir is a completely renewable resource. **Vermiculite** This compound contains both potassium and magnesium. It holds a lot of water and aids in drainage and aeration of the soil, though it is less durable than some other mediums, such as sand and perlite. **Peat Moss** Peat moss retains moisture in growing mediums. Many brands of prepackaged potting soil include peat moss for use in container plants that require excess moisture. Tropical plants require extra moisture and warmth to grow and flourish.

## **2.2 PROBLEMS IN EXISTING SYSTEM:**

Both passive and active hydroponics systems depend on electricity to power the different components such as grow lights, water pumps, fans, etc. Therefore, a power

outage will affect the entire system. In active systems, a loss of power can be detrimental to plants if it goes unnoticed by the grower.

Zigbee technology has a lot of security threats. Since it is prone to interferences, intentional interferences can cause loss of services provided by the network, theft of data from a node, theft of an entire node. The hacker can also get access to a node and even control it in an unauthorized process. It also has compatibility issues. Since it is constantly competing with other technologies that are wireless communications, such as Bluetooth and Wi-Fi, users' choices get limited.

Implementation of a Zigbee technology can be expensive. There are various reasons for it. The size of the network and the range of the network affect the cost of implementation of Zigbee. The price is also affected by the availability of compatible products and devices.

In this paper, Raspberry Pi was used to develop hydroponics system. Raspberry Pi is not compatible with the other operating systems such as Windows. It is a time consuming to download and install software So, unable to do any complex multitasking.

## CHAPTER 3

### HARDWARE DESCRIPTION

#### 3.1 EXISTING SYSTEM

Monitoring of water level, pH, temperature, flow and light intensity can be regulated in hydroponic system autonomously using Raspberry pi and programming language like Python, HTML, CSS, Javascript and MQTT protocol. Cost of this system was very high.

The smart greenhouse is connected to an android application through the Ubidots clouds hosting a web server. The sensor information is provided to the user so that the plants can be monitored from anywhere. This is done through a button showing the live readings of the plants and through graphs plotting the values for the past week or so. This means that a user will be able to see if something has gone wrong with the system. o the bloom cycle Currently the android application is an HTML webpage, that if connected to the proper internet connection could be available anywhere.



***Fig: 3.1 Existing Hydroponics monitoring system***

The system uses two Arduino microcontrollers acting as nodes. Nodes take the data from the sensors and send the data to a third Arduino acting as a gateway in the IoT network. NRF24L01+ radios are used for the communication between the nodes and a gateway. The gateway is connected to the Raspberry Pi running a local server which makes the data available on the web interface and mobile application. The LED's provide

light to the growing plant. The lights are set to a 14 hour ON cycle to simulate daytime. A RealTime Clock (RTC) is used to keep track of the time. The lights, along with a small exhaust fan, are controlled using a relay module. The camera mounted on the system can be accessed remotely through the Domoticz app as well as the web interface to monitor the state of the plant. The state of the system is monitored by using various sensors. An air pump is used to infuse the water with oxygen for the plant to absorb through its roots. The system contains four sensors: an electrical conductivity probe, a pH sensor, a water temperature sensor, and an air temperature/humidity sensor. The electrical conductivity probe allows us to estimate an amount of salts or nutrients in the water

The system includes 4 sections to control and manage the automatic hydroponics application. Arduino boards are used to control the various functions of the system, including temperature and humidity sensors, light sensors, the pH sensor, and the water level sensor. The proposed system covers the process from sending data measured sensor devices, receiving data from an intermediary data storage and sending data to the host computer. Then, the system will analyze the sent value and relay module acts as a switch to turn on-turn off the related module.

In this project , to evaluate and test the proposed project used, all devices that are based on the standard Message Queuing Telemetry Transport (MQTT) and each device sent the data into the system, including the receiving data (subscribe). we compared the three parts including: the light value, the quality of the product and the level of water and when compared with the light value, vegetables grown in the control system with orange light (20000-40000 lux) are better growing than the vegetables grown with regular approach. Also, the result was shown that the amount plant grown in greenhouse with harvest was 35% and the growth plants were 15%. Germination from seed was rate at 20% and the seeds do not grow at 65%. While the sampling of seeds was grown in normal conditions, the number of plants grown was at 18% and the growth plants were 10%. Germination from seed was rate at 25% and the seeds do not grow at 67%.

## **3.2 PROPOSED SYSTEM**

### **3.2.1 AIM:**

Nowadays, agriculture has become more and more effective in sustainable development. Hydroponics system is a growing plant system that does not use soil but uses water with nutrients to save space planting and not contaminated with chemicals in the soil. Hydroponics has a number of innovative techniques and it is not limited to plant with water culture like nutrient film technique, deep flow technique, dynamic root floating technique and etc. The purposes of the research are to design and develop the automation controlling and monitoring plant growth hydroponics system and evaluate the effect of using this prototype. This system is able to control significant environmental factors that affect plant growth including temperature, humidity, and water.

The automated hydroponics system based on mobile application and IOT was developed to facilitate the cultivation and the system can adjust and control important environmental factors that affect plant growth including temperature, humidity, and water.

### **3.2.2 HYDROPONICS TECHNIQUES**

It can be classified into

i) Circulating methods (closed system)/ Continuous flow solution culture

a) Nutrient film technique (NFT)

b) Deep flow technique (DFT)

Flowing solution culture systems can provide a consistent nutrient environment for roots. They are highly amenable to automatic control but are subject to rapid plant desiccation if the flow of solution stops for any reason. Thus frequent attention is required.

ii) Non-circulating method (open systems)/ Static solution culture

a) Root dipping technique

b) Floating technique

c) Capillary action technique

In this project Nutrient Film Technique is used to grow plant in the water.

### **3.2.3 NFT- NUTRIENTS FILM TECHNIQUE**

There are several types of hydroponics today, but the most popular is NFT hydroponics, which has roots directly immersed in a nutrient solution by nutrient solution that flows through piping as a 1–3 mm thin film. The slurry flows continuously and is pumped with circulation back to the storage tank. NFT Hydroponics shows the flow of the water acquisition system from the water storage to transport the nutrient-rich water to the plants grown in layers 1 and 2, and after that water will flow back to the reservoir again. This method can save water for the farmers.

The advantage of NFT hydroponics is that there is no need to control the irrigation as due to the constant supply of water. By to the continuous water supply, this approach prevents and eliminates various plant pathogens. In addition, hydroponic crops are also there is empowering agriculture with automated technology and decision making to improve productivity with quality, and high yield [20]. Many related factors affecting the growth of plants are being studied: temperature, humidity, light, pH, and electrical conductivity. This is done by adopting Artificial Intelligence to help in the analysis and control of plant growth factors. In general, controlling the environmental factors temperature, humidity, and light is sufficient for good growth. However, it has been found that other essential plant growth factors include pH and electrical conductivity. The former should be 5.5–6.5 while electrical conductivity should be 1.8–4.8

### **3.2.4 ADVANTAGES OF HYDROPONICS**

Plants can be grown almost anywhere: Hydroponic plants can be grown without soil and where little light is available, and can be grown with little space. This is particularly useful in an urban environment where space cost is at a premium. Better control over

plant growth: The operator of the hydroponic system can control nutrient delivery and water delivery to the plants, and can grow plants using a wider variety of methods of nutrient and water versus conventional soil based planting. Eliminate some tasks of soil based systems: Hydroponic plants do not require pulling of weeds, fumigation, aeration of soil or application of pesticides like conventional planting does. Conserve water and nutrients: Hydroponic systems can function in a closed loop, allowing for the recycling of water and nutrients.

