



AUTOMATION SYSTEM FOR HYDROPONIC AGRICULTURE USING SOLAR SYSTEM

¹Arati Dagadu Rozodkar , ²Reshma Bashir Shaikh , ³Abhishek Anil Shinde, ⁴Prof. Bhoir N. V

¹UG Scholar, E & TC Dept. Vidya Niketan College of Engineering, Bota

²UG Scholar, E & TC Dept. Vidya Niketan College of Engineering, Bota

³UG Scholar, E & TC Dept. Vidya Niketan College of Engineering, Bota

⁴Asst. Prof., E & TC Dept. Vidya Niketan College of Engineering, Bota

ABSTRACT - “The goal of the Automation System for Hydroponics Using Solar Energy is to use hydroponic technology and renewable solar electricity to create an intelligent, energy-efficient, and environmentally responsible agricultural system. A contemporary farming technique called hydroponics uses water to directly give nutrients to plants in the absence of soil. Using sensors, a microprocessor, relay modules, and Internet of Things technology, the suggested system automates critical agricultural tasks such monitoring temperature, water level, pH value, nutrient concentration (EC), illumination, and water circulation. The technology reduces reliance on traditional energy and supports sustainable agriculture by using solar panels and rechargeable batteries to provide a steady power supply. The Blynk mobile application allows for real-time monitoring and control. Allowing users to operate pumps, fans, and grow lights remotely. The automated control mechanism ensures proper nutrient delivery and environmental conditions for healthy plant growth while minimizing human effort and water wastage. The project improves agricultural productivity, conserves energy, and supports smart farming practices suitable for urban farming, rooftop gardening, and rural areas with limited electricity availability. The integration of automation and solar energy makes the system cost-effective, reliable, and environmentally friendly. Overall, the project demonstrates the successful implementation of renewable energy and IoT-based automation in hydroponic farming for future sustainable agriculture applications.

Keywords: Hydroponics, Solar Energy, Automation System, IoT, Blynk Application, Smart Agriculture, PH Sensor, EC Sensor, Renewable Energy, Arduino Uno, Water Monitoring, Sustainable Farming



I. INTRODUCTION

Hydroponics is a cutting-edge farming method that uses water to directly give vital nutrients to plants without the need for soil. Compared to traditional farming, this approach allows for greater agricultural output, quicker plant development, and better use of resources and space. Hydroponics reduces nutrient waste and enhances overall crop quality since plants get nutrients in a controlled environment. Due to population growth, declining arable land, water shortages, and the rising need for the production of fresh and healthful foods, hydroponic farming has become increasingly important in recent years. Conventional farming practices rely heavily on weather patterns and use a lot of water.

The suggested approach creates a self-sufficient hydroponic system by combining renewable solar energy with automation technologies.

II. OBJECTIVES

- To automatically check the pH level
- Effectively manage the supply of nutrients
- Automate the system's water circulation
- To use rechargeable batteries to store solar energy
- Constantly keep an eye on the environment.

III. SYSTEM OVERVIEW

The illustration shows an Automation System for Hydroponics Using Solar Energy, which uses an automated and energy-efficient system to feed nutrient-rich water to plants without the need for soil. Because the entire system runs on renewable solar energy, it may be used in smart and sustainable agricultural applications. The system receives electricity from the solar panel, which transforms sunshine into electrical energy. The charge controller controls this energy, preventing overcharging and voltage swings in the battery and electrical components. The battery unit then stores the electrical energy, guaranteeing continuous functioning at night or in overcast conditions. The microcontroller, such as an Arduino or ESP32, is the system's core controlling device and serves as the project's brain. The water level sensor checks the amount of nutrient solution available in the tank and prevents low-water conditions. Based on sensor readings, the microcontroller controls the pump and valve unit to circulate nutrient-rich water from the nutrient solution tank to the hydroponic plant bed. Plants absorb nutrients directly through their roots, resulting in faster and healthier growth compared to traditional soil farming. The system also includes an LCD/IoT display unit that shows real-time data such as temperature, pH, water level, and

pump status. Overall, the system reduces manual effort, saves water and electricity, and provides an eco-friendly solution for modern agriculture.

