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Herbs Smart Farming System Using Internet of Things (IoT)

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Abstract: Smart Herbs Hydroponic using (IoT) was developed to provide oversight to the gardener to start hydroponic crops on a medium or commercial basis. The development of this system through the ThingSpeak platform allows water pH level data and Electric Conductivity (EC) in the salt concentration in the nutrient solution to be stored in an online database. The developed hardware system consists of a pH sensor and an EC sensor. The sensor is able to detect value changes and restabilize the water condition by going through three stages. In state 1 EC levels below 1.4 mS/cc and pH values above 6.6 can only be compensated for by adding nutrient solution to the solution. In state 2, If the EC level is measured above 1.4 mS/cm and the pH level is measured above 6.6 and the solution system would add pH down to make the water more acidic. Lastly state 3, no solution would be added if the EC value is above 1.4 mS/cm and the pH value is below 6.6. The results of this project show that the change in water quality is due to plant nutrition and the mixing of foreign matter into the nutrient solution. The level of water quality can be characterized by several categories; 1.5 to 2.0 can be classified as good, below 1.5 and above 2.0 can be classified as harmful to herbaceous crops. For future proposals, this system may be, supplemented with roof control to prevent solution nutrients from mixing with foreign objects such as rainwater. Additional to this, LED lighting can be used in photosynthesis planting, converting this system into an indoor system.

Keywords: ThingSpeak platform, Hydroponic system, Nutrient solution, Internet of Things (IoT)

1. Introduction

In Malaysia, the rural population is the largest proportion of those in the B40 group. Most of the rural population is engaged in subsistence activities such as farming. Agriculture is one of the country's incomes especially herbaceous plants that are rising in their market price. However, the people in the country still use traditional agriculture. Using scientific systems such as hydroponics in agricultural activities can have a significant impact on improving crop production because of the high efficiency of the method of gardening [1].

Internet of Things (IoT) is not a new thing in Malaysia. With its ability, it can change the scenario of traditional farming methods for the better [2]. In addition, by using smart farming that can collect data from various tracking devices available on the farm and send the data to the main server to process agricultural activities. This method focuses on studying crop conditions to improve agricultural yields.

This Herb Smart Hydroponic IoT is proposed to be implemented in this project because of the frequent problems of gardeners with the crops [3]. The purpose of this project is to help gardeners monitor and increase crop yields without variance. This project can facilitate the work of gardeners to cultivate crops.

2.0 Methodology

This part is focusing on the project method advancing in building the project and achieving the objectives of the project, the approach method on data that will be gained from this project. Further discussion in this chapter was regarding the project workflow from a hardware perspective to the Internet of Thing (IoT) platform.

2.1 Block Diagram of the Project

The block diagram and some of the components for is smart herbal hydroponic system project is shown in Figure 1. The Arduino Uno microcontroller is powered by 5VDC. Other 5VDC and 12VDC are provided for the Wi-Fi module, water pump, and pump regulator. A pH sensor is used to detect the acidity and purity of water in a hydroponic system's nutrient tank, whereas an EC sensor is used to detect the concentration of a nutrient solution [4]. The Wi-Fi module serves as a link between the project and the user interface [5].
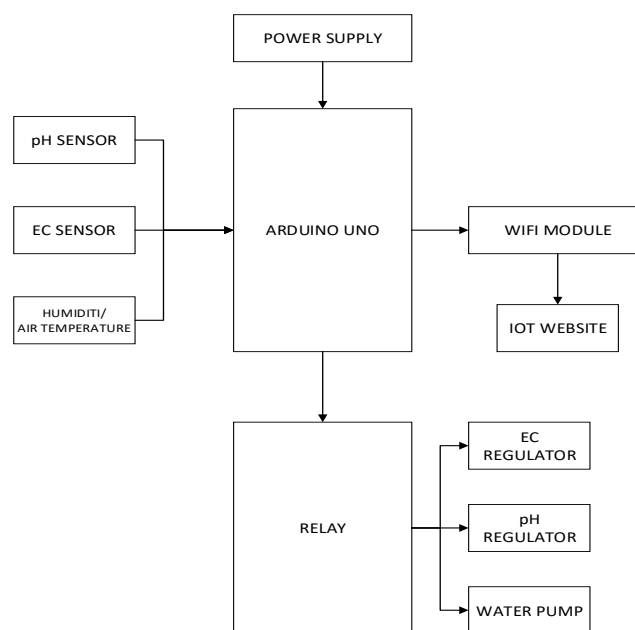
Figure 1: Block diagram of Smart Herbs Hydroponic System