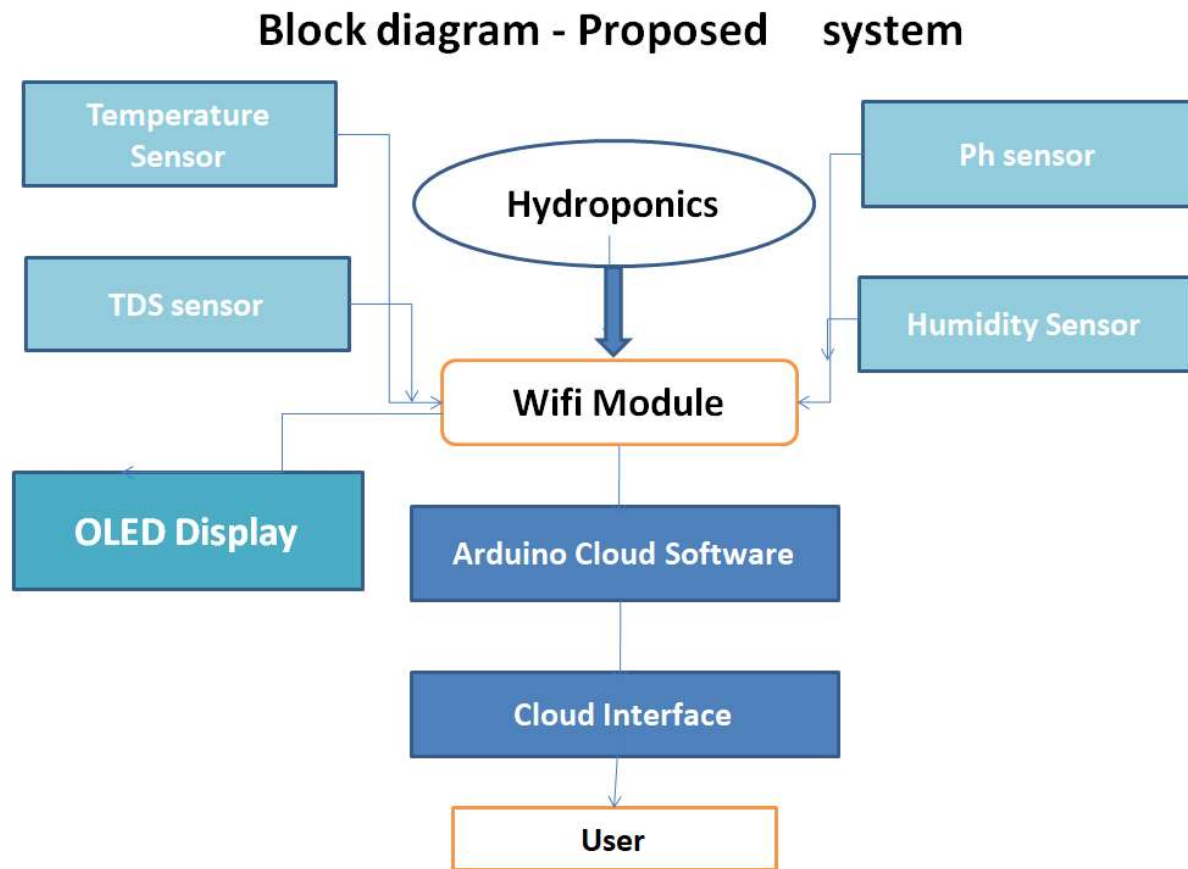
This also reduces the carbon footprint of operations. “Transplanting Shock” is less than in soil systems: Hydroponic seedlings can be grown in a variety of propagation medium that can easily be transplanted into the hydroponic system, as opposed to being removed from the soil media. This also reduces propagation time over soil based growing. Provide the highest yield per area: Hydroponic systems can grow plants all year, and can go vertical. Hydroponics can provide considerably more yields annually than soil based planting.

### **3.3 BLOCK DIAGRAM OF PROPOSED SYSTEM**

In this Project NFT technique of Hydroponics will be followed. NFT is the most popular technique in the world. In NFT method required amount of Nutrients are taken based on the type of plant. These Nutrients contains Nitrogen (N), phosphorus (P), potassium (K) and Calcium. Roots of the plants are submerged in a nutrient that flows through piping as a 2-3 mm thin film. The slurry circulates in a circle while being continuously pumped back to the storage tank. NFT Hydroponics demonstrates how the water acquisition system moves water from the water storage to the plants grown in layers 1 and 2, then flows water back to the reservoir. This method can help farmers conserve water.

Temperature sensor, Ph sensor, Humidity sensor, Light intensity sensor are connected with hydroponics plant. WIFI module is interfaced with these sensor, It continuously monitor the Hydroponics plant using Arduino cloud software. Then the user will get the all details and condition of plant through notification given by this system. Part

of the analysis for this project was through the comparison of a plant within the system and a plant outside the system

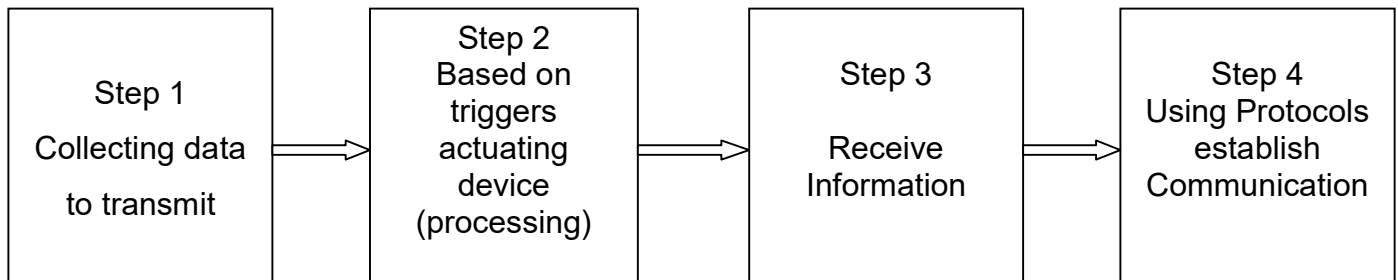


**Fig: 3.2 Block diagram of Proposed system**

Wifi module contain GPIO pins using that all sensors and OLED display are connected. TDS -(Total dissolved solution) is used to measure the nutrients level of the plant . Hydroponics plant will grow only when required amount of nutrients are given so, very essential to determine the nutrients level applied in the water. Wifi module collects all the data from the sensor. These datas are sent to cloud platform like thinkspeak using Wifi module password and ID. using API key and MQTT protocol. All the parameters like Temperature, Humidity, Water Temperature, TDS value, Ph value , Motor state are displayed on the OLED module and it could be stored and visualized Thinkspeak software. Finally user can able to protect their plant based on the data observed in the software and OLED display.

### 3.3.1 WORKING WITH IOT DEVICES

The Internet of Things (IoT) is a method for connecting and controlling any device online. An IoT platform connects things and gadgets with built-in sensors, integrating all the valuable data from various gadgets and utilising analytics to share the most crucial data with specific applications. Important decisions, recommendations, and the early detection of patterns and potential issues can all be made using this information.



***Fig:3.3 Internet of things technology process***

Sensors are frequently employed to acquire data from devices and are utilised in a variety of application areas. If a specific need is met after the trigger is activated, the device has to be actuated. Information obtained from the system is processed and used for analysis. In order to link two or more networking devices, protocols are employed. MQTT, FTP, HTTP, Zigbee, and Constrained Application Protocol are a few examples of communication protocols.

### 3.4 HYDROPONICS SYSTEMS INSTALLATION:

**NFT:** Nutrient Film Technique is highly suited to grow leafy green plants. Rise Hydroponics installs NFT Systems to raise these crops: (Lettuce, Broccoli, Basil, Spinach, Oregano, Bok Choy, etc.)

**Dutch Bucket:** Dutch Bucket System is mostly used for raising large, vining crops, like: (Tomatoes, Cucumber, Pepper, Beans, etc.)

**Grow Bags:** Grow Bags is a pretty good option to grow crops that don't have deep roots. Moreover, Grow Bags have breathable fabric along with the soil medium that prevents over watering. The Crops Grown using Grow Bags are: (Carrots, Potatoes, Coriander, Beetroot, Brinjal, Zucchini, Salad Greens, etc.)

**Tower Setup:** Tower Setup is the best option when we want to grow crops in Vertical Indoor Hydroponics Farming. Rise Hydroponics has a remarkable experience in installing tower setups for growing these crops: (Basil, Cilantro, Kale, Mint, Herbs, Strawberry, Cabbages ( Green & Red), Swiss Chards, etc.)



