2021 International Conference on Advanced Mechatronics, Intelligent Manufacture and Industrial Automation (ICAMIMIA) | 978-1-6654-9969-9/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICAMIMIA54022.2021.9807698

Prototype Design of Automatic Light Intensity Control in Smart Green House

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Abstract— **Lack of sunlight will interfere with the process of photosynthesis and the growth of plants. The amount of needs on each plant depends on the needs of plants. Lack of light will cause symptoms of ethiolasi, i.e. the stem will grow smaller and pale (not green). Therefore, Roof Retractable System is the solution to the problem. The system is equipped with Grow LED that can provide light intensity differ according to the type of plant, for example, Pakcoy needs light 12000 lux, and Lettuce requires light 4305 lux. The result of the Variation of Grow LED is produced by utilizing dimmer rotation controlled by Arduino Mega, Light Intensity Requirement (BH1750) which is then able to be monitored through the Website. Retractable Roof works automatically based on seed and Planting Modes so that it can be seen the response of light intensity values that adjust to the Servo Motor and Growing LED. Test results from Morning to Afternoon Light Intensity following Table 4.5. Where if the Lux value is less than setpoint which is 5000, then Dimmer will create an angle that has been summed up with the existing Lux value in that hour, and then if Lux <.=100 then dimmer will show angle 225 or maximum**.

Keywords— ***Smart Greenhouse, BH1750, Servo Motor, Growing LED, Dimmer***

I. Introduction

Sunlight is needed for plant growth. Light is the main factor for photosynthesis to take place. Photosynthesis is a process that is the key to the ongoing metabolic processes in plants. Each type of plant has an ideal light requirement to carry out the process of photosynthesis. Lack of sunlight as needed will interfere with the growth process or is called etiolation symptoms, namely the stem will grow smaller but weaker and the leaves are small and pale (not green). Symptoms of etiolation are caused by a lack of light or plants in a dark place [1]. The effect of light intensity is also different for each type of plant. Types of plants have different properties in terms of photoperiodism, namely the length of time the irradiation in one day is received by plants. Lack of light causes disruption of the process of photosynthesis and growth, although the need depends on the type of plant [2]. The source of sunlight energy needed in the process of photosynthesis is an important factor in plant growth because unexpected absorption will take place optimally if the lighting lasts between 8-12 hours/day [3].

The influence of sunlight on plants that affect photosynthesis and photo stimulus consisting of the process of movement and expansion of leaves, budding and flowering. Plants or trees have different tolerances for [4]. In addition, if the sun is covered by clouds, one way that can be used to take advantage of sunlight is LED lights or Growing Lights. The light source must be of the right quality for photosynthesis. Chlorophyll can absorb long wavelengths of red (600-700 nm) and blue waves (400-500 nm), so the lamps are designed for plant growth at these wavelengths. LED lights can emit light colors that can speed up the photosynthesis process. The blue color functions in the vegetative phase and the red color functions in the generative phase [5]. Due to unfavorable environmental conditions such as low sunlight, a Retractable Roof Automation System with Light Intensity Control Technology using Servo Motors is needed to open or close the roof for photosynthesis and plant growth. And if when the sun does not meet the setpoint, then there is a support system by LED lights that work to help the photosynthetic process and meet the light needs of the plant. To support a monitoring system that is more accessible or easier to control, the system to be designed will also be equipped with an IoT system that can make it easier for users to see the growth conditions of plants.

II. THEORY

A. Retractable Roof Automation System Technology

Automation system is a technology related to mechanical and electronic applications to provide functions to manipulators (mechanics) so that they will have certain functions [6]. One of them is by setting the Rectractable Roof Automation System on the Smart Green House so that the incoming sunlight matches the set point that has been set on the needs of the plant.

