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Automated Hydroponic System with Solar Powered Battery Management System

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Abstract: ***In hydroponic farming, plants are grown in nutrient-rich water rather than soil. By mounting sensors and actuators on the system, environmental events, including water temperature, relative humidity, light intensity, and pH, are automatically monitored and controlled. The Internet of Things (IoT), used to transport and retrieve data from the Internet (mass storage), is involved in maintenance and automatic monitoring. An application informs the user of the hydroponic system's current state online. The value of hydroponics lies in giving ordinary individuals a means to grow their food without soil. It is crucial to have the proper pH, environmental conditions such as temperature in hydroponics. In order to effectively use solar energy to power the system, solar panels are included. Rechargeable batteries are employed in our hydroponic system. Thus, a battery management system (BMS) is also incorporated. Thus, a controller that monitors these variables may greatly assist and guarantee improved success and efficiency rates. Various devices can link to one another and share real-time data.***
Keywords: Automated, hydroponics, IoT, BMS, solar panel.

I. INTRODUCTION

The best technique to grow plants to their greatest potential is through hydroponic farming. Plants are given as much nutrients and water as they can absorb [1]. Setting up a hydroponic system in the past required research, many installation steps, and daily monitoring to ensure proper growing conditions. In this proposed hydroponic system, continuous monitoring of plant water level, pH level, temperature, and humidity is displayed on an LCD module. It will also upload the sensor data to the ThingSpeak cloud. A battery management system is used, which includes the solar panel. Solar energy is stored in the battery through a charging circuit and relay. This system continually checks the voltage of the battery and the solar panel and connects and disconnects the battery charger accordingly. The primary controlling mechanism is an Arduino UNO microcontroller running a loaded C language program. According to the sensor data that Arduino is continually monitoring, it will operate the devices and use ESP8266 Wi-Fi to post the sensor data into the ThingSpeak cloud. The main goal of this paper is to develop a solar-powered system for monitoring hydroponics nutrition. Arduino, which has a loaded program in embedded C, is the primary controlling device.

II. LITERATURE SURVEY

Mayuri Deokar et al. [2] presented an "IoT-based Automated Hydroponics system." This study aims to connect sensors and actuators to the hydroponic system to create an automated hydroponics system for remote and monitoring and controlling using IoT. The conclusion from this research is that it is not optimum since the circuit employs both the microcontroller ATmega328P on the Arduino UNO and the ESP8266 SoC on the NodeMCU.

Deepika S et al. [3] proposed an "Enhanced Plant Monitoring System for Hydroponics Farming Ecosystem using IoT." This research presents a Hydroponic Farming Ecosystem (HFE) to monitor the environment of the hydroponic system in real time though sensors by employing IoT devices. This study investigates a smart monitoring and controlling system that can facilitate the connectivity of monitoring fields and distant monitoring centers.

The work "Battery Management System Using State of Charge Estimation: An IOT Based Approach" was published at the 2020 National Conference on Emerging Trends in Sustainable Technology and Engineering Applications (NCETSTEA) [4]. This article presented the idea that a battery management system is required for the following reasons:

1) Monitoring and evaluation of battery status,
2) Safety and reliability of battery,
3) Regulating the charge state,
4) Regulating the temperature.

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Sarath Kumar [5] suggested "Solar-based Hydroponics Cultivation." This study investigates the method of growing plants without soil and with solar power. This work aims to demonstrate a low-cost, high-reliability prototype for real-time hydroponic cultivation measurements. This research suggests automating a hydroponics system to eliminate burdensome and time-consuming human processes. Solar energy is captured in the battery and turned into power. The relay controls whether the motor is turned on or off. This study, however, did not explain the use of other critical components of water monitoring in a hydroponics system.

III. PROPOSED SYSTEM

In this hydroponic system, several hardware and software components are integrated. This proposed hydroponic system will monitor the plant's water level, pH level, temperature, and humidity levels, display them on an LCD module, and upload sensor data to the ThingSpeak cloud. The system block diagram is presented below:

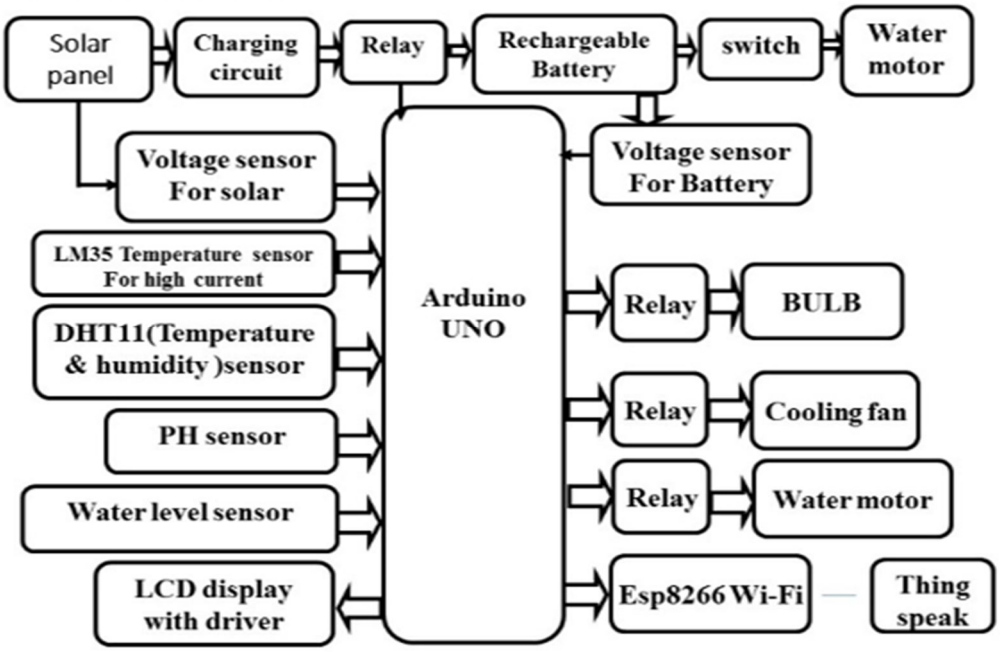


Fig1: Proposed System Block Diagram

The main blocks of this system are:

- Solar panel
- Charging circuit
- Rechargeable battery
- Arduino UNO ATmega328P microcontroller
- pH sensor
- DHT11 sensor
- Water level sensor
- LCD display
- Relays
- LED (Bulb)
- DC water motor
- Cooling fan
- 12 V, 1 Amp battery
- DC water motor
- LM35 temperature sensor
- Voltage sensors
- ESP8266 Wi-Fi module

The blocks are organized in the block diagram depicted. This system includes sensors, actuators, and computing equipment. The sensors include:

1) *LM35 Temperature Sensor:* LM35 sensor is a precision integrated-circuit temperature sensor with voltage linearly proportional output to Celsius (Centigrade) temperature.
2) *Water Level Sensor:* Water level sensor module determines the water level by measuring the volume of droplets/water with series of parallel exposed traces.
3) *DHT11 Sensor:* DHT11 is a hybrid device to sense digital temperature and humidity. This sensor digital signal output is calibrated to temperature and humidity.
4) *pH Sensor:* A pH sensor, which ranges from 0 to 14, helps determine the water's acidity or alkalinity. Water begins to get more acidic as the pH value falls below seven. More alkaline is any number greater than seven. The way that each type of pH sensor measures the water's purity varies.

A. Among the Actuators are the Following

a) *LED:* LED is a semiconductor light source. LEDs are utilized for indication (ON/OFF) with light in various products and are becoming more popular as a light source.
b) *DC Water Motor:* DC water motor is micro submersible mini water pump. It is a small-sized, low-cost 3-6V DC motor that operates with 2.5-6V supply voltage.
c) *Cooling Fan:* Cooling fan provides the air conditioning that must be maintained in order to create the best possible environment setup. Other components of the system include:

B. Other Components of the System Include

1) *Relay:* Relay is an electrically controlled switch. In relays, a low-power signal must control a circuit, or a single signal must control several circuits. The system makes use of three relays.
2) *Solar Panel:* Photovoltaic panels [6] are used in solar-powered electricity generation. Solar panels create power based on the same electronic principles used in chemical batteries or ordinary electrical outlets. Solar panels use the principle of the free flow of electrons in a circuit. Pure silicon, the core material of solar panels, is the same substance that resulted in the computer revolution. When silicon is purified of all impurities, it becomes a perfect neutral platform for electron transmission.
3) *ESP8266 Wi-Fi Module:* This hardware component is the foundation for incorporating IoT technology since it connects to the Arduino board through Wi-Fi.
4) *Rechargeable Battery:* The energy required to charge rechargeable batteries is often supplied by a battery charger powered by alternating current (AC).