***Fig:3.4 Hydroponics initial setup***

### **3.4.1 NUTRIENTS**

Nutrients are one of the basics of any hydroponic system. For a fertilizer to be incorporated into a hydroponic system it must be soluble in water. If not, the plant cannot access it. With Hydroponics, the grower has complete control over the implementation of fertilizer, regarding type and concentration. They also can immediately monitor and maintain a relative consistency, provided a nutrient meter is available. The composition of the nutrients is important and there are over twenty elements that are needed for a plant to grow. Carbon, hydrogen and oxygen are absorbed from the air and water.

The rest of the elements, called mineral nutrients, are dissolved in the nutrient solution and need to be in the correct ratios. Any good Hydroponic nutrient should contain these elements. Nitrogen (N), Potassium (K), Phosphorous (P), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Molybdenum (Mo), Boron (B), Chlorine (Cl). For the most part, this is taken care of with any pre-formulated commercial hydroponic nutrients. Often, these pre-made nutrients come in 1, 2, 3, or even more “parts” so the grower can change the ratio of the 5 mineral elements to allow for either vegetative or fruiting and flowering growth, or for different crops. It is best for the beginner to just follow the general directions before experimenting with changing the ratios. Hydrogen ion concentration (pH) - The pH scale is a way to measure the Acid or Basic (alkaline) in nutrient solution.

The official definition of pH is: a unit of measure that describes the degree of acidity or alkalinity of a liquid solution. It is measured on a scale of 0 to 14. Acids are in a range from 0 to 7, with lower numbers being a stronger acid. Alkaline is in the range from 7 to 14, with the higher numbers being a stronger base. The pH of the nutrient solution is essential to the plants health because it will affect how well each element can pass through the root cell wall and nourish the plant. When the pH of the nutrient solution is out of balance, the plants are not able uptake the nutrients in the water, basically starving them, even when there is plenty of food. The pH requirements for plants are not the same for all plants and you should not grow plants with different pH requirements in the same nutrient solution.

### **3.4.2 IMPORTANCE OF NUTRIENTS ON HYDROPONICS**

Plants cannot properly function without 17 essential nutrients. These nutrients are needed so that processes critical to plant growth and development can occur. For example, magnesium is a critical component of chlorophyll. Chlorophyll is a pigment used to capture energy from light that is needed in photosynthesis. It also reflects green wavelengths and is the reason most plants are green. Magnesium is the center of the chlorophyll molecule. Table 1 lists the plant roles of essential nutrients.

Essential nutrients can be broadly categorized as macronutrients and micronutrients. Macronutrients and micronutrients are both essential for plant growth and development. Macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium. Micronutrients include iron, manganese, zinc, boron, molybdenum, chlorine, copper, and nickel. The difference between macro- and micronutrients is the amount required by plants. Macronutrients are required in higher amounts than micronutrients. Table 1 shows the approximate plant content of essential nutrients. Plants get carbon, hydrogen, and oxygen from air and water. The rest of the nutrients are from soil or in the case of hydroponics from nutrient solutions or aggregate media

### **REQUIRED NUTRIENTS FOR TOMATO PLANTS**

- Boron
- Chlorine
- Copper
- Iron, Manganese
- Molybdenum
- Zinc
- Nitrogen
- Phosphorus
- Potassium



***Fig: 3.5 Nutrients***

### **3.4.3 IMPORTANCE OF MAINTAINING HYDROGEN ION CONCENTRATION**

The pH value determines the nutrients absorbability of plants from given solution. Electrical conductivity determines the nutrient concentration in water. The pH value of each type crops varies. The effects of different pH value affect the root and stem of the plant.

The right pH level is crucial because it affects nutrient availability for your growing plants. A pH level that is too high or alkaline can prevent nutrient uptake and lead to deficiencies. Iron deficiency causes pale or yellow leaves in young plants, while leaf cupping and tip burn are telltale signs of calcium deficiency. Calcium can also form salts that leave white deposits or scale on reservoir walls and equipment.

Hydroponically grown plants need different pH levels than plants grown in soil. Without soil, plants do not benefit from microorganisms, organic matter, and interactions between water and minerals that regulate pH levels. The hydroponic gardener must constantly monitor and adjust pH levels. Make sure that you do not apply pH recommendations for soil-grown plants to hydroponically grown plants.

A pH test shows whether a substance is acidic or alkaline. The pH scale ranges from 0 to 14, with 0 being the most acidic, 14 the most alkaline, and 7 is the pH-neutral point.

Some plants prefer acidic conditions while others require an alkaline environment. There are many methods available for testing and adjusting pH levels in hydroponic systems.

**Table 3.1 – Plant response for pH ranges**

| pH Range   | Plant Response                                                 |
|------------|----------------------------------------------------------------|
| pH<3       | Roots membrane will get damaged                                |
| 3<pH<5     | Roots will be infected by fungaldiseases                       |
| 5.2<pH<5.5 | Solubility of phosphoric acid, calcium and magnesium will drop |
| 5.5<pH<6.5 | Optimal range                                                  |
| 6.5<pH<7.5 | Nutrient intake is reduced                                     |
| 7.5<Ph     | Iron, manganese, copper, zinc and boron are less available     |

#### **3.4.4 BENEFITS OF GROWING TOMATOES HYDROPONICALLY :**

In this project we choosed tomato plant to grow using Hydroponics system

There are many benefits to growing hydroponic tomatoes.

- One of the most significant advantages is controlling the entire growing process from start to finish.
- Don't need to worry about the climate you are living in. All you need is a space that has enough light and can be temperature-controlled, and access to nutrient-rich water!
- By growing tomatoes hydroponically, we can ensure that they are free of pesticides and other harmful chemicals.

- Additionally, hydroponic tomatoes tend to have a higher nutrient content than those grown in soil. This is because the plant's roots are directly exposed to nutrient-rich water, which allows them to absorb more minerals and vitamins.
- Another great benefit is the increased yield. Hydroponic tomatoes can produce up to 30% to 50% more fruit than their soil-grown counterparts!
- Hydroponic tomatoes have a longer shelf life.

## 3.5 COMPONENTS REQUIRED

### 3.5.1 WIFI MODULE

- The ESP32 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP32 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.



***Fig: 3.6 WIFI module***

- The ESP32 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP32 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

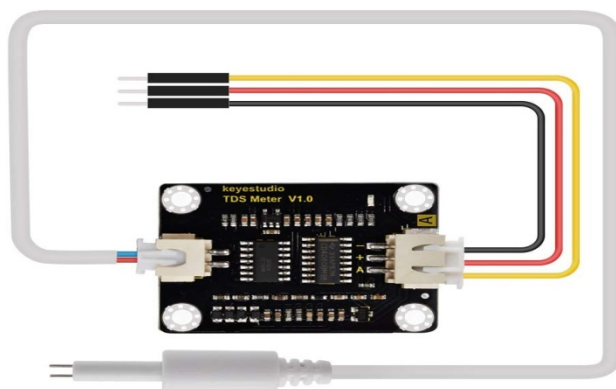
- Each ESP32 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP32 module is an extremely cost effective board with a huge, and ever growing, community.
- This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime.
- Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area.
- The ESP32 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

### **3.5.2 TDS SENSOR**

TDS meters do not measure contaminants in drinking water but can be useful for other insights. A TDS meter is generally easy to use and relatively affordable with some starting as low as \$10. However, check for the presence of contaminants in water. TDS - Total Dissolved Solids. TDS in water refers to the amount of total dissolved solids in tap water.

After water falls to the ground as rain, it dissolves the minerals present in the rocks and soil it passes over or through. As it dissolves these minerals, they remain in the water at varying levels of concentration. This is a very natural process and it helps make water taste “right” by slightly raising the pH of the water. The most common minerals found in water are calcium, magnesium, and sodium.