2.2 Flowchart Process of the Project

Figure 2 shows the flowchart process of the project. The main process consists of program start, main loop, reading value of PH and EC sensors, sent to result sensor and time delay. This process connects hardware and software together.
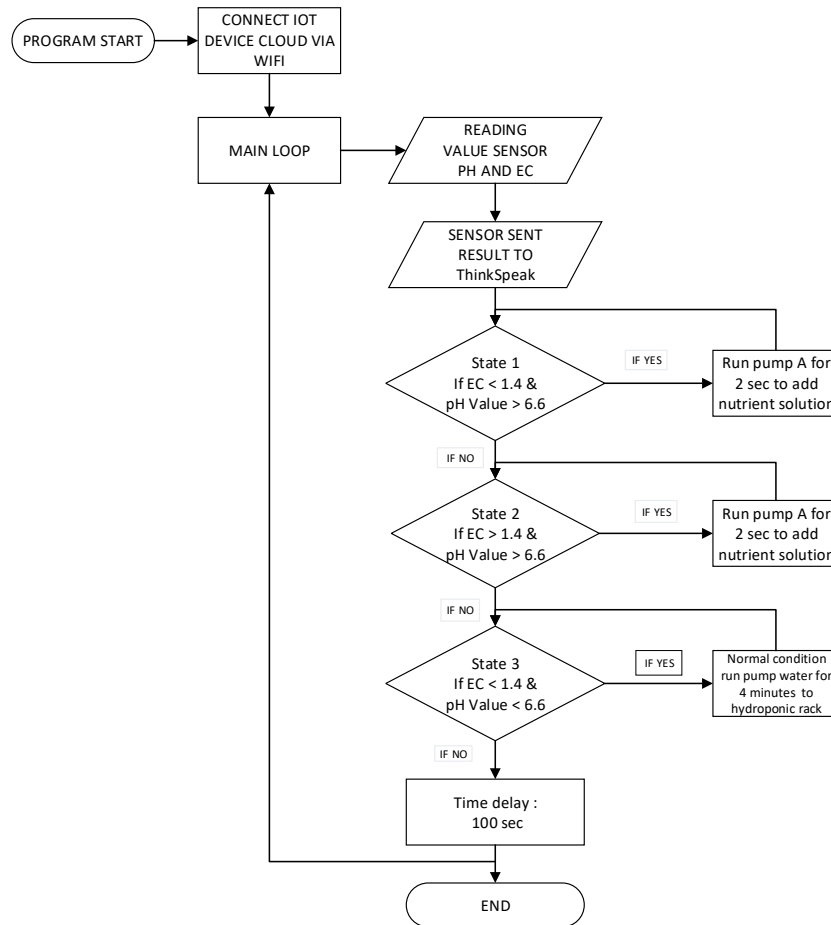
Figure 2: Flowchart Process of the project

2.2.1 Program Start

The code library, pin arrangement for the sensors, and relays that controlled the pumps were all included in this component of the software [6]. The information required by the Wi-Fi chip to connect to ThingSpeak is also defined at the start of the code.

2.2.2 Connect IoT Device

The Arduino chip began communicating directly with the Wi-Fi chip via serial ports, instructing it to connect to the previously configured network. If unable to connect, it will return to the main loop.

2.2.3 Main Loop

This was the cycle that got of the automation, causing the application to take readings from the sensors on a regular basis and upload the data to a ThingSpeak channel.

2.2.4 Reading Value EC and pH Sensor

The pH-sensor took ten sensor test results every time the pH was to be measured, which were then delivered to the Arduino's analog port as an array of 10 integers. The Arduino then turned the average into a pH value. The temperature sensor software was comparable to the pH sensor software in terms of functionality. The voltage drop between the poles of the probe was picked up by the Arduino as an analog input by setting the power supply to 5 V for the EC sensor.

