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# Design of Monitoring and Control System Temperature Based on IoT for Egg Incubator Using Solar Panels

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A R T I C L E I N F O

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A B S T R A C T

Energy is one of the most important components of human life. In the livestock industry, problems occur when there is a power outage so that the incubator cannot function. Solar energy is one of the renewable energy sources that convert solar radiation into electricity based on the photovoltaic effect and can be a solution to the above problems. In addition, another problem is that the egg incubator used by farmers still uses a manual system, the solution to the problem by utilizing IoT technology for monitoring and control systems for temperature, humidity, and egg rotation. the purpose of the research is to develop a smart incubator system to automate IoT-based temperature, humidity, and egg rotation systems so that they can be monitored more effectively using solar power as a power source. This research uses observational and quantitative methods with data collection techniques carried out through observation. The result of this research is the design of an IoT-based automatic incubator system using 30 WP solar panels as an energy source. In the measurement of the temperature monitoring IoT system in real-time, an error value of 0.93 was obtained with a temperature accuracy value of 99.07 which was declared very good, in the blynk test with a thermometer an error value of 2.92 was obtained with an accuracy value of 97.08 which was declared very good, in the humidity test an error value of 6.9 was obtained with an accuracy value of 93.1 which was declared quite good.

## INTRODUCTION

Energy plays an important role in human survival. As much as 80% of total global energy consumption still depends on fossil fuels. (Bayusari & Hutama, 2021) with the existence of, Solar photovoltaics are a renewable energy source that is included in the type of clean energy (Achmad et al., 2023) using type, polycrystalline solar cells are quite sensitive and can obtain high energy from the sun even though the light intensity is low. (Hidayat et al., 2022), from what is experienced by poultry egg farmers by setting the temperature and humidity less accurately, causing it to occur. The main obstacle in using an egg incubator is maintaining the temperature in the incubator at a constant range of 36°C to 40°C. (Afandi et al., 2023), from the results of reading the percentage. Statistics show that around 8-9% of all eggs do not hatch, wasting time, space, effort, and energy. (Maaño et al., 2018) for users of traditional methods, the success rate of egg incubation using this traditional method only reaches around 50-60%. (Auliafitri et al., 2024; Nurul Mukhlisah Abdal, 2018)

Previous research titled Smart Egg Incubator Based on Microcontroller has not used remote control and monitoring of the incubator using Internet of Things (IoTs) technology (Youcif Izadeen & Sarhan Hussein Kocher, 2022) So the updates that need to be developed are digital egg incubators that utilize IoT technology. (Prabowo et al., 2024) Currently, automatic incubation is already used in poultry farms for hatching eggs. (Sruthi B & Jayanthy, 2017; Aldair et al., 2018) because in maintenance, incubation temperature is the most important factor in incubation efficiency. (Ya et al., 2021) The optimal environmental temperature for incubation of poultry species should be between 37°C and 38°C. (Journal et al., 2021). In the egg incubation method, the egg-hatching process requires a consistently stable temperature between 37-39-C (Gutierrez et al., 2019;(Boleli et al., 2016; Prabowo et al., 2024) and a humidity level of 60-80%. (Maaño et al., 2018; Noiva et al., 2014; Tesarova et al., 2021).

From the traditional method, the purpose of making it, the egg incubator machine functions to imitate the natural conditions provided by the mother animal, thereby increasing the success rate of egg hatching beyond its natural ability. (Maroma et al., 2023). Function of the Tool, The incubator is an electro-mechanical device used to provide temperature and humidity for egg fertilization (Kanu et al., 2016; Aldair et al., 2018). Temperature and humidity must be properly controlled to help hatch eggs, which is one of the main objectives of the microcontroller-based egg incubator machine. (Mariani et al., 2021). The temperature and relative humidity (RH) in the incubator must be controlled at optimal environmental conditions in the range of 36-39°C and relative humidity of 60-80%. (Ya et al., 2021)

The solar cell system is one of the sustainable and environmentally friendly energy sources, the need for which is increasing day by day. (Ali et al., 2024). By using solar panels as a backup that can provide continuous electrical energy if the electricity flow in the incubator is disrupted. (Purba & Purba, 2020) A solar-powered incubator is an automatic tool combined with an automatic egg turner with a controller to maintain the required heat, humidity, and air levels needed to carry out tasks. (Ganiyat & Afolake, 2020).

