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Automated Mixing Process for Solar Powered Fertigation System Using IoT Application

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Abstract: The rising population globally, along with the need to maintain sustainable food production, has increased demand for efficient agricultural practices. Fertigation is the combination of fertilization with irrigation, has emerged as an effective method for increasing harvests while using less resources. The problem of traditional method are inefficiency and inaccuracy of manual fertilization methods in agriculture. The traditional methods of fertilization rely on manual application of fertilizers, which can be time- consuming and labor-intensive. Additionally, manual methods can lead to over- or under-fertilization, which can negatively impact plant growth and yield. As a solution, an automated mixing process for fertigation system powered by solar using IoT application was developed to solve the problem. This system can be controlled using a smartphone and all the process from flowing the fertilizer to a mixture tank and watering the plant can be automatically implemented. The nutrient for each type of plant can be established using Blynk application such that the plant could grow properly. This prototype can also help the user monitor the level of fertilizer in the tank in which the user gets a message from the smartphone if the fertilizer level is decreased or low. The data collected is the time taken by the system to mix the setup value of the solution using Electrical Conductivity (EC) sensor. It can be concluded that if the setup EC value in Blynk is large, the time taken to mix the solution increases Another result is monitoring the fertilizer level of fertilizer in two tanks. In this case, the ultrasonic sensor detects the distance of fertilizer in both tanks and if the level of fertilizer in the tank is low, a notification will appear in Blynk application, stating that the tank level is low. All the output from this system is proven to be successful in this work.

Keywords: Solar energy, automatic mixing system, fertigation system

1. Introduction

Agriculture is one of Malaysia's most significant sectors [1]. Fertigation is the process of applying fertilizers to plants through an irrigation system. It is a method of fertilization that uses precision irrigation techniques to deliver the right amount of nutrients to the plants at the right time [2]. This method of fertilization is becoming increasingly popular in agriculture as it allows for more precise and efficient use of fertilizers, which can lead to improved plant growth and increased yields [3]. Plants rely heavily on fertigation and irrigation systems to produce high yields. Different types and combinations of fertilizers are used by different plants [2]. The EC measurements are often used to assess the efficiency of fertilizer mixes on plants [4]. Due to mixing procedures and processes, the accuracy of an EC value might be difficult to attain in a short amount of time. As a result, an automated fertigation system is viewed as a feasible option for achieving the exact specified concentrations (EC values) in the fertilizer mixing process.

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Fertigation systems offer many benefits over traditional methods of fertilization. They can save time and labor, reduce fertilizer waste, and improve crop yields. Fertigation also allows for a more precise and efficient application of fertilizers, which can lead to better plant growth and increased yields [5]. Additionally, fertigation systems can be used to apply other soil amendments such as micronutrients, pesticides and growth regulators. Overall, fertigation is a modern and efficient method of fertilizer application that can help to optimize crop growth and increase yields. The development of an automated mixing process for fertigation systems by using IoT applications is very crucial and can be applied in Malaysia as it provides a low-cost solution for precise control of all automated processes. The developed system that is powered by solar power system will be tested for its effectiveness in optimizing the process of nutrient mixing with water and injection them into the crops according to the EC rate of plants and simultaneously monitoring all main parameters in the fertigation system by using IoT [2], [6,7].

The smart security and monitoring system for agriculture has been developed in this paper [8]. In this project, the system integrated Raspberry Pi as a utilization of the Internet of Things and sensors to improve the efficiency of agriculture. This project enables the user to monitor the output which are temperature, humidity, and soil moisture of the crops. The temperature sensor, humidity sensor and water level sensor were used in the irrigation process.

The objectives of this project are to develop the automated mixing process for the fertigation system using the Blynk application, to integrate the PV panel and controller system design and to evaluate the performance of the automated mixing process for the fertigationsystem and EC value of the solution.

2. Methodology

In this part, it focuses on the methods and the flow process of the project. The aim is to step to modeling and hardware design for the prototype of solar power automated mixing process for fertigation system using IoT application.

