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IoT BASED SMART HYDROPONIC MONITORING SYSTEM

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Abstract

IoT-based method for monitoring and controlling hydroponic systems from scratch. High-yield, high-quality crops are important in today's agricultural industry because they contribute to overall productivity and quality. These goals can be successfully achieved through the integration of the best agricultural tools that play an important role in improving skills and business performance on the farm. While traditional manual maintenance methods are still common, they are now problematic due to their laborious nature and the risk of crop failure associated with improper care. This is where the control system can come into play, allowing instant monitoring and control of key environmental factors such as water temperature, pH, water level and moisture content. Leveraging mechanisms that connect complex sensors and actuators to platforms such as Arduino, the accuracy and response of this monitoring system is excellent. The seamless synergy of the Internet of Things (IoT) framework further enhances this configuration by supporting continuous data acquisition and retrieval from online storage facilities, enabling storage of important information and medication control. Additionally, the use of a mobile app allows users to understand the current status and performance of the hydroponic system directly from their smartphones, thus facilitating accessibility and providing the ability for remote monitoring. Going forward, the potential of this innovation lies in the ability to use data analysis tools and methods to improve decision-making and what is validated through continuous data and analysis. Finally, the futuristic approach not only changes the way agriculture is managed, but also creates new standards in productivity, sustainability and innovation in agriculture.

Index Terms: IOT, Hydroponic, Nutrient film technique (NFT), Arduino, Sensors, Sustainability.

1. Introduction

Agriculture, an important part of human life and economic maintenance, depends on the relationship between soil composition and nutrition. At the same time, the great impact of global warming and the increasing world has caused lands to become less suitable for agriculture. These declines pose a serious threat to the quality of many crops and increase the challenges facing agriculture. In response to this growing problem, over-reliance on chemical fertilizers and pesticides for a good harvest has become a necessary but dangerous practice. While these chemical products increase crop yields, their broader negative effects cannot be ignored. Careless use of waste and pesticides causes soil degradation, water pollution and many other negative effects on ecosystems and human health. But to these problems and environmental conflicts, a promising solution has emerged in the form of hydroponics, a new method that is changing the face of agriculture. Hydroponic systems provide stability and benefits to plants by overcoming the need for soil as a growing medium. Rooted in the use of water-soluble mineral solutions, hydroponics represents a revolution in agriculture, making plants more productive and productive.

The meaning of hydroponics comes from the verb "Hydro", meaning water and work, and represents the harmony of innovation and social thought. In this happy way, plants in the soil leave their roots in water or grow in a poor environment such as perlite or gravel. The dynamic versatility of hydroponic systems allows the use of a variety of nutrients, from organic substrates such as hatchery fish and duck cages, or carefully formulated chemical fertilizers. The basis of successful hydroponic growing is careful calibration and control of the growing medium. By controlling key factors such as moisture content, pH and precise nutrient levels, growers can achieve faster growth and yield larger yields. Good management of growth not only improves resource use, but also reduces environmental impacts, promotes sustainable agriculture and works well for future generations.

2. Literature Survey

Hydroponic systems use water-rich water as the growing medium for plants. The use of hydroponic systems in agricultural technology has increased significantly. The world may change some agricultural methods in food production [1]. One of the advantages of hydroponic growing systems is that they can control environmental factors to produce good results in the limited space of the vertical garden. Other benefits include reducing water loss through recycling, growing plants in a controlled environment (such as monitoring nutrients, plant insects, and other desirables possible for plants to grow), and controlling conditions, which would potentially have a good effect on vertical gardening. space. [2]. Kularbphyttong et al. [3] developed a strategy to control plant growth. The system controls important environmental factors such as temperature, humidity and water that affect plant growth. The application system automatically mixes selected chemicals to determine accuracy, collects information about the cost of mixing during planting, and can estimate the cost of food production and determine the profit of all products to help you decide on planting. Hu et al. [4] studied the effect of microalgae on plant growth and examined the removal of nutrients and wastewater in greenhouses from three vegetables grown hydroponically in greenhouses using nitrate-rich synthetic fertilizers. The results show that most vegetables are more profitable due to the use of microalgae as a sustainable production process. Puno et al. [5] developed a hydroponic system combining fuzzy logic and nutrient film technology. Thanks to this technology, many plants can be grown in a limited area. Monitor the importance of crop survival and use fuzzy logic to control freshwater pumps and tanks with high quality content. Water flow from the mixing tank is also monitored using sensors for conductivity, pH and tank water level data. Ramos et al. [6] developed an aquaculture system using feed membrane technology to study and develop algorithms that make water efficient by saving approximately 40% of electricity compared to traditional models.