Some areas of the country have higher levels of these dissolved minerals in their water making it “hard” and other areas have lower levels. According to the Water Quality Association, water in the 120 mg/L (or ppm) and above range is considered hard, with 180 mg/L being considered very hard. Water in the 80 to 100 mg/L range is ideal, meaning it’s not too hard and has the right amount of dissolved minerals for optimal taste. As the TDS level goes below 17 mg/L, (as the minerals are removed) it becomes “soft”, with a lower pH and more acidity.



***Fig: 3.7 TDS sensor***

In addition to inorganic materials like minerals, TDS also features a small amount of organic material from sources such as leaves, sewage, and waste as well. Keep in mind a water filter is not a water conditioner. The ultimate goal of a water filter is not to remove all solids in the water. A TDS meter is a small hand-held device used to indicate the Total Dissolved Solids in a solution, usually water. Since dissolved ionized solids, such as salts and minerals, increase the conductivity of a solution, a TDS meter measures the conductivity of the solution and estimates the TDS from that reading.

TDS meters may be referred to as TDS testers or PPM (parts per million) testers, but all of these are different names for the same thing. TDS meters can be purchased for as low as \$10, but more advanced models can cost \$1,000+ based on the level of accuracy and additional features offered. For example, a basic TDS meter may only

measure the amount of total dissolved solids in a solution while an advanced model may be able to check salinity, temperature, and more.

### **3.5.3 REASON FOR TDS MEASUREMENT**

A high TDS level means you have an abundance of dissolved solids in your water, which typically includes minerals. Over time, the constant presence of these minerals in your water can lead to scale buildup in your pipes and appliances which shortens their lifespan and effectiveness. By knowing your TDS level, you can determine whether you need something to combat this issue, like a Salt-Free Water Conditioner or a water softener for, especially hard water.

Salt-Free Water Conditioners inhibit scale buildup by transforming dissolved hard minerals into harmless, microscopic crystals that don't accumulate over time. Salt-Free Water Conditioners can protect pipes and plumbing, decrease spots and stains on dishes and shower doors, increase the life of brighter clothing, and more, without wasting salt or water. Keep in mind that a Salt-Free Water Conditioner is different from a water filter. The ultimate goal of a water filter is not to remove all solids in the water. A TDS meter does not measure contaminants. It will not tell you if your water is healthy. The TDS meter reading simply refers to the amount of total dissolved solids in your water, it will not tell you what those solids actually are and if they are harmful for your health.

For example, you could have a high TDS meter reading but no harmful contaminants in your water. Some healthy minerals like potassium, magnesium, and calcium can actually cause your TDS meter to spike. So, any water filter with a remineralizer could cause a high reading on TDS meter, even though the remineralizer is adding good minerals.

On the other hand, you could have a low TDS level even if several harmful contaminants are present in your drinking water. Water could have heavy metals like lead, or other contaminants like pesticides, pharmaceuticals, or hexavalent chromium. The TDS meter will not pick these contaminants up. This is why you shouldn't rely on a

TDS meter to determine your water quality. Need to understand not just how many dissolved solids are in your water, but what those solids are and if they're harmful for your health.

Total dissolved solids (TDS) are measured in milligrams per unit volume of water (mg / l) or also referred to as parts per million (ppm). For drinking water, the maximum concentration level established by the EPA (the United States Environmental Protection Agency) is 500 mg / L. So TDS value is used as a reference in knowing the quality of water for drinking, Aquaponics, hydroponics and where the quality of water matters. So taking this into consideration we are going to build an IOT TDS monitoring device with the help of Arduino with Gravity Analog TDS sensor which is designed for Arduino with simple plug and play use. As TDS is dependent on temperature we use a waterproof temperature sensor bundled with the TDS sensor probe.

TDS (Total dissolved solids), are inorganic compounds found in water, such as salts, heavy metals, and some traces of organic compounds that dissolve in water. Some of these compounds or substances can be essential for life, however, it can be harmful when taking more than the desired amount that the body needs.

The TDS reader works by measuring Electronic conductivity(EC) of water and calculating it and bringing TDS value. This is measured in PPM (Parts Per Million). Pure H<sub>2</sub>O water or distilled water does not conduct electricity, so if a TDS reader is immersed in fully distilled water the result will be "0" or a very low number in the event that there are trace minerals in the Water. It is the charge of electrons that make up the minerals that conducts electricity. In short, a water with more minerals conducts more electricity than a water without minerals.

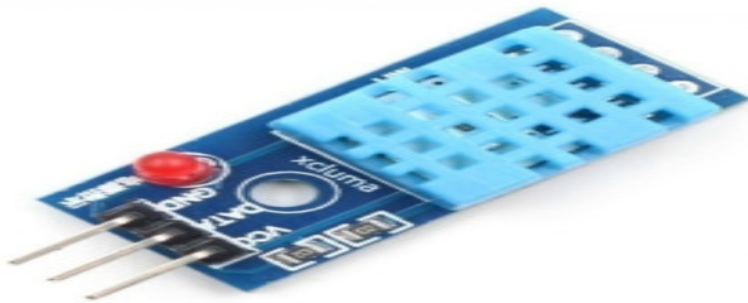
This sensor is specially designed to be compatible with arduino for measuring water for drinking, aquaponics and more. it operates between input voltages 3.3v to 5v. So it can be uses with multiple compatible MCU's available, like Arduino, ESP32, Nodemcu, and more. It outputs an analog voltage from 0 to 2.3v.

As the DC signal can add polarization errors to the value and corrode the probe pins used, this sensor uses an AC signal because of no polarity to get better accuracy

and for long term usage of the waterproof TDS Probe. The probe has 2 metallic pins through which the electrical conductivity is calculated.

### 3.5.4 TEMPERATURE SENSOR

- ❖ A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes.



***Fig: 3.8 Temperature sensor***

- ❖ The working of a temperature meter depends upon the voltage across the diode. The temperature change is directly proportional to the diode's resistance.
- ❖ HVAC/R systems, our digital temperature sensors help monitor industrial heating and cooling systems and control smart thermostats while thermocouples provide feedback to boiler controls in the home. In commercial aircraft, our NTC thermistors measure air and gas temperature, in a miniature and lightweight design that save space in small systems. In household stoves and appliances, our platinum temperature sensor can help amateur chefs prepare a meal perfectly – and ensure they store it safely. In microwave In ovens, our thermopile sensors can measure temperature without making contact with food. With TE temperature

sensors, you gain the value of our deep experience in helping customers develop technology that can respond to the way people live.

### **3.5.5 HUMIDITY SENSOR:**

Humidity sensors are electronic devices that measure and report the moisture and air temperature of the surrounding environment where they are deployed e.g., in air, soil, or confined spaces.

Humidity measurements indicate the concentration of water vapor presented in the air. They provide their measurements in the form of a proper electronic signal. Moreover, they also report relative humidity i.e. the ratio of moisture in the air to the maximum moisture at a given temperature. Relative humidity is useful for many applications, like HVAC (Heating Ventilation Air Conditioning) and comfort optimization applications in Smart Buildings and Facilities Management.

State of the art humidity sensors provide support for internet connectivity and can be flexibly deployed in the Internet of Things (IoT) applications. This facilitates the integration of humidity measurements with the output of other sensors (e.g., temperature sensors) and boosts IoT applications intelligence in various industry applications.

The quality of a humidity sensor is reflected in its accuracy, reliability, response time, longevity, security, robustness, and ease of deployment. These characteristics also determine the sensor's cost. Furthermore, they drive the selection of humidity sensors for different applications.

### **3.5.6 OLED DISPLAY**

The acronym 'OLED' stands for Organic Light-Emitting Diode - a technology that uses LEDs in which the light is produced by organic molecules. These organic LEDs are used to create what are considered to be the world's best display panels.

OLED displays are made by placing a series of organic thin films between two conductors. When an electrical current is applied, a bright light is emitted. A simple design - which brings with it many advantages over other display technologies.



***Fig: 3.9 OLED Display***

OLEDs enable emissive displays - which means that each pixel is controlled individually and emits its own light (unlike LCDs in which the light comes from a backlighting unit). OLED displays feature great image quality - bright colors, fast motion and most importantly - very high contrast. Most notably, “real” blacks (that cannot be achieved in LCDs due to the backlighting). The simple OLED design also means that it is relatively easy to produce flexible and transparent displays.