Servo motors are motors that can work in two directions (CW and CCW) where the direction and angle of the rotor movement can be controlled only by setting the PWM signal duty cycle on the control pin, the servo motor works with a closed feedback system where the position of the servo motor will be adjusted. inform back to the control circuit. The servo motor consists of a motor, a gear circuit, a potentiometer, and a control circuit. [7] Therefore we need an automation system on this servo motor as a driver on the Rectractable Roof as an open and close to meet the needs of sunlight.

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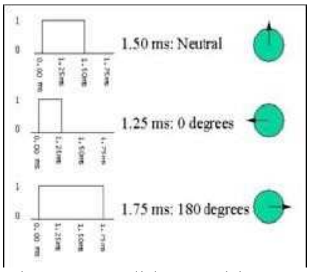

Figure 1 Crediting Position

B. Light Intensity on Pakcoy and Lettuce Plant Growth

Light intensity is one of the important factors in plant growth and the ongoing process of photosynthesis in plants [8]. The level of light intensity in the greenhouse in the morning ranges from 300-22800 lux, during the day it ranges from 7200-78900 lux, and in the afternoon it ranges from 800-25600 lux. While the ideal requirement for mustard plants is with a temperature of 35'C with a light level of 12000 Lux. Then the light needs of lettuce plants are between 200-400 footcandle (2152.78-4305.56) lux. The light emitted from the source, namely energy in the form of waves, is part of the group of electromagnetic waves and natural light from the sun which consists of invisible light and visible light. Visible light is also called PAR (Photosynthesis Active Radiation) designating the spectral range of solar radiation 400-700 nanometers.

Table 1 Light Intensity On Growing LED

Intensitas (Lux)	Spectrum Cmposition	Exposure Duration Hours/Day
591-874000	Spektrum Penuh	12
3580	Red 80% blue 20%	18
4440	Red 20% blue 80%	18
3770	Red 50% blue 50% Bright White 100% Daylight	18
8830	Color Temperature 6500 Kelvin	18

It is in this range that photosynthetic organisms can use it in the photosynthesis process.

III. METHOD

A. The Research Flow Chart

The research procedure is shown in the following figure 2 below.

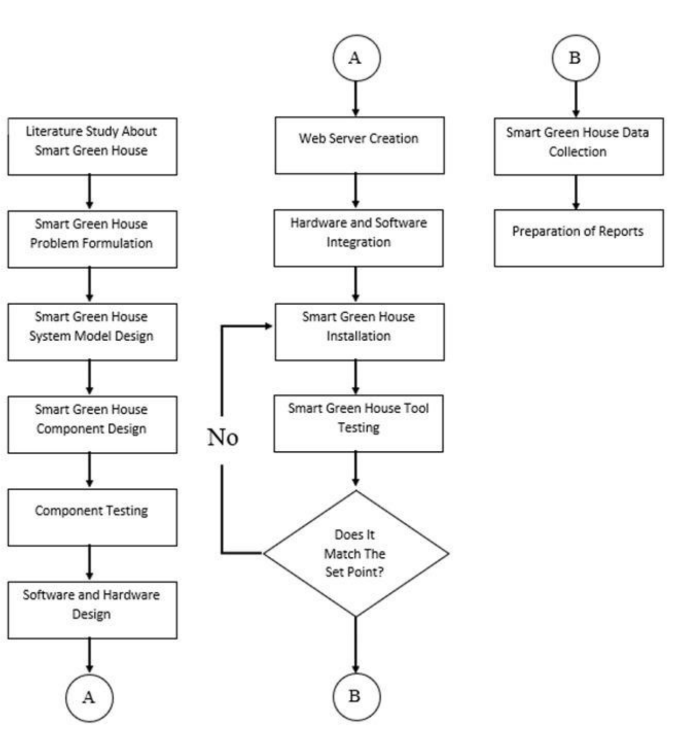

Figure 2 The flow chart of research

This research begins with a literature study on Smart Greenhouses and the formulation of the problem regarding light in the greenhouse. Then the design of the Smart Greenhouse includes an explanation regarding the modeling of the control system. From the design results, then the selection and testing of the Smart Greenhouse component are carried out. The next stage is software and hardware design. then enter into making Webserver which will be integrated in Hardware and Software. The next stage is entering the installation on the Smart Greenhouse and then testing whether it is in accordance with the setpoint, if the data has been taken from the Smart Greenhouse after that the report is prepared.

