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Conditioning of Temperature and Soil Moisture in Chrysanthemum Cut Flowers Greenhouse Prototype based on Internet of Things (IoT)

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***Abstract*- Currently, cut chrysanthemum cultivation in a greenhouse is still using a conventional system. Temperature and soil moisture are the most important factors in the growth process. If the temperature and humidity of the soil are not conditioned, the roots will quickly rot and slow the growth process of chrysanthemums. Internet of Things is an integrated system with a data-based server that stores data in the cloud from sensors so that the system can be monitored remotely in real-time. Based on this, an integrated system was designed to make it easier for farmers to condition the temperature and humidity of the chrysanthemum flower soil. In temperature conditioning, if the temperature of cut chrysanthemum is detected <24 °C then the heater will be "on" by adjusting the fan rotation and vice versa. Meanwhile, soil moisture conditioning is carried out by distributing water if the detected soil moisture is <50%, then the water pump is in the "on" state. The data on the degree of temperature and the percent of soil moisture will be recorded into the cloud which will then be displayed in the form of graphs and history data on the webserver and Android. By using this system, it is found that the growth process of cut chrysanthemums can grow 7 days faster than the standard harvest time of 30 days.**

Keywords: Chrysanthemum, Greenhouse, Internet of Things Temperature, Soil Moisture.

I. INTRODUCTION

At present, the level of efficiency and ease of application is a benchmark in the application of developing technology can make activities effectively. One form of technology that is closely related to the level of human productivity is the Internet of Things or the so-called IoT. IoT is data communication that occurs between physical objects and virtual objects on a global network [1]. The implementation of IoT tools can be applied in various sectors, such as agriculture, plantations, and even industry. This is because there is a microcontroller that acts as the main processor of the sensor that is applied and can be connected to the internet so that the results of the sensor readings obtained can be monitored and analyzed automatically and in real-time by being connected to various platforms, such as the web and Android applications [2].

IoT is defined as a form of activity carried out using media access so that all forms of activity become easy, and can also be connected to the cloud which will make the IoT system more efficient. Not only that, the data stored in the cloud can make it easy for users to monitor data anytime and anywhere, and its security is guaranteed. However, to run IoT integrated cloud computing, sufficient bandwidth access and large storage must be fulfilled [3] - [5].

This IoT technology can also be developed in ornamental plant cultivation systems. One of the developments of ornamental plant cultivation which is able to increase farmer productivity is chrysanthemum cut flowers. Chrysanthemum cut flowers requires an ideal temperature of 24°C - 27°C and soil moisture of 50% - 70% in order to produce optimal chrysanthemums cut flowers. Ornamental chrysanthemum cut flowers requires adequate water, but cannot withstand rain. Therefore, it must be done in a greenhouse [6].

There are several problems in the greenhouse cut flower cultivation system using conventional methods, namely as follows.

a. The distance from the farmer house to the greenhouse is quite far. This will have a big impact on managers because managers will find it difficult to monitor and control the growth process of chrysanthemum cut flowers at night. So that a stable monitoring and control system is needed so that managers can monitor and control the growth process of this chrysanthemum cut flowers anywhere and anytime.
b. Erratic weather can make it difficult for farmer to condition the temperature suitable for the growing process of chrysanthemums cut flower. This will have an impact on the blooming process of chrysanthemums cut flowers. If this is not done, it can slow down the blooming process of cut chrysanthemums
c. Farmers find it difficult to arrange a proper water supply. The lack of water will disrupt the growth process of chrysanthemums cut flowers. On the other hand, giving excessive water will cause the chrysanthemum cut flowers to die and the roots to rot quickly.

Referring to previous research [7] which discusses integrated systems using IoT in orchid flowers, this study discusses how to increase the productivity of cut chrysanthemum farmers with the help of technology. In this study, using 2 different platforms for monitoring and control of cut chrysanthemums, namely using an android application and a web server which can be displayed in the form of graphics, history or changing the auto system to a manual mode system.