2.2.5 Sensor Sent Result to ThingSpeak

The data was delivered to the ThingSpeak channel after the sensors had produced a set of values. Through the serial ports on the Arduino, commands would be sent to the Wi-Fi-chip. These commands would tell the Wi-Fi chip to use an IP address to connect to the ThingSpeak channel.

2.2.6 Parameter of Sensor

To restabilize the pH value and concentration of the solution in EC. A pump regulator is used to pump a tiny volume of liquid at once. Based on the three states listed below, the algorithm would pick which solution to be added to the solvent [8]. Table 1 shows the parameter of the solution in the stage.

Table 1: The parameter of solution in the stage.

	Parameter	Solution
State 1	If the EC level is measured below 1.4 mS/cm and the pH value is measured above 6.6.	The system would only compensate by adding nutrient solution.
State 2	If the EC level is measured above 1.4 mS/cm and the pH level is measured above 6.6.	The system would add pH down buffer to make the water more acidic.
State 3	If the EC value is above 1.4 mS/cm and pH-value below 6.6.	The system normal condition and run water pump to hydroponic rack.

2.2.7 Time cycle,

It was important to let the water solvent mix correctly if solution was introduced to the water solvent during the loop cycle. For the next loop cycle, faulty sensor readings could be avoided. As a result, after each Main Loop cycle, a 100 second time delay was applied.

2.3 Circuit Diagram

Figure 3 shows the design of circuit diagram of project. The circuit is designed by using Fritzing software.
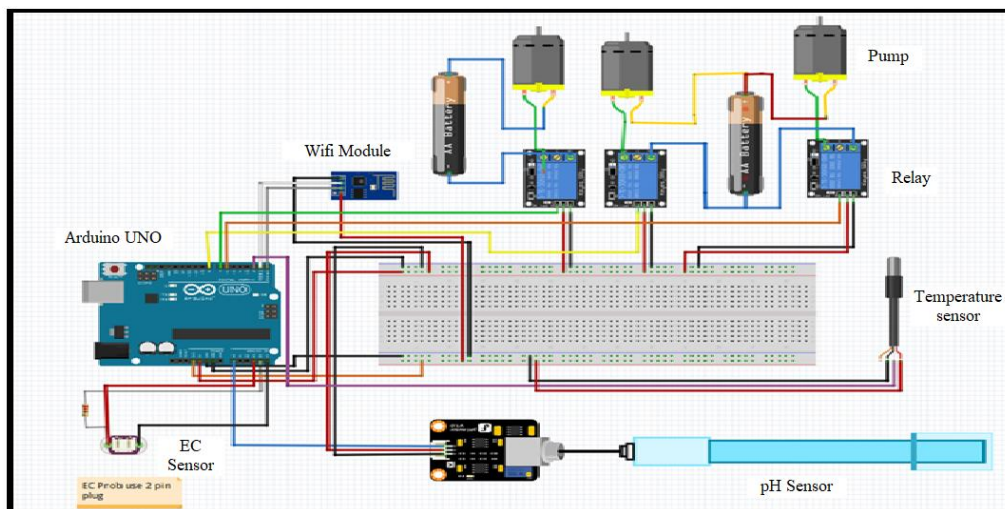

Figure 3: Circuit Diagram of project

The pH sensor probe was connected to the Arduino microcontroller using a pH meter board. The pH meter was powered by the Arduino microcontroller's analogue gates and 5V. The glass-bulb

electrode pH probe was used in this study. The probe could also be submerged for a long time [5]. This means it could measure the water solvent for a long time without calibration.