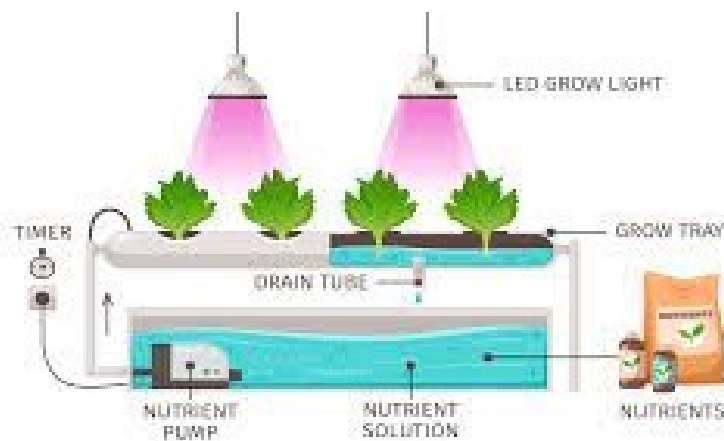
## CHAPTER 4

### METHODOLOGY

#### 4.1 WORKING METHODOLOGY

The smart hydroponics system which consists of three major parts Input data, Cloud server (Monitoring and controlling) and Output data. Starting with the input data, as IOT stands for the internet of things, basically a group of things more specifically the sensors communicate with each other via a network, thus a group of sensors is required to make up the IOT system.

The smart hydroponics system consists of variety of sensor that acquires the following data: room temperature, room humidity, water temperature and pH level and fertilizers level. In addition, the horticultural light status to be utilized for controlling purposes, with the telegram bot input data which is also considered as an input to the system for processing later on.



***Fig: 4.1 NFT method of Hydroponics***

Plants cannot properly function without essential nutrients. Essential nutrients can be broadly categorized as macronutrients and micronutrients. Macronutrients and

micronutrients are both essential for plant growth and development. The difference between macro and micronutrients is the amount required by plants. Macronutrients are required in higher amounts than micronutrients. Using Tds sensor nutrients value will be calculated and stored on the cloud. According to the TDS value shown by the sensor required amount nutrients are added to the water at the regular interval.

#### **4.1.1 WIFI MODULE WORKING :**

A set of AT commands are needed by the microcontroller to communicate with the ESP32 Wi-Fi module. Hence it is developed with AT commands software to allow the Arduino Wi-Fi functionalities, and also allows loading various software to design the own application on the memory and processor of the module.

The processor of this module is based on the Tensilica Xtensa Diamond Standard 106 micro and operates easily at 80 MHz. There are different types of ESP modules designed by third-party manufacturers. A set of AT commands are needed by the microcontroller to communicate with the ESP32 Wi-Fi module

The ESP32 Wi-Fi module comes with a boot ROM of 64 KB, user data RAM of 80 KB, and instruction RAM of 32 KB. It can support 802.11 b/g/n Wi-Fi network at 2.4 GHz along with the features of I2C, SPI, I2C interfacing with DMA, and 10-bit ADC. Interfacing this module with the microcontroller can be done easily through a serial port. An external voltage converter is required only if the operating voltage exceeds 3.6 Volts. It is most widely used in robotics and IoT applications due to its low cost and compact size.

The power supply required for the ESP32 module is only 3.3 Volts. If it is more than 3.7 Volts, then the module gets damaged, and this leads to circuit failure. Hence it is necessary to program the ESP-01 Wi-Fi module by using either Arduino board or FTDI device, which supports the programming 3.3 Volts supply. It is recommended for the user to buy either one FTDI device or an Arduino board.

The most common issue with the ESP-01 module is the powering up issue. The 3.3 Volts pin on the Arduino board is used to power up this module or simply we can use the potential divider. So, to provide a minimum current of 500 mA, the voltage regulator

that supports 3.3 Volts is mandatory. The LM317 voltage regulator does this work very easily and effectively.

#### **4.1.2 HOW PH SENSOR WORKS**

A pH meter uses a pH probe to measure the acidity or alkalinity (hydrogen-ion activity) of a solution, expressed as pH. The pH value of a solution is related to the hydrogen ion ratio inside the pH probe and the solution being tested.

When dip a pH probe into a solution, a number of hydrogen ions will move towards the glass electrode, replacing some metal ions inside, while some hydrogen ions will disperse into the solution being tested. This process of ion-swapping is known as ion exchange and is the main principle of how the glass electrode inside a pH probe works.

Ion exchange also occurs on the inside surface of the glass electrode. Because the potassium chloride inside the electrode and the solution being tested has different acidity, a difference in hydrogen-ion activity happens, resulting in a difference in electrical charges. When this happens, a potential difference appears between the sides of the glass electrode and the reference electrode producing a pH reading on the meter. Despite the meter measuring voltage, the digital display shows it as a pH measurement. It calculates this based on the voltage difference; the greater the voltage between the pH probe (electrodes) and the solution being tested, the greater the difference in hydrogen-ion activity. The more hydrogen-ion activity that happens, the lower the pH is, and vice versa.

Before using a pH meter, it is important to calibrate it for accurate results and is an important part of general electrode maintenance. We recommend you follow our advice on pH probe calibration to always ensure your pH readings are reliable.

#### **4.1.3 HOW TDS SENSOR MEASURE THE VALUE**

A TDS meter is a small hand-held device used to indicate the Total Dissolved Solids in a solution, usually water. Since dissolved ionized solids, such as salts and minerals, increase the conductivity of a solution, a TDS meter measures the conductivity of the solution and estimates the TDS from that reading.

A TDS meter measures the electrical conductivity of water or, in other words, the total amount of mobile charged ions found in water. If an element is dissolved in water and can conduct electricity, it is called an electrolyte. Salt, for example, is an electrolyte. Sugar, however, is not and will therefore not register on a conductivity or TDS meter. This is one reason why a TDS meter is only an estimate of the true TDS.

Additionally, different types of water will contain different quantities of certain dissolved substances. For example, seawater will naturally have far more salt than freshwater. To accommodate this difference, TDS meters will incorporate conversion factors, typically ranging from 0.4 to 1, to convert the conductivity to the estimated TDS level. As a general rule of thumb, the higher the conductivity, the higher the conversion factor.

Although the measurement on a TDS meter is an estimate, it is reasonably accurate. When simplicity, accessibility and cost are taken into account compared with a precision analytical balance, a TDS meter is more than sufficient for most applications.

Reading taken daily from the Proposed Automated hydroponic system

**Table 4.1 – Daily update of plant pH and TDS readings**

| <b>Date</b> | <b>Time</b> | <b>pH</b> | <b>TDS</b> |
|-------------|-------------|-----------|------------|
| 23 – March  | 22:12       | 5.4       | 1270       |
| 24 – March  | 10:40       | 6.8       | 1190       |
| 25 – March  | 11:35       | 6         | 1060       |
| 25 – March  | 19:40       | 6.6       | 1050       |

#### **4.1.4 HOW TEMPERATURE AND HUMIDITY SENSOR WORKS**

Temperature sensors measure temperature readings via electrical signals. They contain two metals that generate an electrical voltage or resistance when a temperature change occurs.

The sensor plays a vital role in maintaining a specific temperature for a variety of industries, including medical applications, HVAC systems, and electrical appliances in our homes. Temperature sensors are critical for accuracy and temperature control in industries like these.

Temperature sensors work by measuring the voltage across the diode terminals. When the voltage increases, the temperature also increases, which is then followed by a voltage drop between the transistor terminals and the emitter (in a diode).

The sensors come in different types, which are categorized based on their connection. There are two main categories when it comes to temperature sensors, depending on the type of application being used or the industry you are working in:

- Contact Temperature Sensors
- Non-contact Temperature Sensors

Relative humidity sensors usually contain a humidity sensing element along with a thermistor to measure temperature. For a capacitive sensor, the sensing element is a capacitor. Here the change in electrical permittivity of the dielectric material is measured to calculate the relative humidity values.