B. Control System Concept in Smart Greenhouse

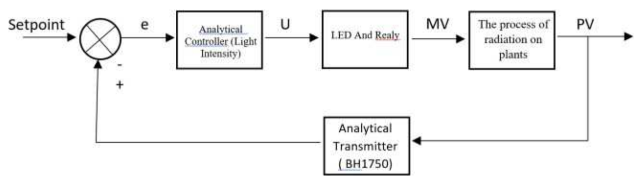

Figure 3 Grow Led and Relay Control Block Diagram

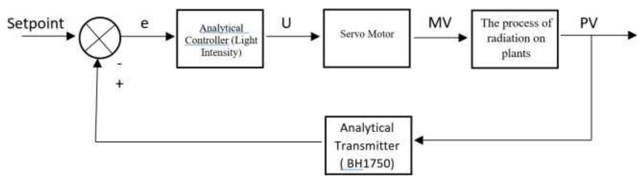

Figure 4 Servo Motor Control Block Diagram

The closed-loop control system is a control system whose output signal has a direct influence on the control action performed as a closed-loop control system [6]. The control block diagram above explains the work process on irradiating plants, where the light intensity is set according to the setpoint for each type of plant and then controlled by Arduino Mega. Arduino Mega will give a signal to reach the setpoint to the servo motor or LED. The signal serves as the action of irradiating the Light Intensity for each type of plant. Furthermore, the BH1750 sensor sends feedback where the results measured by the sensor are compared with the setpoint processed by the controller. Then the controller sends an output signal to control the rotation of the Servo Motor and the Light Intensity on the LED to match the setpoint of each type of plant.

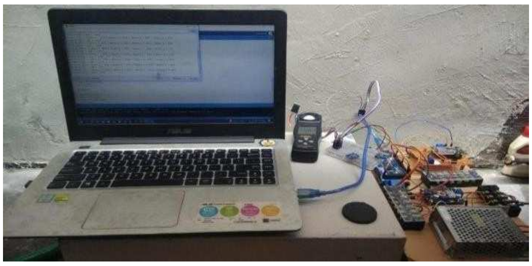

Figure 5 Testing on the light intensity sensor BH1750

At this stage, the BH1750 light intensity sensor component is tested to determine the measurement performance. This test is carried out in the following steps:

1. Testing the characteristics of the light intensity static measurement using the BH1750 light intensity sensor.
2. Validation of the light intensity sensor BH1750 with Luxmeter.
3. If the results obtained are appropriate, it can be seen the results of the calculation of the static characteristics of the BH1750. light intensity sensor measurement

C. *Component Testing on Servo*

At this stage, the servo motor components are tested with a timer to find out whether the components are working according to the desired timer. First, testing is done on the servo as an actuator whether it is following what was ordered by the controller by setting a timer that has been adjusted to the needs of the plant. So when the timer runs, the servo motor is closed, and if the timer stops, the servo motor is open.

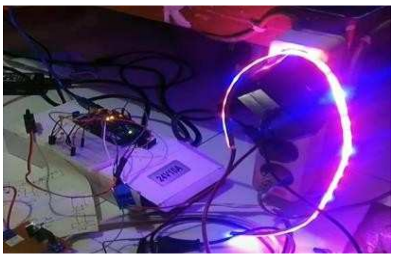

Figure 6 Timer Testing on Servo Motors

The steps in testing a servo motor with a timer are as follows:

1. The servo motor pins are connected according to Figure 6 on the Arduino Mega2560
2. Wiring on the cable is checked again with the Avometer, if the Avometer is Analog then the X1 option is on the Ohm symbol (Ω) and the choice of sound-symbol or diode if the Avometer is digital. Is it already connected or not.
3. Tested on the performance of the Servo Motor which is controlled by the Microcontroller with Arduino software.
4. Tests were carried out on the Seedling and Planting System section on the Microcontroller that was connected to the Laptop by giving a Setpoint according to the needs of the plant.
5. If the timer is ready, the seedling will run according to the setpoint then the servo motor is ordered by the relay by closing the roof until the timer has stopped.