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With the addition of this web server platform, farmers can monitor and control soil moisture remotely and also if farmers only have electronic devices such as laptops. So without the need to download or install Android apps, users (farmers) can open them via a laptop and a web browser. The manual mode system functions so that farmers can provide more water and also to accelerate the growth process of cut chrysanthemums. Whereas in [7] only uses the android platform which is mentioned only displays temperature and soil moisture data in the form of charts and history.

Furthermore, in this research the temperature conditioning system uses the LM35 sensor and signal conditioner. The use of this sensor is able to reduce costs in making hardware and also the error generated by 1%. Compared [7] which uses a DHT 22 sensor, the error is 4% (according to the datasheet). Then in this study the results of the system were able to accelerate the growth process of cut chrysanthemum flowers to 7 days faster than the standard growth of 30 days. (Pages 7 and 8). Meanwhile, the journal "design of orchid monitoring system based on IoT" does not mention the growth results, only able to condition the temperature and humidity of orchids.

The solution in this research is to design a temperature and humidity conditioning system based on internet of things using the LM35 temperature sensor and YL-69 soil moisture which can be remotely conditioned and run automatically using a *web server* and android as a user interface for monitoring and control chrysanthemum flowers. In Section II is Methodology, Section III is Result and Discussion, Section IV is Conclusion.

II. Methodology

This research will discuss several things, namely: chrysanthemum, *greenhouses*, temperature sensors, soil moisture sensors, microcontrollers, Internet of Things, design all system, and design system diagrams.

A. *Chrysanthemum Sp & Greenhouse Prototype*

Cut chrysanthemum is a type of flower that has high economic value, has many types, shapes, and colors flowers. In this study, the chrysanthemum cut flowers used were interim type flowers that had entered the vegetative phase. Cut chrysanthemum was planted at an altitude of 400 mdpl with a temperature range of 24-27 ° C, and soil moisture reached 50-70% [8]. For the growth process of cut chrysanthemum to run smoothly, a prototype greenhouse was designed to protect, avoid, and care for the flowers from all kinds of weather changes [9].

This greenhouse prototype measures 100 cm x 75 cm x 300 cm, is made of wood, and is made of UV plastic. Besides, this research also installed an LM35 temperature sensor and signal conditioner to condition the temperature using a heating element (peltier) and a fan by turning the DC fan slowly in the greenhouse prototype. The soil moisture sensor YL-69 type is used to condition the soil moisture of cut chrysanthemum using a DC water pump by pouring water into the greenhouse prototype. *Greenhouse prototype* the cut chrysanthemums flowers can be seen in Figure 1.

Figure 1. *Greenhouse* prototype

B. Sensor

1) Temperature Sensor and Signal Conditioning

In this design, the LM35 temperature sensor is used as a temperature reading of the cut chrysanthemum flowers in the greenhouse prototype [9]. The LM35 temperature sensor can read temperatures of -55 ºC to 150 ºC. The setpoint used in this study were 24 ºC and 27 ºC. According to the datasheet, the LM35 is a temperature sensor that has a very small output voltage from the temperature sensor, which is 10 mv for every 1 ºC increase. While the voltage received by the Arduino Ethernet Shield is 5 volts. Therefore, a voltage amplifier is needed so that it can be read by the Arduino Ethernet Shield. The following is a block diagram of the LM35 temperature sensor amplification.

For signal conditioning calculations, straight line linear equations can be used. Straight line linear equation is an equation that forms a straight line. The general form of straight-line linear equations can be formulated as follows:

1. $ax + by + c = 0$ (1)
2. $y = mx + c$ (2)

In the calculation of LM35 temperature sensor signal conditioners, linear equations can be used straight-line explicit form with the following information:

- y = V out, which is the output voltage (0 mV - 5000 mV).
- x = V in, which is the LM35 temperature sensor output voltage (240 mV - 270 mV).
- m, which is the slope of the line, which represents the gain.
- c = V offset, which is the output offset voltage.

