Valve Controlled Automatic Opto-Hydroponics System

Kushagra Singh, Praveen Kumar Maduri, Apurva Soni, Rishabh Maurya
Galgotias College of Engineering and Technology, Greater Noida, India

Email- kushagrasingh2707@gmail.com

Abstract - In the growth of plants, various geological parameters like soil, air and water have been greatly affected by the increase in level of pollution and climate change. Degradation of soil, harmful gases in the air and loss of various macro nutrients are some common problems affecting the growth of plants. The only way that the plants could survive in a polluted environment is growing them in a well-managed and monitored greenhouse system. In this paper, a system is demonstrated which uses hydroponics technique and an artificial led light (Blue Red Pink) system to grow plants. The system is an automatic setup of hydroponics and led lights integration various sensors to manage the physical environment inside the greenhouse. System also proposes a hydroponics tube which is created for the seeds to directly grow on the tubes without shifting.

Keywords- microcontroller, sensors, automatic, led light, management, plants, hydroponics

1. INTRODUCTION

This study focuses on making an automatic opto-hydroponics system [1] which consists of two parts. The first part includes the hydroponics system in which plants are grown with a special hydroponic solution which contains all the nutrients required by plants. The second part is the artificial grow lights which mimics the light of the sun utilized by the plants to grow and perform photosynthesis. This light emits a particular wavelength favorable and best suited for the plants. The whole system is controlled, monitored and managed by the microcontroller setup which effectively controls all the physical parameters responsible for the growth of the plants [2]. The systems truly mimic the weather conditions like appropriate humidity, temperature and transpiration rate which the help of exhaust fans [3]. The system is also capable to manage the time period or the photo period of led grow lights automatically with the help of micro controller and timers. This system is best suited for areas where there is little or no light and also in areas where the soil is not supportive for the growth of plants. They are able to manage pH and nutrients to make sure plants are getting the exact nutrients they need. The systems are closed and recycle the water that is not used by plants. The ability to grow indoors allows farmers to control temperatures and lighting schedules to improve plant production [4]. Systems can be designed to make use of vertical space and increase planting density. Hydroponics also allow us to create farms in locations where soil conditions are too poor to support farming, or space is limited and a farm otherwise couldn’t exist.

2. WHAT IS HYDROPONICS AND GROW LIGHTS

Hydroponics is growing plants without soil. The roots are grown in a nutrient solution that is dissolved in water. It was not formally called hydroponics until 1940 when William F. Gericke adopted the word from the Greek. Gericke was one of the first to grow plants in what he called “litter” where the plants were suspended above a tank of water containing a nutrient solution.

Hydroponic growing is an extremely efficient way to provide your plants with the food and water they need, when they need it, in the amounts they need which allows the plants to be as healthy as possible. The energy the plants save by taking nutrients up through their roots allows them to focus their energy on producing fruits and flowers. This allows the plants to grow faster and be ready to harvest sooner.

Hydroponic gardening systems can be set up to recycle water and nutrients, greatly reducing the resources necessary to grow food. Hydroponic way of growing plants can be useful in eliminating the need for herbicides and pesticides. It promotes an overall awareness of our environment and can even help to protect the environment by reducing traditional agricultural pollution [5].
A grow light/plant light is an artificial light source, this could be an electric light (mainly led lights) designed to stimulate plant growth by emitting a light which is appropriate for photosynthesis.

Grow lights can be used in various places where there is either no naturally occurring light, or where additional light source is required for the plants to grow well. For example, in the winter months when the available hours of daylight may be insufficient for the desired plant growth, lights are used to extend the time the plants receive light.

In sufficient amount of light can lead to long and spindly growth of plants which is not fruitful. Grow lights can either help to provide a light spectrum similar to that of the sun, or to provide a spectrum that is more favorable to the needs of the plants being cultivated.

Outdoor conditions are mimicked with varying color, temperatures and spectral outputs from the grow light, as well as varying the intensity of the lamps.

Factors affecting the growth of plants with grow lights- the photo period required by the plants, specific ranges of spectrum, luminous efficacy and color temperature.

3. METHODOLOGY

Automatic Opto-Hydroponics system is an automatic growth system for plants which provides artificial environmental conditions in a greenhouse system which is capable of managing, monitoring and configuring the artificial environment [6]. This setup consists of the following operating sections.

a. Automatic Hydroponics Setup
This setup is the combination of traditional hydroponic system and the advance automatic micro controller setup.
i. Humidity Sensor and Temperature Sensor (DHT22)

The DHT22 sensor consists of a humidity sensing component, an NTC temperature sensor (or thermistor) and an IC on the backside of the sensor. The term “NTC” means “Negative Temperature Coefficient”, which means the resistance decreases with an increase in the temperature. To measure the humidity, it uses the humidity sensing component which has two electrodes with moisture holding substrate between them. So, as the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes’ changes. The change in resistance is further measured and processed by the IC which makes it ready to be read by a microcontroller. For measuring temperature this sensor uses an NTC temperature sensor or a thermistor.