2.1 The Process of the Project

The flow of the project which consists of designing, simulating and developing the prototype and integration system needs to be planned correctly according to the step in Figure 1 and Figure 2 shows the flowchart of the system. Figure 1 shows the flow chart of the process of the system. The system is on when it connects to the Wi-Fi. LCD will display the value of EC that is measured by the EC sensor. The Blynk application can be used after connecting to Wi-Fi. In the Blynk application, it will display the button OFF, EC value, temperature, tank A and B, EC setting and water timer setting. If the user has already set the EC setting and water timer setting, press the OFF button to start the whole process of the system. After the EC sensor in the mixture tank achieves the EC setting value, the pump in fertilizers A and B will be off and the plant pump will be turned on and flow the solution to the plant within the time that has been set up in Blynk. Then, the system will be turned off. In fertilizers A and B, there is an ultrasonic sensor that will detect and measure the level of fertilizer. If the fertilizer level is not in the range or low, a notification will appear in the Blynk application to alert the user to top up the fertilizer in that tank.

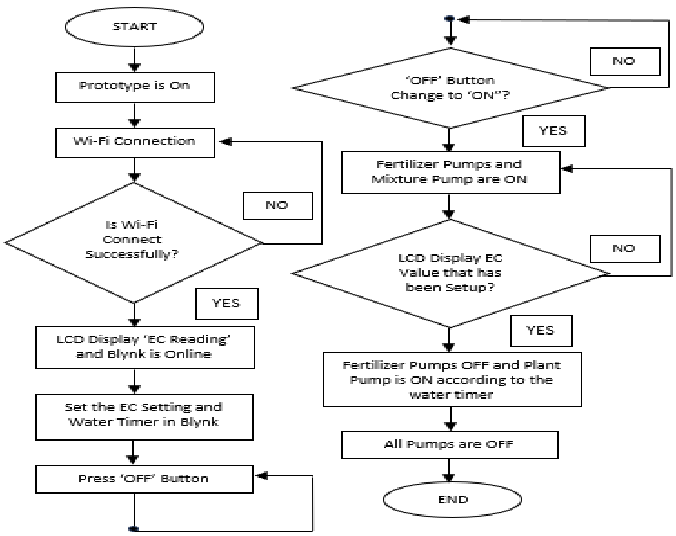

Fig. 1 - Flowchart of the system

The solar power supply consists of a 20-watt mono-crystalline photovoltaic (PV) solar panel, a solar charger controller rated at maximum 6A for solar panel and load, and a battery. The charging controller has a 14.3 V regulatory voltage and low voltage disconnects occur at 11.5 V and 12.6 V reconnected voltages, respectively. The 12 V, 6 Amp/hour battery is rechargeable, sealed, and made of lead acid. The EC Sensor will be used as a sensor to read the EC level. As its job is to regulate the opening and shutting of an electrical circuit's circuit connections, the relay will be coupled to DC water pumps. The nutrient EC level data will be sent to the ESP32 board and saved in the Blynk application as part of the Internet of Things implementation (IoT). The hardware must be tested to ensure that it functions properly and by the plan. If it functions well, the mistake must be recognized and corrected. Figure 2 shows the block diagram and components of the automated fertigation system solar-powered using the Blynk application.

