Available *online* at : http://chipset.fti.unand.ac.id/

Journal on Computer Hardware, Signal Processing, Embedded System and Networking

| ISSN (Online) 2722-4422 |

Embedded System, Internet of Things

Prototype of Monitoring System for Power Absorption and Solar Panel Maintenance on Website-Based Solar Power Plant

*Melly Wasilah Ananda [1], Desta Yolanda [*2], Arrya Anandika [3]*

[1,2,3] *Department of Computer Engineering, Faculty of Information Technology, Andalas University, Padang City, West Sumatra, 25163, Indonesia*

ARTICLE INFORMATION

Received: 17 Maret 2024
Revised: 21 April 2024
Available online: 30 April 2024

KEYWORDS

Solar Panels, *Monitoring*, BH1750, INA219, FC-37

CORRESPONDENCE

E-mail: destayola@fti.unand.ac.id

A B S T R A C T

Solar power plants (PLTS) are a source of electrical energy that will never run out and will not damage the environment. PLTS is an alternative energy source when an electricity supply has not reached an area or has no commonly used power generation source, such as gas or water. In PLTS, solar panels are devices that need to be considered to maintain the performance of solar panels on PLTS. Several things must be considered, as solar panels must be protected from dust and dirt that can block sunlight. Solar panels should also not dry themselves after being wet with water because there will be traces of water left behind. Moisture on the surface of solar cells significantly reduces cell performance due to the disruption of the absorption and refraction of sunlight. To overcome this problem, the author proposes to design a system that can monitor the absorption of power carried out by solar panels and perform maintenance on solar panels in the form of cleaning from dust and dirt automatically and helping to dry after the rain subsides on the surface of solar panels. This system is integrated with the website so that officers can monitor through the monitoring website interface. This designed system can optimize power absorption on solar panels and help officers know the results of power absorption by solar panels.

INTRODUCTION

Solar power plants (PLTS) are a source of electrical energy that will never run out and does not damage the environment. The components that makeup PLTS are solar panels as a device that can convert sunlight into electrical energy, a controller to control the current to the battery, a battery as a place to store power, and an inverter to convert DC into AC [1]. PLTS is an alternative energy source used when an area has no electricity or does not have commonly used electricity generation sources such as gas or water.

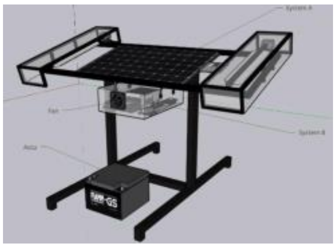
In PLTS, solar panels are devices that need to be considered to maintain the performance of the solar panels in PLTS. Several things must be paid attention to: the solar panels must be protected from dust and dirt, which can block sunlight. Data from research on the Effect of Solar Module Cleanliness on PLTS Performance shows that solar panels that are not cleaned experience a decrease in the power produced by 5.48% even though the test was carried out during the rainy season [2]. Solar panels should also not dry themselves after being wet with water because there will be traces of water left behind. Moisture on the surface of solar cells significantly reduces cell performance because it disrupts the process of absorption and refraction of sunlight. Moisture on the cell surface also creates the growth of organic substances, which will effectively block sunlight from entering the solar panel cells [3]. Therefore, solar panel maintenance must be carried out periodically, such as in the morning and evening, and the drying process must also be assisted by wiping the surface of the solar panel after it gets wet [4]. Based on the conditions above, there should be a tool that can monitor power absorption on solar panels and help with regular maintenance so that the performance of solar panels on PLTS is maintained.

Several previous studies have produced tools that can help maintain solar panels automatically. This research used two inputs to clean dust on solar panels: the RTC and the dust sensor. The RTC will set the cleaning time every 08.00 and 16.00, while the dust sensor will put the cleaning time when the dust value on the solar panel exceeds 0.04 mg/m3 [5]. However, in the image of a tool made for research, the wiper for cleaning solar panels covers several solar panel cells. This test can reduce the solar panel's performance because the wiper covers it. This research only focuses on the cleaning system and tests that produce voltage to prove that the power produced differs. In research [6], the solar panel cleaner was quite large and required water to clean, so it

