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Realtime and Centralized Solar Panel Online Monitoring System Design Using Thingspeak

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ABSTRACT

Indonesia is a country with a tropical climate and has a high intensity of solar irradiation. Seeing this situation, Indonesia is the right region to implement the installation of new and renewable energy such as PLTS. In the use of solar panels, the magnitude of the output power is determined by several environmental conditions, such as the intensity of sunlight, temperature, and the direction in which sunlight comes. To prevent damage and deterioration in the performance of solar panels, research is needed for a more accurate and efficient use of renewable energy. The study was a solar panel system with a Wemos D1 microcontroller that monitored online using Thing speak with the help of INA 219 and LDR sensors. Online monitoring system by recording data on current, voltage, and light intensity in real time and centralized. The system will store and record measurement data every 15 seconds in the form of JSON, XML, CSV file extensions. Error on the voltage sensor of 1.7% for and 3.2% for the current sensor. average panel voltage value of 12.77 V, average panel current value of 0.43 A and 2410 lux for light intensity at interval testing from 07:00 a.m.to 16:00p.m.

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1. INTRODUCTION

Indonesia is a country with a tropical climate and has a high intensity of sunlight. This is because Indonesia's position is on the equator so that the territory of Indonesia gets good sunlight. Seeing this situation, Indonesia is the right area to implement the installation of new renewable energy such as Solar Power Plants[1]–[3]. Monitoring has the aim of obtaining feedback on the needs of the program being implemented, by knowing to need, the implementation of the program will be prepared as well as possible. The output power generated by a solar power plant can be affected by the shading on the solar panels[4]–[7]. Research conducted by Murshiduzzaman which was published in 2021 discusses the effect of shading due to the density level of dust that sticks to or is in the environment where solar panels are placed. This study calculates the dust on solar panels by online monitoring. Furthermore, the accumulation and look for the effectiveness of solar panels. In this study it is known that dust greatly affects the output results in the form of power generated by solar panels. It also depends on the results of monitoring at the time, location and geographic conditions of observation [8]–[10].

Monitoring the energy produced by the sun has been carried out in various mechanisms[11]. Digital video watermarking mechanism is one of the mechanisms that can be used in monitoring solar panels. With video watermarking techniques, GPS coordinates, date, time and temperature can be monitored in real time [12]–[14]. Another mechanism for monitoring can also be done by using a Wireless Sensor Network (WSN). With WSN, monitoring can be done effectively and efficiently. However, this also depends on the quality of the WSN sensor used [15]–[17]. The monitoring process carried out on solar panels is carried out to see incoming data in real time, find out the amount of average daily consumption of energy produced, and the amount of loading capacity, so that electricity supply is guaranteed [18]. In addition, Mallor in 2017 also explained that monitoring on solar panels has benefits as a study in the development of solar panels in the future [19].

From several facts and the need for the development of previous research, research is needed for the use of renewable energy (sunlight) that is more accurate and efficient. This research is a solar panel system with the Wemos D1 microcontroller that monitors online using Thingspeak. Online monitoring system by recording current, voltage and light intensity data in real time and centrally[20]–[22]. The system will store and record measurement data every 15 seconds in the form of JSON, XML, CSV file extensions. Therefore, it is necessary to conduct research on Designing a Realtime and Centralized Solar Panel Online Monitoring System Using Thingspeak.

2. RESEARCH METHOD

The implementation of this research is an effort to get results that are in accordance with the objectives of the tool made. To get the expected research results, carried out step by step in going through it.

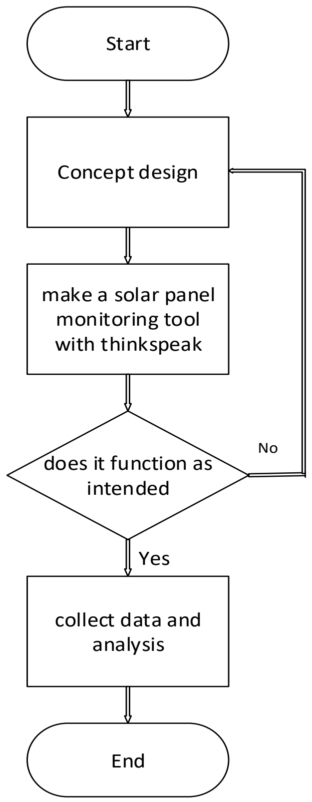


Figure 1. Research Flowchart

Figure 1 is a flowchart of the research method used as a reference for the stages of the research process. The concept in designing the monitoring tool that will be made is carried out starting from collecting data to look for theories and data related to the research that will be carried out. Next, the design of a solar panel monitoring tool is carried out using thinkspeak. In this design includes circuit hardware design, software design (program), and tool mechanical design. Then do the integration between hardware and software. The function of the equipment that has been made is tested to find out whether it is functioning as expected. Testing is divided into three categories of testing, namely hardware testing on each system set, software testing on each system set, and overall tool system testing. If the results of the tests that have been carried out are in accordance with the expected results, then the test is declared to have been completed. However, if the tests carried out are not in accordance with the expected results, then a re-check will be carried out in the design.