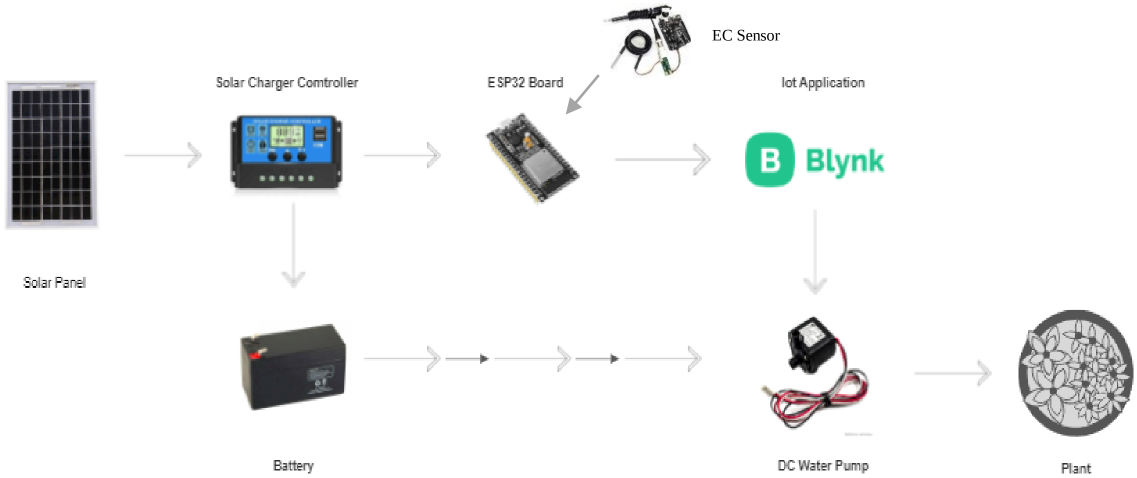

Fig. 2 - Block diagram of the system

In Figure 2, there are three parts which are the source which is a solar panel, the ESP32 board is the system that will be connected with the Blynk application and the last one is the plant. A 20-watt mono-crystalline photovoltaic (PV) solar panel, a solar charger controller rated at maximum 6A for solar panel and load, and a battery comprise the solar power supply. The charging controller has a 14.3 V regulatory voltage, low voltage disconnects occur at reconnected voltages of 11.5 V and 12.6 V, respectively. The 12 V, 6 Amp/hour battery is rechargeable, sealed, and lead-acid in construction. Analog EC Meter SKU: DFR0300 EC Sensor Module will be used as a sensor to read the value of the EC level.

As its job is to regulate the opening and shutting of an electrical circuit's circuit connections, the relay will be coupled to DC water pumps. The nutrient EC level data will be sent to the ESP32 board and saved in the Blynk application as part of the Internet of Things implementation (IoT).

3. Results and Discussion

This part described and examined the results and design of a 3D model for an automated mixing process for a fertigation system. Sketchup software was used to create the 3D model. To proceed with hardware development, the circuit connection in this project must be simulated using Proteus 8 Professional and Arduino IDE software.

3.1 3D Design of the System

The project's design must be displayed in 3D to guarantee that it is more realistic when making hardware for this project. In this program, all the major components were developed in 3D. The 3D model design is shown in Figure 3 and Figure 4.