Calculation:

$$y = mx + c \quad (3)$$

Elimination of Eq: 5000 = m.270 + V offset (4)

0 = m.240 + V offset (5)

5000 = m.30

$\frac{5000}{30}$ = m

167 = m

Find V Offset (Substitution to one of the questions):

$$y = mx + c \quad (6)$$

0 = m (240) + c

0 = 167 (240) + c

0 = 40.000 + c

c = - 40.000

So y = 167x - 40.000 (7)

So that Av = 167x - 40,000 and Vout = 5V are obtained. From this equation, 2 RF and Rin resistors are needed. The gain (Av) of this amplifier is determined by the RF and Rin values. In this design using 3 Op-Amp inverting and 1 Op-Amp Summing. Therefore, one of the variables must be determined. By determining the value of Rin, the RF value can be calculated as follows:

$$|Av| = -\frac{Rf}{Rin} \quad (8)$$

$$-Rf = |Av\ x\ Rin|$$

$$Rf = Av\ x\ Rin \quad (9)$$

Information as follows:

- Rin = Input resistance
- Rf = Resistance feedback
- Av = Gain / amplifier

If the Av value is known and the Rin value is determined independently, then Rf can be calculated. The following is the calculation to determine the Rf value for each Op-Amp with known Av and Rin values:

Calculation:

1. Op-Amp 1 (Inverting Amplifier)

- Planned Amplifier Value (Av_1) = 167 x
- Input Resistor Value (Rin_1) = 100Ω

$$|Av1| = -\frac{Rf1}{Rin1} \quad (10)$$

$$|167| = -\frac{Rf1}{100\Omega}$$

$$-Rf1 = |167 \text{ x } 100\Omega|$$

$$Rf1 = 16{,}7K\Omega$$

2. Op-Amp 2 (Inverting Amplifier)

- Planned Amplifier Value (Av_2) = 10 x
- Input Resistor Value (Rin_2) = 100Ω

$$|Av2| = -\frac{Rf2}{Rin2} \quad (11)$$

$$|10| = -\frac{Rf2}{100\Omega}$$

$$-Rf2 = |10 \text{ x } 100\Omega|$$

$$Rf2 = 1K\Omega$$

3. Op-Amp 3 (Inverting Amplifier)

- Planned Amplifier Value (Av_3) = 1 x
- Input Resistor Value (Rin_3) = 100Ω

$$|Av3| = -\frac{Rf3}{Rin3} \quad (12)$$

$$|1| = -\frac{Rf1}{100\Omega}$$

$$-Rf1 = |1 \text{ x } 100\Omega|$$

$$Rf1 = 100\Omega$$

4. Op-Amp 4 (Summing Amplifier)

- Planned Amplifier Value (Av_4) = 1 x
- Input Resistor Value (Rin_4=Rin_5) = 100Ω

$$|Av4| = -\frac{Rf4}{Rin4} \quad (13)$$

$$|1| = -\frac{Rf4}{100\Omega}$$

$$-Rf4 = |1 \text{ x } 100\Omega|$$

$$Rf4 = 100\Omega$$

From the calculations above, the resistor values are obtained as follows:

Rf = 16,7kΩ	Rf = 100Ω
Rf = 1KΩ	Rf = 100Ω
Rf = 100Ω	Rf = 100Ω
Rf = 100Ω	Rf = 100Ω
Rf = 100Ω	

The amount of the resistor value affects the output of the circuit which will produce an amplification of the circuit. The following is the calculation of the inverting amplifier and the summing amplifier according to Figure 2.