Power requirements for incubators, Using Solar energy is the most effective renewable source to convert solar radiation into electricity based on the photovoltaic effect. (Ugale & Dixit, 2017; Kosunalp, 2016) because, the intensity of light affects the amount of current, voltage, and power produced by solar panels. (Salim et al., 2020). The use of electricity needs is increasing from renewable energy, so Solar energy has received great attention as a means of providing electricity to incubators for egg incubation, this will be the answer to the electricity limitations faced by the poultry industry in remote areas. (Baraza et al., 2022).

Researchers developed an incubator to automate the adjustment system, such as temperature, humidity, egg turning based on IoT, and photovoltaic as a power supply for the incubator (Sanjaya et al., 2018). The latest update of the IoT-based Incubator uses sensors and microcontrollers to monitor and observe environmental conditions in the poultry farm. (Ahmad et al., 2021). The real-time online monitoring system is considered to be a solution so that monitoring egg hatching can be more efficient. The monitoring system uses the Internet of Things. (Sanjaya et al., 2018; Rakhmawati et al., 2019; Lestari et al., 2020; Parenreng et al., 2024)

The purpose of designing and assessing an incubator that can maintain temperature and humidity using a DHT22 sensor with a thermometer measuring device is to obtain error values and accuracy of temperature and humidity measurements, using the Blynk application, which will be an extension of the Internet of Things. By utilizing energy from solar panels.

## METHODS

This research method used observation and quantitative methods. Observation is a data collection technique that is carried out through observation, accompanied by notes on the state or behavior of the target object under study. Quantitative observation is a type of research that basically uses a deductive-inductive approach.

Table 1. Solar panel specifications 30 wp

| Specification | Value |
|---|---|
| Material | Polycrystalline |
| Maximum power value | 30 watts of power |
| Tolerance | ±3% |
| Maximum power output | 18 Voltage |
| Maximum current value | 1,67 current |
| Size | 630 x 350 x 17 Mm |

The power source used in this study is a polycrystalline solar panel which has a lower efficiency and can produce electrical energy in cloudy or cloudy weather. Table 1 shows the specifications of the 30wp polycrystalline solar panel used to supply voltage from solar power to the incubator.