D. *Grow LED Test on Dimmer*

At this stage, testing is carried out on the Grow Led component on the Dimmer as a support system from Matahari Light if it does not meet the value of the Setpoint. First, the dimmer is tested as an actuator whether it is following what was ordered by the controller by testing the dimmer rotation at a certain angle.

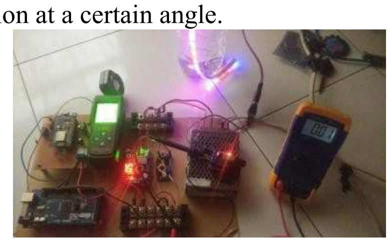

Figure 7 Grow LED Test on Dimmer

The steps in testing the Grow LED on the dimmer are as follows:

1. The Grow LED pin on the dimmer is connected according to Figure 8 on the Arduino Mega2560
2. Wiring on the cable is checked again with the Avometer, if the Avometer is Analog then the X1 option is on the Ohm symbol (Ω) and the choice of sound-symbol or diode if the Avometer is digital. Is it already connected or not.
3. Testing the output value of the measurement on the Grow LED Current with a digital Avometer on the Current option (A) to display the value results.
4. Tests were carried out by turning the dimmer at a certain angle that had been ordered by the controller to determine the value of the Grow LED light intensity.
5. The light intensity value of Grow LED is validated by Luxmeter.
6. If the data obtained is processed to determine the performance of Grow LED on the dimmer.

E. Making a webserver on a smart greenhouse

Test the remote controller communication and then monitor through the HMI, whether the intensity meets the setpoint in accordance with the desired output. So that the measurement results of the BH1750 sensor can be transmitted via a wireless module. The wireless module here uses phrasing data communication by using data sharing or separator from the captured sensor to a laptop that gets the reading results so that it can be compared with a validated measuring instrument and perform an action such as the Servo Motor output.

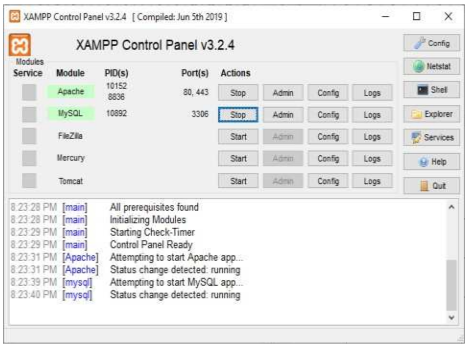

Figure 8 Control Panel XAMPP

In the xampp control panel, it functions as a connection from the sql database which will be connected by the webserver.

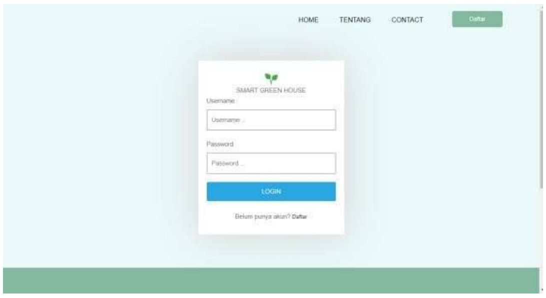

Figure 9 Login view Webserver

As for the smart greenhouse website login display, several components can be selected, including the profile of the maker and other.