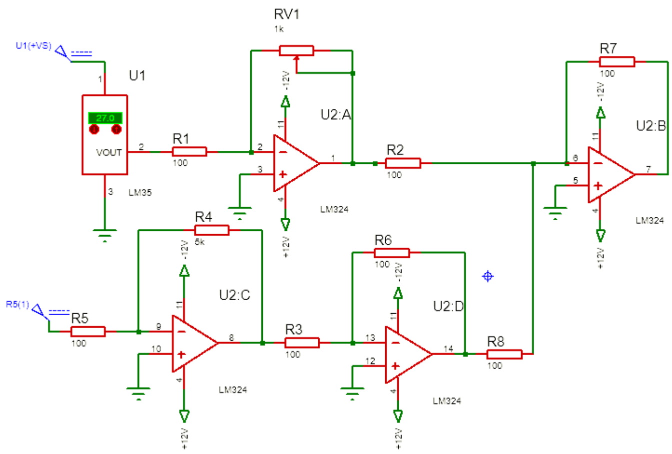

Figure 2. Design condition signal temperature sensor LM35

Calculation:

1. Op-Amp 1 (Inverting Amplifier)

$$Vout\ 1 = -\frac{Rf1}{Rin1} . Vin1 \quad (14)$$

$$Vout\ 1 = -\frac{16.7K\Omega}{100\Omega} . Vin1$$

$$Vout\ 1 = -167\ Vin1$$

2. Op-Amp 2 (Inverting Amplifier)

$$Vout\ 2 = -\frac{Rf2}{Rin2} . Vin2 \quad (15)$$

$$Vout\ 2 = -\frac{1K\Omega}{100\Omega} . 4000\ mv$$

$$Vout\ 2 = -40.000Vin2$$

3. Op-Amp 3 (Inverting Amplifier)

$$Vout\ 3 = -\frac{Rf1}{Rin1} . Vout2 \quad (16)$$

$$Vout\ 3 = -\frac{100\Omega}{100\Omega} . -40.000\ mv$$

$$Vout\ 3 = 40.000$$

4. Op-Amp 4 (Summing Amplifier)

$$\text{Vout Total} = -(\frac{Rf4}{Rin4}.(\text{Vout1}) + \frac{Rf4}{Rin5}.(\text{Vout3})) \quad (17)$$

$$\text{Vout Total} = -(\frac{100\Omega}{100\Omega}.(-167\ \text{Vin1}) + \frac{100\Omega}{100\Omega}.(40.000))$$

$$\text{Vout Total} = -(-167\ \text{Vin1} + 40.000)$$

$$\text{Vout Total} = 167\ \text{Vin1} - 40.000$$

Final result Vout (24ºC) = 167 (240) – 40.000
= 40.000 – 40.000
= 0 mv
Vout (27ºC) = 167 (270) – 40.000
= 45.000 – 40.000
= 5000 mV

2) Soil Moisture Sensor YL-69

In the conditioning of soil moisture, chrysanthemum cut flowers are used is soil moisture sensor type YL-69 which functions to detect and measure soil moisture by plugging it into the soil [10].The working principle of the soil moisture sensor is to provide an output value in the form of an electrical quantity as a result of water between the capacitor sensor plates. The YL-69 soil moisture sensor is equipped with an LM393 and a potentiometer comparator, so we can calibrate the sensitivity when using the digital output. This sensor will read soil moisture, if the soil is already dry. This will trigger the pump to water the chrysanthemum cut flowers. Dry soil values between 0% - 50%, humidity between 50% - 70%, and wet above 75%. Illustration of soil moisture sensor hardware YL-69 can be seen in Figure 3.

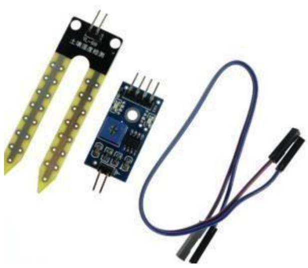

Figure 3. Soil moisture sensor type YL-69

C. Arduino Ethernet Shield

The Arduino Ethernet Shield is an electronic board containing the Wiznet W5100 ethernet chip, which functions as an Arduino platform in writing Android programming (using Lua language) and programming web servers that can connect to the internet network. The choice of this controller is due to the fast data transmission and programming language for web servers that is easy compared to other IoT controllers [11]. The illustration of the Arduino Ethernet Shield can be seen in Figure 4.