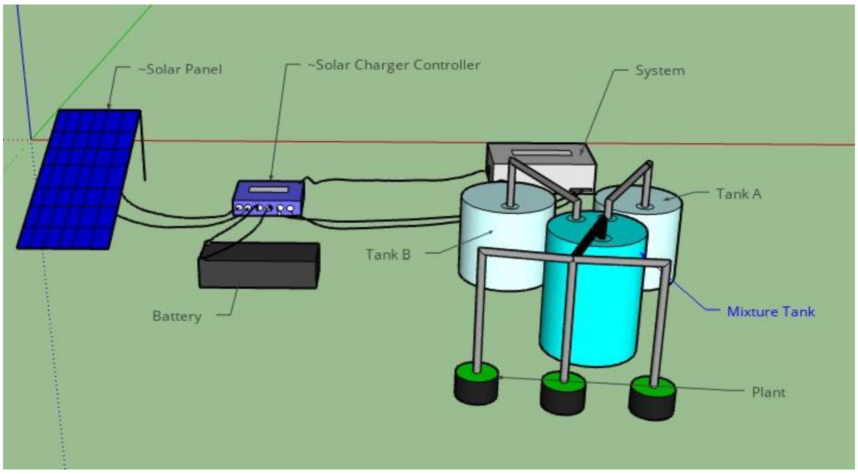

Fig. 3 - Front view of 3D

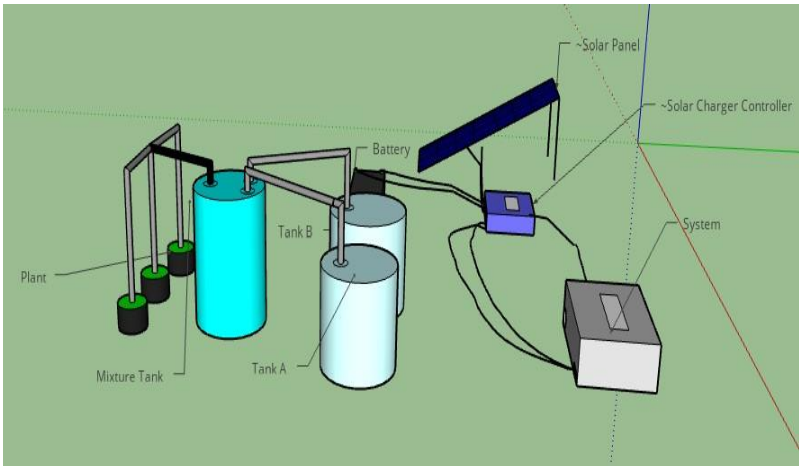

Fig. 4 - Side view of 3D model

3.2 Circuit Simulation

Figure 5 shows the whole circuit for the automated mixing process for the fertigation system. In Proteus 8 Professional, there are a lot of limitations, including a non-existent EC sensor component. In this case, the EC sensor will be replaced with a potentiometer. EC sensor will measure the value of EC of fertilizer for this system so replace it with a potentiometer that will measure voltage. The value of the EC is also measured in voltage.

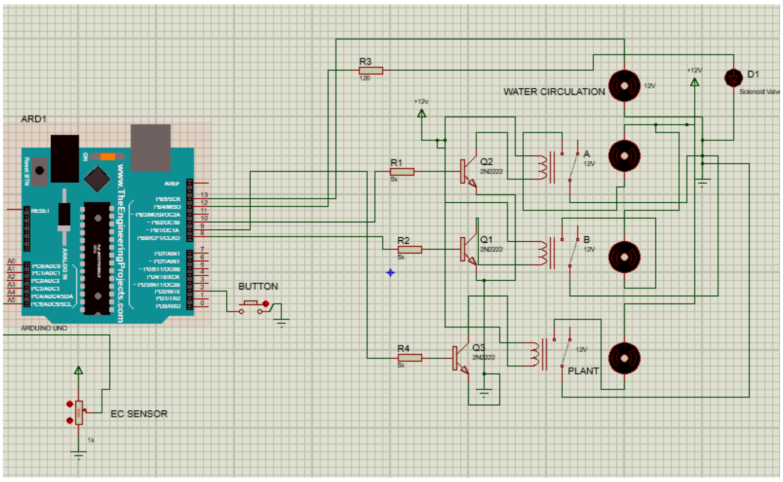

Fig. 5 - Circuit design for automated mixing process for fertigation system

Figure 6 shows the system is on. When the push button is pressed, the system starts. The circulation pump will turn on with the fertilizer pump which is pump A and pump B. Before all the pump that has been mentioned turn on, the relay for pump A and B will trigger first so the pump will be turned on. EC sensor will also measure the EC value of the solution in the mixing process.

