

## IoT Based Automated Hydroponic System

Mayuri Deokar<sup>1</sup>, Vignesh Iyer<sup>1</sup>, Siddhant Badgujar<sup>1</sup>, Hrishikesh Yadav<sup>1</sup>, Jadhav Venkat<sup>2</sup>

<sup>1</sup>Student, Electronics Engineering B.E., Datta Meghe College of Engineering, Affiliated to University of Mumbai

<sup>2</sup>Asst. Professor, Dept. of Electronics Engineering, Datta Meghe College of Engineering, Navi Mumbai, India

\*\*\*

**Abstract** - Hydroponics is a form of gardening that uses no soil, but instead grows plants in a solution of water and nutrients. A hydroponic system can grow plants and vegetables faster and year-round with an efficient use of resources. Plants grown this way usually yield more, require less space, and conserve soil and water. This system is an ideal solution if you are an apartment dweller who does not have an outdoor gardening plot. Throughout the growing process, one needs to control several factors such as lighting, water quality, air circulation, and more. Here we use Deep water culture (DWC) which is a hydroponic method of plant production by means of suspending the plant roots in a solution of nutrient-rich, oxygenated water. This method uses floating rafts to suspend plant roots into a pond of water often 8–12 inches deep. Since there is a relatively large reservoir of nutrient rich water for each plant, there is buffering for pH, EC, and temperature, which means these elements of the system won't fluctuate undesirably. For oxygenation of the hydroponic solution, an airstone is added. This air stone is then connected to an airline that runs to an air pump. Sunlight is usually required for the growth of the plants but in hydroponics, it is supplemented with artificial lighting. The lighting has to be according to the plant's type and requirement.

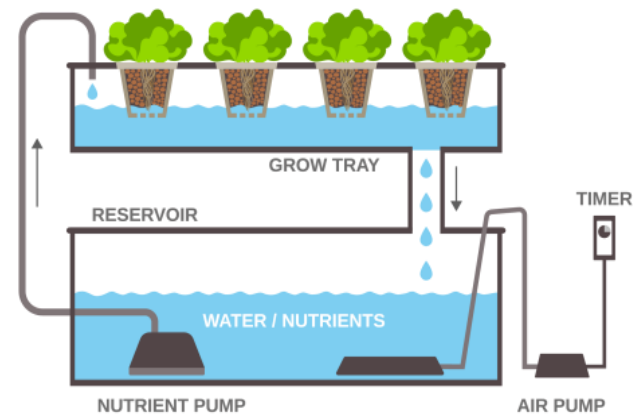


Figure - 1: Physical Structure

The purpose of this project is to interface an electronic circuit of sensors and actuators to a hydroponic system in order to develop an IoT based automated hydroponic system for remote monitoring and control.

The block diagram illustrates the interaction between all the sensors, actuators and the respective microcontrollers or SoC (System-on-Chip) involved in the hardware.

**Key Words:** Hydroponics, Deep Water Culture, Internet of Things, Android, Google Firebase Realtime Database, Arduino, WiFi Module

### 1.INTRODUCTION

Since hydroponics takes much less water to grow produce, it could be possible in the future for providers in harsh environments with little accessible water to grow their own food. In recent decades, NASA has done extensive hydroponic research developing a Martian environment using LED lighting to grow in a different color spectrum with much less heat. They believe hydroponics will create advances within space travel as a bioregenerative life support system.

Hydroponic Farming can be a better alternative to traditional farming along with options like automation of monitoring and controlling the environment through grow lights and heaters as required by the plant.