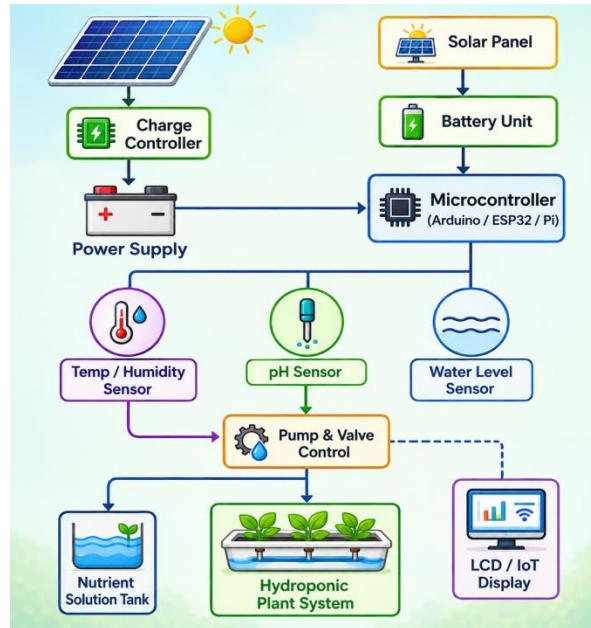


Fig. 1 -Proposed System

HARDWARE COMPONENTS

ESP 8266 Nodemcu

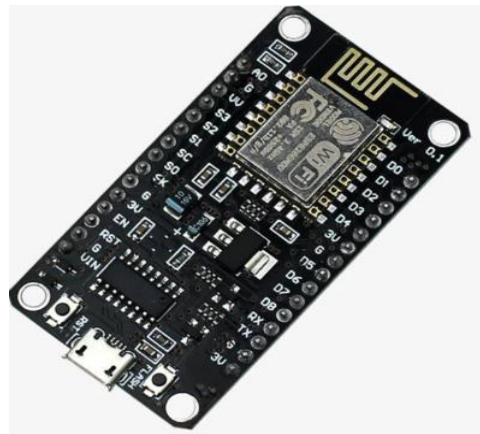


Fig.2- ESP 8266 Nodemcu

The ESP8266 NodeMCU is one of the most important components used in the project Automation System for Hydroponics using Solar Energy. It acts as a smart Wi-Fi-enabled microcontroller that controls and monitors the entire hydroponic system. The NodeMCU is developed using the ESP8266 Wi-Fi module integrated with

a programmable microcontroller and USB interface. It is compact in size, low in power consumption, and suitable for IoT-based agricultural applications.

In the construction of the system, the ESP8266 NodeMCU is mounted on a PCB or breadboard and connected to various sensors such as the temperature and humidity sensor, pH sensor, and water level sensor. The module operates on 3.3V DC power supplied from the solar-powered battery unit through a voltage regulator.

PH Sensor



Fig 3- .PH Sensor

The PH Sensor is an important component used in the project Automation System for Hydroponics using Solar Energy. Its main function is to measure the acidity or alkalinity of the nutrient solution used in the hydroponic plant system. Maintaining the correct pH level is essential because plants absorb nutrients efficiently only within a specific pH range, generally between 5.5 and 6.5. The pH sensor helps in automatic monitoring and maintaining proper nutrient conditions for healthy plant growth. The construction of the pH sensor consists of a sensitive glass electrode probe connected to a signal conditioning module.