3. Methodology

The approach to IoT-based smart hydroponic monitoring systems involves several key steps to ensure efficient operation and data collection. First of all, it is important to choose the right sensor, taking into account factors such as accuracy, reliability and compatibility with the hydroponic environment. These will include sensors to monitor pH, nutrient concentration, temperature, humidity and water level. Once the sensors are selected, the next step is to install them in the hydroponic system. This often involves setting up hardware and connecting to transfer data to a central hub or IoT gateway.

Additionally, the system needs to be configured to receive, process, and store sensor data efficiently. IoT platforms play an important role in this approach and act as the interface between sensors and end users. It should facilitate instant monitoring, data visualization and analysis capabilities. Cloud-based platforms are often preferred due to their scalability and accessibility, allowing users to access data remotely from any internet device. Finally, ensuring the security and reliability of the IoT infrastructure is critical. Overall, a clear approach to IoT-based smart hydroponic monitoring systems includes sensor selection, integration, IoT platform development, data analysis and security measures and is cyber-engineered to ensure efficient and reliable operation for efficient cultivation and production.

4. Block Diagram

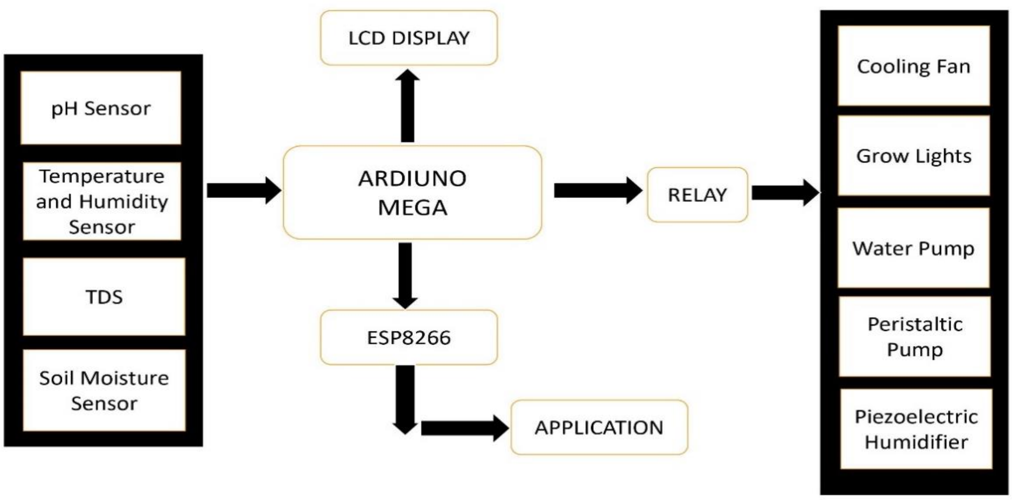

Fig.1: Block Diagram of IoT Based Smart Hydroponic Monitoring System

5. Implementation

Fig.2: Hydroponics Stand Front View

Fig.3: Hydroponics Stand Side View

In hydroponic farming, the process begins by seeding plants in traditional soil until their roots establish themselves. Once the young plants reach a suitable stage, they are carefully transplanted into a hydroponic system. This system comprises an intricate network of pipes filled with a precise blend of nutrient solution, meticulously prepared to provide essential nutrients typically obtained from soil. These nutrients are expertly mixed into the water reservoir feeding the pipes. The strategic placement of the plants ensures their roots have direct contact with the nutrient-rich solution, allowing efficient uptake of moisture and nutrients. This innovative approach guarantees optimal nutrition for the plants, ensuring unhindered growth without deficiencies and facilitating robust photosynthesis, vital for overall health and development. The tailored environment provided by hydroponic farming exemplifies a harmonious blend of scientific precision and natural processes, offering a sustainable and efficient method for cultivating healthy, flourishing plants.