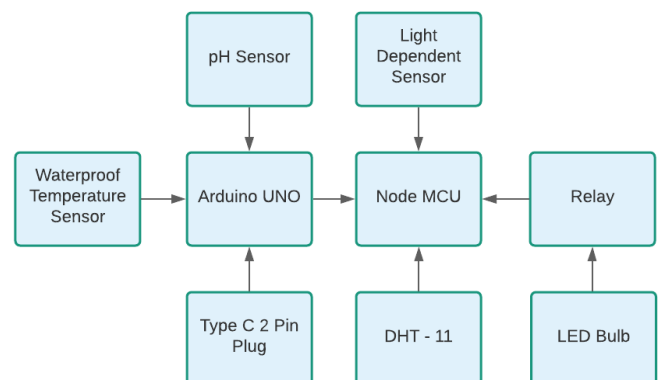


Chart - 1: Block Diagram

The system flow chart explains the complete process of the automation carried out within the concerned hydroponic system. The flow chart and block diagram presented here have the potential to add customized functions according to various hydroponic systems other than DWC hydroponic systems like Nutrient Film Technique (NFT) and even Aeroponics.

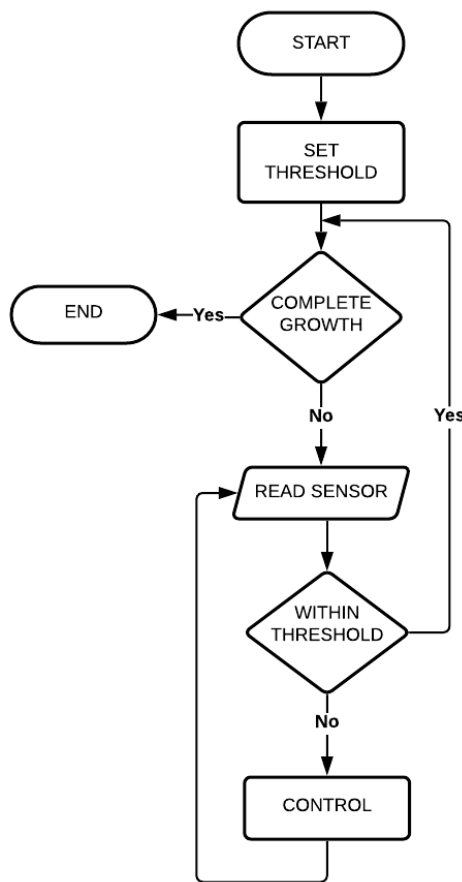


Chart - 1: System Flow Chart

## 2. SENSOR PARAMETERS MEASURED

The sensors being used here to monitor surrounding air parameters along with the water quality essential for plant growth are as follows: Digital humidity and temperature sensor DHT-11 which provides temperature in degrees celsius and humidity in percentage. Light dependent resistor LDR to calculate the luminous flux in lux which is directly related to luminous intensity in lumens. pH sensor indicates the acidity or alkalinity of water-based solutions. The EC sensor measures the electrical conductivity in a solution to monitor the amount of nutrients, salts or impurities in the water in mSiemen/cm. Here, Seeed Studio Grove pH Sensor Kit was used to measure the pH of the nutrient-rich solution whereas the EC sensor was built using a simple type C plug and waterproof temperature sensor DS18B20 for temperature compensation.

## 3. ACTUATOR CONTROLLED

So far, sensors being used and their working principle have been explained. Now let's move on further to the actuator being controlled in this project. This actuator is a simple LED bulb of wattage 5W and around 500 lumen with white light.

The only actuator, a grow light LED bulb is switched to an AC circuit using a 5V relay to safely isolate it from the DC circuit. The AC circuit of the bulb is connected across the normally open and common pin while normally closed is left open (not connected). A free-wheeling diode is connected in parallel to the relay coil which prevents damage to the transistor from voltage spike when the coil is deactivated. This transistor is used as a switch with the base connected to the digital output pin used to control the relay. Thus, control is established and this is done remotely using the Android application.

## 4. METHODOLOGY

Initially, the seeds are grown in soil to develop small saplings which are then transferred into net pots where their roots are supported with inert media and exposed to the nutrient-rich oxygenated water solution.



Figure - 3: Net Pots Assembly

The plants cultivated in the container having net pots are fruiting citrus lemon plants which required parameters in ranges as follows:

For the surrounding ambient temperature, the plants require 15°C to 21°C.