A thermistor is a variable resistor that changes its resistance with a change of the temperature. The sensor is made by the fritting of semi conductive materials like ceramics or polymers to provide larger changes in the resistance with small changes in temperature.

| Specification             | Details               |
|---------------------------|-----------------------|
| Temperature Range         | -40 - 125 °C / ± 0.5 °C |
| Humidity Range            | 0 - 100 % / ± 2.5%    |
| Sampling Rate             | 0.5 Hz (one reading every two seconds) |
| Body Size                 | 15.1mm x 25mm x 7.7mm |
| Operating Voltage         | 3 - 5V                |
| Max Current During Measuring | 2.5mA               |

ii. pH sensor Module
pH can be defined as the numeric representation of gram concentration in any solution. It varies between 0 to 14. It is the logarithmic measurement of moles of hydrogen ions per liter of solution. The solutions having a pH value between 0 to 7 are acidic solutions with a large concentration of hydrogen ions whereas solutions having a pH value between 8 to 14 are basic solutions with small hydrogen concentration. The solutions having a pH value of 7 are neutral solutions. pH measurement gives the measure of alkalinity or acidity of a solution.

pH meter basically works on the fact that an interface of two liquids produces an electric potential which can be measured. In other words, when a liquid inside an enclosure made of glass is placed inside a solution other than that liquid, there exists an electrochemical potential between the two liquids.

Firstly, the electrode is placed inside the beaker filled with a solution whose pH is to be measure. The glass bulb which is fixed at the end of the measurement electrode consists of lithium ions doped to it which makes it act as an ion-selective barrier and allows the hydrogen ions from the unknown solution to migrate through the barrier and interacts with the glass, developing an electrochemical potential related to the hydrogen ion concentration. The measurement electrode potential thus changes with the hydrogen ion concentration. The reference electrode potential doesn’t change with the hydrogen ion concentration and provides a stable potential against which the measuring electrode is compared. It consists of a neutral solution that is allowed to exchange ions with the unknown solution through a porous separator, thus forming a low resistance connection to complete the whole circuit. Potential difference between the two electrodes gives a direct measurement of the hydrogen ion concentration or pH of the system and is first pre-amplified to strengthen it and then given to the voltmeter.

\[ U = E_{pH} - E_{ref} \]

\[ E_{pH} \] – Voltage potential of the measurement electrode
\[ E_{ref} \] – Voltage potential of a reference electrode

The pH is calculated based on the Nernst’s equation which states that change in the total potential for every change in pH is

\[ U = -kT \Delta \text{pH} \]

\[ k \] - Boltzmann’s constant, \( T \) - temperature.
\[-\text{equivalent per litre of hydrogen ion}\]

In the hydroponic setup, pH sensor continuously monitors the pH of the hydroponic solution to provide the chemical free growing environment [7].
iii. Electrical Conductivity Sensor

Some of the root area factors like the salinity of the soil, irrigation water systems or fertilizer solutions can have a significant effect on the health, growth and quality of the plant if not monitored carefully [8]. Low and High salt levels could lead to the damage of plants. Hence, an electrical conductivity sensor in a hydroponics system helps to alert the salinity of the solution. In liquids, we often use the reciprocal of resistance, which is conductance, as a measurement. The water conductivity can reflect the level of electrolytes present in the water. The sensor is specially designed for the microcontroller to interface directly and give the output [9].

iv. NPK Sensor using optical transducer and microcontroller

In this technique of measuring the nitrogen, phosphorous and potassium content in the medium, three optical transducers are used.
These optical transducers are used as a detection sensor with the help of Arduino microcontroller [10][11].

v. Solenoid Valve
A two-way solenoid valve is used at the outlet of the tank containing a hydroponics solution. In two-way valves are shut-off valves with one inlet port and one outlet port. When the solenoid valve is in de-energized condition, the core spring, assisted by the fluid pressure, holds the valve seal on the valve seat to shut off the flow. When the valve is in an energized state, the core and seal are pulled into the solenoid coil and the valve opens. Hence, the electromagnetic force is greater than the combined spring force and the static and dynamic pressure forces of the medium.

vi. Electrostatic precipitator and Exhaust fans
Exhaust fans are used to keep the greenhouse environment ventilated and remove the oxygen during the time of photosynthesis and at the time of respiration co2 is blown out of the green house. Electrical filters are used to purify the air so that plants could easily absorb them and grow well in a purified air. Polluted air can damage the leaves of the plants and can make them unhealthy.