The following software tools are utilized in this system:

a) *Arduino IDE:* Arduino IDE is a platform to program the Arduino UNO controller.
b) *ThingSpeak:* ThingSpeak is a platform that offers various services that have been developed specifically for developing applications using IoT. It supports collection of data in real-time, visualize the collected data with charts, and design apps and plugins with web services, social networks, and other APIs. The central component of ThingSpeak is Channel. In ThingSpeak, after singing up, a channel is created and data transmitted is stored in the channel. ThingSpeak processes it and also retrieves it. Therefore, environmental parameters such as temperature, humidity, water level, and pH level; and also battery temperature, solar voltage can be constantly monitored on the ThingSpeak platform.

IV. RESULT

This system is designed for hydroponic plant monitoring. Arduino is the system's primary controller. The Arduino is interfaced with water level sensor, DHT11 sensor, pH sensor, DC water motor, relay, and cooling fan. Arduino continually checks the sensor data and shows it on the LCD.

Actuators like cooling fan, light bulb, and water pump operate according to the required conditions in the code. Utilizing a Wi-Fi module incorporates IoT technology. The battery management system and solar panel are part of this system.

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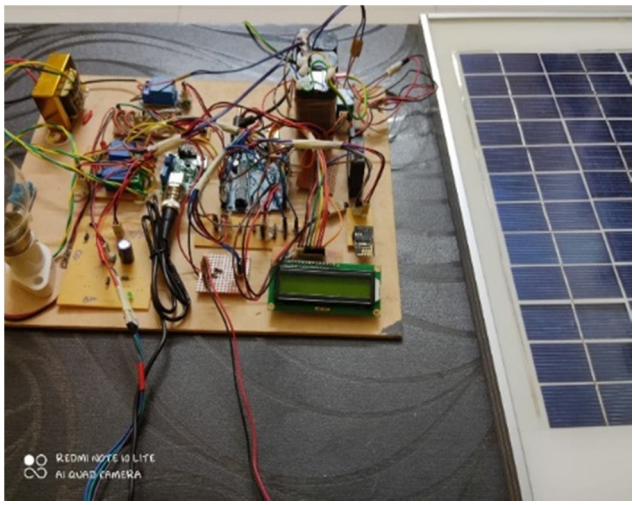


Fig2: Circuit components



Fig3: Hydroponic Plant

The ThingSpeak IoT platform is utilized in this system to transmit sensor data and continuously check the condition. For internet connectivity, a Wi-Fi module is included in the hardware system. The parameters that the ThingSpeak platform senses and keeps track of are displayed below:

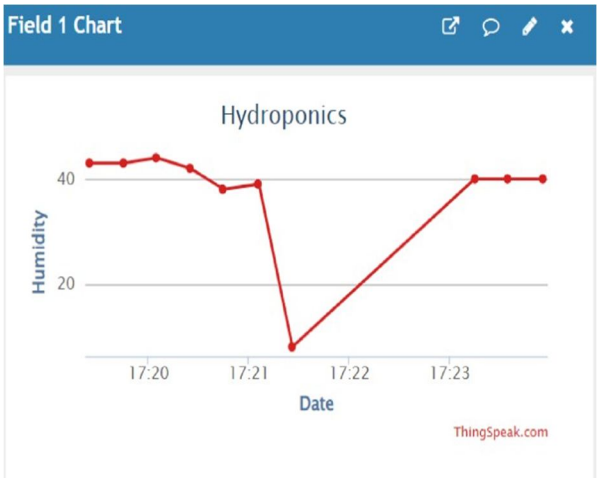


Fig4: DHT11 Humidity

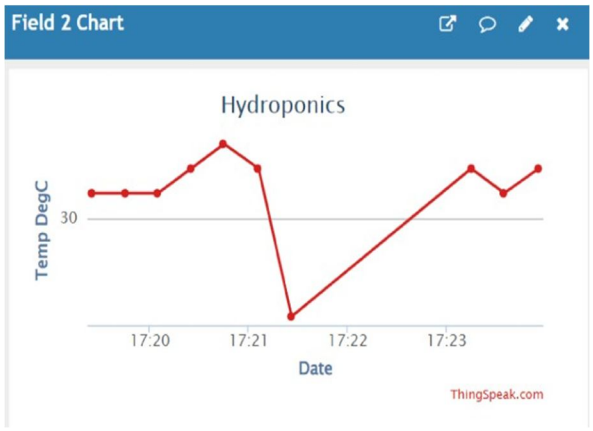


Fig5: DHT11 Temperature

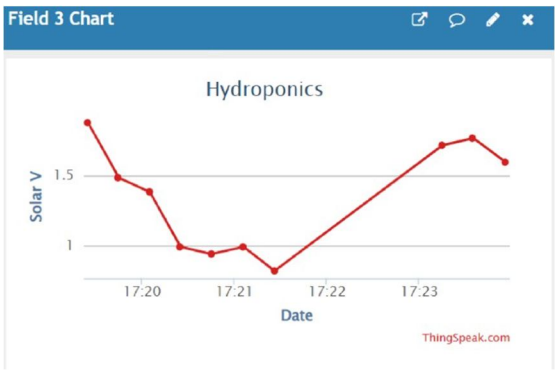


Fig6: Solar voltage

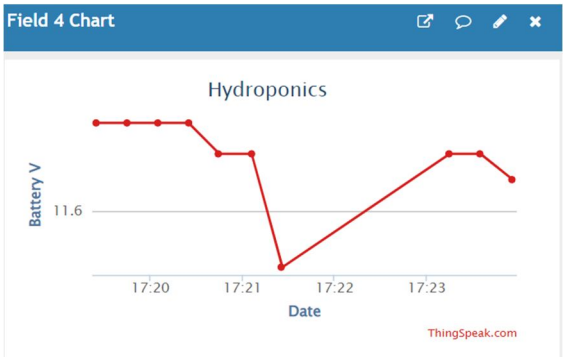


Fig7: Battery Voltage

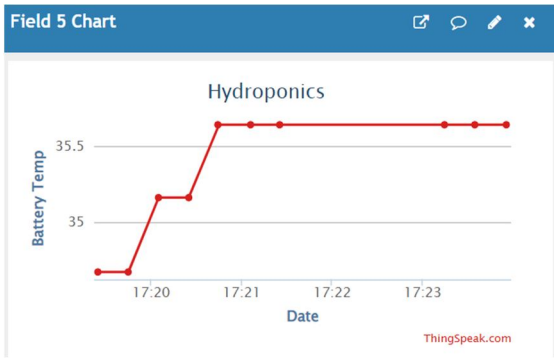


Fig8: Battery Temperature

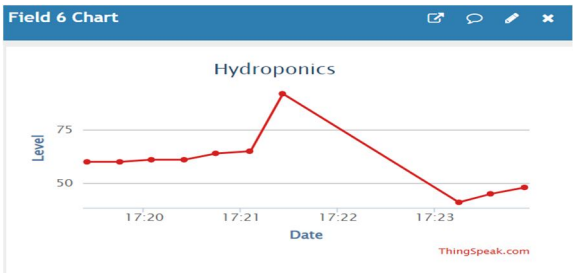


Fig9: Water level

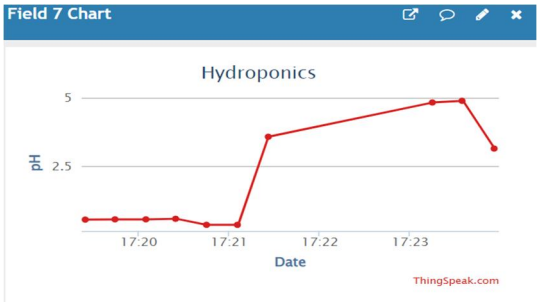


Fig10: pH

The primary parameters [7] that are handled by this system are those that are displayed above. These parameters are tracked and managed for automated purposes in a hydroponic plant monitoring system.