3. Hardware design

The block diagram in Figure 2 above is a block of the process of designing solar panel hardware to be the main supply for generating the voltage that is stored in the battery. The battery can be used to supply the Wemos microcontroller, the supply from the battery to the microcontroller is coupled with a stepdown voltage to lower the voltage from 12 Volts to 5 Volts as the voltage required by the microcontroller to monitor it, when the current and voltage sensors have measured the current generated by the solar panel, then on Wemos will be controlled and regulated to calculate the amount of current, voltage, and light intensity. A change in the intensity of the sun's light causes other sensor parameters to change in value as well. The resulting values of the parameters can be monitored through the website which is connected via the Wemos communication line with the Esp8266 Wi-Fi module. Thingspeak as an interface will display data from the serial monitor and will be sent.

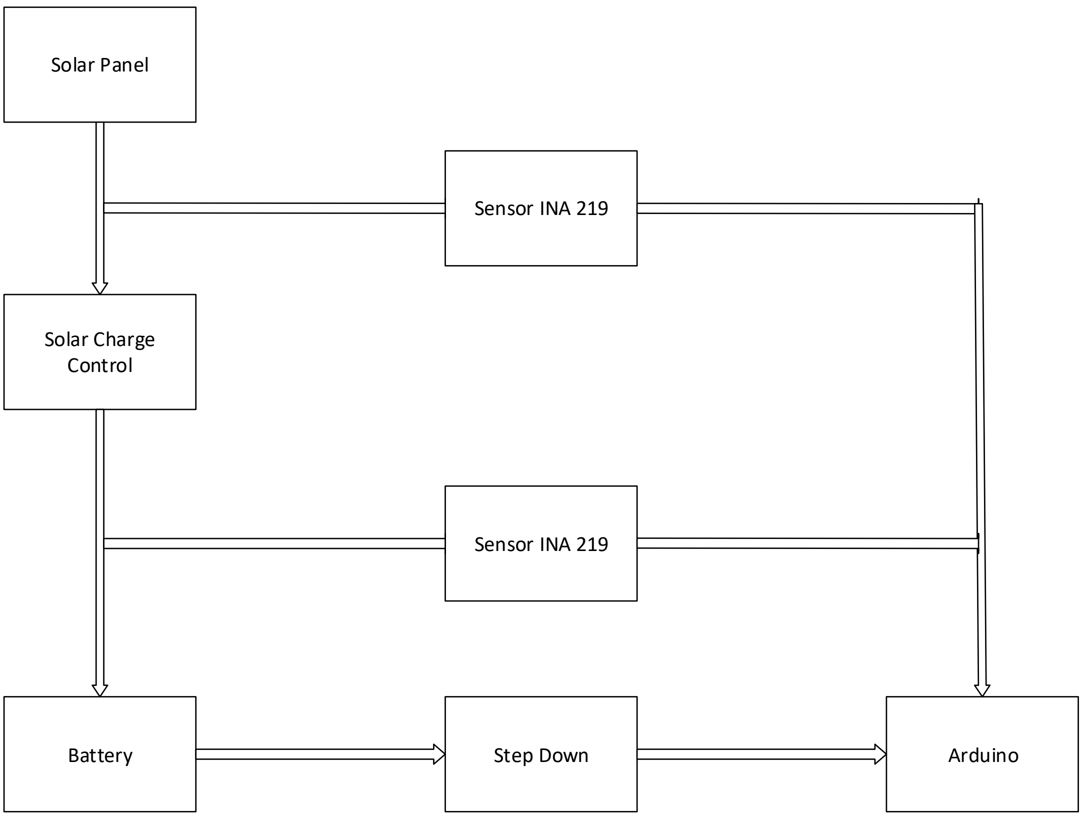


Figure 2. System Block Diagram

The hardware design will discuss the overall schematic of the tool system. The overall system schematic is a combination of several circuits that have been configured with each other. The schematic of this system is the overall circuit used in the tool control system. The schematic of the overall tool control system used in the design of the final project tool is shown in Figure 3.

