Development of Integrated EC and pH Sensor for Low-Cost Fertigation System

S M Shamsi1, H B Abdullah1, and L Bakar1

1 Fakulti Perladangan dan Agroteknologi, Universiti Teknologi Mara, Kampus Jasin, Melaka

Corresponding author’s email address: mariam_shamsi@uitm.edu.my

Abstract. Nowadays, crop yields within the planting vegetables and fruits in Malaysia using fertigation system has been emerging technology adapted by modern farmer in agriculture practice. Fertigation techniques is one amongst the ways to increasing export and reducing import to urge a precision farming is should have most doable use efficiency of applied inputs particularly for water and fertilizer. Fertilizer got to be monitor and check on a daily basis to make sure the nutrient content was enough for plants. Two (2) vital parameter required to be monitored are water pH and EC (electric conductivity). In normal practice, these parameters need to be check manually and recorded the data for further analysis. This practice takes a lot of time and wastes energy toward the worker or farmer. So, the aim of this projects is to integrate pH and EC sensor module that can monitoring the system automatically beside able to reduce time while not taking the data manually. This wireless agriculture monitoring system uses the Arduino Uno as the processing unit and ESP8266 Wi-Fi module as the communication unit. This sensor module transfers the data to user via mobile application wirelessly.

Keywords: Fertigation; EC sensor; pH sensor; Precision Farming; Arduino

1. Introduction

Fertigation technique is one of the emerging technologies adapted especially by the modern farmer in agriculture practice. Introduction to fertigation techniques is one of the ways to increasing export and reducing import. To get a precision farming is must have maximum possible use efficiency of applied inputs especially for water and fertilizer. Fertilizer is dissolved at convenient concentrations in water then applied at irrigation water by the micro irrigation system. Fertigation technique is where the nutrient and water in required quantity are placed in the root zone, so it will give the maximum absorption nutrient and the water use is assured to achieve more crop.

In fertigation, the process irrigation and fertilizing are combined. The crop is planted in a polybag using coco peat as planting media. This can reduce the risk of soil Bourne disease. The water and fertilizer are supplied daily on the precise amount at the right time. This can lead to higher crop production and optimize usage of fertilizer thus increase the farmer income while reducing the environmental pollution that comes from fertilizer leaching. In the fertigation technique, it can improve the performance of the crops regarding the nutrient solution, root stimulation and root bio protection, shown in Figure 1. The nutrient solution is related to the control of pH and electric conductivity (EC) of the crop and it most important when talking about fertigation (García-Gaytán, et al., 2018). By using fertigation technique, the government can make benefit from barren land for agriculture practices thus optimizing the land usage.
Figure 1. Fertigation Improvement

Fertilizer is medium used in plants that need to be monitor and check by farmer every day to ensure the nutrients contained in the fertilizer was sufficient for plant required. There is two (2) important parameter that needs to be monitored by the farmer which is water pH and electric conductivity (EC). In normal practice, workers need to check these two parameters in each planting pots. The water pH and EC reading were taken manually and recorded for further analysis. This process takes a lot of time and wastes energy toward the worker or farmer. Therefore, there is a need for a long-term effective solution to this problem. Thus, a system is implementing to facilitate the worker to monitor the water pH and EC without taking the reading manually. This system is known as integrated pH and EC sensor module for a monitoring system for agriculture where the user can track the pH and EC of water used in real time without taking in manually. The main objective of this project is to develop an integrated EC and pH for low cost fertigation monitoring system.

2. Methods

This wireless agriculture monitoring system uses the Arduino Uno as the processing unit and ESP8266 Wi-Fi module as the communication unit. This module will transfer the data to the mobile application wirelessly for further analysis. Based on the components selected in this project, it can save a lot of money compared to using other components.

