The control system for the nutrition concentration of hydroponic using web server

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Abstract. This research was conducted to realize a nutrient solution concentration control system using web interface monitoring. The hydroponic system only relies on nutrient solutions whose nutrient levels must be maintained to anticipate the increase in acidic acid levels of the nutrient solutions. The provision of monitoring and recording changes in hydroponic system nutrition is very helpful in maintaining the quality of hydroponic agricultural production. The provision of data from electrical power measurements needs to be supported by information technology, especially remote data measurement technology. This remote data monitoring uses a wireless network system using a TDS (Total Dissolved Solids) sensor, Arduino DUE microcontroller, WiFi module and internet connection for the observation process. The TDS sensor used previously was characterized and calibrated. The data obtained by the sensor is used to exercise control before sending it to the thingSpeak.com channel to be recorded and displayed in realtime. In testing the sensor TDS meter error of 2.88%. The results of the test for 2 hours obtained the results of the control system can increase the nutritional PPM from 213 PPM to 451 PPM within 30 seconds with a nutrient enhancer sample of 779 PPM, and decrease from 779 PPM to 431 PPM within 70 seconds with a water-enhancing sample of 213 PPM for the 445 PPM set point. In the second test result for 2 hours, the control system results can increase the nutritional PPM from 215 PPM to 814 PPM within 30 seconds with a nutrient enhancer sample of 956 PPM, and decrease from 956 PPM to 754 PPM within 40 seconds with a water-enhancing sample of 215 PPM for the 780 PPM set point. PPM value of nutrients can be affected by the presence of other solids such as sand which dissolves with water.

1. Introduction

Agriculture is one of the most productive sectors in each region. Especially in areas where there are still many rice fields or open land. However, there is not much agricultural land to farm [1]. Agriculture also contributes to the supply of food. Achievement of production figures and figures for food needs in Indonesia in 2014, the government targets rice self-sufficiency to reach 10 million tons, which is an accumulation of surplus from 2012 to 2014 and to achieve this figure, a quite high increase in production is needed, which is around> 5% per year [2].

For the development of the hydroponic system has carried out further studies on the hydroponic planting system, which is a landless planting system using only minerals and nutrients dissolved in water [3]. In the hydroponic system, nutrients are needed, which are generally obtained from fertilizers. For plants that are commonly encountered are nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). And the most often used by
fertilizers is urea fertilizer (CO (NH2) 2) where it is a fertilizer with sufficient nitrogen levels, with a large amount of nitrogen makes plants produce more chlorophyll and plants look greener and more fertile [4].

With this nutrient from fertilizer, the plant becomes greener and more fertile but if the dose is given too much it will increase the acidity of the water, whereas if the deficiency will become alkaline [5]. So to regulate the levels of nutrients in the water, it takes control. One important factor in determining the mineral content contained in water in a hydroponic system is by using a TDS (Total Dissolved Solids) sensor in water. TDS is the number of dissolved solids either in the form of organic ions, compounds, or colloids in water [5].

TDS sensors can be used to measure the number of organic compounds dissolved in water in a hydroponic system. The concentration of ionized nutrients in a liquid affects the conductivity of the solution, the higher the concentration of nutrients the more conductive the solution [6]. For the continuation of supervision, data processing can be used using the Arduino DUE microcontroller as a data processing control center and as a control center for moving the servo motor which will be integrated with a water valve and also a nutrient solution. For monitoring data, it can be seen and stored using a database that can be identified through the device.

A system commonly referred to as data acquisition and monitoring control system is used to find data using a 445 PPM set point for plants such as Watercress and Spices, 780 PPM set point for plants such as Fennel (AtsiriAdas) and Lemon Balm (Mint Leaf). Process data and also display and execute commands to perform an activity that can monitor system maintenance [7]. This system can be obtained the ease in overseeing the hydroponic system. And it can treat plants better with the presence of PPM control in the hydroponic system.

Hydroponics is an agricultural cultivation land that does not use soil growing media in general, hydroponic farmers carry out their agricultural activities using water planting media instead of soil planting media. Hydroponic means hydro which means water and phonic which means workmanship. So in general, hydroponics means the system of agricultural cultivation using water growing media that contains a nutrient solution. Some of the advantages of this hydroponic cultivation system include plant density can be doubled per unit area of planting area to save the land. The quality of the cultivation product can be guaranteed to start from the taste, size, shape, color, and cleanliness because the nutritional needs are adjusted according to the needs and not depend on the growing season so that it can adjust the market needs [8].

Nutrition for the plant is a chemical bond needed by every living creature to be able to carry out its activities, with nutrition functioning to build, maintain and as a source of tissue energy [9]. For hydroponic cultivation, in addition to being able to reduce production costs and choosing alternative nutrients, it can also increase yields. [10] have conducted research that provides results that regulating EC (electrical conductivity) values in plants can increase yields, these results are in line with research conducted by Binardi and Hendrian (2017) [11] that the provision of nutrients with a total N (nitrogen) formulation worth 200 PPM can provide optimum results on production yields.