Similarly,

Humidity: 10% - 50%

White Light of 300 - 800 lumens

pH: 5.5 - 6.5

EC: 1.0 - 1.6 mSiemen/cm

Thus, the thresholds were set according to these plant requirements using the Android Application - Rio which we built with the Android Studio IDE. These thresholds are defined in the form of a range with an upper limit and a lower limit. When the sensor data deviates from this threshold range and if notifications are enabled, the drop or increase of the respective parameter is notified, even after killing the app provided the android device is connected to an internet network. This function will be

demonstrated further in this paper presentation.

### 5. GOOGLE FIREBASE

Firestore is a platform developed by Google for creating mobile and web applications. There are many services provided by Firestore like Cloud Firestore, Realtime Database, Crash Analytics Authentication and much more. The Firestore Realtime Database is a cloud-hosted database. Data is stored as JSON (JavaScript Object Notation) and synchronized in realtime to every connected client. When we build cross-platform apps with iOS, Android, and JavaScript SDKs (Software Development Kit), all the clients share one Realtime Database instance and automatically receive updates with the newest data. Here, Android SDK is used for developing the Android Application named Rio along with connecting NodeMCU to the Google Firestore Realtime Database using FirestoreESP8266.h library.



Figure - 4: IoT Based System

So, sensor data is collected, processed and pushed into the realtime database by the NodeMCU in the form of key-value pairs of JSON in respective nodes over a WiFi network. Similarly, when the control node in the database is enabled through the Android Application Rio, the grow light connected through a 5V relay is switched on after a small considerable delay to provide light over the plants and subsequently switched off once the control node is disabled through the app remotely. Thus, we have a fully functional smart hydroponic system to grow crops at ease and convenience.

### 6. CIRCUIT DESIGN

The circuit is designed for interfacing the required hardware. As mentioned before the hardware includes the various sensors for monitoring pH, EC and liquid temperature of the water-nutrient solution by the Arduino UNO whereas the NodeMCU takes care of luminous intensity, temperature and humidity of the surrounding air. We also control the LED bulb switching with NodeMCU with a 5V relay which isolates the AC circuit from the DC circuit. The DHT-11 has 4 terminals namely VCC, GND, DATA and NC (not connected). The LDR circuit is a simple voltage divider with 10kΩ. The pH Sensor board is

interfaced with a 4 pin JST cable and connector which also has 4 pins similar to DHT11. Similarly, the DS1820 waterproof temperature sensor has 3 wires of VDD, GND and DQ (Data from a one-wire bus) and requires a resistance of 4.7kΩ between data DQ and VDD. The type C 2-pin plug needs a 500Ω resistance to one terminal through 5V voltage but we used 1kΩ instead as it renders a smaller range for the electrical conductivity and is enough for hydroponics. This terminal takes in the voltage whereas the other terminal is grounded. The pH and EC is taken care of by the ArduinoUNO.

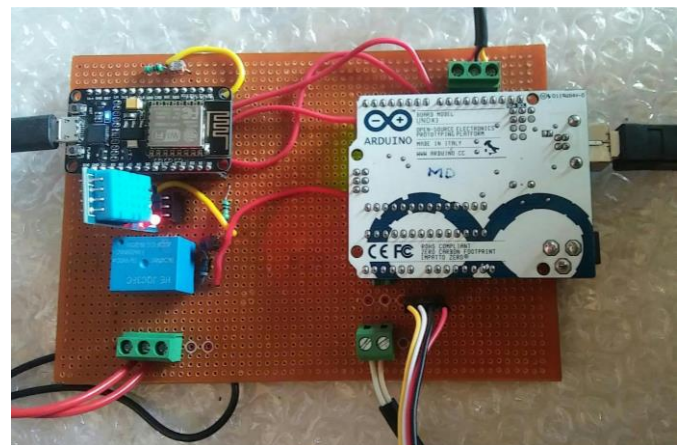


Figure - 5: Soldered PCB

So far, the circuit design has been discussed, now let's move on to the data transfer. Transfer and reception take place through the SoftwareSerial.h library for which digital pins of both the boards are connected with the grounds made common.