The EC meter is made of an EU power cord as a probe and a 1000ohm resistor. The Arduino microcontroller's A1, A2, and A3 analogue pins were then connected to the cable's two poles. The A2 pin is used as a ground reference for one of the power wire's poles. The A1 pin would power the power cord's poles to produce voltage. The A3 pin with a resistor would measure the voltage between the A1 and A2 pins. The Arduino chip would then convert the voltage input to an analogue value, which could then be converted to an EC value for the water solvent. The Wi-Fi module's serial ports were connected to the microcontroller's RX and TX serial ports to establish serial communication. The Wi-Fi chip was powered by the Arduino's 3.3 V port. Figure 4 shows the component of the herbs smart farming project
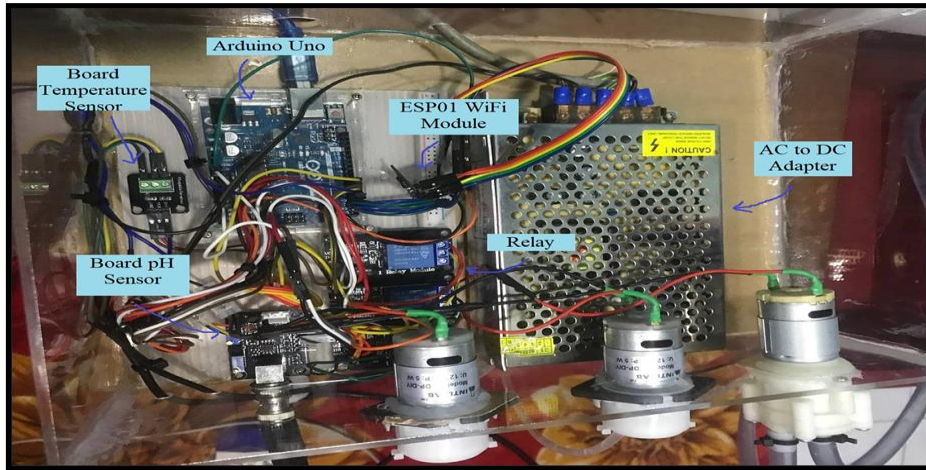

Figure 4: The component of the herbs smart farming project

In order to control each pump independently, the fluid pumps were linked in three separate circuits (Figure 3). These pumps only had three controls: full speed, liquid feed, and power output cutoff. So, in each of the two circuits, a relay board was installed. The relay boards were connected to the microcontroller's digital pins, 5 V for power, and ground. The pump DC motors were connected in series to a 5 V power supply, then to the normally closed (NC) port on the relay boards. The pumps were always off until the Arduino told the relays to open and turn them on.

3.0 Results and Discussion

This chapter analyzes the experimental results and progress of the project development for Herbs Smart Farming System using IoT attained from each phase of the methodology implemented. This chapter presents raw data in the shape of graphs. The information is acquired because of the various testing.

3.1 Arduino Software Performance for Prototype

The Arduino board was designed to download the Arduino software's code (IDE). The Arduino Uno enabled the PH sensor to sense changes in pH and the EC sensor to sense changes in EC of herbaceous plants, ensuring the program ran properly within the project scope. The NodeMCU ESP01 Wifi only connects to the Arduino, which connects to the internet network to display the PH and EC sensor data. After uploading the code to Arduino, the serial monitor of the Arduino software (IDE) displays the PH sensor value and the EC sensor value. Figure 5 shows the serial monitor display PH sensor value.
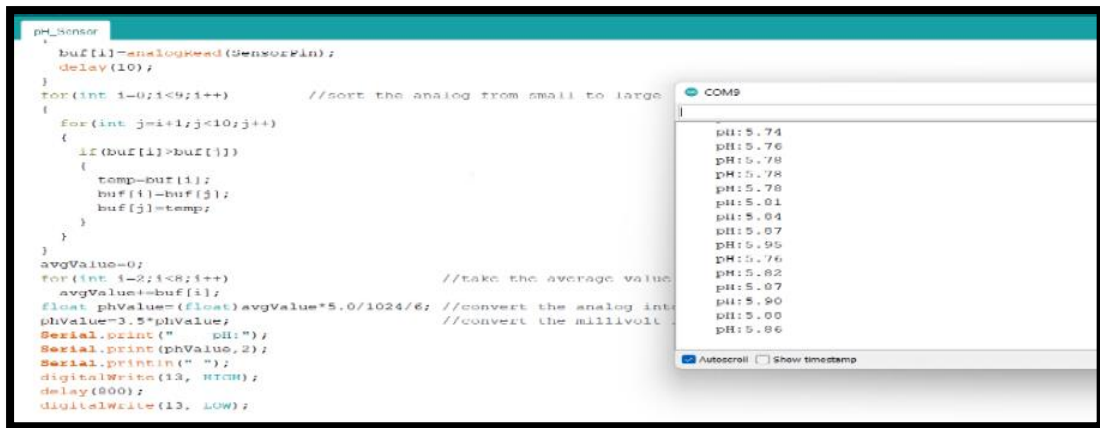
Figure 5: The serial monitor display PH sensor value.