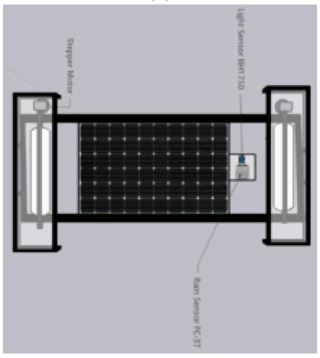
https://doi.org/10.25077/chipset.5.01.40-48.2024

was needed to make its water tank. However, the tool only works to clean dirt on the surface of the solar panel without thinking about the moisture left on the solar panel. In research [7], tests were carried out on several solar panel conditions, and there were differences in power absorption and battery charging time. So it was found that the condition of the solar panels when dry and clean had better performance than other conditions, namely when clean wet, polluted wet, and polluted dry. From several previous studies that have been described, it can be seen that the effect of cleanliness and dryness on solar panels affects the power absorption or performance of solar panels.

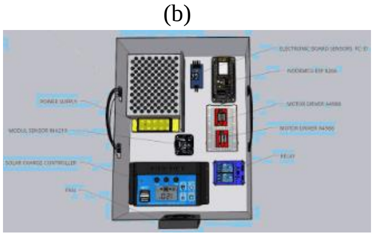
METHOD



(a)



(b)



(c)

Figure 1. General System Design (a) overall system, (b) system A (c) system B

Based on Figure 1, it can be seen that in this system, the input is obtained from the BH1750 light sensor, FC-37 rain sensor, and INA219 sensor module, and the output will later be on the website and the stepper motor via the motor driver. This system works according to time and is synchronized via NTP to retrieve and display data on the website. The INA219 sensor module will calculate the power absorption of the solar panel, the rain sensor will provide output whether it is raining or not, and the light sensor will output the light intensity value when data collection takes place. The output from all sensors will be sent to Firebase via NodeMCU ESP8266 and displayed on the monitoring website later. The stepper motor that will move the dust wiper and rain wiper will follow the conditions met in the system.

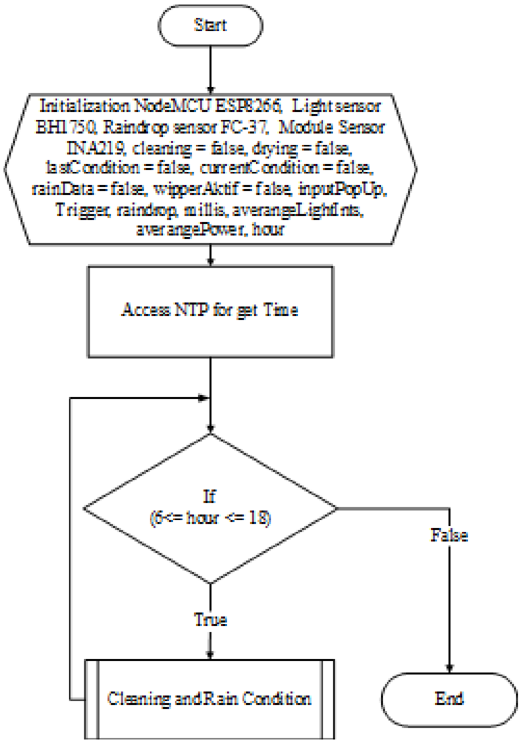


Figure 2. General System Design Flowchart

Based on Figure 2, it can be seen that the core of this system is in the time conditions, and after that, it will continue into the cleaning and rain conditions sub-process, which later in this sub-process there will be several more sub-processes. Initially, the system was started by initializing the NodeMCU ESP8266, BH1750 light sensor, FC-37 rain sensor, INA219 sensor module, and several variables needed for conditioning in the system later. Next, you will enter the NTP access process to get the time. Furthermore, if the NTP time matches the time conditions set for data retrieval, the system will continue the process until the set time limit.

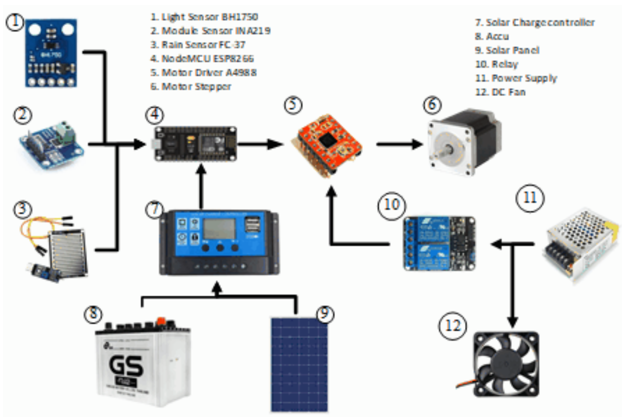


Figure 3. Hardware Design

Based on Figure 3, the work of each device used in the system is as follows.