Hydroponic farming employs the Nutrient Film Technique (NFT) as its primary system. This system includes a grow charger containing essential water and nutrients, while net pots house plants and growing media. A return system guides used nutrient solution back to the source. The grow charger is set at a pitch, allowing water to flow down towards the nutrient return pipe. Any excess nutrient solution exits through this pipe, entering another channel for uninterrupted circulation. The roots of the plants pierce the shallow film of nutrient solution, absorbing vital nutrients for growth. This system also keeps the upper portion of the roots dry, providing them with oxygen for optimal development. While growing media are often used, some farmers choose to forego them in the NFT system.

A smart hydroponic monitoring system integrates various components to automate and optimize the hydroponic environment. At its core, an Arduino Mega Board serves as the central control unit, receiving data from sensors and controlling output devices. pH and conductivity sensors continuously monitor the nutrient solution's acidity and concentration, ensuring optimal growing conditions. Temperature and humidity sensors track environmental parameters for plant health adjustments.

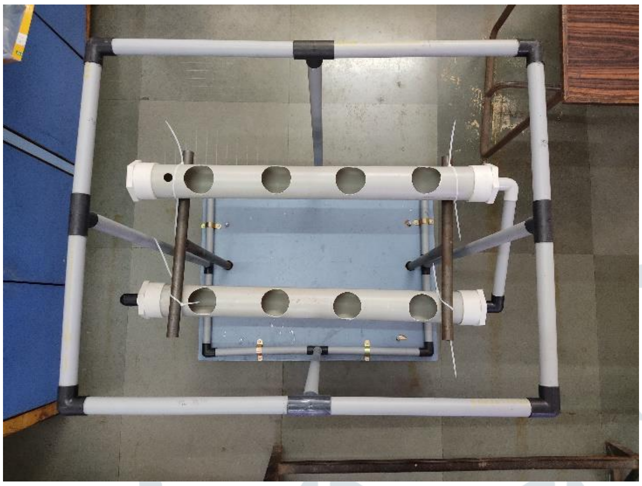

Fig.4: Hydroponics Stand Top View

The L298N driver module controls a motor for nutrient mixing or water circulation, while a Bluetooth module enables remote monitoring and control via mobile devices or computers. An LCD display provides real-time feedback on system parameters. Grow lights ensure plants receive adequate illumination for photosynthesis, while a cooling fan helps regulate temperature. Together, these components create an efficient, automated hydroponic system capable of maintaining ideal growing conditions for plants.

6. Advantages

- Hydroponics, used in areas with severe soil degradation, can be grown indoors.
- Used for landscaping terraces.
- Soilless agriculture.
- The plant can be grown all year round both indoors and outdoors.
- Reduce water consumption.
- Multi-level farming increases crop yield per area.
- Plants grow faster and are organic in nature.
- Soil pests are eliminated, reducing the need for pesticides.
- Efficient use of nutrients.