Servo motor is a device as a rotary actuator (motor) that is designed with a closed-loop feedback control system (servo) so that it can be adjusted or set to determine and ascertain the angular position of the motor output shaft. Servo motors are commonly used in industrial applications, but they are also used in various other applications such as radio-controlled toy cars, robots, aircraft, and so on. DC servo motors have a closed feedback system where the position of the rotor will be informed back to the control circuit in the servo motor. Servo motors are made using DC motors which are equipped with a controller and position sensor so that they can have movements of 0, 90, 120, 180 or 360 [12].

The sensor is an electronic device that can convert physical quantities into electrical quantities. The sensor can be used as a physical mass input device to the data processing device. Sensors consist of two types of sensors namely active sensors and passive sensors. Active sensors produce voltage outputs that function as references on data processing devices or microcontrollers. Passive sensors are sensors that do not directly produce voltage output, but rather act as passive devices, like resistors whose values change in response to external physical quantities. The sensor needs to be strengthened
to produce a suitable voltage as the input of the microprocessor and an analog to digital converter [13]. The microcontroller is a small computer (commonly known as a special-purpose computer) in an IC that contains CPU, memory, timer, serial and parallel communication channels, input/output ports and analog to digital converter (ADC). Microcontrollers are used for tasks and running a program [14].

The microprocessor is the central processing unit (CPU) in a single chip. Which has important components such as arithmetic and logic units (ALU), instruction decoders, registers, bus control circuits, etc. A microcomputer is a microprocessor that is connected to a supporting circuit. I / O and memory components (programs and data) are placed together to form small computers specifically for data acquisition and control applications. The components that make up a microcomputer are put together in single-chip silicon, called a microcontroller [15].

The CPU functions to divide the interface of the FLASH memory code section, the data memory section, and EEPROM memory. FLASH memory is a block of FLASH memory that starts at 0x000 location and its size depends on the microcontroller used. FLASH memory is a non-volatile memory and is used to store the execution code and constants because the codes are reused even though the microcontroller is not connected to the power supply. Data memory consists of three parts of reading/write memory, registers, and internal SRAM.

2. Material and methods

The study was conducted using literature study methods, making assumptions and developing and reducing equations. The control system monitoring scheme and PPM level in hydroponic cultivation using Arduino DUE are used as follows:

**Figure 1.** Schematic of a concentration monitoring control system (PPM).

In Figure 1 the required components are TDS sensor (5), sensor signal amplifier (4), ESP 8266 (3), microcontroller (1), motor servo (2) and router (6) connected to the internet.
The system workflow is clearly illustrated in the block diagram below:

![Block diagram](image)

**Figure 2. System diagram**

3. **Result and discussion**

3.1. **Servo motor test**

Testing on servo motors aims to determine the ability of rotation. Testing is done by comparing the rotation angle of a servo motor with a protractor. The results of the comparison of the angle of rotation of the servo motor with an arc can be seen in Table 1.

| No. | Arc  | Turning Angle Motor 1 | Turning Angle Motor 2 | Error (%) Motor 1 | Error (%) Motor 2 |
|-----|------|-----------------------|-----------------------|-------------------|-------------------|
| 1   | 0°   | 0°                    | 0°                    | 0                 | 0                 |
| 2   | 30°  | 30°                   | 30°                   | 0                 | 0                 |
| 3   | 45°  | 45°                   | 45°                   | 0                 | 0                 |
| 4   | 60°  | 60°                   | 60°                   | 0                 | 0                 |
| 5   | 90°  | 90°                   | 90°                   | 0                 | 0                 |
| 6   | 120° | 120°                  | 120°                  | 0                 | 0                 |
| 7   | 135° | 135°                  | 135°                  | 0                 | 0                 |
| 8   | 150° | 150°                  | 150°                  | 0                 | 0                 |
| 9   | 180° | 180°                  | 180°                  | 0                 | 0                 |

Average Error: 0% 0%

From Table 1 it can be concluded that the servo motor can rotate according to the angle indicated by the protractor from 0° to 180°.

3.2. **Testing a wireless network**

The wireless network used is a router or hotspot connected to the internet network. The WiFi ESP 8266 module will automatically search for connections on the router or hotspot network where the SSID and password have been entered into the Arduino program. Followed by calling the channel on thing speak by using APIKEY WRITE. The data is then sent and displayed on the channel page that has been prepared previously in graphical form. The PPM measurement graph on the interface system is shown in Figure 3. Downloading the observation data is shown in Figure 4 in the export section.
The data acquisition system test results are displayed using a user interface between users with a programming language. Control system testing is carried out in the field by giving excessive nutrient samples and non-nutrient samples. Testing the data acquisition system is stored and displayed via thingspeak. Retrieval of data using a TDS sensor for PPM values, the data is then sent to the Arduino DUE microcontroller to be processed and control commands are carried out on the control system. Sending data from the microcontroller to thingspeak via the ESP 8266 Wi-Fi module. ESP 8266 that has been connected to a router connected to the internet network then the data is stored and displayed on the account channel on the thingspeak.