Temperature Sensor

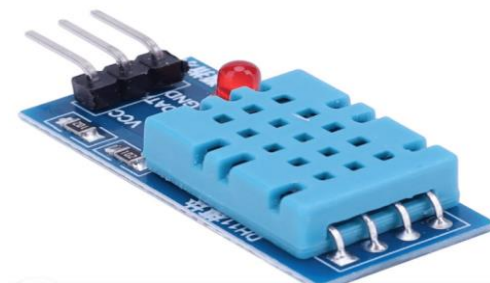


Fig.4- Temperature Sensor

Water Level Sensor



Fig.5- Water Level Sensor

The Water Level Sensor is an important component used in the project Automation System for Hydroponics using Solar Energy. Its main purpose is to monitor the level of nutrient solution present inside the hydroponic tank. Proper water level maintenance is essential because plants require a continuous supply of nutrient-rich water for healthy growth. The sensor helps prevent water shortage, overflow, and dry running of the pump. The construction of the water level sensor consists of conductive sensing probes or a float-based sensing mechanism connected to a control circuit.

Water Pump

The Water Pump is a vital component used in the project Automation System for Hydroponics using Solar Energy. Its main function is to circulate the nutrient-rich water from the storage tank to the hydroponic plant bed. Continuous circulation of nutrient solution ensures that plant roots receive sufficient water, oxygen, and essential minerals for healthy growth. The pump enables automatic irrigation and reduces manual effort in hydroponic farming. The construction of the water pump consists of a DC motor, impeller, pump casing, inlet and outlet ports, and sealing arrangement. In this project, a small DC submersible pump is generally used because it operates efficiently on low voltage supplied by the solar-powered battery system.



Fig.6- Water Pump

10 W Solar Panel



Fig.7- 10 W Solar Panel

Its main purpose is to convert sunlight into electrical energy and provide power to the hydroponic automation system. The solar panel supplies electricity to charge the battery and operate components such as the ESP8266 NodeMCU, sensors, relay module, water pump, and display unit. The use of solar energy reduces electricity consumption and makes the system environmentally friendly. The construction of the 10W solar panel consists of multiple photovoltaic (PV) cells connected in series and enclosed within a protective aluminum frame. The PV cells are made from semiconductor materials such as silicon, which generate electricity when exposed to sunlight.

DC-DC Buck Converter



Fig.8- DC-DC Buck Converter

The DC-DC Buck Converter is an important power management component used in the project Automation System for Hydroponics using Solar Energy. Its main function is to step down higher DC voltage from the battery or solar panel to a lower stable voltage required by electronic components such as the ESP8266 NodeMCU, sensors, relay module, and display unit. It ensures efficient power distribution and protects sensitive devices from overvoltage damage. The construction of the DC-DC buck converter consists of switching components such as MOSFETs or transistors, an inductor, capacitors, diode, and control IC mounted on a compact PCB board.