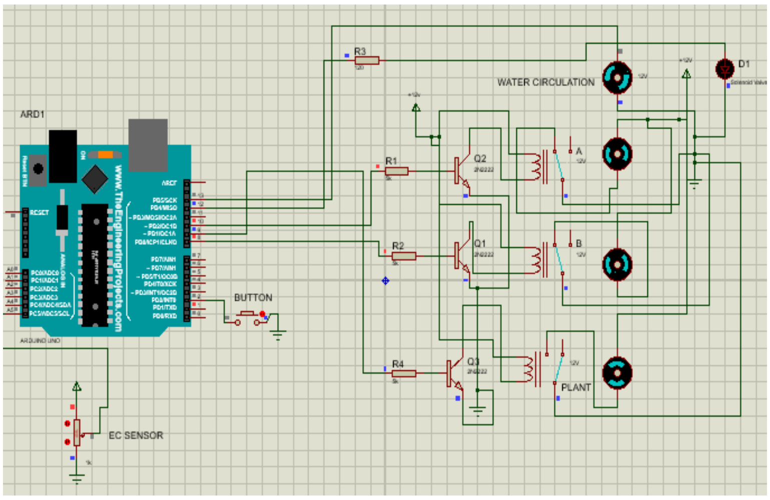

Fig. 6 - System is on

From Figure 7, the pumping plant which is a pump that pumps the mixing fertilizer and water to the plant is turned on and pumps A and B will be turned off. During this time, the EC sensor measures the value of EC that has been set for the plant. After a few minutes, the mixing pump and the pump plant will be turned off which is the last process for the system. Meanwhile, Figure 8 shows the system is off.

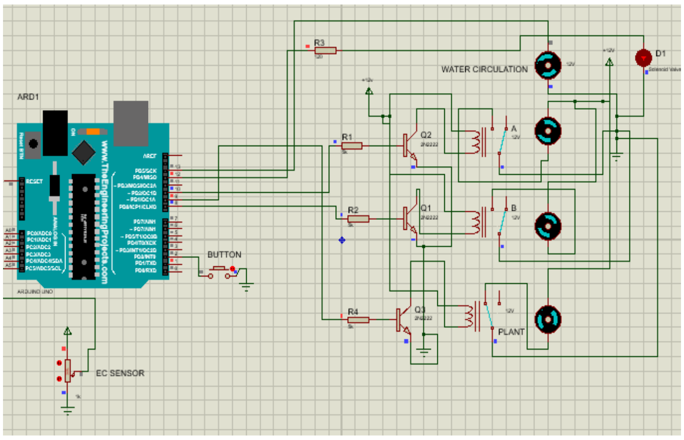

Fig. 7 - Pump plant is on

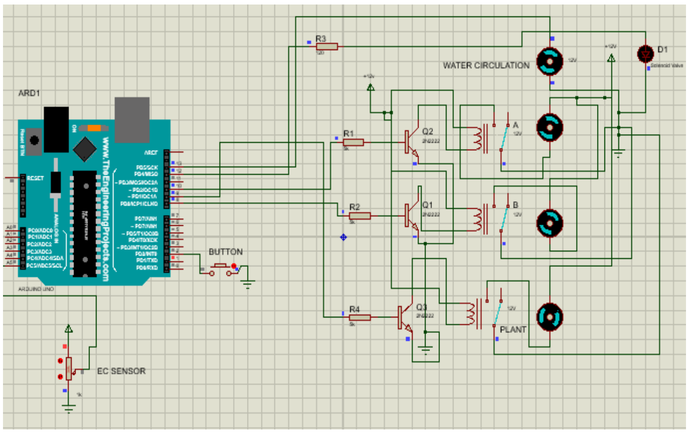

Fig. 8 - The system is off

3.3 Hardware Development

A prototype for an automated mixing process for the fertigation system has been developed with the solar panel and microcontroller components to show how the system works. Two results need to be studied and analyzed which are how long does it take for the fertilizer and water to mix properly according to the EC value that has been set and the output in the Blynk application if the level of fertilizer in both tanks decreased. Figures 9 and 10 show the hardware design.