### Table 2. Data transmission test results

| No. | Input | Thingspeak | Error (%) |
|-----|-------|------------|-----------|
| 1.  | 0     | 0          | 0         |
| 2.  | 512   | 512        | 0         |
| 3.  | 1024  | 1024       | 0         |
| 4.  | 1536  | 1536       | 0         |
| 5.  | 2048  | 2048       | 0         |
| 6.  | 2560  | 2560       | 0         |
| 7.  | 3072  | 3072       | 0         |
| 8.  | 3584  | 3584       | 0         |
|     |       |            | **Average Error 0%** |

Based on table 2, we can find out if the value sent from the microcontroller is the same as the value displayed on the thingspeak.com channel page. Since there is no data sending error, no error correction is needed for sending data from the microcontroller to the thingspeak.com channel page.

### 3.3. Characterization and calibration of the TDS sensor

Characterization of analog TDS sensors is done by comparing the standard TDS values to the ADC reading results on Arduino DUE. The characterization graph between the ADC output values and the standard TDS is shown in Figure 5. After that, a calibration is performed by comparing the data read by the analog TDS circuit with data from the standard TDS the results are shown in Table 3.
Figure 5. TDS sensor characterization

Figure 5 shows the characterization graph showing the linear equation between the x-axis variable, namely the ADC reading and the y-axis, the standard multimeter voltage value. The relationship between the ADC reading with the standard voltage value produces an equation. The results of the equation are included in the data acquisition equation so that the PPM value obtained from the TDS sensor reading is following the PPM standard tool with an average error value of 2.88%.

Table 3. Characterization of TDS sensors

| No. | ADC | Standard TDS |
|-----|-----|--------------|
| 1.  | 20  | 38           |
| 2.  | 28  | 47           |
| 3.  | 55  | 82           |
| 4.  | 73  | 106          |
| 5.  | 105 | 150          |
| 6.  | 116 | 168          |
| 7.  | 145 | 202          |

From table 3 we have obtained an error value from the TDS sensor reading system which is compared with a standard concentration measuring instrument which is carried out using 10 samples of concentration solution which is varied in its concentration. From the test obtained an error value of 2.88%, with an error value from the standard measuring instrument of 2%.

3.4. Control system test result

The test results are carried out to determine the character of the control system. From the test, the data will be obtained in the form of time needed by the control system to adjust the system's nutrient content. In this test samples of excess nutrient solution and low nutrient solution were used. And given to the control system to adjust PPM at a value of 445 PPM and 780 PPM. At the setpoint control of 445 PPM, Figure 6 obtained results that fell from seconds 0 to 70 seconds, PPM dropped from values 779 to 431 by using high nutrient samples 779 PPM and 213 PPM water samples.

At seconds 70 to 115 show up and down results in the range of 445 PPM. These results are consistent with what was predicted, the results will move up and down in the range of the set point to maintain the PPM level does not exceed the PPM range that it should. Control works by adding water and concentrated nutrient solutions into the solution in the hydroponic system. The control system will add water to the system if the nutrients exceed 445 PPM, and will add nutrients if the nutrients are less than 445 PPM.
Figure 6. Concentration test on over nutrition of 445 PPM

Testing on hydroponic systems that lack nutrients, the control system requires a shorter time to reach the set point. Besides being due to shorter valve opening times, it is also due to the concentrated nutrient solution. It can be seen in Figure 7 that the time needed is only 30 seconds, to increase the PPM from a value of 213 to 451 by using a low nutrient sample 213 PPM and a nutrient enhancer sample 779 PPM. Then the control system keeps PPM levels in the range of 445 PPM.

Figure 7. Testing the concentration on low nutrition of 445 PPM

At the set point control of 780 PPM, Figure 8 obtained results that fell from seconds 0 to 40 seconds, PPM dropped from 956 to 754 using 956 PPM high nutrient samples and 215 PPM water samples. In seconds 40 to 100, the results show up and down in the range of 780 PPM. These results are consistent with what was predicted, the results will move up and down in the range of the set point to maintain the PPM level does not exceed the PPM range that it should. Control works by adding water and concentrated nutrient solutions into the solution in the hydroponic system. The control system will add water to the system if the nutrients exceed 780 PPM, and will add nutrients if the nutrients are less than 780 PPM.
4. Conclusion
From the results of the research that has been done, it is obtained the realization of the control system of hydroponic nutrient solution concentration using a monitoring web interface and produces several conclusions that the data acquisition system in the control system can be used by the TDS sensor. The results of the TDS sensor testing error value of 2.88%. The sensor can be used for data acquisition. In the results of the control system character test carried out for 2 hours, the results obtained control time to achieve the desired PPM state for 1 minute 10 seconds from the state of excess nutrition, and 40 seconds for the nutritional deficiency state for the 445 PPM set point. The set point of 780 PPM is obtained 40 seconds for conditioning excess nutrients, and 30 seconds for conditioning low nutrients.

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