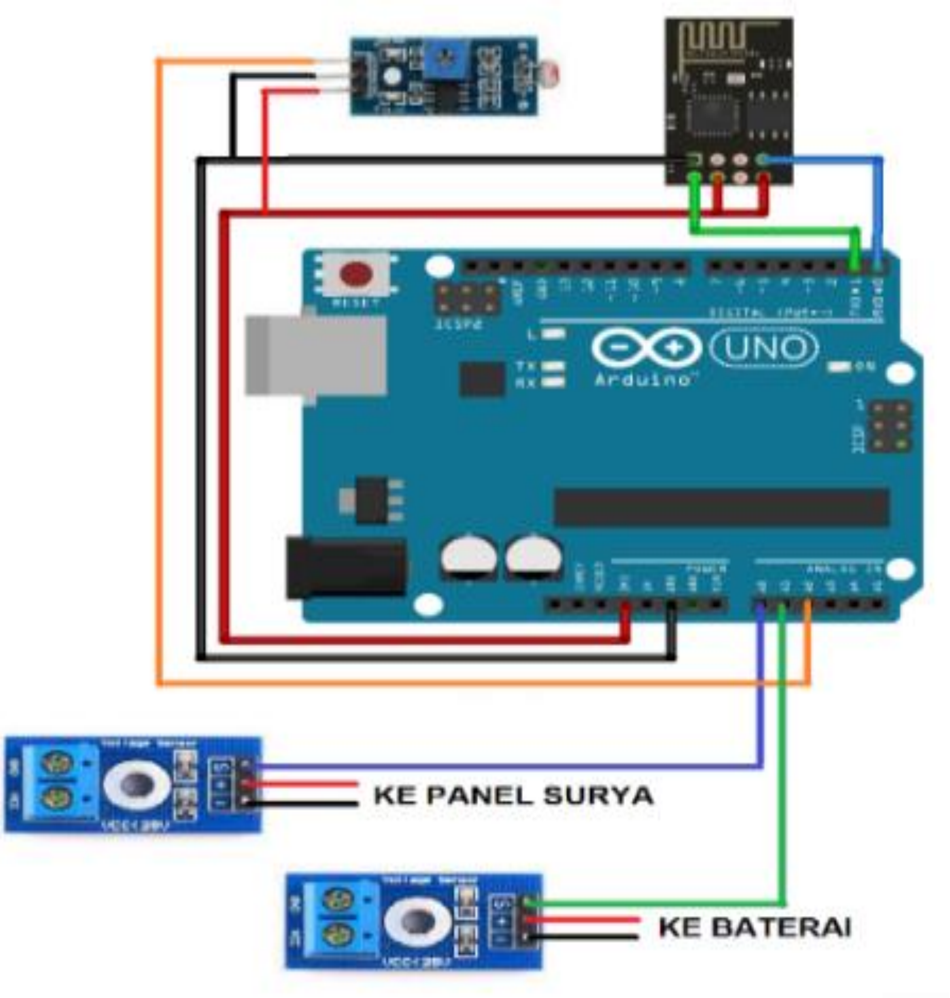
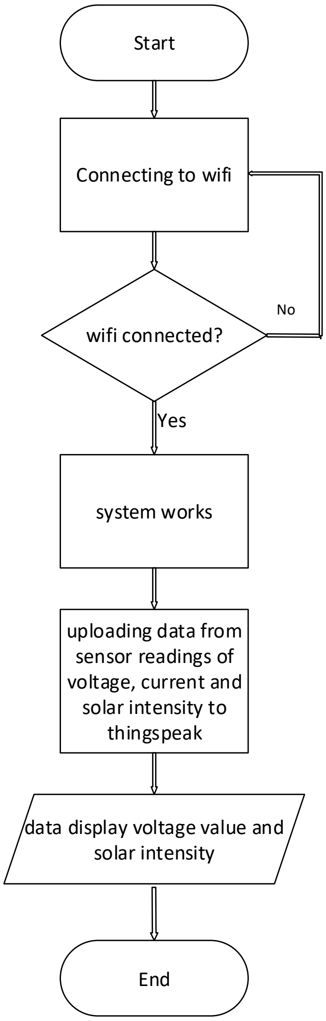


Figure 3. Schematic

4. software design

Software design contains the process of creating a tool system program. Furthermore, the electrical design contains the process of making a centralized solar panel online monitoring system tool using the Thingspeak web. The system design stages that will be carried out in this study are explained in the flowchart of Figure 4 (a). Starting with testing the connection on the wifi. If the device is connected to wifi then the system will start working. Furthermore, data in the form of voltage, current and solar intensity from sensor readings can be sent to thingspeak. Program design for a solar panel monitoring system is done with the Arduino IDE software.