The sensor module is equipped with the water pH, electric conductive (EC) sensor and Wi-Fi module. The data transfer is done wirelessly. The water pH and EC will be attached to the processing unit to measure and collect the data on the quality of the water nutrients in the crop. Figure 2 below are showing the main concept of the proposed system in this project.
Figure 2. Project Proposed System

**pH Sensor:**
In this project, Atlas Scientific pH probe is used to measure the water pH of the plant in fertigation system. This prob can measure the full pH range within 0 to 14 and operate from 1°C to 99°C at time response about 1 second. This sensor is producing an analogue output that operates between 2.5V to 5.5V and measures pH at two decimals places, i.e. 4.10. Water pH is important for the quality of crop growth. The main resources for the plant to grow are they need light, carbon dioxide, water and mineral nutrients. Plants require these resources to create food or sugar. The movement of nutrients is determined by the pH of the solution.

**Electric Conductivity (EC) Sensor:**
In the fertigation system, EC sensor is used prob from the Atlas Scientific for sensing the water nutrients of the crops. This prob can operate from 1°C to 110°C at time response in 1 second. This sensor electrode constants are, K=1.0 and producing an analogue output that operates voltage at 3.3V to 5V. Moreover, this prob also consists of a BNC connector that allows for breadboard interfacing. A control kit that provided will be attached with the controller, Arduino Uno.

**ESP8266 Transceiver Wi-Fi Module Pin:**
ESP8266 is the micro-controller that is used in this project. It will be the brain of the system in which it will collect data and send it to the internet by contained SOC with integrated TCO/IP protocol stack. The ESP8266 is able to hosting an application and offloading all Wi-Fi networking function from another application processor. The module has capability to storage and powerful enough on-board processing that allow to integrated with the sensors through its GPIOs during run time. The ESP8266 also support APSD for VoIP applications Bluetooth co-existence interfaces that allow it work under all operating condition with contained a self-calibrated.

**Blynk:**
Blynk is very user-friendly and it works all over the Internet. So, the only need is that the equipment or hardware can converse with the internet. Regardless of what type of connection user pick even Ethernet, Wi-Fi or possible ESP8266, the Blynk libraries and example will get the user on the web, interface with Blynk Server and combine up with the mobile device. This software is used because it is easier for the farmer to viewing the water pH and EC toward the crop in real time for further analysis used. The GUI of this project can show the quality of the water used at that time in seconds, minutes and hours.

**Algorithm Design:**
An algorithm was proposed to describe the operation of the system. The algorithm as below:

Step 1: Start
Step 2: Fit sensor into the solution
Step 3: Program the sensor module to send the data via ESP8266
Step 4: Program the module to display data on Blynk
Step 5: Stop

Blynk application was used to display the result of the nutrient’s crop and it has user friendly interface and is accessible by both iOS and android users. The GUI displays the graphical output of the pH and EC in the fertigation used on the crop and it will automatically update every minute or any setting by the user. The flowchart of the software development is shown in figure 3.

3. Results and Discussion

Several data in pH and EC have been collected in different solution to see the performance of the sensors and the system. The results obtained from the experiments have shown that performance of the system is quite accurate and easy to be handle by non-technical person. Field experiment has shown that EC and pH sensors are very useful in monitoring the nutrients changes and to fine-tune fertigation practices. Figure 4 shows the actual hardware model of the proposed system. The hardware model
consists of EC sensor and pH sensor. While figure 5 shows the results generated in the Blynk interface.

![Figure 4. Hardware of the system](image)

![Figure 5. Results in Blynk Interface](image)
4. Conclusions

In a conclusion, through all the study and analysis that had been made, this prototype of wireless water nutrients for crop monitoring system has been developed. The integrated pH and EC sensor module have been successfully collecting the data of water nutrients in the crop through fertigation system then transfer the data to the display unit wirelessly. At a meantime, the graphical data also has been successfully displayed on the Graphical User Interface (GUI) at the mobile device to analyse the water nutrients reading in real time by using Blynk application.

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