3.2 The Functionality of Web Page and Herbs Smart Farming System

The desired functionality of the web page, as well as web-based herbs smart farming generated using an online ThingSpeak platform, will be covered in two separate sections, namely the 'Online Database' and the 'User's View,' which defines the functionalities supplied to the user.

3.2.1 Online database

The herbs smart farming can be added as a new database operation using ThingSpeak, which stores information about pH, EC, temperature, and current date and time. Figure 6 shows the new structure labelled 'Smart Herbs Hydroponic System' on the left sidebar of the database menu. The following sections explain how each party's details and information are organized systematically into their respective structures.
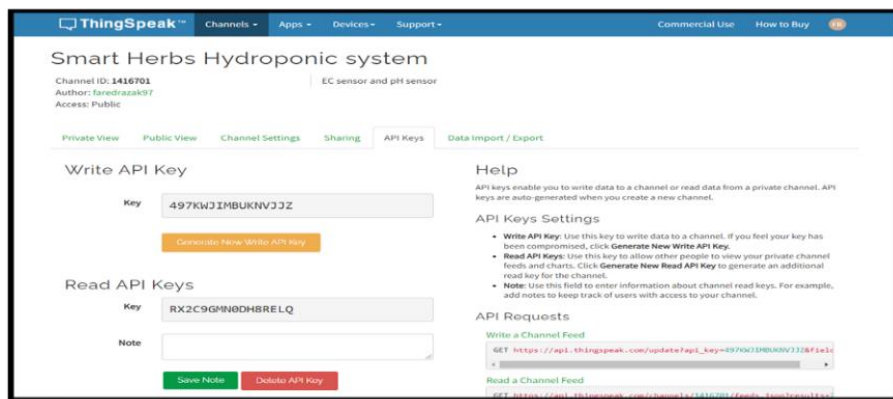

Figure 6: Homepage of the herbs smart farming system in the database.

The system was designed to collect data from the sensors and store it in a central microcontroller before sending it to an Internet of Things platform (IoT). The Internet of Things platform is capable of storing, analysing, and previewing data for the user through a private or public web interface. Figure 7 shows the result of smart farming of four types of reading a) pH value, b) EC value, c) ppm value and d) Temperature value by using the website ThingSpeak.

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(a)   (b)

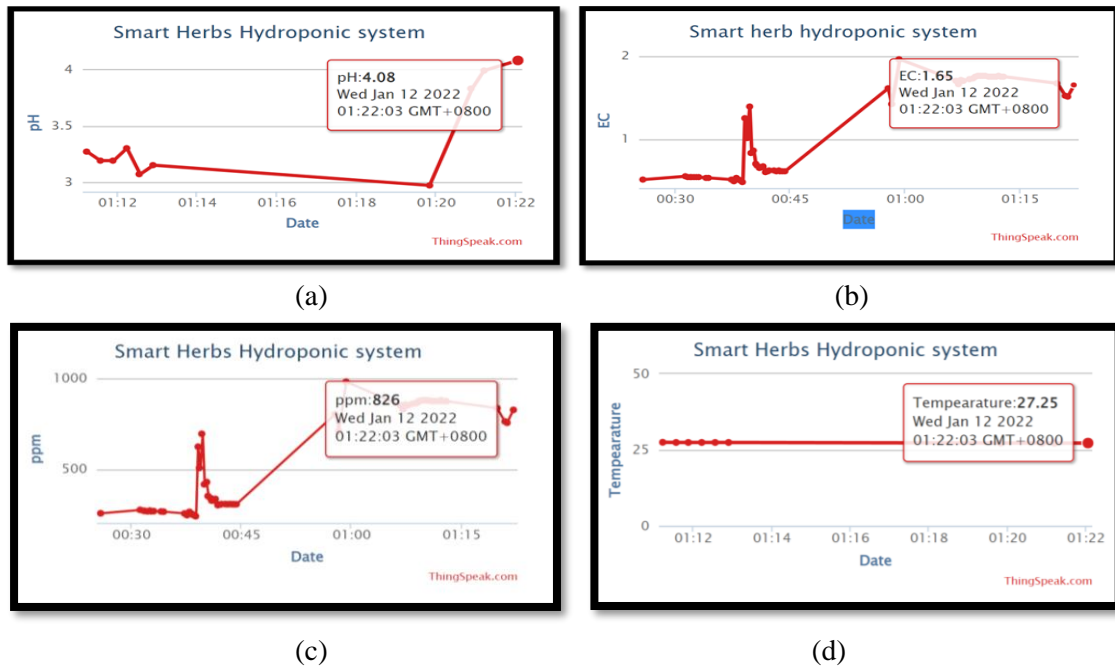(c)   (d)