In programming on arduino the sensor reading results will be sent to the ESP-826 module. The program for reading the voltage, current and solar intensity sensors is shown in Figure 4(b). ESP8266 is in charge of sending data from sensor readings to the Thingspeak platform via Wi-Fi. Program to send data to the Thingspeak platform via a secret API key that has been obtained from an email that has been registered as a user. The program as a Thingspeak Network Connection is shown in Figure 4 (c).



(a)

```
void loop()
{
 int Solar_Intensity1= digitalRead(D6);
 Solar_Intensity1= Solar_Intensity1-1;
 cahaya = abs(Solar_Intensity1);
 Serial.println(Solar Intensity);
  value = analogRead(analogPin);
  Vmodul = (value * 5.0) / 1023.0;
  vf= Vmodul / (R2/(R1+R2));
  hasil = vf-7;
 Serial.print("Module output voltage = ");
 Serial.print(Vmodul,2);
 Serial.print("volt");
 Serial.print(", Measurement results = ");
 Serial.print(output,2);
 Serial.println("volt");

delay(500);
```

(b)

```
#include <ESP8266WiFi.h>
String apiKey = "N5B1UHD5X3IAXGKB";
const char* ssid = "Berkah1";
const char* password = "Berkah123456";

const char* server = "api.thingspeak.com";
```

(c)

Figure 4. Building system for design monitoring of solar panels (a) Monitoring System Flowchart, (b) Arduino reading sensor program, (c) Thingspeak Network Connection

5. RESULTS AND DISCUSSION

This section describes the results and testing of the tool that has been designed. Tested whether the tool produced can operate in accordance with the desired operating principle. The method used to test this tool is to make observations on the designed system and observe the sensor readings installed.

5.1. Data receiving platform on thingspeak

In testing the Thingspeak platform, the display used is in the form of four gauges and four graphs that have been provided by the Thingspeak platform. For current, voltage and light intensity measurements use a display gauge type and each of the current, voltage and light intensity measurements has a graphic display. Everything served from the Thingspeak platform is free to use. The following is a display of the solar panel performance monitoring system using the Thingspeak platform.