1. The BH1750 light sensor is used to calculate the intensity of sunlight.
2. The INA219 sensor module is used to calculate power absorption in solar panels
3. The FC-37 rain sensor determines whether the weather is rainy.

 https://doi.org/10.25077/chipset.5.01.40-48.2024

4. NodeMCU ESP8266 is a microcontroller that connects the system with the NTP server and sends output to websites and stepper motors.
5. The A4988 Motor Driver is used to drive the stepper motor.
6. Stepper motors are used to drive the wipers.

In Figure 12, it can be seen that there is one sub-process, namely cleaning and rain conditions. This is a continuation of the general system design in software program design.

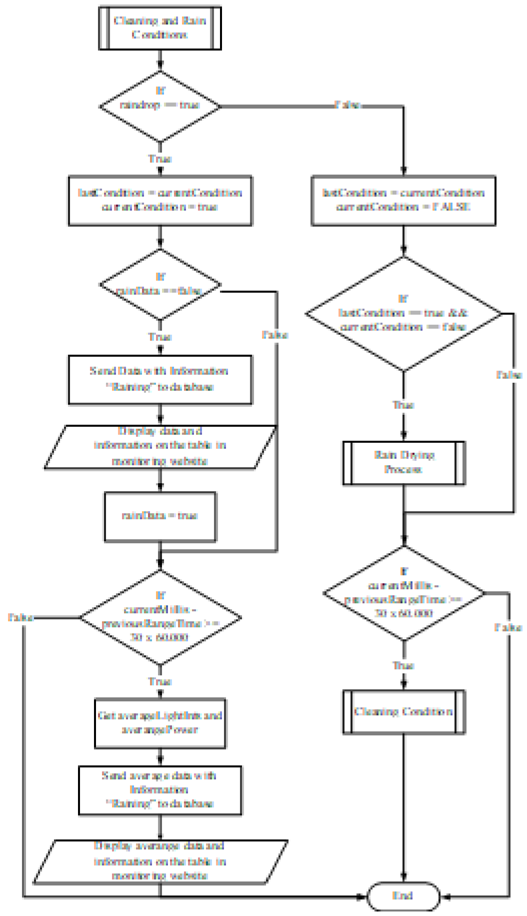


Figure 4. Flowchart of Cleaning and Rain Conditions

In Figure 4, it can be seen that the initial condition is rain. If the raindrop variable is valid, it is said to be raining. If the rain stops, the program continues to the drying subprocess if the specified variable conditions are met. Suppose data collection for 30 minutes has occurred. In that case, it will enter the cleaning conditions subprocess, which includes a cleaning process for maintaining the solar panels from dust and dirt if the conditions are met.