Figure 7: The result smart farming of four types of reading a) pH value, b) EC value, c) ppm value and d) Temperature value by using website ThingSpeak

3.2.2 User Viewer's

The web interface may be viewed at any time from a smartphone or a computer, and the mobile application is a straightforward and simply available option. The result is smart farming by using ThingView application mobile same as using ThingSpeak website. However, the Thingspeak web interface can display data for several days at a time, but the Thingspeak mobile application can display data for a shorter period of time with the most recent data point emphasised.

3.3 Reaction Test of Herbs Smart Farming System

The system was tested by mixing nutrient and pH buffer solutions with water solvent. A 15-liter plastic container full of tap water was used to test it. A solvent was added to the herb roots and placed on top of the container. The starting pH was 7.48 and the EC was 0.31 mS/cm. Initially, one of the peristaltic pumps injected nutritional fluid for two seconds. After 150 minutes, a second peristaltic pump delivered a pH-lowering buffer solution. The study lasted 22 hours. Every 100 seconds, data were collected during the test. Figure 8 shows the result of this experiment.
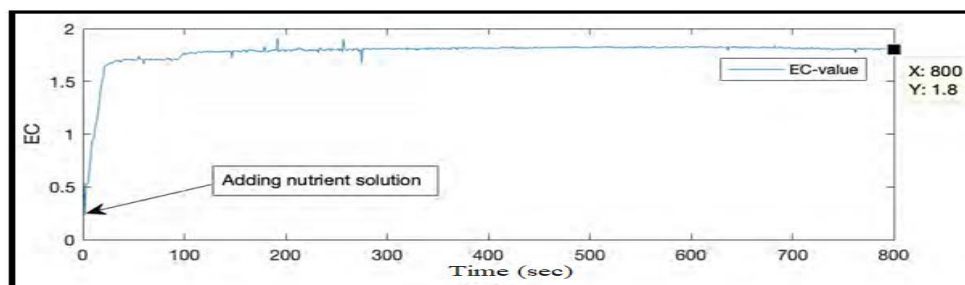

Figure 8: Data collected EC value during reaction test, plot in MATLAB.

This system kept the parameters within acceptable limits. The electrical conductivity of the nutrient solution was tested, and the system was able to maintain the required level quickly. Figure 8 shows the graph of electrical conductivity (EC) and the developed control system's actions to maintain the range. A highly concentrated nutrition solution was injected into the reservoir to bring the EC back into balance. In a running system, 2ml of highly concentrated nutrient solution stabilises EC from 0.6

mS/cm to 1.5 mS/cm in 75 seconds. A highly concentrated nutritional solution causes a non-uniform disruption in EC levels, but these values settle within seconds and are within range.