Figure 4. Arduino Ethernet Shield

D. Heater

To get maximum hot air, a heater consisting of a peltier, heatsink, and fan is designed. For the peltier, it is attached to one heatsink of size (Long 70 cm x Wide 10 cm x High 40 cm). The hot side is given a fan to direct the heat in the prototype greenhouse. The level of effectiveness in the use of heaters can accelerate the growth process of chrysanthemums cut flowers. The heater configuration can be seen in Figure 5.

Figure 5. The heater configuration

E. Monitoring & Controlling System

In this research, the monitoring and control system uses data server-based technology that can store sensor data for processing via the cloud, namely using the internet of things system.

The Internet of Things is the use of the internet for three relationships, namely human to human, human to machine, and machine to machine, which interact via the internet. In other words, IoT connects electronic equipment, sensors, and automobile equipment via the internet. Products that are smart and connected are the terminology for the emergence of the term IoT [12].

Thus, it can be concluded that the Internet of Things makes a connection between the machine and the machine so that the machines can interact and work independently in accordance with the data obtained and processed independently. The goal is to make humans interact with objects more easily, even so, that objects can also communicate with other objects. There are several platforms used for monitoring and control, namely.

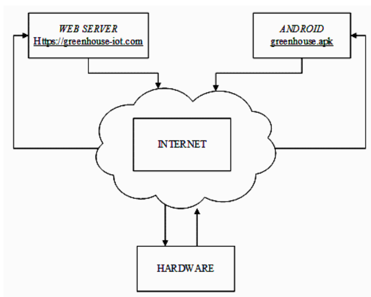

Figure 6. Design system Internet of things

1) Android

Android is an open source software platform for mobile devices. Android contains a Linux based operating system. Apart from that, Android also provides an open platform for developers to create applications using the MIT App Inventor programming application. In this study, Android is used as a platform for users to monitor temperature and control soil moisture remotely in real time connected to the internet. In this android application there are 3 menus, namely manual mode, graphics and logger. In this manual mode menu, there is a pump on which can be used to turn off or turn on the water pump to condition the soil. The graph menu is used to display temperature and humidity data in the form of a diagram. While the logger menu functions to display temperature and humidity data every 5 seconds so that users can monitor it in real time [13]. Illustration of proses making android application can be seen in Figure 7.

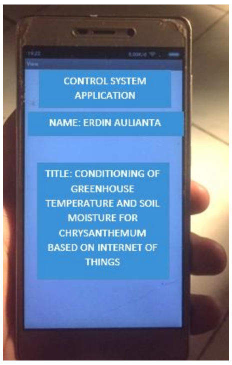

Figure 7. Android interface design

2) *Web Server*

Web Server is a data-based service and functions to receive requests from HTTP (*Hypertext Transfer Protocol*) or HTTPS (*Hypertext Transfer Protocol Secure*) on a client commonly known as a web browser and send the results back in the form of several web pages, generally in the form of HTML documents [14]. In this research, the web server is used as another platform for users to be able to monitor temperature and control soil moisture remotely in real time connected to the internet. In this web server there are 3 menus, namely manual mode, graphics and logger. In this manual mode menu, there is a pump on which can be used to turn off or turn on the water pump to condition soil moisture. The graph menu is used to display temperature and humidity data in the form of a diagram. While the logger menu functions to display temperature and soil moisture data every 5 seconds so that users can monitor in real time. Web Server illustration can be seen in Figure 8.

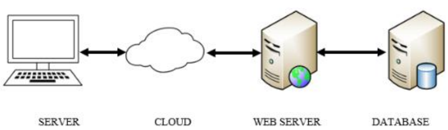

Figure 8. Architecture *web server*

3) Hardware

In this research, the hardware used includes the Arduino Mega 2560, Arduino Ethernet shield, temperature sensor LM25, soil moisture sensor, and LCD. The entire hardware circuit can be seen in Figure 9.