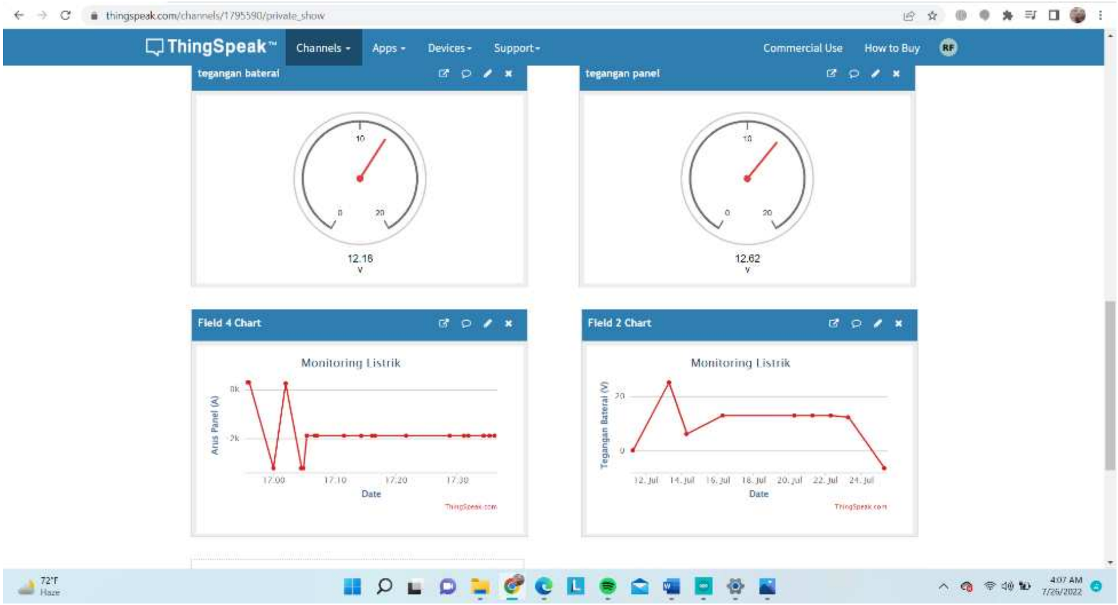


Figure 5. Main Display of Thingspeak

5.2. Calibration Test

Calibration here is done to determine the level of accuracy of the tool that has been built. This test is carried out by measuring the difference in the output voltage value of the solar panels between the voltage value at Thingspeak and the multimeter. From the experimental results it is known that there is a difference between the measured voltage value displayed on Thingspeak and the voltage value on the multimeter, for the biggest difference at 15.00 hours with an error value of 2.33%. the average percentage of the accuracy of the tools that have been made is 99.07%. The results of the comparison between the measured voltages at thingspeak and the multimeter are in Figure 6.

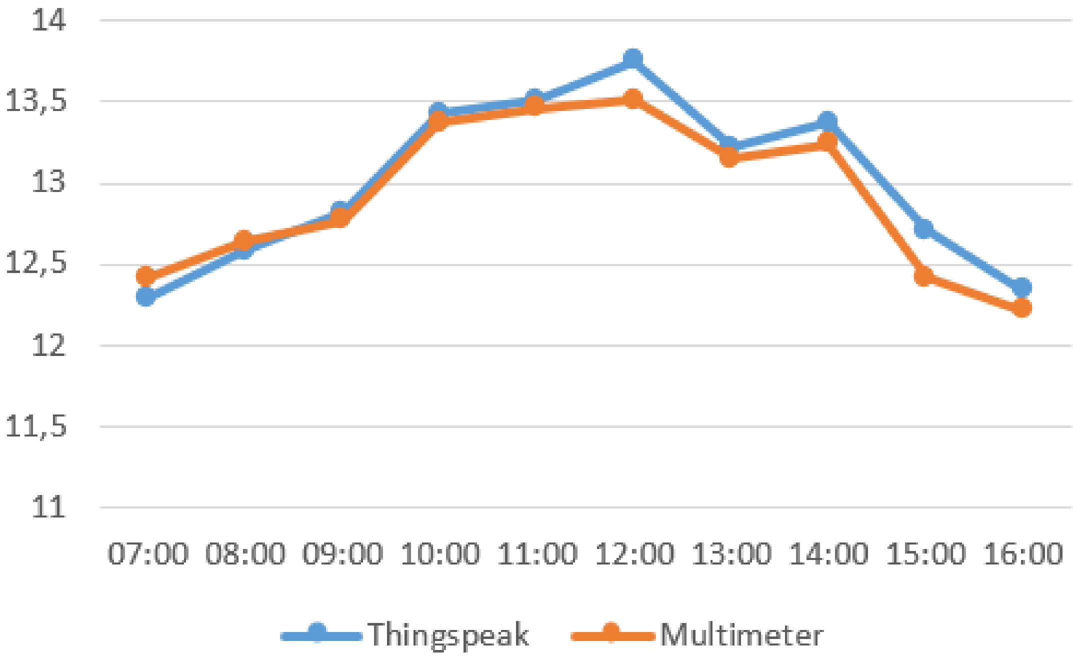


Figure 6. Comparison thingspeak and the multimeter

5.3. Solar Panel Measurement Test Results

Solar panel measurements aim to determine the value of the voltage and current that goes into the solar charge controller. Voltage measurement with parallel configuration and current measurement with series configuration to the panel. The following is a series of measurements with data sent via Thingspeak. Measurements were taken from 07.00 a.m. to 04.00 p.m. Measurements were made to determine the value of the voltage and current generated by the solar panel. The results of measuring current and voltage values are in table 1. From the measurement results obtained an average voltage value of 12.94 V, an average current value of 0.35A and an average power value of 4.58 W. The highest voltage value was 13.78 V at 12.00 hours and the highest current value was 0.51 A at 01.00 p.m.