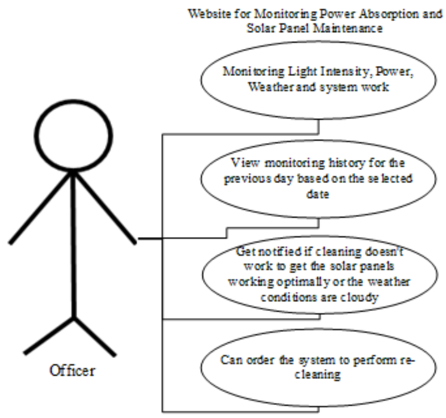


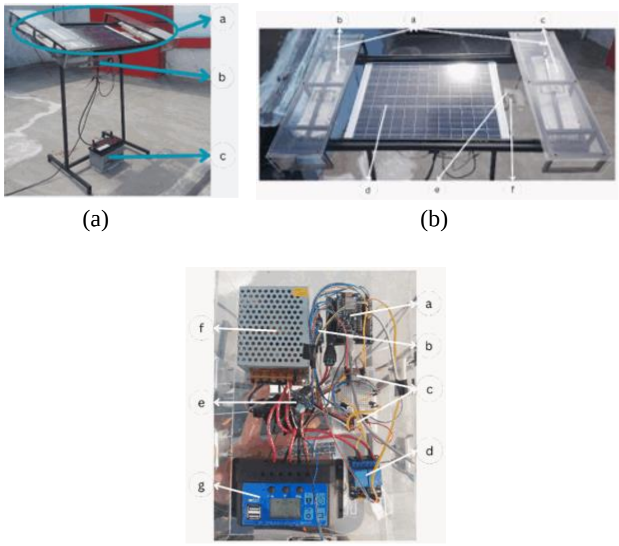
Figure 5. Use Case Diagram

Figure 5 is a use case diagram from the website for monitoring power absorption and solar panel maintenance. On this monitoring website, officers can monitor light intensity, power, weather, and whatever the system does. Then, officers can view monitoring data from the previous day based on the selected date. Officers can also get notifications if the cleaning that has been carried out previously could be more successful in making the solar panels work optimally or because the weather conditions are cloudy. After receiving a notification, officers can ask the system to clean again via the monitoring website.

RESULTS AND DISCUSSION

Hardware Implementation

The hardware used in the system and which supports the system's work consists of NodeMCU ESP8266, BH1750 light sensor, INA219 sensor module, FC-37 rain sensor, A4988 motor driver, Nema 17 stepper motor, 2 Channel relay, power supply, DC fan, battery, and solar charge controller. The hardware implementation is assembled into two parts, namely System A in the solar panel and System B in the component box. The hardware implementation can be seen in Figure 6.



(a) (b) (c)

Figure 6. Hardware Implementation (a) entire system (b) system A (c) system B

In Figure 6(a), you can see the hardware implementation of the entire system from various directions. This research divides the system into two large systems, as shown in Figure 6(a), with the following explanation.

a. System A, with a BH1750 light sensor, an FC-37 rain sensor, and a wiper driven by a stepper motor.
b. System B, a container for placing components such as NodeMCU ESP8266, FC-37 rain sensor comparator, INA219 sensor module, A4988 motor driver, two-channel relay, power supply, and solar charge controller.
c. Battery that functions as storage for the energy produced by the solar panels and as a power source for the system.

Figure 6(b) shows System A hardware implementation from various directions; the following is an explanation.

a. Stepper motor, which functions to move the wiper
b. Rain wiper helps dry the surface of the solar panel after the rain stops.
c. Dust wiper that cleans the surface of the solar panel from dust and dirt.
d. Solar panel, which is the object of research.
e. The BH1750 light sensor functions as input to the system to determine the intensity of sunlight.
f. The FC-37 rain sensor PCB board functions as input to the system to determine whether or not the weather is raining.

Figure 6(c) is a hardware implementation of System B from various directions; the following is explained.

a. ESP8266 NodeMCU functions as a microcontroller to process and run programs.
b. FC-37 rain sensor comparator IC processes input from the FC-37 rain sensor PCB board.
c. A4988 motor driver that regulates the operation of the stepper motor
d. Two-channel relay functions as an electronic switch so that voltage and current do not continue to flow to the A4988 motor driver and make the motor driver hot.
e. INA219 sensor module functions as input to the system to determine the power produced.
f. Power supply is a power source for the stepper motor and DC fan.
g. Solar charge controller, which functions as a regulator of the current charged to the battery and taken from the battery to the load.
h. DC fan that functions as a system cooler, so it doesn't get hot quickly.

Software Implementation

The monitoring website was designed using the Node.js framework and written using JavaScript. This website is on the local host network, meaning it can only be accessed when the server is live and on the same network. This website was created so that users can more easily understand the data produced by the system for monitoring power absorption and solar panel maintenance, which can be used as material for further research. The features of the monitoring website can be seen in the following images.