IV. SYSTEM DESIGN

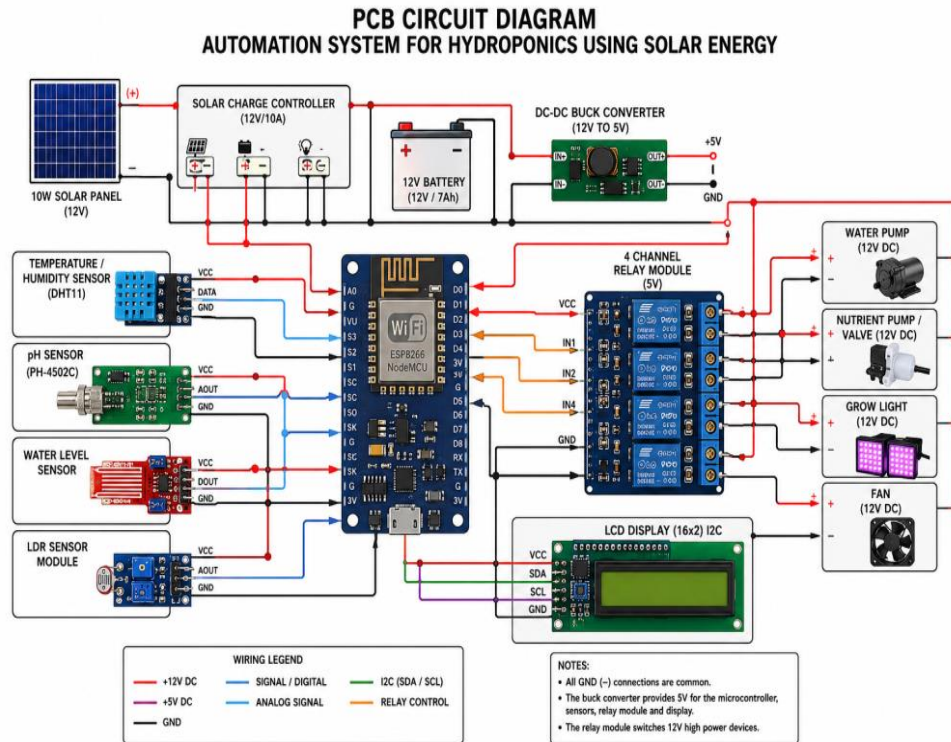


Fig.9- System Design Overview

An sophisticated Automation System for Hydroponics utilizing Solar Energy, designed for intelligent monitoring and autonomous control of hydroponic farming, is depicted in the circuit diagram. The system ensures effective plant development with little human labor by combining renewable solar power, embedded control, environmental monitoring, and automated actuation. In order to securely charge a rechargeable battery while safeguarding the system from overcharging and voltage fluctuations, a 10W solar panel transforms sunshine into 12V DC electricity, which is controlled by a solar charge controller.

The ESP8266 NodeMCU and sensor modules are powered by a DC-DC buck converter, which reduces the 12V supply to 5V. As the primary controller, the NodeMCU processes information from the DHT11 temperature and humidity sensor, pH sensor, water level sensor, and LDR sensor.

V. EXPERIMENTAL SETUP



VI. RESULT AND DISCUSSION

Sr. No	Water Level	Temp.	Electrical Conductivity (Nutrient Content)	PH
1	Low	31 ⁰	1.2 %	5.4%

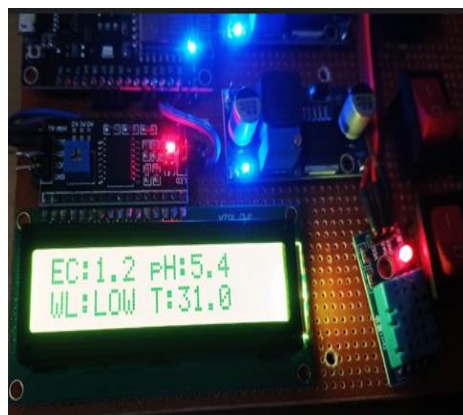


Fig.10- Result

The aforementioned outcome demonstrates the Automation System for Hydroponics Using Solar Energy project's successful operation as observed by the hardware display module and Blynk IoT application. Using several sensors linked to the microcontroller, the system continually detects critical hydroponic parameters including temperature, water level, fertilizer concentration (EC), and pH level. The temperature in the Blynk



program is shown as 31°C, which represents the hydroponic setup's surrounding ambient conditions. The amount of fertilizer solution in the tank is displayed by the water level indicator. While the nutrition and pump switches may be manipulated remotely via the mobile application, the light control switch is turned ON, indicating that the grow light is now operating to assist plant development. is suitable for hydroponic cultivation because most plants grow efficiently in slightly acidic conditions.

VII. CONCLUSION

By combining hydroponics, renewable energy, automation, and Internet of Things technologies, "Automation System for Hydroponics Using Solar Energy" effectively illustrates a clever and sustainable approach to contemporary agriculture. Using sensors and the ESP8266 NodeMCU, the system efficiently monitors and regulates critical factors including temperature, pH level, fertilizer content, water level, illumination, and water circulation. Real-time monitoring and remote control via smartphones are made possible by the integration of the Blynk application, which enhances user convenience and system effectiveness. Particularly in rural and isolated places, the use of solar energy with battery backup promotes environmentally beneficial farming methods and lessens reliance on traditional electricity. In addition to minimizing human labor and water waste, automated management of pumps, lighting, and fertilizer flow guarantees healthy plant development and increased output. In general, the project provides a reliable, energy-efficient, and cost-effective farming solution with future scope for advanced technologies such as artificial intelligence, cloud monitoring, and automated nutrient management systems.