Table 1- Results of Solar Panel Measurements at PPI Madiun

Hours	Voltage (V)	Current (A)	Power (W)
07.00	12.31	0.14	1.72
08.00	12.58	0.23	2.89
09.00	12.84	0.35	4.49
10.00	13.41	0.39	5.22
11.00	13.51	0.41	5.53
12.00	13.78	0.47	6.47
01.00	13.25	0,51	6.75
02.00	12.87	0.43	5.53
03.00	12.54	0.32	4.01
04.00	12.36	0.26	3.21

5.4. Battery Function Testing

Battery measurement to measure the value of voltage and current during charging and discharging. Measurements were made to determine the effectiveness of the solar panels when charging the battery and determine the condition of the battery when discharging or when supplying a load. The battery charging test is carried out when the PV has maximum power conversion, namely at 07.00 a.m. to 4:00 p.m. From the measurement results, the maximum voltage value is obtained at 01.00 p.m. namely 12.92 V. Detailed description of the battery charging condition is shown in Figure 7. The battery discharge data is collected every 30 minutes for 10 hours and 30 minutes. The battery used is a new condition battery with an initial condition of 13.6 volts. When done discharging for 10 hours 30 minutes the battery voltage becomes 10 volts. The results of measuring the voltage from battery discharging due to battery discharge are shown in Figure 8.

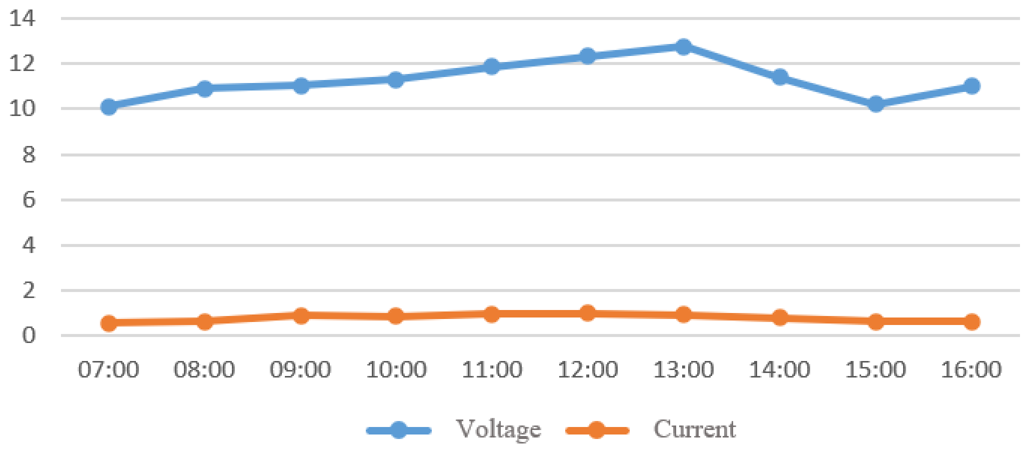


Figure 7. Battery Charge Condition

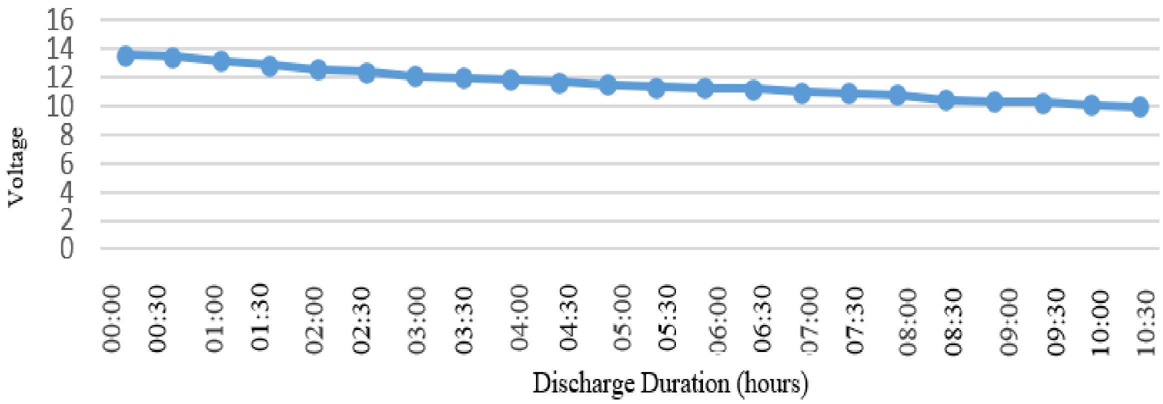


Figure 8. Battery discharge Condition

6. CONCLUSION

In designing a solar panel performance monitoring system using the Thingspeak platform with Wemos D1 R2 as a microcontroller, there is a difference in the results of the data received by the sensor and multimeter because the sensitivity level of the multimeter is higher than that of the sensor in measuring voltage. The error on the voltage sensor is 1.7% for and 3.2% for the current sensor. the average panel voltage value is 12.77 V, the average panel current value is 0.43 A from 07:00 a.m. to 4:00 p.m. However, in further research it is necessary to add a database to store the data that has been displayed on thingspeak.

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