Low resistivity materials are used for the construction of a Resistive sensor. This resistive material is placed on top of two electrodes. Change in the resistivity value of this material is used to measure the change in humidity.

Salt, solid electrolytes and conductive polymers are the examples of resistive material used in Resistive sensor. Thermal conductive sensors measure Absolute humidity values.

## **4.2 SOFTWARE REQUIRED**

### **4.2.1 ARDUINO SOFTWARE**

- ❖ The Arduino is a platform that allows anyone to create IoT projects, with a user friendly interface, and an all in one solution for configuration, writing code, uploading and visualization. Using this software we can build visual dashboards to monitor and control our devices, integrate with other services and much more.
- ❖ The Arduino IoT Cloud supports a wide range of third party boards based on the ESP32 and ESP8266 microcontrollers with support for Wi-Fi. To set them up, simply choose the third party option in the device setup.
- ❖ Using variable synchronization feature of this software we can link variables of the same data type between two or more cloud-enabled devices, and Arduino IoT Cloud will automatically ensure any change to their value is propagated among all linked boards.

### **4.2.2 PROCEDURE FOR CONNECT ESP- 32 MODULE**

#### **Installing ESP32 Add-on in Arduino IDE**

- ❖ Install Arduino IDE latest version
- ❖ In Arduino IDE, go to File>Preferences
- ❖ Enter the following url into the “Additional Board Manager URLs” field:
- ❖ [https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package\\_esp32\\_index.json](https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json) Then, click the “OK” button:

- ❖ Open the Boards Manager. Go to Tools>Boards>Board Manager
- ❖ Search for ESP32 and press install button for the ESP32 by “espressif system “. It should be installed after a few seconds. After installing the ESP32 Arduino Core, restart yo Arduino IDE and navigate to Tools > Board to ensure you have ESP32 boards available.
- ❖ Install required drivers for ESP32 module to enable the port.
- ❖ Finally, connect the ESP32 board to the computer and select the Port.

### 4.2.3 THINKSPEAK SOFTWARE

One of the key elements of a generic IoT system that bridges the various ‘things’ is an IoT service. An interesting implication from the ‘things’ comprising the IoT systems is that the things by themselves cannot do anything. At a bare minimum, they should have an ability to connect to other ‘things’. But the real power of IoT is harnessed when the things connect to a ‘service’ either directly or via other ‘things’. In such systems, the service plays the role of an invisible manager by providing capabilities ranging from simple data collection and monitoring to complex data analytics. One such IoT application platform that offers a wide variety of analysis, monitoring and counteraction capabilities is ‘ThingSpeak’.

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below. The core element of ThingSpeak is a ‘ThingSpeak Channel’. A channel stores the data that we send to ThingSpeak and comprises of the below elements: 8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device.

3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device. 1 status field - A short message to describe the data stored in the channel. To use ThingSpeak, we need to signup and create a channel. Once we have a channel, we can send the data, allow ThingSpeak to process it and also retrieve the same.

The write API key is used for sending data to the channel and the read API key(s) is used to read the channel data. When we create a channel, by default, a write API key is generated. We generate read API keys by clicking the 'Generate New Read API Key' button under this tab.

#### **4.2.4 PROCEDURE TO CONNECT THINGSPEAK**

The first thing need to do is to set up ThingSpeak account.

Head over to the ThingSpeak website.

Need to create an account before we can use it.

Create a New Channel, which will find under Channels > My Channels.

We are presented with several options that need to complete. So give the channel a name.

In the next box is the description; here we enter a description of ThingSpeak channel, Then presented with a series of field boxes, of which we need a minimum of 1 and a maximum of 8. Check the box to enable the field, and enter a field name.

With our channel set up we can look at the data tools. Click on Channels > My Channels and will be presented with all the channels that have created.

Click on our newly created channel and will be greeted by our data, displayed as a basic bar graph.

ThingSpeak requires the use of API keys, and will find these in the API Keys.

The API itself, is quite simple in terms of how it works. We need to do a basic URL call, to read and write to the channel. The examples below show how this is structured

### **4.3 ADVANTAGES OF PROPOSED SYSTEM :**

- ❖ The challenges to be solved with this system are the increasing food demand in the world, the need of market of new sustainable method of farming using the Internet of Things.
- ❖ Using this project we can continuously monitor the plants condition So, Plants are healthier and reach maturity faster.
- ❖ Components used for this project was reduced compared to other Hydroponics system Thus the cost of making this hydroponics system was very low.
- ❖ This system helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition.
- ❖ The automated system can record our plant conditions, EC, pH, temperature, humidity, etc. so that we can monitor the data and run the process as per our preferences and convenience.
- ❖ In hydroponics farming, data or any automation software can help to achieve better yield and optimum production
- ❖ Also, we can link the automation software to our phone and access farm remotely from anywhere.

## CHAPTER 5

### RESULTS AND DISCUSSION

#### 5.1 RESULTS

Arduino IDE software is used to write source code for measure readings of plant condition. Libraries included are SPI.h, WiFi.h, Adafruit\_GFX.h, Adafruit\_GFX.h, Adafruit\_SSD1306.h, DHT.h. These libraries are available in the form of zip need add that file into the code.

WiFi.h library is required to use WiFi module with Arduino library. Using this library all the sensors are integrated with wifi module. Embedded C programming language is used to implement the application

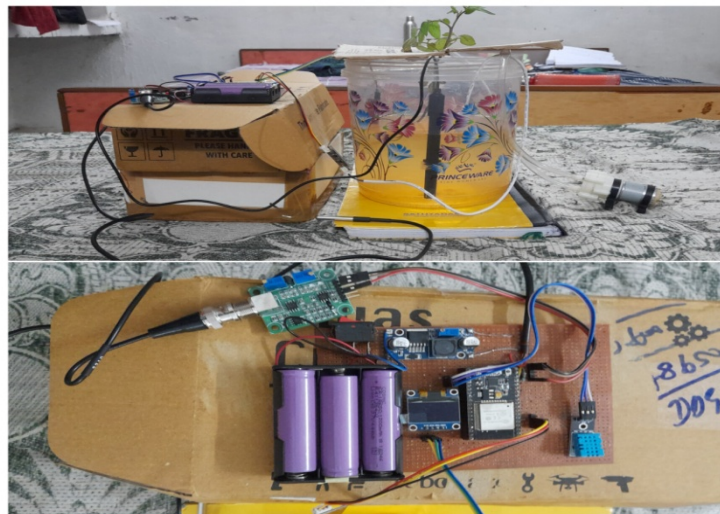
The pin connected to take readings are defined initially, using #define macro. To connect Nodemcu (Wifi module) with our mobile device ssid and password are created. Likewise same ssid and password given to mobile hotspot name and password. To access the thingspeak software, server thingspeak written as [api.thingspeak.com](https://api.thingspeak.com)

In this project, decoration plant and tomato plant are grown based on the Nutrient film technique of Hydroponics. The plant placed in the plastic box with water. Nutrients are added in the water according to the type of plant, Circulation of water has been given to the plant to avoid bacteria infection.



***Fig: 5.1 Type of Decoration plant on hydroponics system***

Figure 4.2 is the output of Tomato plant growth using water. For Tomato plant pH value between in the range of 5-6. Water sensor and Ph probe are used to measure temperature and Ph value of tomato plant. It should be placed with the water to measure the value.