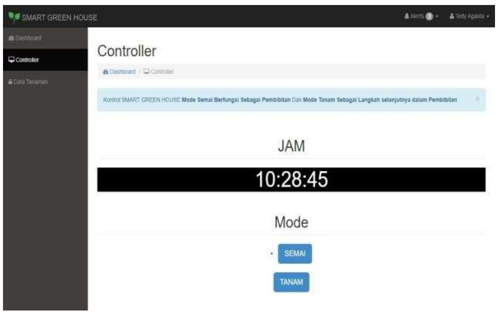

Figure 10 Dashboard Website

IV. Results and Discussion

A. Light Intensity Sensor Component Test Results

In testing a component, it is very necessary related to whether the component is functioning or not. Testing these components is also a comparison between measuring instruments that have been validated and whether they meet the standards. Here are the Test Results of the Light Intensity Sensor Components that have been tested }. The test results are shown in Figure 11 below.

Figure 11 Light Intensity Sensor Test

Figure 11 is the position of placing 4 light intensity sensors in different places. The intensity value sensed by 4 light intensity sensors is then averaged to obtain the intensity of sunlight. The average sensing result from the light intensity sensor is compared with the Luxmeter measuring instrument which works as a standard measuring instrument. The results of the light intensity test taken from morning to day are shown in table 1 The experiment was carried out with an interval of 30 minutes. The readings that have been made in the table are as follows:

Table 2 Light Intensity Sensor Test Results with Setpoint 500 Lux

Time	Light Intensity (Lux)						Servo Motor Condition
	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Rata-Rata (X)	Lux Meter	
6:00:00	3255	3453	2216	2023	2737	2800	Open
6:30:00	5246	5495	3845	3543	4532	4556	Open
7:00:00	7280	7522	5935	5786	6631	6642	Open
7:30:00	13673	14252	11060	10147	12283	12300	Open
8:00:00	20217	18350	15786	13992	17086	17120	Open
8:30:00	11350	12140	10824	7424	10435	10459	Open
9:00:00	21755	22236	14511	13164	17917	17960	Open
9:30:00	23145	22320	14284	13772	18380	18402	Open
10:00:00	17640	18039	11129	10610	14355	14400	Open
10:30:00	14007	13121	8884	8551	11141	11155	Open
11:00:00	10711	10915	6483	6209	8580	8602	Open
11:30:00	9663	9970	5907	5625	7791	7805	Open
12:00:00	8240	8657	5160	4870	6732	6752	Open
12:30:00	7513	7949	4853	4585	6225	6244	Open
1:00:00	6939	7440	4630	4355	5841	5842	Open
1:30:00	6335	6944	4385	4097	5440	5444	Open
2:00:00	5695	6288	4083	3787	4963	4991	Open
2:30:00	4564	5078	3515	3254	4103	4151	Open
3:00:00	4390	4906	3445	3328	4017	4022	Open
3:30:00	3685	4149	3062	2782	3420	3452	Open
4:00:00	3192	3636	2759	1653	2810	2832	Open
4:30:00	2457	2805	2172	1527	2240	2247	Open
5:00:00	1187	1352	1043	702	1071	1078	Open
5:30:00	138	155	124	104	130	132	Open
6:00:00	1	1	1	1	1	1	Open

Table 2 shows the light intensity values of 4 BH1750 sensors placed in each corner of the roof. The light intensity value obtained varies with a range of 0 to 22320. This variation is caused by the influence of sensor placement on the Smart Greenhouse prototype. Each sensor will be added up and taken on average to produce a value of sunlight intensity (Lux). So that the condition of the Servo Motor takes the Setpoint value of 500 Lux, where if the average value of the 4 sensors does not exceed the Setpoint value, the Servo Motor will be closed..