vii. Grow Lights
LED grow lights are composed of multiple individual light-emitting diodes, usually in a casing with a heat sink and built-in fans. In this system, combination of Blue Red and Pink lights is used for the effective growth of plants.
viii. Tank

Tank contains the organic hydroponics solution N-3.90, P-0.51, K-1.47, Ca-0.01, S-0.12, Mg-0.018, Zn-0.026, Mn-0.0003, Cu-0.0005, B-Trace, Mo-0.003, +/- Herbal and Enzymatic properties.

ix. Hydroponics Tube and Seed Bed

Hydroponics tube consists of three main sections. The inner most is hydroponic solution flow path through which the organic hydroponic solution will flow with the downward opening which act as a drip with the help of gravity. The middle portion consists of sponge to store the solution. The outer portion has a seed bed on the upper side to rest the seeds and so that they can grow there. There are also two openings on the above for the exchange of gases from roots as well.

![Diagram of Hydroponics Tube](image_url)

Fig 2: Cross section of Hydroponics Tube for plant growth (Proposed Diagram)
4. **CONCLUSION/ RECOMMENDATION**

Based on the implementation of automatic opto-hydroponics it can be said that our system is capable of healthiest growth of plants with minimum resources and maximum output. Aim of the system was to build cost effective and efficient setup to provide the best environmental conditions in an artificial setup.

Hydroponics is an environment-friendly and profitable technology. It has been promoted by the various governments and non-governmental organizations for its benefits in terms of food security. High-cost is the only major drawback in technology. However, a lot of R&D activity is being carried out globally to reduce the cost involved in technology.

Hydroponics involves the process of growing plants by using mineral nutrient solutions in sand, gravel, or liquid, without using soil. Due to the increasing success rates associated with the commercial hydroponics industry and the increasing difficulty of growing crops on soil, the hydroponics market is expanding exponentially. Along with the market expansion, manufacturers of hydroponic equipment are focusing on the development of new efficient systems.

Hydroponics is currently ahead of its time in India. The cost of produce coming out of a hydroponic unit currently is much higher than the cost of one coming out of traditional units. As such the market for hydroponic produce is limited to largely Metro’s and a few tier 1 cities for now. However, with constant innovation and adoption of newer techniques of growing, the cost differential is reducing. So, we will see progressive farmers adopting the technologies faster in coming years. But still the large part of farming in India will remain traditional due to cost considerations and also technology limitations.
5. REFERENCES

a. Albery W, John B.GD, Haggett, Robert Svanberg L. 1985, The development of sensors for hydroponics. Biosensors 1.4, 369-397.

b. Pitakphongmetha J, Boonnam N, Wongkoon S, Horanont T, Somkiadcharoen D, & Prapakornpilai J. 2016, Internet of things for planting in smart farm hydroponics style. Computer Science and Engineering Conference (ICSEC)

c. Moreno D. A, López-Berenguer C, Martínez-Ballesta M. C, Carvajal M, & García-Viguera C. 2008, Basis for the new challenges of growing broccoli for health in hydroponics. Journal of the Science of Food and Agriculture 88.8: 1472-1481.

d. Helmy H, Mahaidayu MG, Nursyahid A, Setyawan TA, Hasan A. 2017. Nutrient Film Technique (NFT) Hydroponic Monitoring System Based on Wireless Sensor Network. 2017 IEEE International Conference on Communication, Networks and Satellite (Connetsat)

e. Ferentinos K. P, Albright L.D. 2003, Fault detection and diagnosis in deep-trough hydroponics using intelligent computational tools, Biosystems Engineering 84.1, 1330.

f. Gagnon V., Maltais-Landry G, Puigagut J, Chazarenc F, & Brisson J. 2010, Treatment of hydroponics wastewater using constructed wetlands in winter conditions, Water, Air, & Soil Pollution 212.1-4 483-490.

g. Saaid M.F, Sanuddin A, Megat A, Yassin M. 2015. Automated pH Controller System for Hydroponic Cultivation 2015 IEEE 9th International Colloquium

h. Ferentinos, Konstantinos P, Louis D. A, and Norman R. S, 2000, Modeling pH and Electrical Conductivity in Hydroponics using Artificial Neural Networks. IFAC Proceedings Volumes 33.19 173-178.

i. Kaewwiset T and Yooyativong T. 2017, Estimation of electrical conductivity and pH in hydroponic nutrient mixing system using Linear Regression algorithm. International Conference on Digital Arts, Media and Technology (ICDAMT).

j. Sihombing P, Karina N. A, Tarigan, J. T, & Syarif, M. I. 2018, Automated hydroponics nutrition plants systems using arduino uno microcontroller based on android, Journal of Physics: Conference Series. Vol. 978. No. 1. IOP Publishing.

k. Masrie M, Aizuddin Rosman S, Sam R and Janin Z. Proc. of the 4th IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA) 28-30 November 2017