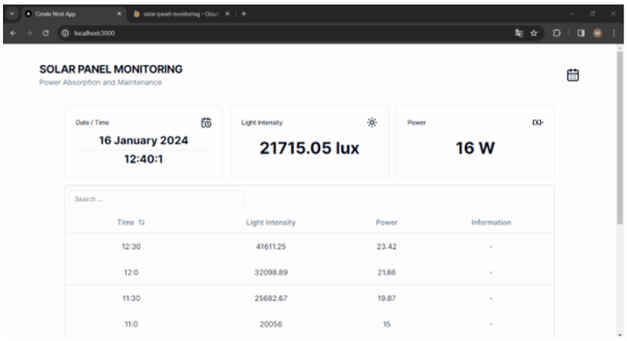


Figure 7. Home Page

In Figure 7, you can see the monitoring website's home page or main page. On this main page, officers can directly monitor the intensity of sunlight, the power produced by solar panels, the weather, and what the system is doing. The three columns or cards above will display the date and time in real time; the light intensity and power will be updated every minute. Then, the column below shows a table updated every 30 minutes and when the weather changes. From this main page, you can also see several other features such as the search bar, sorting in the "Time" column, calendar, and "Previous" and "Next" buttons.

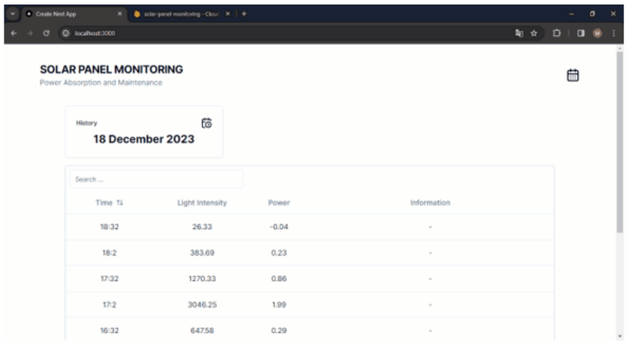


Figure 8. History

Figure 8 shows when the officer views the history according to the selected date. The visible difference in the display is that of the three columns or cards at the top; only one remains to indicate that you are currently in the history display or the history of data taken on the selected date. However, the other features are the same as the features on the home page, so the search bar, sorting, and "Previous" and "Next" buttons can be used according to their function.

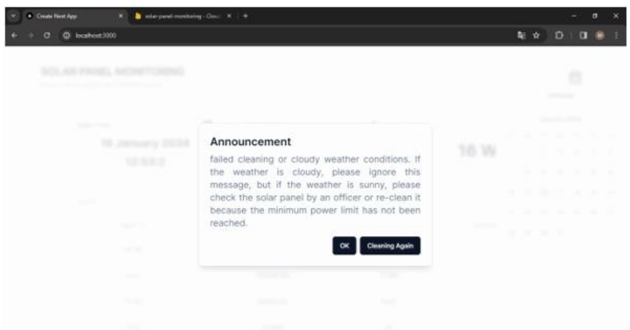


Figure 9. Alert Dialog

Figure 9 is the final feature of this monitoring website. A dialog alert will appear when the conditions set on the system are met, so the dialog alert trigger comes from a program running on the hardware. The alert dialog has two button options, "OK" and

https://doi.org/10.25077/chipset.5.01.40-48.2024

"Cleaning Again". If the "OK" button is selected, it will only close the alert dialog. Still, if the "Cleaning Again" button is selected, it will send data of the boolean type with an accurate value to the database, and this data will trigger a re-cleaning of the hardware.

Testing the BH1750 Light Sensor

This sensor testing was conducted from 06.00 to 18.00 and compared using a lux meter measuring instrument. Testing showed a big difference between the lux meter measuring instrument and the BH1750 light sensor. This might happen because the measuring limits between these two components are different. For the BH1750 light sensor, the maximum measuring limit that the sensor can read is 54,612.50 lux, while the measuring limit for the lux meter is 200,000 lux. So, the intensity of sunlight obtained was compared according to the grouping of light sources in the book [8] and my research.