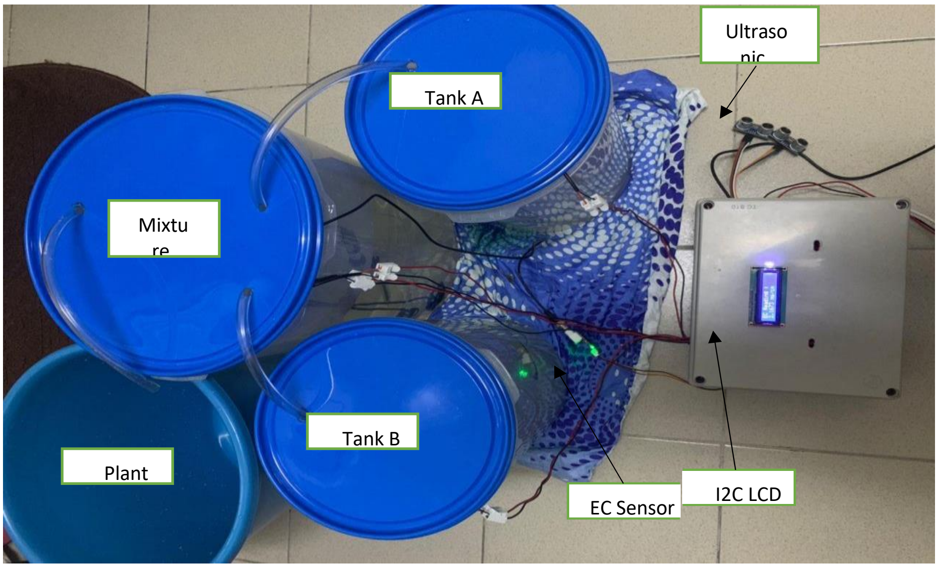

Fig. 9 - Prototype design for automated mixing process for fertigation system

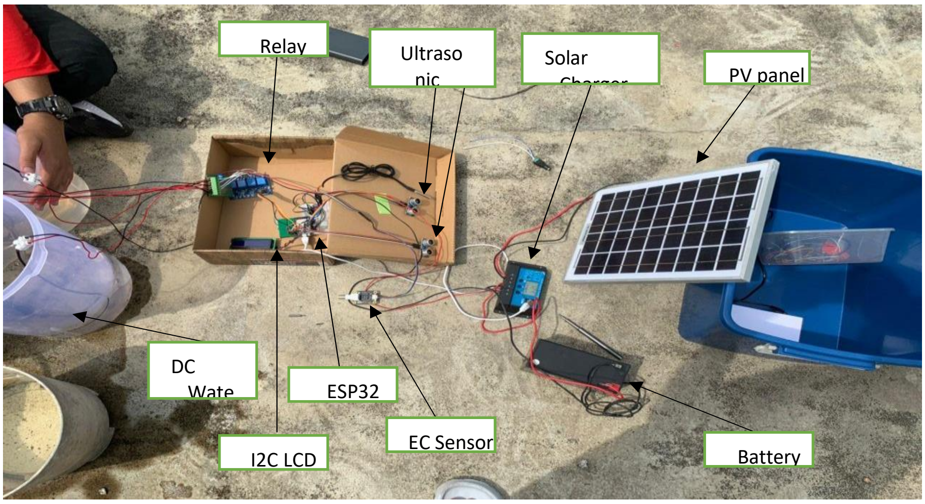

Fig.10 - Prototype design for automated mixing process for fertigation systempowered by solar panel.

3.4 Results and Discussion

The result of the hardware for the automated mixing process for the fertigation system using the Blynk application will be discussed in this section. The time taken for the solution to mix properly automatically will be recorded and the result if the level of fertilizer in tanks A and B decreases.

(A)Result of Time Taken for Mixing Process

To evaluate the performance of the automated mixing process for the fertigation system using IoT application by taking the time that the system takes to mix the fertilizer A and B and water according to the EC value that has been set up in the Blynk application. Then, set up different EC values and record the time taken by the system. Table 1 shows the time taken by the system to mix the solution properly according to the EC value that has been set up in the Blynk application.

Table 1 - The time taken of the system to mix the solution properly according to the EC Value

EC Value (*mS/cm*)	EC Value From LCD	Time Taken (*s*)
2		2.03
4		6.67
6		9.06
8		15.62

Figure 11 shows the graph of EC Values versus time. Form the result, it can be concluded that when the EC value set in the Blynk application increases, the time taken by the system to mix the solution properly according to the EC value that has been set up in the Blynk application also increases. Furthermore, based on the graph, the graph shows the linear trendline. Besides that, the accuracy of the system is not accurate at all because when the system is stopped, the value of the EC will not be the same as the value that has been set up in the Blynk application such as the value of EC that set up in Blynk is 2, the EC value of the sensor detect is 2.1. This is because the solution is not mixed very well and the EC value of the solution is not stable.