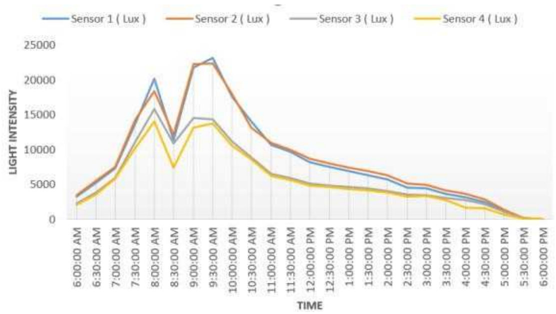

Figure 12 Graph of Light Intensity Sensor Value Morning to Evening

Figure 12 shows a graph that goes up - down at a certain time, at 08.00 - 08.30 there is a decrease in the value of light intensity because the sun's light is covered by clouds and then it increases again at 09.00 WIB because the intensity of sunlight is not blocked by clouds.

Correction = Luxmeter – Light Intensity

The result of the correction value serves to determine the difference between the measuring instrument and the light intensity sensor. Then the error value obtained is following the calculation, namely:

$$Error = \frac{\text{Nilai Lux Meter} - \text{Nilai Sensor}}{\text{Nilai Lux Meter}} \text{ x } 100\%$$

The results of the sensor reading error value obtained an average value of 0.46%. This can be caused by the quality of the sensor used and the influence of the intensity of sunlight from the environment.

Then the calculation of the value of the static characteristics of the measurement system based on the light intensity sensor (BH1750) is as follows:

- Accuracy :

$$A = 1 - \left|\frac{Y_n - X_n}{Y_n}\right| \times 100\%$$

$$A = 1 - \left|\frac{177860 - 179388}{177860}\right| \times 100\%$$

Dengan :

Y_n = Standard Reading

X_n = Tool Reading

$$A = 0{,}997 \times 100\% = 99{,}70\%$$

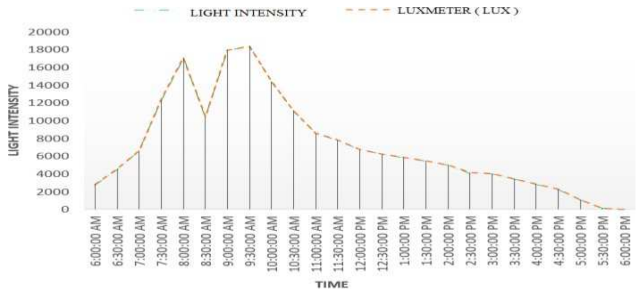

Figure 13 Graph of Light Intensity Values with Luxmeter

Figure 13 is the result of testing the light intensity sensor from 06.00 AM to 06.00 PM which has been validated by Luxmeter in accordance with Table 2. Then after looking at the graph in Figure 14 there is the linearity of the reading results from the comparison between the Light Intensity Sensor and Luxmeter..

Linearity Regression : Y = a + bx

In calculating the value of a is not calculated because X has a value, therefore the results obtained from the calculation of Linearity Regression with the equation Y = 1.00103X

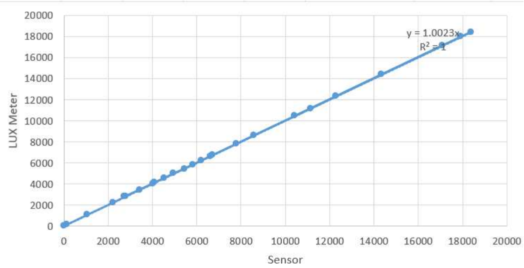

Figure 14 Morning to Evening Linearity Regression Graph

B. Result of GROW LED Intensity Variation on Control Dimmer according to setpoint

In testing a component that is very necessary regarding whether the component is functioning or not. This test, comparing components with a validated measuring instrument, namely Luxmeter. Based on the steps described in sub-chapter 3.6.3 regarding the Grow LED test, here is the dimmer test on the wiring circuit before testing:

Figure 15 Testing of Light Intensity Variations on Grow LEDs using a Dimmer

Led component as a support system from Cahaya Matahari if it does not meet the value of the setpoint. The Grow Led response to the dimmer rotation is influenced according to the input from the light intensity sensor by testing on GrowLed. Here are the results of the GrowLed Variation test