Table 1. Testing the BH1750 Light Sensor

NO	Time	Light intensity (lux)		Light Source	
		BH1750 Sensor	*Lux* Meter	BH1750 Sensor	*Lux* Meter
1	06.00	125,83	155	Cloudy day	Cloudy day
2	06.30	1.050	1.540	Cloudy day	Cloudy day
3	07.00	3.48	4.643	Cloudy day	Partly cloudy
4	07.30	5.001,67	7.072	Partly cloudy	Partly cloudy
5	08.00	9.488	13.840	Partly cloudy	Midday
6	08.30	54.612,50	59.890	Direct sunlight	Direct sunlight
7	09.00	54.612,50	63.700	Direct sunlight	Direct sunlight
8	09.30	54.612,50	72.694	Direct sunlight	Direct sunlight
9	10.00	54.612,50	94.590	Direct sunlight	Direct sunlight
10	10.30	54.612,50	124.900	Direct sunlight	Direct sunlight
11	11.00	54.612,50	132.400	Direct sunlight	Direct sunlight
12	11.30	54.612,50	138.200	Direct sunlight	Direct sunlight
13	12.00	22.027 *lux*	28.180	Midday	Midday
14	12.30	54.612,50	62.230	Direct sunlight	Direct sunlight
15	13.00	31.160	38.180	Direct sunlight	Direct sunlight
16	13.30	20.453	26.620	Midday	Midday
17	14.00	13.763	19.530	Midday	Midday
18	14.30	54.612,50	82.010	Direct sunlight	Direct sunlight
19	15.00	31.290	39.270	Direct sunlight	Direct sunlight
20	15.30	4.303	6.702	Partly cloudy	Partly cloudy
21	16.00	4.294	6.182	Partly cloudy	Partly cloudy
22	16.30	14.120	17.100	Midday	Midday
23	17.00	9.181	11.050	Partly cloudy	Midday
24	17.30	2.091	2.735	Cloudy day	Cloudy day
25	18.00	441	633	Cloudy day	Cloudy day

The solar light sources are grouped as follows: Light in cloudy conditions produces a light intensity value of 100 to 3500 lux. Light in cloudy conditions produces light intensity values from 3500 to 10,000 lux. Light in daytime conditions produces a light intensity of 10,000 to less than 31,000 lux. Light emitted directly by the sun without any obstruction will make a significant intensity of 31,000 lux.

In Table 1, it can be seen that there are still differences between sensors and lux meters. Apart from disagreements due to very different reading results, differences based on the grouping of light sources are also still visible. At 07.00, the sensor reading results produce an intensity which, if grouped as light sources, falls into cloudy day conditions, and the lux meter reading results produce an intensity that falls into cloudy day conditions if grouped as light sources. At 08.00 and 17.00, there are also differences in sensor reading results, which result in differences in the grouping of light sources according to the sensor and lux meter readings. Based on the comparison between the BH1750 light sensor and the lux meter, several things could be improved in the reading results of the BH1750 light sensor.

Testing the INA219 Sensor Module

Table 2. Testing the INA219 Sensor Module

NO	Voltage		Error	Current		Error
	Sensor	Multimeter		Sensor	Multimeter	
1	3,01 V	3,02 V	0,33%	2,71 mA	2,90 mA	6,55%
2	5,06 V	5,04 V	0,39%	8,42 mA	8,50 mA	0,94%
3	7,04 V	7,02 V	0,28%	10,15 mA	10,30 mA	1,45%
4	9,04 V	9,02 V	0,22%	11,12 mA	11,30 mA	1,59%
5	12,09 V	12,06 V	0,24%	7,90 mA	8 mA	1,25%
Average voltage error			0,292%	Average current error		2,356%

$$error = \frac{nilai\ Modul\ Sensor\ INA219 - nilai\ Multimeter}{nilai\ Multimeter} \times 100\%$$

The average error is calculated by adding all the error values obtained in each experiment and dividing it by the number of experiments carried out. So, the average voltage measurement error obtained by the INA219 sensor module is 0.292%, and the average current measurement error by the INA219 sensor module is 2.356%. Based on the average sensor measurement error value, the accuracy value of the INA219 sensor module can be determined. The accuracy value of the INA219 sensor module in measuring voltage is 99.708%, and the accuracy value of the INA219 sensor in measuring current is 97.644%. The voltage measurement accuracy value is higher than the current measurement accuracy value; this can be seen in Table 4.2, where the difference in voltage measurement results between the INA219 sensor module and the multimeter is 0.01 to 0.03. Meanwhile, the difference in current measurement results on the INA219 sensor module and the multimeter is 0.08 to 0.19. The sensor accuracy obtained exceeds the desired target.

FC-37 Rain Sensor Testing

Testing the FC-37 rain sensor aims to determine whether this sensor can detect rain. Testing is done by looking at the values obtained by the rain sensor according to weather conditions, dripping water onto the sensor's surface, and then at the digital and analog sensor value readings. Many experiments were carried out in weather experiments three times and by dripping water on the sensor surface ten times.