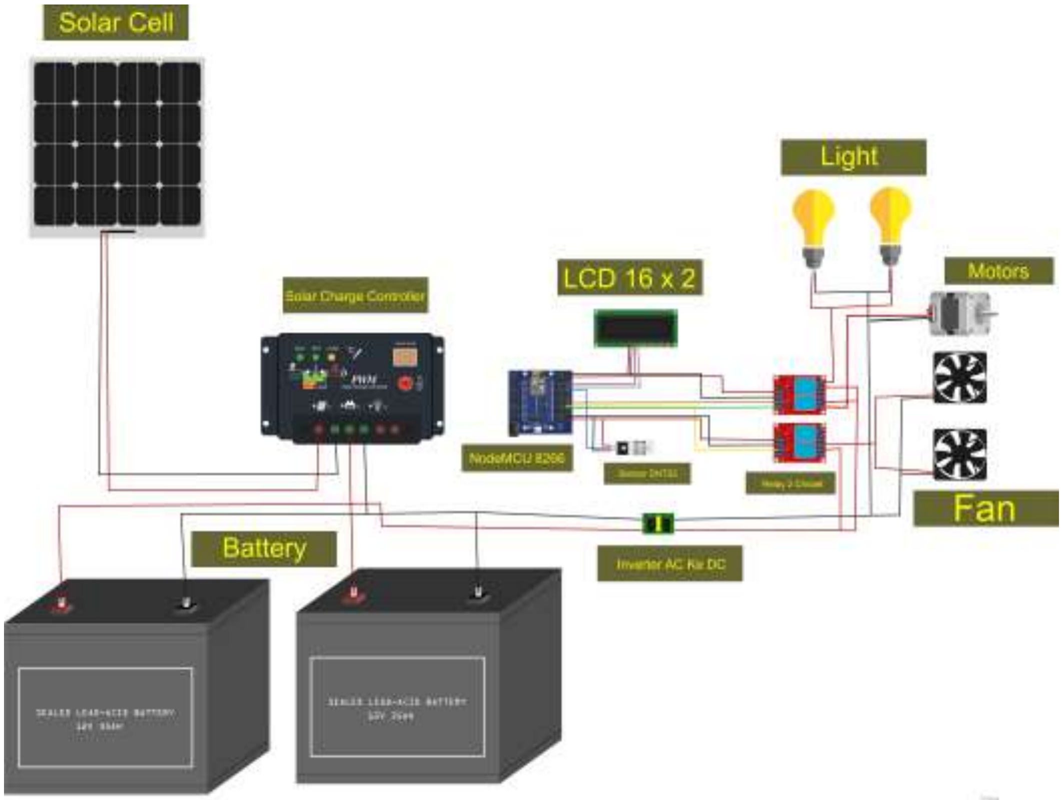


Figure 1. Block Diagram of the system

Figure 1 shows the block diagram of the design of the incubator temperature and humidity monitoring system based on the Internet of Things using a 30 wp solar panel made with the function of the following components:

1. Solar panels are devices consisting of solar cells that absorb or store solar energy and are used as a source of electricity.
2. A solar charger controller is used to control battery charging with energy produced by solar panels.
3. NodeMCU 8266 board with the ability to carry out microcontroller functions and carry out internet connectivity.
4. Relay electronic component which functions as a switch operated by voltage.
5. DHT22 sensor is a sensor that can measure two environmental parameters, temperature and humidity.
6. LCD functions to display temperature and humidity values.
7. Blynk can control electronic components by connecting to the internet.
8. The incubator power load used consists of a light bulb, stepper motor, and DC fan with the following functions:
   a. Light bulbs are used to generate the heat needed to increase the ambient temperature of the incubator.
   b. The drive motor is used to drive the egg-turning tray and tilt it to form a 45-degree angle.
   c. The fan ensures the cooling of overheated incubators and ensures the maximum exchange of oxygen and carbon dioxide.