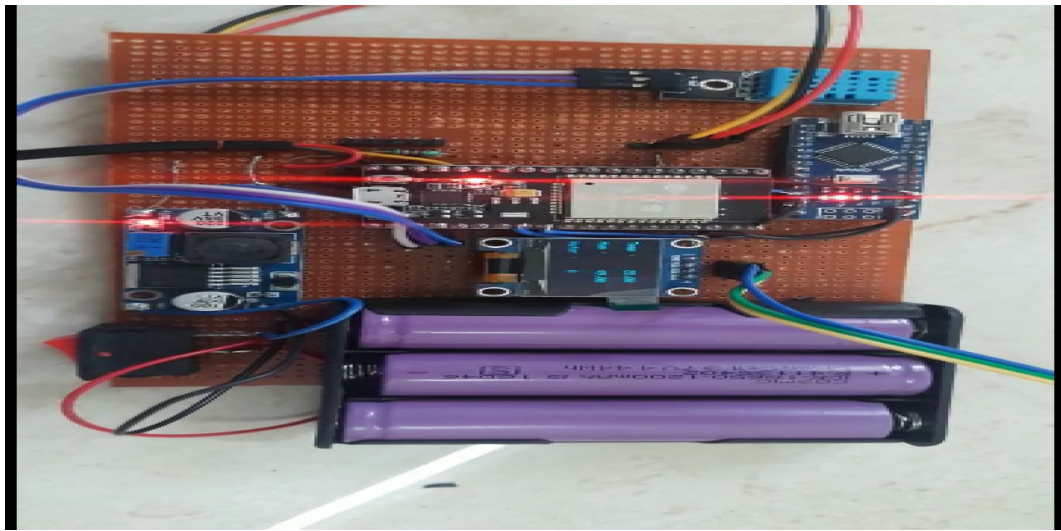


***Fig: 5.2 Tomato plant Growth with water***

Need to add below mentioned nutrients into the water for the growth of Tomato plant. Nutrients required for Tomato plant are Boron, Chlorine, Copper, Iron, Manganese, Molybdenum, Zinc, Nitrogen, Phosphorus, Potassium. TDS sensor connected with

Nodemcu will be used to detect the Nutrients level. Regularly the farmer need to add nutrients when it is low. TDS and pH value will be displayed on OLED display. This reading helpful to provide required amount temperature, pH and Nutrients.

## 5.2 HARDWARE CONNECTION



*Fig: 5.3 Hardware Connection for Automatic system*

Hardware Components used for hydroponics system are NodeMcu, OLED display, Voltage regulator, DHT11 sensor, Water sensor, TDS sensor, Battery, Ph sensor and probe, DC motor, Pipe, Switch, PCB board and Jumper wires.

Connection with OLED - Nodemcu

SCK - 022 , SDA- D21 , GND - GND, VDO – 3V3

Connection with TDS sensor - Nodemcu and OLED Display

+ve - 3V3, -ve – GND, A - VP

Connection with pH sensor - Nodemcu and OLED Display

A0 – VP, GND – GND, 9V – Battery

Connection with Water sensor – NodeMcu and OLED display

S - VP, GND – GND, 9V – Battery

Connection with DHT11 sensor(Temperature and Humidity sensor) and OLED display

Vcc - 3V3, GND – GND, data – D1

### **OLED DISPLAY OUTPUT**

After giving power supply this system starts to read the water temperature value, ph and TDS value, Temperature and Humidity value of plant. Then, these all the readings are displayed on the OLED display. So, This output on the OLED display used to monitor the plant condition. If the lower TDS value occur means farmer need to add the nutrients accordingly.

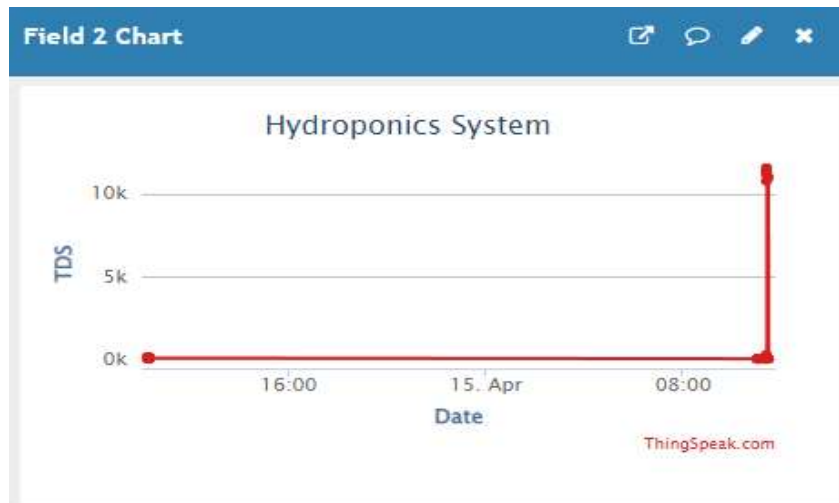


***Fig: 5.4 Plant Parameters on OLED Display***

The system will display the results on the web. The farmers are able to access sensor data from their mobile devices, which gives farmers convenience /and ability to view sensor data for use in planning and crop management.

### 5.3 DATA VISUALIZATION USING THINGSPEAK

Thingspeak is a IoT service provider used to analyze that collected from sensors via the NodeMCU module. All the data from sensors are sent to the Thingspeak using API keys. This API key provided to Nodemcu. Date of the particular day was represented on X axis. TDS value represented on Y-axis.



**Fig: 5.5 TDS visualization**

Thingspeak is a IoT service provider used to analyze that collected from sensors via the NodeMCU module. All the data from sensors are sent to the Thingspeak using API keys. This API key provided to Nodemcu. Date and condition of Nutrients level are represented on x axis and y axis respectively. These data are recorded with the date and stored in the cloud. After some days tds value will get reduced.



Write API key used in this project is 9XV2ZYMQSCS1VMX. Read API key is VWE003I66AT950NN7. Write API key is a key used to write data to a channel. Read API key is used to allow other people to view private channel feeds and charts.



Because the water pump is constantly running and heating the water with energy input, sensors in both regulated and unregulated systems had temperatures that were greater than room temperature. The water temperatures that resulted were still within the range that is ideal for plant growth. For the growth of plants, pH is very significant. It is

evident that, despite being within the ideal range, the plants grown without control had excessive pH levels. Plants in the unregulated system may have been harmed as a result.

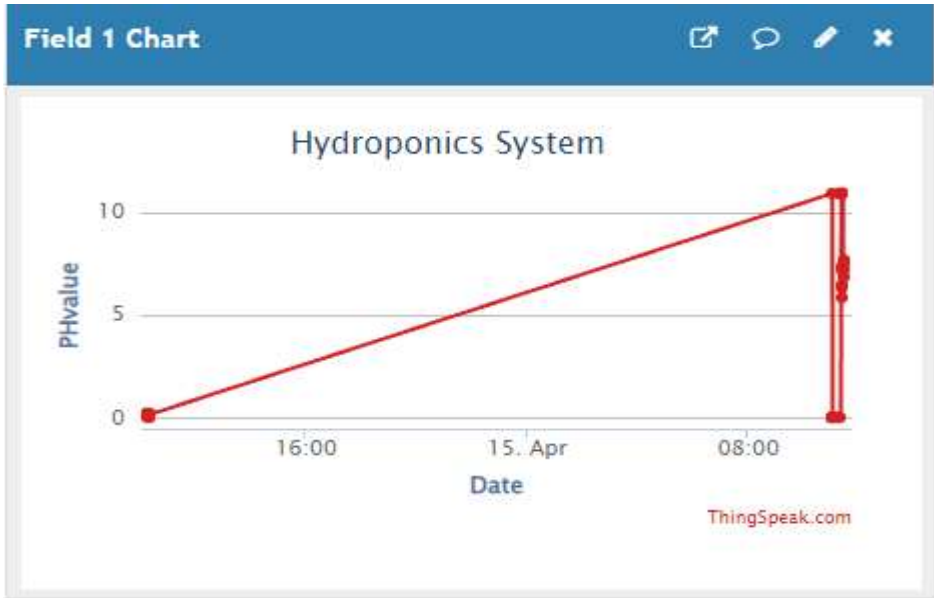


Fig: 5.7 PH visualization

In thingspeak software six channels are created for different dashboard of Hydroponics application like Temperature, Humidity, Ph value, Motor state, TDS value and Water level. Plant data are visualized with date and time in the form of graph using Thingspeak. It makes it easier to visualize condition of the plant.



Fig: 5.7 Motor State

Motor level should be on only. Motor is used here to ensure the circulation water for the plant. When the system has a malfunction, such as a power outage or sensor failure, the installed system will have a notification to the farmer. The data page in the dashboard displays data from the sensors used to measure the environment in the system. The displayed data includes temperature, humidity, water temperature, pH and EC. The displayed data is the latest data obtained from the sensors stored in the base.