7. Simulation in Cirkit Designer

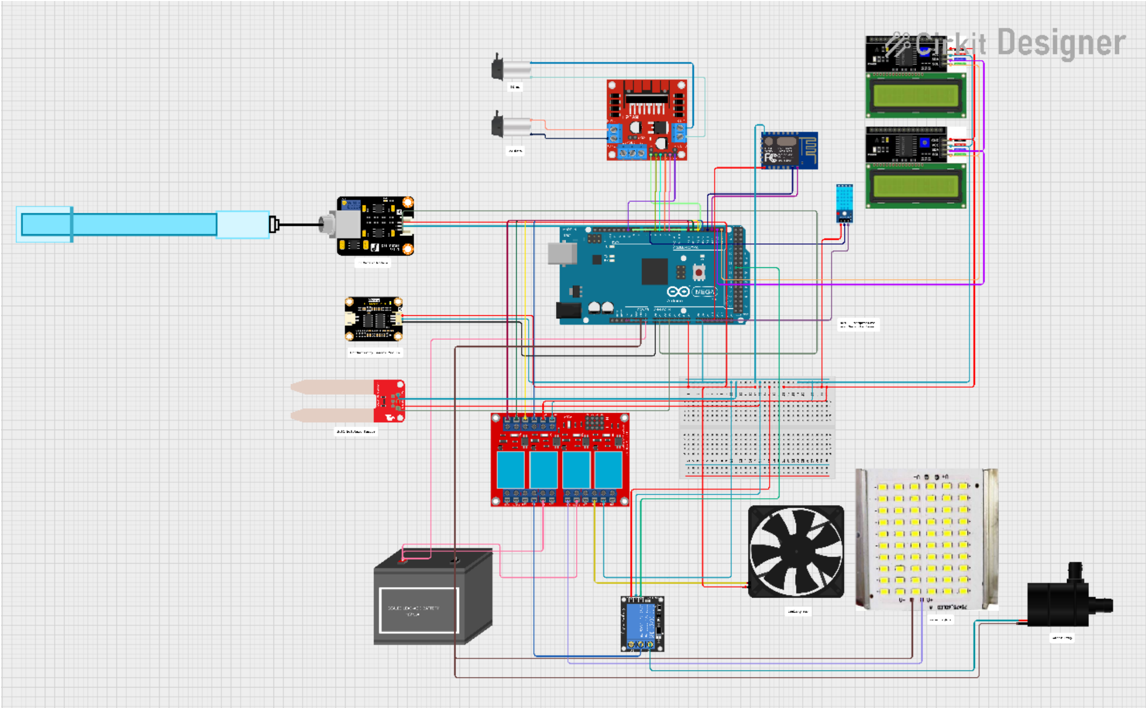

Fig.5: System Simulation in Cirkit Designer

8. Observation Table.

The ideal environmental conditions for a range of plant species grown hydroponically are shown in this table. For common hydroponic crops such as lettuce, tomatoes, cucumbers, basil, spinach, and coriander, it contains suggested TDS levels (in parts per million), pH ranges, temperature (in Celsius), and humidity percentages. These recommendations can be used as a guide to keep hydroponic systems operating at optimal conditions and to maximize productivity.

Sr.No.	Plant	TDS (ppm)	pH	Temperature (°C)	Humidity (%)
01.	Coriander	800-1200	5.5-7.0	18-24	50-70
02.	Spinach	1000-1500	5.5-7.0	18-24	50-60
03.	Lettuce	800-1500	5.5-6.5	18-24	50-70
04.	Basil	1000-1500	5.5-6.5	18-24	50-70
05.	Tomatoes	1000-2000	5.5-6.5	18-24	60-80

"Temperature and humidity values, TDS, and pH values that we observed for coriander and spinach."