Just like JSON (JavaScript Object Notation) was used for pushing key-value pairs into the Google Firestore Realtime Database, we use the same concept to transfer pH and EC data from ArduinoUNO to NodeMCU using ArduinoJSON.h library. There are two entities related to it: Static and Dynamic JSON Document. We use a static JSON document as it can be recreated each time in a loop when there is a new set of data. So, it has to be serialized from ArduinoUNO through software serial and it gets deserialized at NodeMCU. We got these documents printed on the serial monitor using JSON pretty print.



Figure - 6: Actual Hydroponic System

### 7. PHYSICAL SET-UP WORKING

The plants are transferred into net pots where their roots are supported with inert media and exposed to the nutrient-rich oxygenated water solution which is flushed through two pipes to pump and drain water with the help of a motor. An airstone is placed in the reservoir and is used to oxygenate the water solution. There is an electronic soldered circuit interfaced with the Android App Rio as well as the Serial Monitor displaying the readings. Here, we carry out pH and EC monitoring after interfacing the circuit with the main setup while the electrodes are immersed in the solution of the water reservoir whereas readings are displayed on the serial monitor when connected through the USB cable to a computer using Arduino IDE. Soon after the interfacing of the circuit with the main physical system, it was observed that there is considerable delay between enabling the switch, the bulb turning on and the LED status to change into ON state. However, this delay does not affect the reliability of the system.

### 8. INTEGRATED SOFTWARE OPERATION

After the circuit has been interfaced with the actual physical hydroponic set-up, the software integrated with the hardware plays a major role in the complete functional working and success of the project. This project is IoT based as it includes connecting the hardware to an existing WiFi network and communicating with a cloud based realtime database to monitor and control various parameters in our system.

In the Realtime Database of the Google Firebase, the red highlight indicates that the data is being deleted. Similarly, yellow resembles change in data and the green highlight shows that this is new data created, all done in real-time. There is no change in the “cont” key used to control the

grow light LED bulb with values “enable” or “disable” until the switch status in the app is changed.

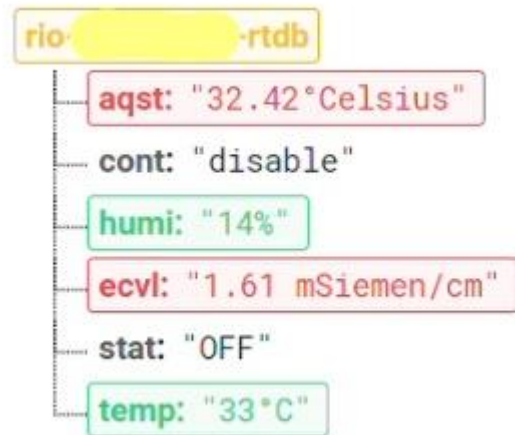


Figure - 7: Google Firebase Realtime Database

The application’s UI allows the values of various parameters being measured to be monitored in real-time provided the android device is connected to the internet. The application also provides notifications for indicating threshold deviation by enabling the “get notified” switch.

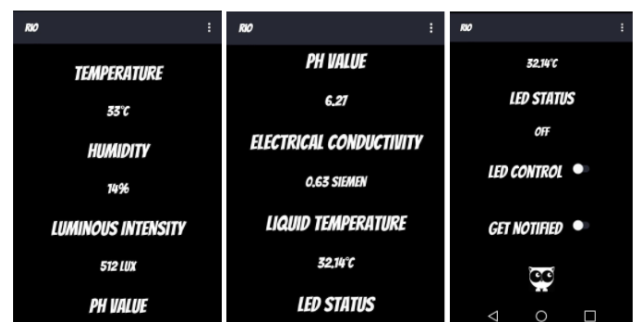


Figure - 8: App UI

We have three functions in the menu and one of them is to set thresholds for temperature, humidity and luminous intensity. Thresholds can be defined as a range with an upper limit and a lower limit. When there is no input to any field or the lower limit exceeds the upper limit, we get errors. Once proper values are set, we now get a notification when there is a drop or the sensor value exceeds the range.