## **CHAPTER 6**

### **CONCLUSION**

#### **6.1 CONCLUSION**

The challenges to be solved with this system are the increasing food demand in the world, the need of market of new sustainable method of farming using the Internet of Things. The design was implemented using NodeMcu, and sensors that were chosen during component selection based on required parameters and sending it to the cloud to monitor and be processed. First the prototype was constructed, programmed and tested, as well as sensors data between two different environments were taken and monitored on cloud-based web page with mobile application. By adding the internet of things, it solves one the key challenges in automation today which is maintenance, by providing a platform for monitoring the entire system from cloud, thus reducing the cost of maintenance by fraction. Lastly, the performance of the smart hydroponic system is evaluated.

#### **6.2 FUTURE WORK**

In proposed system, the measured pH value always tries to cope up with the reference pH value by considering calibrations of pH sensor as a prime factor. The values obtained from flow sensors, pH sensor and air quality index sensor are sent to the app through a Wi-Fi module, to enable the user to track performance remotely.

Designed system is able to monitor and control pH and air quality, rest of the factors such as temperature, humidity and EC are not considered. These might play a vital role in promoting efficient plant growth. To overcome this the controller needs to be interfaced and calibrated with various sensors supporting the above said factors. The motors used in the system can be replaced by PWM for more precision. Air quality index sensors can be along with the formaldehyde sensor to detect accurate variations in air quality. Further artificial intelligence can be used to make the system self- reliant so that it can analyze the conditions, requirements and act accordingly

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## APPENDIX

### SOURCE CODE

```
#include <SPI.h>

#include <WiFi.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>

#include <DHT.h>

#define TdsSensorPin 34

#define VREF 5.0    // analog reference voltage(Volt) of the ADC

#define SCOUNT 30    // sum of sample point

#define OLED_RESET 4

#define DHTPIN 2

#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);

Adafruit_SSD1306 display(OLED_RESET);

const int potPin=A0;

float ph;

float tmp;

float hum;

float temp;

float watlvl;
```

```

int motst;

int chk;

float Value=0;

int analogBuffer[SCOUNT]; // store the analog value in the array, read from ADC

int analogBufferTemp[SCOUNT];

int analogBufferIndex = 0,copyIndex = 0;

float averageVoltage = 0,tdsValue = 0,temperature = 25;

String apiKey = "9XV52ZYMQSCS1VMX"; // Enter your Write API key from ThingSpeak

const char *ssid = "akilesh"; // replace with your wifi ssid and wpa2 key

const char *password = "AkiLesHSeIva2506";

const char* server = "api.thingspeak.com";// don't change this

WiFiClient client;

void setup() {

    // put your setup code here, to run once:

    pinMode(potPin,INPUT);

    pinMode(TdsSensorPin,INPUT);

    display.begin(SSD1306_SWITCHCAPVCC, 0x3C);

    display.clearDisplay();

    Serial.begin(115200);

    dht.begin();

    delay(1000);

```

```

Serial.print("Connecting to ");

Serial.println(ssid);

WiFi.begin(ssid, password);

while (WiFi.status() != WL_CONNECTED) {

  delay(2000);

  Serial.print(".");

}

// Print local IP address and start web server

Serial.println("");

Serial.println("WiFi connected.");

Serial.println("IP address: ");

Serial.println(WiFi.localIP());

}

void loop() {

  static unsigned long analogSampleTimepoint = millis();

  Value= analogRead(potPin);

  hum = dht.readHumidity();

  temp= dht.readTemperature();

  float voltage=Value*(3.3/4095.0);

  ph=(3.3*voltage);

```

```

if(millis()-analogSampleTimepoint > 40U)    //every 40 milliseconds,read the analog
value from the ADC

{

    analogSampleTimepoint = millis();

    analogBuffer[analogBufferIndex] = analogRead(TdsSensorPin);    //read the analog
value and store into the buffer

    analogBufferIndex++;

    if(analogBufferIndex == SCOUNT)

        analogBufferIndex = 0;

}

static unsigned long printTimepoint = millis();

if(millis()-printTimepoint > 800U)

{

    printTimepoint = millis();

    for(copyIndex=0;copyIndex<SCOUNT;copyIndex++)

        analogBufferTemp[copyIndex]= analogBuffer[copyIndex];

    averageVoltage = getMedianNum(analogBufferTemp,SCOUNT) * (float)VREF /
1024.0; // read the analog value more stable by the median filtering algorithm, and
convert to voltage value

    float compensationCoefficient=1.0+0.02*(temperature-25.0);    //temperature
compensation formula: fFinalResult(25^C) = fFinalResult(current)/(1.0+0.02*(fTP-25.0));

    float compensationVolatge=averageVoltage/compensationCoefficient; //temperature
compensation

```

```
    tdsValue=(133.42*compensationVolatge*compensationVolatge*compensationVolatge  
- 255.86*compensationVolatge*compensationVolatge +  
857.39*compensationVolatge)*0.5; //convert voltage value to tds value
```

```
    //Serial.print("voltage:");
```

```
    //Serial.print(averageVoltage,2);
```

```
    //Serial.print("V  ");
```

```
}
```

```
Serial.print(Value);
```

```
Serial.print(" | ");
```

```
Serial.println(ph);
```

```
Serial.print("TDS Value:");
```

```
Serial.print(tdsValue,0);
```

```
Serial.println("ppm");
```

```
Serial.print("Humidity: ");
```

```
Serial.print(hum);
```

```
Serial.print(" %, Temp: ");
```

```
Serial.print(temp);
```

```
display.setTextSize(1);
```

```
display.setTextColor(WHITE);
```

```
display.setCursor(0,0);
```

```
display.println("PH Level : ");
```

```
display.setCursor(0,15);

display.println(ph);

display.setCursor(0,30);

display.println("TDS : ");

display.setCursor(15,30);

display.println(tdsValue);

display.setCursor(0,45);

display.println("W-Temp : ");

display.setCursor(15,45);

display.println(tmp);

delay(2000);

display.clearDisplay();

display.setCursor(0,0);

display.println("Temp : ");

display.setCursor(0,30);

display.println(temp);

display.setCursor(15,30);

display.println("Hum : ");

display.setCursor(15,40);

display.println(hum);

delay(2000);
```

```

display.clearDisplay();

if (client.connect(server, 80))
{
    String postStr = apiKey;

    postStr += "&field1=";

    postStr += String(ph);

    postStr += "&field2=";

    postStr += String(tdsValue);

    postStr += "&field3=";

    postStr += String(tmp);

    postStr += "&field4=";

    postStr += String(temp);

    postStr += "&field5=";

    postStr += String(hum);

    postStr += "&field6=";

    postStr += String(watlvl);

    postStr += "&field7=";

    postStr += String(motst);

    postStr += "\r\n\r\n\r\n\r\n\r\n\r\n\r\n\r\n\r\n";

    client.print("POST /update HTTP/1.1\r\n");
}

```

```

client.print("Host: api.thingspeak.com\n");

client.print("Connection: close\n");

client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");

client.print("Content-Type: application/x-www-form-urlencoded\n");

client.print("Content-Length: ");

client.print(postStr.length());

client.print("\n\n");

client.print(postStr);

}

}

```

```

int getMedianNum(int bArray[], int iFilterLen)

```

```

{
    int bTab[iFilterLen];

    for (byte i = 0; i<iFilterLen; i++)

        bTab[i] = bArray[i];

    int i, j, bTemp;

    for (j = 0; j < iFilterLen - 1; j++)

    {

        for (i = 0; i < iFilterLen - j - 1; i++)

        {

            if (bTab[i] > bTab[i + 1])

```

```

    {
        bTemp = bTab[i];

        bTab[i] = bTab[i + 1];

        bTab[i + 1] = bTemp;
    }
}

}

if ((iFilterLen & 1) > 0)
    bTemp = bTab[(iFilterLen - 1) / 2];

    else

    bTemp = (bTab[iFilterLen / 2] + bTab[iFilterLen / 2 - 1]) / 2;

    return bTemp;
}

```