REFERENCES

- 1.“Automation System Hydroponic Using Smart Solar Power Plant Unit”Simon Siregar, Marlindia Ike Sari, Rakhmi Jauhari Jurnal Teknologi (Sciences & Engineering) 2016.
- 2.“Automated Hydroponic System with Solar Powered Battery Management System” A. Chandra Shaker, L. Sai Srivalli, K. Sharanya, D. Akhila, T. Madhu Chandana International Journal for Research in Applied Science & Engineering Technology (IJRASET) 2023.
- 3.“Automated Hydroponics Systems, A Review and Improvement” Aman Pache, Amartya Dudhe, Bhagyashree Dharaskar International Journal of Science and Research (IJSR),2022
- 4.“A Systematic Literature Review for Smart Hydroponic System” Haifaa Jassim Muhasin, Ali Yahya Ghani, Nur Ilyana Ismarau Tajuddin, Nor Aziyatul Izni, Yusmadi Yah Jusoh, Khairi Azhar Aziz Bulletin of Electrical Engineering and Informatics 2024.
- 5.“A Systematic Literature Review on Parameters Optimization for Smart Hydroponic Systems” Umar Shareef, Ateeq Ur Rehman, Rafiq Ahmad AI Journal (MDPI) 2024.



6. “The Role of Automation and Robotics in Transforming Hydroponics and Aquaponics to Large Scale” Milon Selvam Dennison, P. Sathish Kumar, Fwangmun Wamyil, M. Abisha Meji, T. Ganapathy Discover Sustainability 2025.
7. “Towards Automated Aquaponics: A Review on Monitoring, IoT, and Smart Systems” José António Fernandes, Pedro C. Moura Oliveira, and collaborators Journal of Cleaner Production 2020.
8. “Review Paper on Automated Hydroponics” Konade S. B, Khilari V. S, Aswale L. S, Jadhav A.F. International Engineering Journal for Research & Development. 2021 .
9. “Hydroponics Review and a Proposed Automated Hydroponics System for Urban Family” M. Atiar Rahman, M. A. A. Mamun, Sabiha Sattar, Mist. Toma Khatun, M. Shohel Rana, Mohaimina Begum International Journal of Current Microbiology and Applied Science. 2025.
10. “IoT Based Smart Hydroponics Monitoring System Using Arduino” R. K. Sharma, P. Verma, S. Gupta International Journal of Innovative Technology and Exploring Engineering (IJITEE) 2021.
11. “Smart Hydroponic Farming with Renewable Energy Integration” N. Prakash, V. Ramesh, K. Arun Kumar International Journal of Engineering Research & Technology (IJERT) 2022.
12. “Design and Development of Automated Hydroponic Nutrient Control System” A. B. Patil, S. D. Jadhav, P. M. Chavan International Research Journal of Engineering and Technology (IRJET) 2020.
13. “Solar Powered IoT Enabled Hydroponic Monitoring and Control System” M. K. Singh, R. Tiwari, A. Yadav International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE) 2023.
14. “Intelligent Hydroponic System Using Internet of Things Technology” F. Ahmad, M. Hussain, T. Ali Journal of Physics: Conference Series 2021.
15. “Development of Smart Hydroponics Agriculture System” S. K. Mishra, D. Roy, P. Das International Journal of Recent Technology and Engineering (IJRTE) 2020.
16. “Automation and Monitoring of Hydroponic System Using Wireless Sensor Network” J. Pradeep, R. Naveen Kumar, K. Venkatesh International Journal of Scientific & Technology Research 2021.
17. “Renewable Energy Based Smart Hydroponic Farming System” P. Srinivas, M. Lavanya, G. Tejaswini International Journal of Scientific Research in Engineering and Management (IJSREM) 2024.