The pH of a nutrient solution determines its alkalinity or acidity. It may inhibit photosynthesis or burn plant roots [8]. The proposed control system could automatically regulate pH levels. If the reservoir's pH is too high, a pH-Down solution is injected to lower it. Figure 9 shows the system's pH stability graph; when the nutrient solution's pH rises above the required range, the system takes action to bring it back down. As in EC, the injected pH-down solution causes a sudden drop in the pH of the nutrient solution in the reservoir. As shown in Figure 9, the pH level stabilises after 15 seconds.
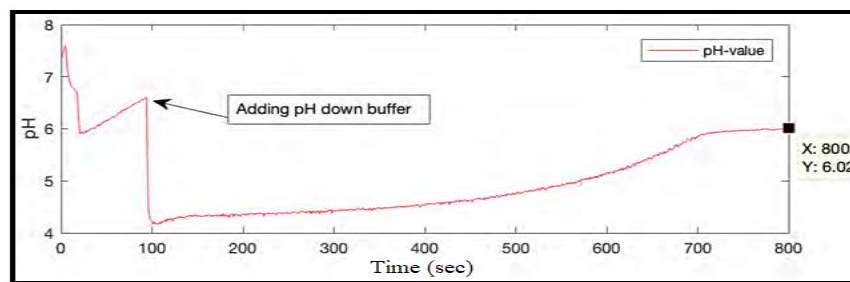

Figure 9: Data collected PH value during reaction test, plot in MATLAB.

3.3.1 Analysis of hydroponic system by reaction test

The addition of nutritional solution lowers the pH, as shown in the response test results (Figure 8). Adding a pH-decreasing buffer solution had no discernible impact on the EC value, according to the results of the experiment. The EC-value remained stable and rose at a constant pace after the pH buffer solution and the nutrition solution were introduced. The pH, on the other hand, rose steadily for about 16 hours before finally reaching a pH of about six. In hydroponics, mature plants have been found to raise the pH-value of the system.

3.4 System Behavior Test of Smart Herbs Hydroponic System

A 10-day test was conducted to assess the system's ability to maintain acceptable parameter ranges. The experiment used three fully grown sweet basil plants in a 20liter plastic container. Then 15 liters of tap water were added, and all electrical components were turned on. The pH will be 7.56 and the EC will be 0.70 mS/cm. After 7 days, 2 liters of water were added to the water solvent to compensate for evaporation. Every 100 seconds, data was collected. Figure 10 shows Data collected (a) pH value, (b) EC value and (C)Temperature value during reaction test, plot in MATLAB.
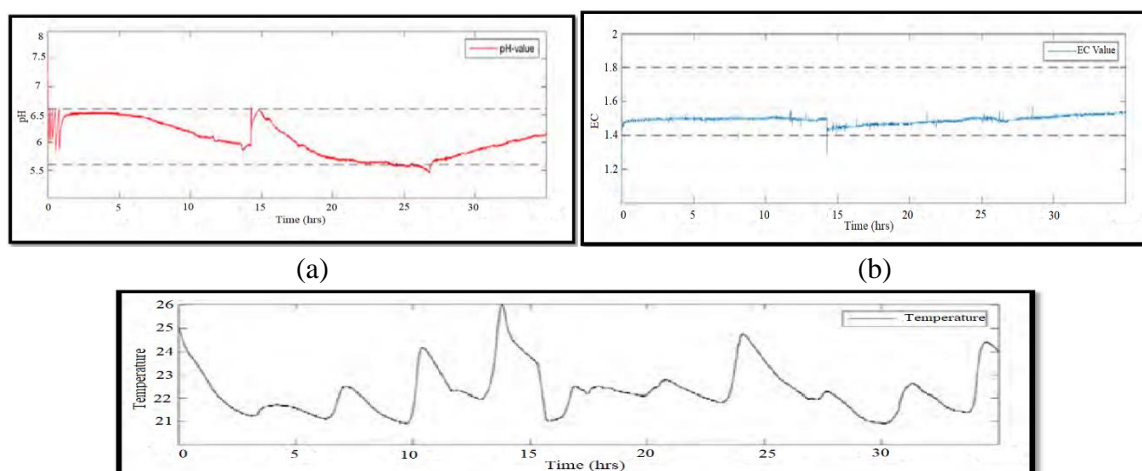

(a)

(b)

Figure 10: Data collected (a) ph value, (b) EC value and (c) Temperature value during reaction test, plot in MATLAB.