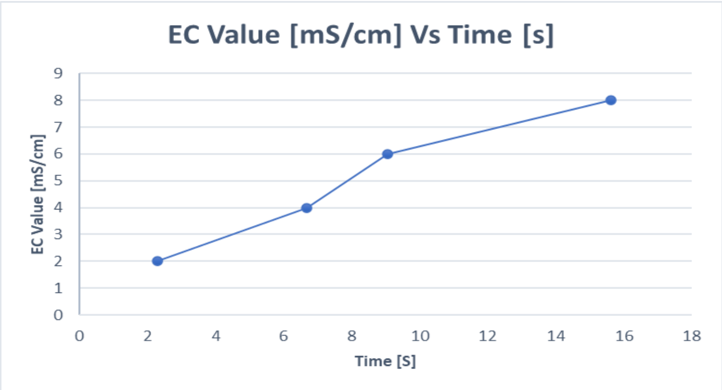

Fig. 11 - Graph of the EC value vs time

(B) Result of the Fertilizer Level

Another data that wants to be collected from this system is to get a message or notification from the Blynk application if the fertilizer levels A and B are in low condition or decreased. It will alert the farmer that the farmer needs to top up the fertilizer or cannot use the system because of not enough fertilizer. Figures 12 and 13 show the message or notification from the Blynk application.

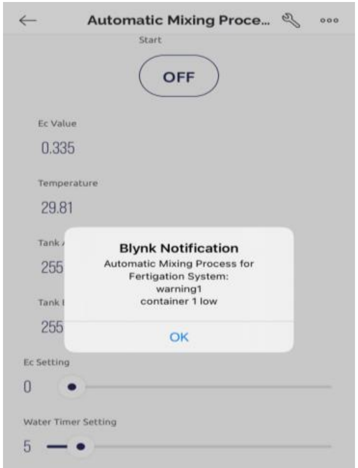

Fig. 12 - Notification from Blynk for Tank A

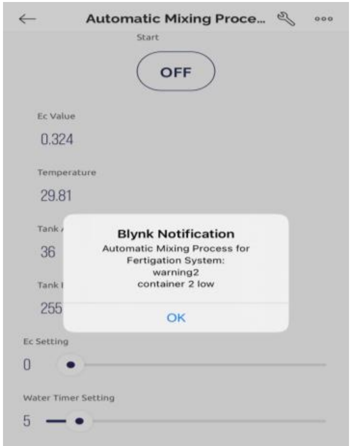

Fig. 13 - Notification from Blynk for Tank B

From the notification, the system has another function besides the automated mixing process for the fertigation system. The ultrasonic sensor will detect the fertilizer in tanks A and B from the top of the tank. If the distance of the fertilizer increases and the notification pops up, it means the fertilizer is decreased and not at a sufficient level to use.

4. Conclusion

This project's objective is to develop an automated mixing process for a fertigation system using the Blynk application. The display of the system is designed using the Blynk application and controls the whole system. ESP32 board was used in this project to make sure that the system can be used and controlled via smartphone. The system also uses renewable solar energy. Based on this project, the second objective has been achieved which is to integrate the PV panel and controller system design. The system is powered by a solar panel through a solar charger controller and battery. The system can be turned on and work properly using the solar energy. From this objective, the usage of electricity can be reduced, and the electricity bill cost savings can be made. It will also impact farmers using this energy in the future to reduce energy waste. Furthermore, the last objective has been gained which is to evaluate the performance of the automated mixing process for the fertigation system. The evaluation has been proven to be successful in this project.

Another advantage of this system, the user can monitor all the equipment and functionality from the Blynk application such as the EC value of the solution, temperature, and fertilizer level, and can control the system via smartphone. The user also gets a message from the Blynk if the level of fertilizer is not within the range that has been set up. The user can save their energy and time by controlling the system via the Blynk application. The user can modify the system by themselves through Arduino IDE software. This system is suitable for a user who is interested in small-scale fertigation systems.

Lastly, the ability and cost of combining software and hardware into a project are based on their ability and cost to integrate efficiently with one another. Each component is critical to the system's operation. From the objective that has been stated for this project, all the objectives have been achieved and the system functions smoothly and very well.

Acknowledgement

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