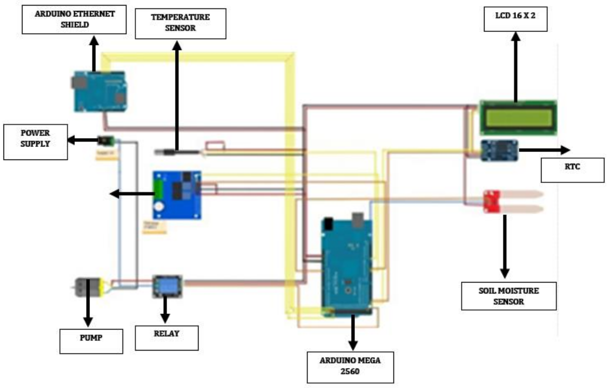

Figure 9. The entire hardware circuit

4) Software

In software design, the programs used include the Arduino IDE which allows us to write a program step by step, then the instructions can be uploaded to the Arduino board [15]. Apart from the Arduino IDE, other software applications used are the sublime text application for writing web programs and the MIT App Inventor for creating android applications. The appearance of web software and android applications can be seen in Figures 10.

Figure 10. Web Software and Android Application Software

5) Design System Diagram

The design system diagram of the conditioning of temperature and soil moisture in the prototype *greenhouse* is shown in Figure 11.

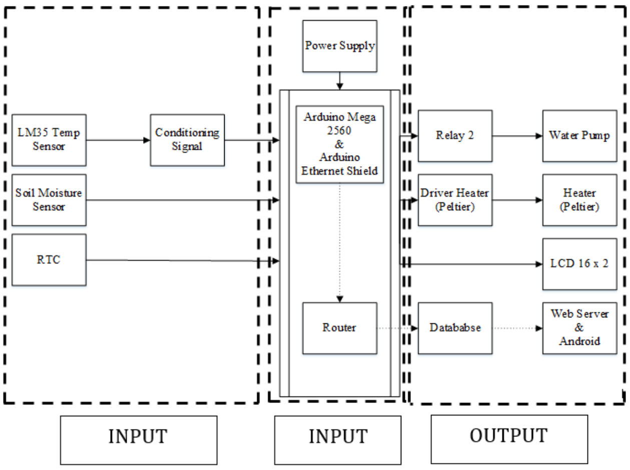

Figure 11. Design system diagram

The working principle of the conditioning system of temperature and soil moisture in the prototype greenhouse based on the internet of things is to first turn on the power router and microcontroller. Then the soil temperature and humidity sensors will be active and carry out the process of reading the degree of temperature and soil moisture percent according to the set point. If the temperature sensor value is ≤ 24 ° C then the heater (peltier) will work (on) by turning the DC fan slowly to heat the plants in the prototype greenhouse. If the temperature sensor value is ≥ 27 ° C, then the heater does not work (off). Furthermore, if the soil moisture sensor value is ≤ 50%, the water pump will water the plants in the greenhouse. Then the soil moisture sensor value is ≥ 70%, then the water pump does not work (off). There are a manual mode and an automatic mode for the watering process. This mode can be used when the soil moisture sensor value is <50%.

The reading of these two sensors will be processed by the microcontroller which will then be sent to cloud computing via an internet connection using a router. The data that has been sent to cloud computing can later be stored and can be accessed by the user to monitor the temperature and moisture degree of the chrysanthemum cut flower.

III. RESULTS AND DISCUSSION

A. Hardware Testing

1) Temperature Sensor

This temperature sensor testing aims to determine whether the LM35 temperature sensor can function properly or not. The test is done by observing the temperature data from the temperature sensor readings that are displayed on the LCD and compared with a thermometer. For more details, the data can be seen in Figure 12 and Table 1.