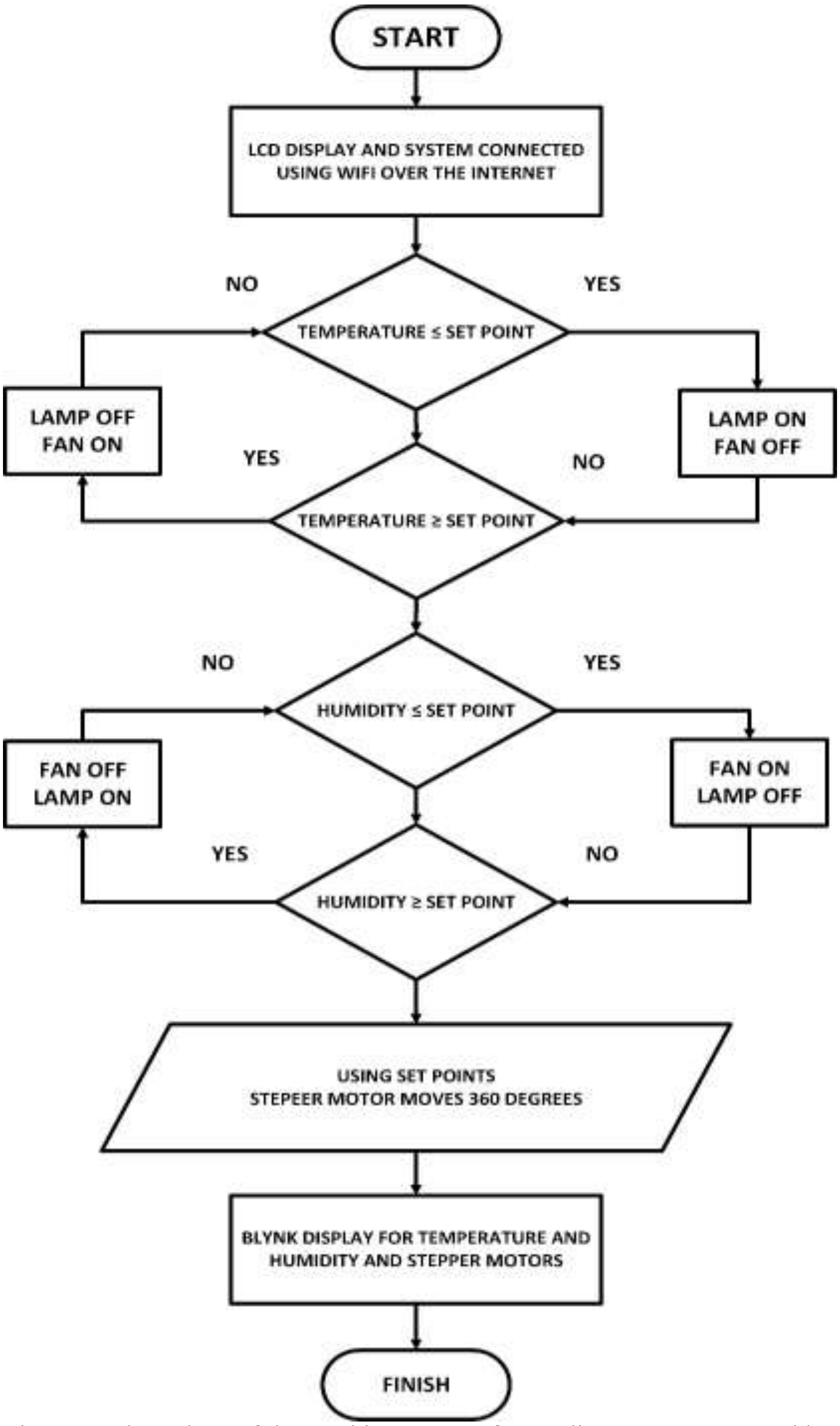


Figure 2. Flow chart of the working system for reading temperature and humidity

Figure 2 is a diagram of the Internet of Things-based temperature and humidity monitoring system that works using temperature and humidity measurements. The system starts by interpreting internet connection commands from the temperature and humidity data displayed on the Blynk and LCD screens. By analyzing the temperature and humidity conditions on the Blynk interface and LCD screen, which is then sent through the given command:

1. The first condition is that if the temperature range is lower than the specified level, the fan will switch off and the light will switch on to raise the temperature until it reaches the specified temperature value.
2. The second condition is that if the value is higher than the specified value, the lights will turn off and the fan will turn on to cool and reduce the heat so that in the second condition

the humidity value will increase and the temperature value will decrease.

3. The third condition is that if the motion command is read, the stepper motor will rotate 360 degrees to move the egg rack. Failure to read the command will result in the stepper motor not rotating, as seen on the LCD screen and Blynk website.

## RESULTS AND DISCUSSION

This research has successfully designed a smart incubator control temperature and humidity monitoring system based on the Internet of Things by using a 30wp solar panel as a power supply. This research includes the development of software systems based on the Internet of Things and electricity-generating devices using solar panels on incubators. The main objective of this research is how to design an incubator temperature and humidity monitoring system using the Internet of Things shown in Figure 3, and how to make an incubator device using a source of electrical energy from solar panels is shown in Figure 5.

Figure 3. Design and build of an automatic incubator system

Figure 3 is the result of research on the development of an automatic incubator design tool with dimensions of 60 cm long x 40 cm wide and 40 cm high which has the capacity to hold 60 eggs. Inside the black box there is a NodeMCU 8266 microcontroller with a relay as an automatic switch, on the front there is an LCD screen that functions to display data to monitor temperature and humidity, using sensors to read the temperature and humidity installed in the incubator. on the incubator load using 2 bulb lights to warm the incubator room and stepper motors rotate eggs automatically, and fans are used to remove air when the temperature is above a predetermined range.

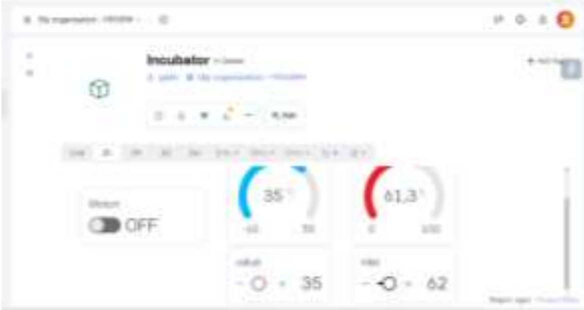


Figure 4. Blynk display system

Figure 4 shows the Blynk interface that can be remotely accessed via the Internet of Things that can improve system performance by automatically switching on and controlling temperature, humidity, or motors as needed. Humidity decreases as temperature rises and the system heats up, while temperature decreases as humidity increases. The results of this research bring an update The interface provides a detailed view of the temperature, humidity, and other parameters. Users can easily access and monitor the temperature and humidity status of the incubator in real-time.