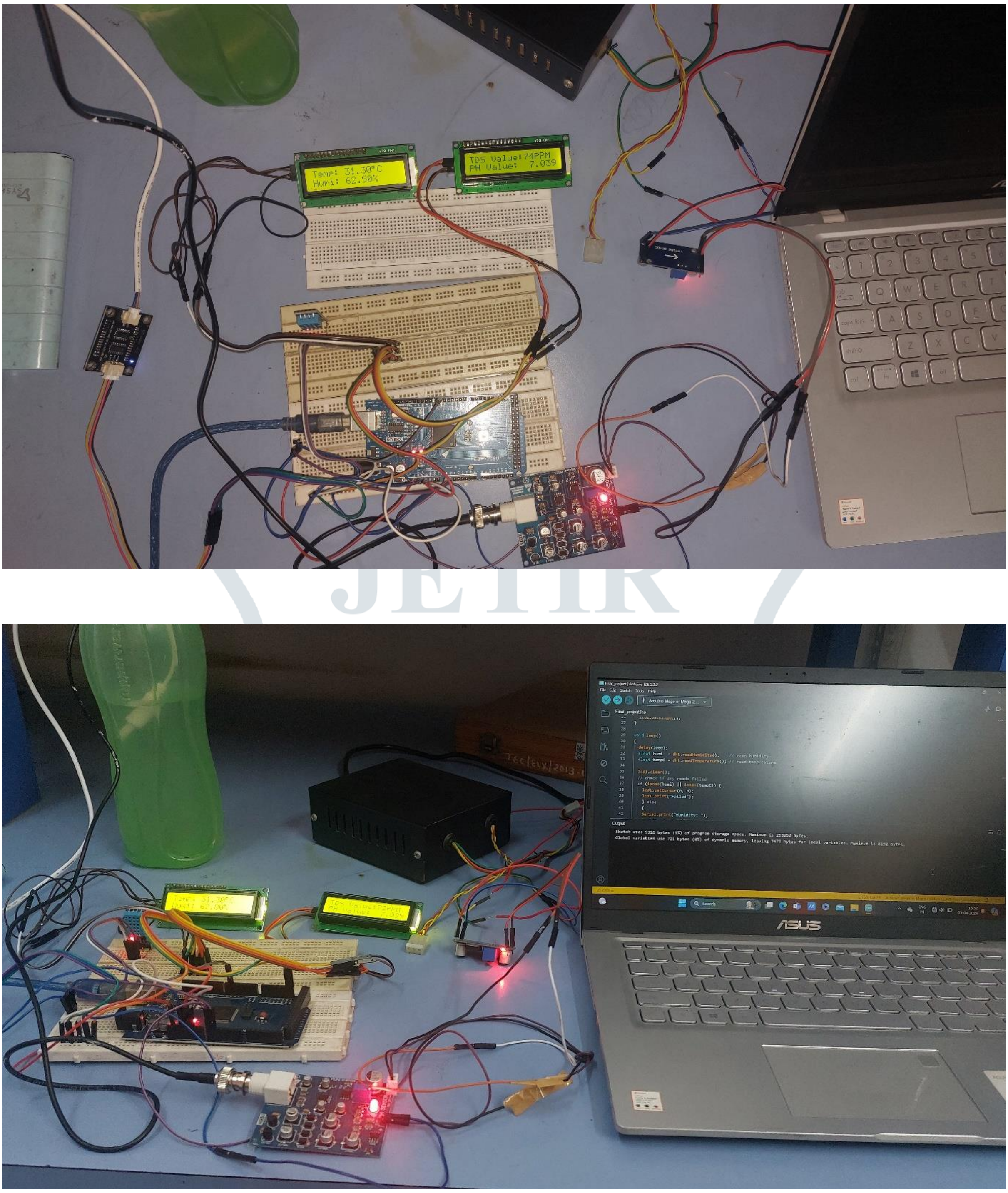

Fig.6: Prototype of the "Temperature and humidity values, TDS, and pH values

9. Conclusion

Hydroponic cultivation, the method of growing plants without soil, has been a focal point of our discussions regarding its control and monitoring processes. Our system exhibits significant potential for agricultural applications. In the present era, the Internet of Things (IoT) has revolutionized various aspects of life, prompting us to integrate hydroponic devices with social media platforms. By means of applications, individuals could engage with their hydroponically grown plants virtually.

Hydroponic farming represents a progressive approach that markedly reduces costs by eliminating the necessity for fungicides, pesticides, and soil preparation. It mitigates water wastage, optimizes growth, and diminishes the prevalence of pests and diseases transmitted through soil. Furthermore, the integration of IoT technology has enhanced hydroponic farming, enabling the creation of intricate setups such as rooftop farms, vertical farms, and green buildings in close proximity to urban areas. Through IoT-enabled monitoring systems, the strategic placement of these setups minimizes transportation expenses and ensures the safe and efficient transit of plants. Comprehensive websites aggregating sensor data allow farmers to refine their farming practices and access crucial insights. Growing concerns about diminishing arable land, water scarcity, climate change, and population expansion have heightened the awareness of governments and businesses regarding the potential of hydroponics. Consequently, this practice is witnessing widespread adoption.

10. Future Scope.

Many hydroponic farms enabled by IoT technology, including rooftop, vertical, and green buildings, can strategically position themselves near urban areas. This placement not only reduces transportation costs but also ensures the safe transport of IoT plants. To efficiently manage these farms, developers can create a user-friendly standard website. This website would collect sensor data and present it through visually appealing graphs, aiding farmers in gaining valuable insights and making informed decisions about their crops. Moreover, integrating IoT technology in these farms will open avenues for research, turning each farm into a hub for innovative agricultural studies. Given the challenges of limited arable land, water scarcity, rising costs, climate change, and a growing population, it is expected that both government entities and large corporations will increasingly invest in hydroponic farming solutions. This shift toward hydroponics is motivated by the urgent need to address these complex challenges with sustainable and technologically advanced agricultural practices. By harnessing IoT technology in hydroponic farming, stakeholders can strive to enhance food production efficiency, reduce environmental impact, and ensure food security for future generations.

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