Figure 16 The results of the Grow LED light intensity variation test at an Angle of 225 Degrees

Figure 16 is tested in a room that does not get the intensity of sunlight and is only illuminated by light from the door which has little effect on the intensity of the Grow LED. This is one of the results of testing variations in light intensity at an angle of 225 degrees on the dimmer component with the current results measured by the avometer. 0.34 A with a Grow Led light intensity value of 312. In the above test, the comparison graph value between the Grow LED light intensity value and the current required to turn on the light or not is as follows:

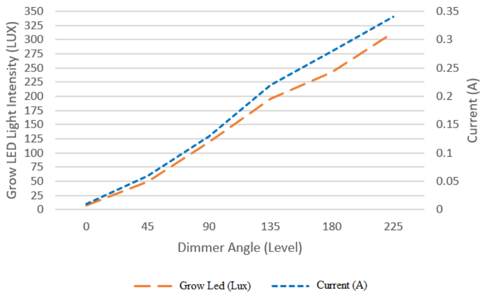

Figure 17 Grow LED light intensity variation test graph

Figure 17 shows the results of a comparison graph which will be used as a reference for the Setpoint value to meet the needs of light intensity at night if it is not following the Setpoint.

Table 3 Test results of variations in the light intensity of Grow LED against the dimmer angle

Time	Light Intensity (Lux)		Servo Motor Condition	Dimmer Angle
	Rata-Rata (X)	Lux Meter		
6:00:00	2737	2800	Open	123
6:30:00	4532	4556	Open	20
7:00:00	6631	6642	Open	0
7:30:00	12283	12300	Open	0
8:00:00	17086	17120	Open	0
8:30:00	10435	10459	Open	0
9:00:00	17917	17960	Open	0
9:30:00	18380	18402	Open	0
10:00:00	14355	14400	Open	0
10:30:00	11141	11155	Open	0
11:00:00	8580	8602	Open	0
11:30:00	7791	7805	Open	0
12:00:00	6732	6752	Open	0
12:30:00	6225	6244	Open	0
1:00:00	5841	5842	Open	0
1:30:00	5440	5444	Open	0
2:00:00	4963	4991	Open	2
2:30:00	4103	4151	Open	41
3:00:00	4017	4022	Open	45
3:30:00	3420	3452	Open	50
4:00:00	2810	2832	Open	99
4:30:00	2240	2247	Open	125
5:00:00	1071	1078	Open	177
5:30:00	130	132	Open	220
6:00:00	1	1	Open	225

Table 3 are the test results of the light intensity in the morning to the evening in accordance with the light intensity value. Where if the Lux value is less than the Setpoint, which is 5000, then the Dimmer will make the angle that has been added up with the Lux value on the hour then if Lux <.=100 then the Dimmer will show the angle of 225 or maximum. In the above test, the results of the graph are as follows:

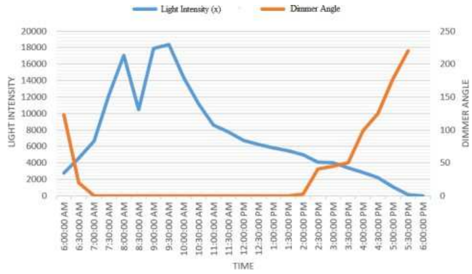

Figure 18 Graph of Test Results of Grow LED light intensity variations against dimmer angle and time

CONCLUSION

Results The performance of monitoring light intensity (Lux) using the BH1750 sensor has worked well. This is shown from the results of the accuracy value of 99.70% and error 0.46%. Meanwhile, the performance of the light intensity control system on the dimmer will adjust the light intensity of the Grow LED according to the Setpoint. at 05:30 AM the intensity of the external light gets a value of 108 Lux with an increase in the angle of the dimmer of 135 degrees, then the Grow LED intensity of 196 degrees is added which has been validated by Luxmeter..

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