Figure 5. Solar panel circuit

In Figure 5, the research results use a poly-crystalline solar panel type because this type has an energy conversion efficiency of around 15-17%, which means that around 15-17% of the sunlight energy received by the solar panel can be converted into electrical energy. Designed in the form of an angled triangle with a 30-degree tilt so that it can face the sun to get maximum sunlight.

In this study using two tests, namely testing temperature and humidity monitoring software connected to the Internet of Things, the system will be tested to ensure the website can receive and display real-time temperature and humidity data accurately and it is hoped that this system can monitor and control the temperature and humidity of the incubator effectively, and provide easy access through a secure and reliable online platform and testing solar panel devices that aim to determine the amount of voltage and current that can be obtained by solar panels when getting sunlight.

**Temperature and Humidity Monitoring Testing**

Software testing is carried out using the black box testing method to test the accuracy and reliability of temperature and humidity, which is shown in the measurement results in tables number 1, 2, and 3. The following are the temperature and humidity testing criteria:

Table 2 contains the accuracy measurement of the temperature system by comparing the setpoint with the Blynk temperature value, which establishes the conditions under which the accuracy of the temperature value displayed on the Blynk website can be achieved.

Table 2. Temperature system test results

| Time | Set point (C˚) | BLYNK (C˚) | Error | Information |
|---|---|---|---|---|
| 10.30 | 34 | 34,1 | 0,29 | archived |
| 11.00 | 35 | 35,1 | 0,28 | archived |
| 11.30 | 36 | 36,1 | 0,27 | archived |
| 12.00 | 37 | 37,1 | 0,26 | archived |
| 12.30 | 38 | 38,1 | 0,26 | archived |
| 13.00 | 39 | 39,1 | 0,25 | archived |
| 13.30 | 38 | 38,1 | 0,26 | archived |
| 14.00 | 37 | 37,3 | 0,8 | archived |
| 14.30 | 36 | 36,6 | 1,6 | archived |
| 15.00 | 35 | 35,7 | 1,9 | archived |
| 15.30 | 34 | 34,9 | 2,5 | archived |
| 16.00 | 33 | 33,9 | 2,6 | archived |
| Error value | | | 0,93 | |
| Accuracy Value | | | 99,07 | |

In Table 2 the results of the temperature system testing carried out from 10.30 to 16.00 with the test method of increasing and decreasing the temperature gradually to get the results of the accuracy of the temperature value by using the comparison of the set point temperature value set with the blynk temperature value so that in this study the results obtained an error value of 0.93 and an accuracy value of 99.07 which is declared accurate. The test results show that the test time per 1 hour 30 minutes obtained the results of achieving the accuracy of the temperature set point comparison as determined by the temperature value display on Blynk which shows the temperature condition is reached.

Table Number 3 contains temperature accuracy measurements comparing the Blynk temperature display and a thermometer gauge for the purpose of calibrating and measuring accurate temperature accuracy levels.

Table 3. Test results with thermometer

| Time | BLYNK (C˚) | Thermometer (C˚) | Error |
|---|---|---|---|
| 10.30 | 34,1 | 33,5 | 1,7 |
| 11.00 | 35,1 | 34,2 | 2,6 |
| 11.30 | 36,1 | 35 | 3,1 |
| 12.00 | 37,1 | 35,5 | 4,5 |
| 12.30 | 38,1 | 36,2 | 5,2 |
| 13.00 | 39,1 | 36,9 | 6,7 |
| 13.30 | 38,1 | 37 | 2,9 |
| 14.00 | 37,3 | 36,2 | 3 |
| 14.30 | 36,6 | 35,5 | 3 |
| 15.00 | 35,7 | 35,4 | 0,8 |
| 15.30 | 34,9 | 35 | 0,2 |
| 16.00 | 33,9 | 33,4 | 1,4 |
| Error value | | 2,92 | |
| Accuracy Value | | 97,08 | |

In Table 3 the test results were carried out from 10.30 to 16.00 to test the comparison of how the accuracy of the temperature value on the Blynk display with the HTC-1 thermometer temperature measuring instrument that has been tested, in the test there is the smallest error value of 0.2 at 15.30 and there is the largest error value of 6.7 at 13.00, from the whole test getting the results of the error value of 2.92, with an accuracy value of 97.08 with an accuracy value that is declared quite accurate.