Figure 12. Temperature Sensors Testing

Table 1. Temperature Sensors Test Results

Testing Number-	Temperature Measurement (°C)		Error (%)
	Thermometer	Temperature Sensors	
1.	25	26	4 %
2.	26	27	3%
3.	27	28	3%
4.	26	27	4%
5.	25	26	4%
6.	25	26	4%
7.	24	25	4%
8.	24	25	4%
9.	23	24	4%
10.	23	24	4%
Average Temperature Degree Error			3.8%

Table 1 shows the data on the comparison of temperature degrees using the LM35 temperature sensor and a thermometer. The average percentage error (%) of the temperature degree reading on the LM35 temperature sensor reaches 3.8%. The difference in temperature degree readings is due to the level of sensitivity to detect the degree of the temperature detected by the LM35 temperature sensor or thermometer. Also, unstable airflow can affect the temperature in the surrounding area. This causes the sensing of the sensor disrupted (measuring the temperature through the air entering the sensor) because the LM35 temperature sensor sensitivity level is higher and faster than a thermometer.

2) Soil Moisture Sensor

Soil moisture sensor testing aims to determine whether the YL-69 soil moisture sensor can function properly or not. The test was carried out by observing the percent soil moisture data from the soil moisture sensor reading YL-69 which was displayed on the LCD and compared with a moisture tester. For more details, the data can be seen in Figure 13 and Table 2.

Figure 13. Soil moisture sensor testing

Table 2. Soil Moisture Sensors Test Results

Testing Number-	Soil Moisture Measurement (%)		Error (%)
	Moisture tester	Soil Moisture Sensors	
1.	80	82	2.5%
2.	80	82	2.5%
3.	80	82	2.5%
4.	75	78	4%
5.	75	78	4%
6.	75	78	4%
7.	70	74	5.7%
8.	70	74	5.7%
9.	70	74	5.7%
10.	70	74	5.7%
Average Error			4.2%

Table 2 shows the comparison data for measuring the percent of soil moisture using a soil moisture sensor and a moisture tester. The average percentage error (%) of reading the percent of soil moisture on the soil moisture sensor reaches 4.2%. The difference in the reading of the percent of soil moisture is due to the level of sensitivity to detect soil moisture as detected by the soil moisture sensor and moisture tester. Also, soil conditions that are not moist can affect soil moisture in the surrounding area. This causes the sensing of the sensor disrupted (measuring soil moisture through a sensor plugged into the ground), because the sensitivity level of the soil moisture sensor is higher and faster than the moisture tester.

B. Software Testing

1) Android Testing

Testing of the prototype greenhouse conditioning system using android aims to determine whether the system performance is running well or not. This test is done by turning on all systems as a whole and observing the value of the temperature degree from the temperature sensor and the percent of soil moisture from the soil moisture sensor on Android. The data obtained from the temperature and humidity sensor readings of the soil will be processed by the microcontroller which will then be sent to cloud computing via an internet connection using a router.

The data that has been sent to cloud computing can later be stored and can be accessed by the user to monitor the temperature and humidity values of the cut chrysanthemum soil or change the automatic mode to manual mode in the watering process using an android application that has been made and has been downloaded via a smartphone. The following is a web view of the prototype greenhouse conditioning system and the results of android testing.

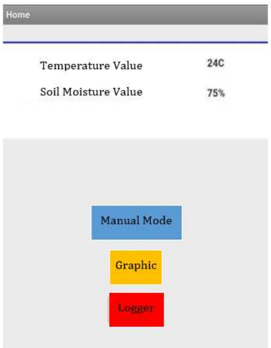

Figure 14. Android apps view of conditioning chrysanthemum

Table 4. Android Test Result

Testing Number-	Android	
	Temperature (^{O}C)	Soil Moisture (%)
1.	24	75
2.	24	75
3.	25	75
4.	26	75
5.	27	75
6.	28	75
7.	27	75
8.	26	75
9.	25	75
10.	25	75

2) Web Testing

Testing of the prototype greenhouse conditioning system using the web aims to determine whether the system performance is running well or not. This test is done by turning on all systems as a whole and observing the value of the temperature degree from the temperature sensor and the percent of soil moisture from the soil moisture sensor on the web. The data obtained from the temperature and humidity sensor readings of the soil will be processed by the microcontroller which will then be sent to cloud computing via an internet connection using a router.