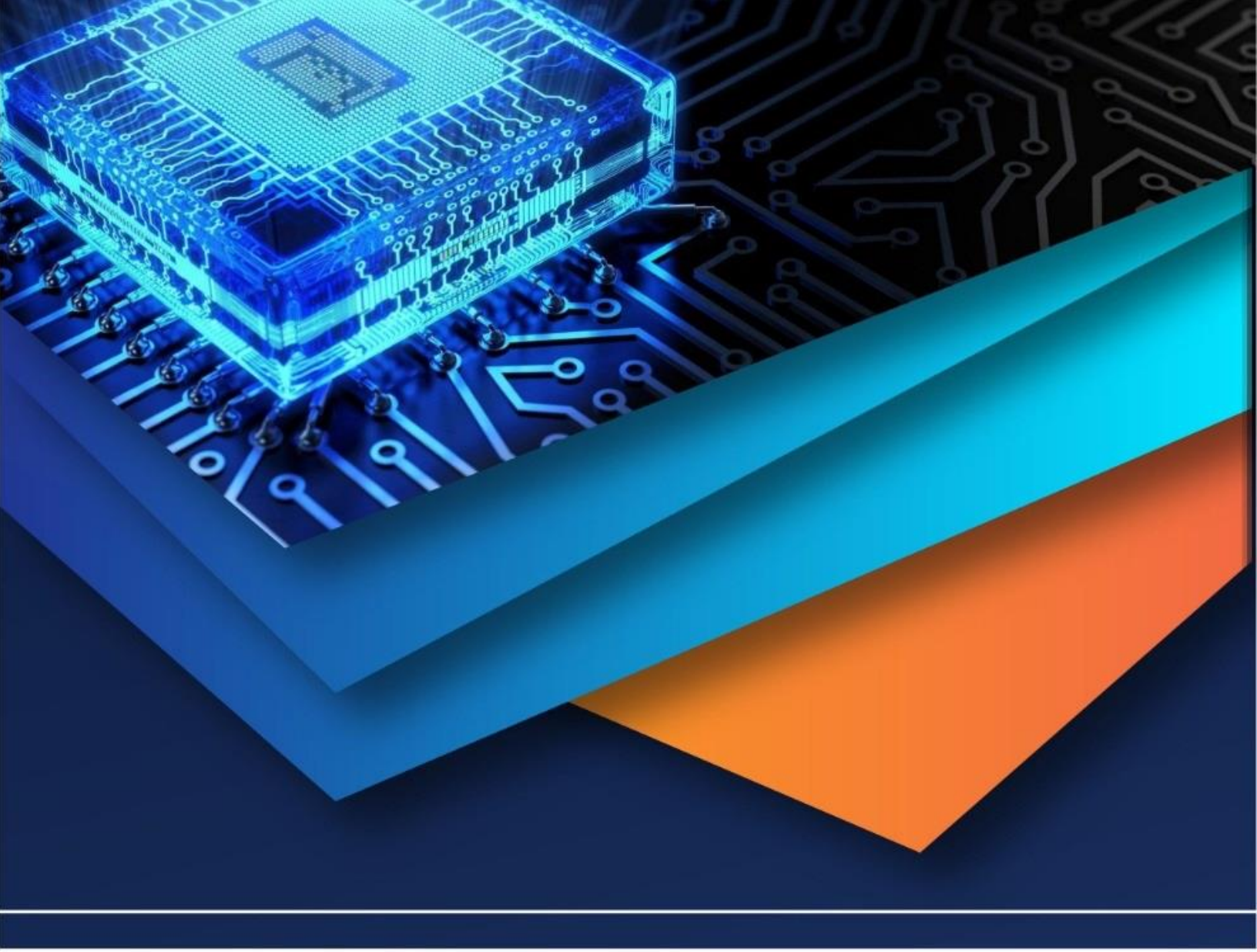
V. CONCLUSION

The plants in Nutrient Film Technique (NFT) may be cultivated utilizing vertical farming, reducing the area needed for hydroponic plantations. Due to the roots' direct access to the nutrient solution, plants grown in hydroponic systems grow twice as quickly. So, it is the most effective technique to provide the plant with the proper nourishment. An overview of soilless culture is followed by a management and monitoring system for hydroponics cultivation. The system's attributes make it a good choice for agricultural applications. More and more people understand that the Internet of Things (IoT), one of its most popular uses, will spur universal advancement in smart life. One of the most popular demands is the ability to communicate online with hydroponic system using mobile phone through social communication platform.

This hydroponic system is designed with integrating features for every piece of hardware utilized. Each module and placement have been thoughtfully considered to optimize the performance. This system utilizes solar energy. It is successfully created and tested. The emphasis of this system is on improvements in hydroponic plant growing automation. The literature on automated hydroponic systems has been examined in this research. Little AI-based research has demonstrated that AI is a helpful tool for controlling the hydroponic system, but they are costly and demand much computing. The most appealing type of automation is IoT, which also offers flexibility during system design. Hence, enhancing the security of the hydroponic system is essential.

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