The app also shows the current threshold and provides a default set of values to be set at one click and indicates the same once the button is clicked. If we check the current threshold, we see it is set to default.

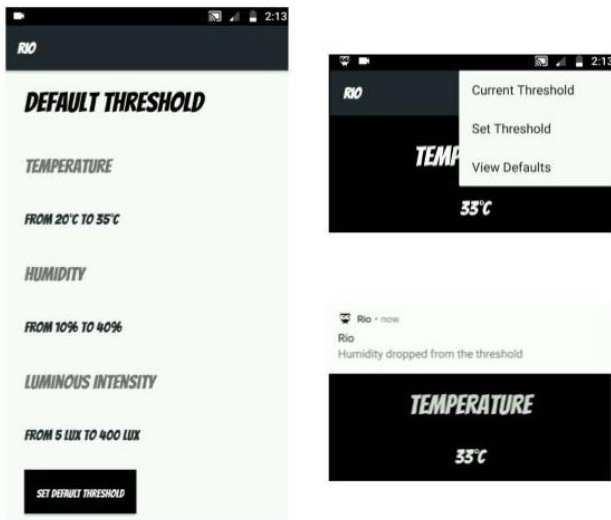


Figure - 9: App Functions

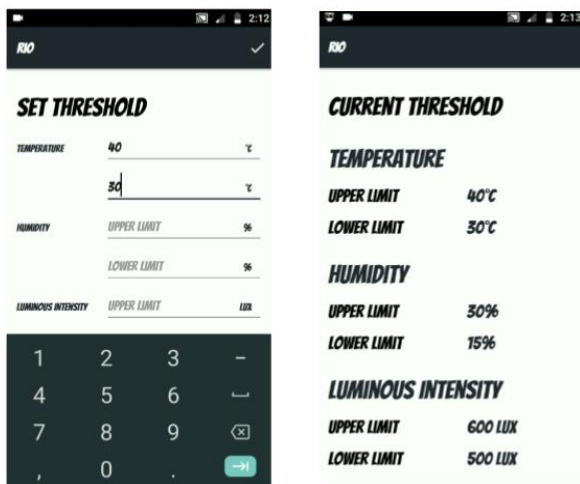


Figure - 10: Threshold Settings

## 9. CONCLUSIONS

The conclusion drawn from this project is that it is not optimal as both the microcontroller ATmega328P on ArduinoUNO as well as ESP8266 SoC on NodeMCU are used in the circuit. We built this project with all the possible resources available during this ongoing pandemic and it has a great potential to be made more optimum. There are many ways of optimizing the project, some of them are:

- (1) Using an external ADC with NodeMCU for more analog inputs
- (2) Using ESP8266 - 01 WiFi Module with Arduino UNO for WiFi Connectivity:

Therefore, the automated hydroponics system based on android application and IoT was developed to facilitate the

cultivation and the system can help adjust and control important environmental factors that affect plant growth with notifications which makes the process more convenient and easier.

## REFERENCES

- [1] AI in Hydroponics: The Future Of Smart Farming March 1, 2021 by Anju Nambiar  
<https://analyticsindiamag.com/ai-in-hydroponics-the-future-of-smart-farming/>
- [2] Design a Lux Meter Using a Light Dependent Resistor December 13, 2015 by David Williams  
<https://www.allaboutcircuits.com/projects/design-a-luxmeter-using-a-light-dependent-resistor/>
- [3] A review on Seed Studio pH and EC Sensor Kits July 2, 2020  
<https://www.e-tinkers.com/2020/07/a-review-on-seed-studio-ph-and-ec-sensor-kits-part-1/>
- [4] Three Dollar EC - PPM Meter [Arduino] April 9, 2015 by Michael Ratcliffe  
<https://hackaday.io/project/7008-fly-wars-a-hackers-solution-to-world-hunger/log/24646-three-dollar-ec-ppm-meter-arduino>