The data that has been sent to cloud computing can later be stored and can be accessed by the user to monitor the value of the temperature and humidity of the cut chrysanthemum soil or change the automatic mode to manual mode in the watering process using a web browser on a laptop or smartphone. The following is a web view of the prototype greenhouse conditioning system and the results of web testing.

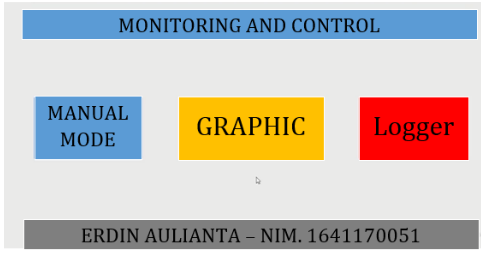

Figure 15. *Web server* interface view of conditioning chrysanthemum

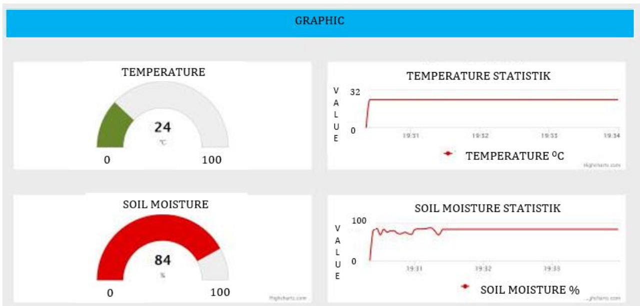

Figure 16. *Web server* view of conditioning chrysanthemum

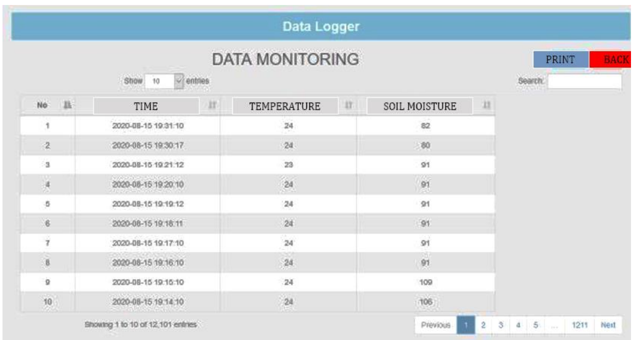

Figure 17. Historical view from *web server* of conditioning chrysanthemum

Table 3. Web Test Result

Testing Number-	Web	
	Temperature (^{o}C)	Soil Moisture (%)
1.	24	75
2.	24	75
3.	25	75
4.	26	75
5.	27	75
6.	28	75
7.	27	75
8.	26	75
9.	25	75
10.	25	75

C. Result Chrysanthemum Cut Flowers

This section showed that chrysanthemum cut that uses temperature and humidity conditioned ground using the Internet of things technology can grow faster 7 days compared with chrysanthemum cut using a manual system. The following is photos of chrysanthemum cut flowers growth using technology (greenhouse 1) and without technology (greenhouse 2).

(A)

(B)

Figure 18. (A) Greenhouse 1 (B) Greenhouse 2

IV. CONCLUSIONS

From the results of research that has been done, this system can condition the temperature and humidity of the soil in the chrysanthemum cut flower *greenhouse* prototype according to the required conditions. Based on the results of the tests that have been carried out, the temperature and soil moisture conditioning system on the object-based internet of things can read, saving and display data on temperature degrees and soil moisture percentages with remote internet network communication via *web server* and android applications. The web server and android applications used by users as interfaces for monitoring and controlling chrysanthemum work well, namely by running using automatic mode or manual mode. In addition, Android and the web can display historical data previously stored in the cloud in the form of graphs and data loggers. From this system, it is found that the system is able to accelerate the growth process of chrysanthemum cut flowers by growing 7 days faster than using the conventional system which is usually completed within 30 days.

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