Table 2 shows that the electrical conductivity is 0.6 and the pH is 7.89 in the morning on the first day. This is because the water in the tank is tap water, which contains no nutrient mixture. State 1 EC less than 1.5 and state 2 pH greater than 6.6 activates this system's nutrition and pH stabilization functions. In the evening, the water nutrient solution returns to "state 3," its normal state. From the second to the eighth day, electrical conductivity decreases due to herb growth that absorbs more nutrients. On the ninth day, Pump B will function (state 1) to add nutrition to the water solution with an EC value of less than 1.5 in the morning. The pH reading increased from 5.7 to 6.5 on the second to seventh day due to the pH change in the water. Pump C is activated (state 2) during the seventh day's night to bring the pH back to normal (state 3). In state 3, the water pump will pump water solution to the hydroponic rack for 5 minutes on and 10 minutes off.

Table 2: The details of analysis in actual situation

DATE	TIME DURATION	HYDROPONIC SYSTEM						SOLUTION
		ELECTRICAL CONDUCTIVITY			PH			
		MORNING	EVENING	NIGHT	MORNING	EVENING	NIGHT	
1 DEC	100sec	0.6	1.9 - 2.2	1.9 – 2.1	7.89	5.5 – 5.7	5.6 – 5 .7	State 1 & State 2
2 DEC	100sec	1.8 – 2.0	1.8 - 1.9	1.8 – 1.9	5.7 – 5.8	5.8 – 5.9	5.8 - 5.9	State 3
3 DEC	100sec	1.7 - 1.9	1.7 – 1.9	1.7 – 1.8	5.9 – 6.0	5.9 – 6.1	6.0 – 6.2	State 3
4 DEC	100sec	1.7 – 1.8	1.7 – 1.8	1.6 – 1.8	6.1 – 6.2	6.1 – 6.2	6.1 – 6.3	State 3
5 DEC	100sec	1.6 – 1.8	1.6 – 1.7	1.6 – 1.7	6.1 - 6.3	6.1- 6.3	6.2 – 6.3	State 3
6 DEC	100sec	1.5 – 1.7	1.5 – 1.7	1.5 – 1.7	6.2 – 6.3	6.2 -6.3	6.2 – 6.4	State 3
7 DEC	100sec	1.5 -1.7	1.5 – 1.6	1.5 -1.6	6.3 – 6.4	6.3 – 6.4	6.4 - 6.5	State 2
8 DEC	100sec	1.5 – 1.6	1.5 – 1.6	1.5 - 1.6	5.4 – 5.5	5.4 – 5.5	5.4 – 5.6	State 3
9 DEC	100sec	2.0 – 2.3	2.0 -2.2	2.0 -2.2	5.7 – 5.8	5.7- 5.8	5.7 - 5.9	State 1
10 DEC	100sec	1.9 – 2.2	1.9 - 2.1	1.9 – 2.1	5.8 – 5.9	5.8 – 5.9	5.8 – 5.9	State 3

3.4.1 Analysis of hydroponic system by system behavior

In Figure 10, the system was successful in maintaining the pH and EC levels within the desired ranges for a significant portion of the test period. That time 15 hrs were obtained, and we added an extra two liters of tap water to the solvent, which was around the time 14 hrs was taken. Because of the elevated pH and reduced EC levels, it was necessary to supply the system with additional nutrients to keep it running properly. There was a steady decline in pH between time 1 hrs and 14 hrs, and another steady decline between time 16 hrs and 27 hrs. It's probable that the water source employed in this experiment was to blame for the failure of the experiment. The tap water used in hydroponics systems is frequently contaminated with pesticides and other components that can cause pH abnormalities. It is possible that additional factors contributed to the outcome as a result of the usage of a different chemical.

4   Conclusion

In conclusion, Smart Herbal Hydroponic System using IoT has achieved its first preset objective of designing a smart herbal hydroponic system capable of detecting changes in water pH and electrical conductivity by using PH and EC sensors. It can spread awareness about air changes that are important to know the nutritional needs of plants towards herbs growth. Using IoT ThingSpeak app to design an automated hydroponic system for growing herbs was a secondary goal that was achieved as a result. Arduino Uno Microcontroller, pH sensor, EC sensor, and NodeMCU (ESP8266) are just some of the hardware and software components of the overall system, which also include the Thingspeak database system. These features have been meticulously crafted to ensure that they function in harmony to give users the best possible experience.

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