Table Number 4 contains humidity accuracy measurements comparing the Blynk display and a thermometer gauge for the purpose of calibrating and measuring humidity accuracy.

Table 4. Thermometer humidity test results

| Time | BLYNK (%) | Thermometer (%) | Error |
|---|---|---|---|
| 10.30 | 62,20% | 64% | 2,8 |
| 11.00 | 59.2% | 61% | 2,9 |
| 11.30 | 56.9% | 60% | 5,1 |
| 12.00 | 54% | 59% | 8,4 |
| 12.30 | 52.2% | 58% | 10 |
| 13.00 | 50.3% | 57% | 11,7 |
| 13.30 | 50.4% | 56% | 10 |
| 14.00 | 52.1% | 57% | 8,5 |
| 14.30 | 55.1% | 61% | 9,6 |
| 15.00 | 56% | 60% | 6,6 |
| 15.30 | 59.2% | 61% | 2,9 |
| 16.00 | 60.5% | 64% | 5,4 |
| Error value | | 6,9 | |
| Accuracy Value | | 93,1 | |

Table 4 the results of testing the blynk humidity with the HTC-1 thermometer measuring instrument, from the comparison results can assess the extent to which the blynk humidity value provides accurate and consistent humidity readings approaching the results of the humidity value of the HTC-1 thermometer, from testing at 10.30 to 16.00 there is the smallest humidity error value of 2.8 at 10.30 and at 13.00 there is the largest humidity error value of 11.7, by producing an error value of 6.9 from an accuracy value of 93.1 humidity which is declared quite good.

The overall goal of the testing was to ensure that the website display and navigation are responsive and easy to use, in accordance with the temperature and humidity monitoring system and user needs, as shown in Figure 5. The designed system has been able to regulate and maintain the temperature at a constant condition in the incubator. The test results show that the temperature control system in the egg incubator room has been successfully implemented.

**Solar Panel Testing**

In testing the solar panel device to supply electrical energy using a Polycrystalline type solar panel with a power of 30 wp, with measurements including the voltage and current generated by the solar panel to produce electrical energy power to supply the incubator shown in Table 5.

Table 5. Solar panel testing

| Solar Panel | | | | |
|---|---|---|---|---|
| Time | Weather | Voltage (V) | Current (I) | Power (W) |
| 10.30 | Sunny | 13,38 | 1,24 | 16,59 |
| 11.00 | Sunny | 12,98 | 1,05 | 13,62 |
| 11.30 | Sunny | 13,08 | 1,15 | 15,73 |
| 12.00 | Sunny | 12,64 | 1,04 | 13,14 |
| 12.30 | Sunny | 12,55 | 1,03 | 12,92 |
| 13.00 | Sunny | 11,45 | 0,99 | 11,33 |
| 13.30 | Sunny | 12,9 | 1,07 | 13,8 |
| 14.00 | Sunny | 12,77 | 1,06 | 13,53 |
| 14.30 | Sunny | 12,75 | 1,04 | 13,26 |
| 15.00 | Sunny | 12,37 | 0,7 | 8,65 |
| 15.30 | Sunny | 12,3 | 0,61 | 7,5 |
| 16.00 | Sunny | 12,12 | 0,55 | 6,66 |
| Max Power | | | 16,59 | |
| Total Power | | | 146,73 | |

In Table 5, the results of testing solar panels from 10.30 to 16.00 with sunny weather conditions at 10.30 solar panels produce the largest voltage of 13.38, and at 13.00 solar panels produce the smallest voltage of 11.45 so from the entire test solar panels get a maximum power of 16.59 and a total power of 146.73 as an incubator power supply.

## CONCLUSION

The result of the design is a smart incubator based on 30 watts of solar panel power using an Internet of Things system connected to Blynk as a user interface that can control temperature and humidity remotely. The power needs of the incubator can be met by using a solar module with a capacity of 30 watts of power which produces a maximum output of 16.59 watts and a total output of 146.73 watts. By getting the results of checking the accuracy of the temperature value, the system has an update that can adjust the temperature to produce an error value of 0.93 with an accuracy value of 99.07 which can be adjusted to meet the needs of different types of poultry farmers. The accuracy of several temperature tests using thermometers as a comparison is good, with an error value of 2.92 and an accuracy value of 97.08. With an accuracy of 93.1 and an error value of 6.9, the humidity test produced excellent results.

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