Table 3. FC-37 Rain Sensor Testing According to Weather Conditions

No.	Kondisi Cuaca	Kondisi Digital yang dibaca sensor	Kondisi Analog yang dibaca sensor
1		HIGH	1024
2		HIGH	840
3		HIGH	747

Table 3 shows the results of rain sensor testing according to weather conditions. This test was carried out during sunny, light, and heavy rain. When the weather is sunny, the rain sensor produces a digital value of HIGH and an analog value of 1024. When the weather is light rain, the sensor produces a digital value of HIGH and an analog value of 840. When the weather is heavy rain, the sensor produces a digital value of HIGH and an analog value of 747.

Table 4. Testing the FC-37 Rain Sensor by Dropping Water

NO	Real Conditions (Dropped with water)	Digital condition read by the sensor	Analog condition read by the sensor
1		HIGH	1024
2		HIGH	1024
3		HIGH	930
4		HIGH	862
5		HIGH	774
6		HIGH	614
7		HIGH	578
8		LOW	481
9		LOW	382

 https://doi.org/10.25077/chipset.5.01.40-48.2024

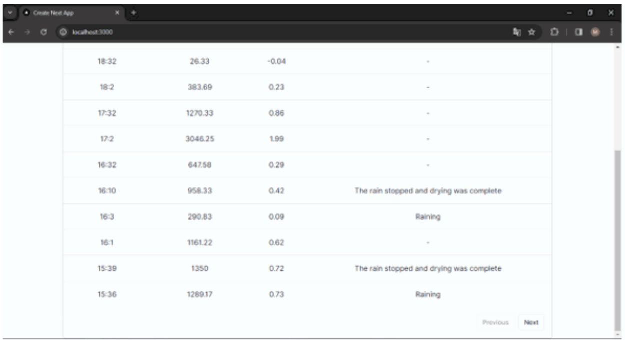
10		LOW	291

Table 4 shows the results of testing the rain sensor by dripping water onto it. This test is carried out by dripping water on the sensor surface with different intensities. From Table 4.4, it can be seen that the more water on the sensor surface, the lower the resulting analog value.

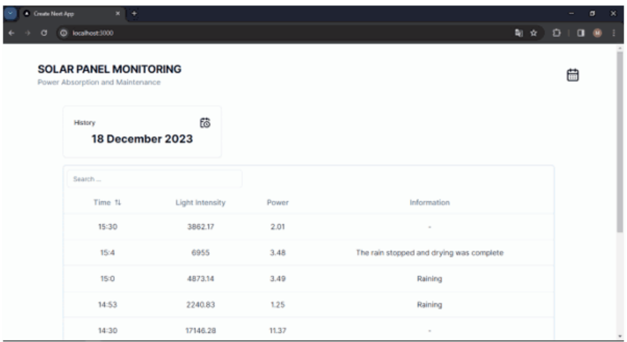
From testing the FC-37 rain sensor, which was carried out according to weather conditions and dripping water on the sensor surface, it was found that the larger the scale of the water droplets on the sensor surface, the lower the analog and digital sensor values. It can be stated that the sensor can detect water droplets on the sensor's surface. So we can conclude that this sensor can detect whether there is rain.

System Functional Testing and Analysis

The overall test aims to determine whether the system can function properly according to the system's functional design. In this research, the process of monitoring power absorption and maintenance of solar panels was carried out on the roof of the Faculty of Pharmacy building. Testing is carried out by testing all the conditions that could occur on the solar panel when absorbing sunlight.



(a)



(b)

Figure 10. Monitoring Power Absorption and Weather (a) first page (b) second page

Figure 10 (b) shows the results of monitoring power absorption and weather on 18 December 2023. This picture shows that the average light intensity from 12.00 to 14.30 is relatively high, and the average power produced is above 10 Watts. However, at 14.53, rain was detected, and the light intensity and power produced decreased drastically; rain was detected until 15.04. After the rain stops, the average light intensity and power produced do not increase significantly because the sky is likely still cloudy. This is proven in Figure 10 (a), where rain was detected again at 15.36 and stopped at 15.39, then rained again at 16.03 and stopped at 16.10.

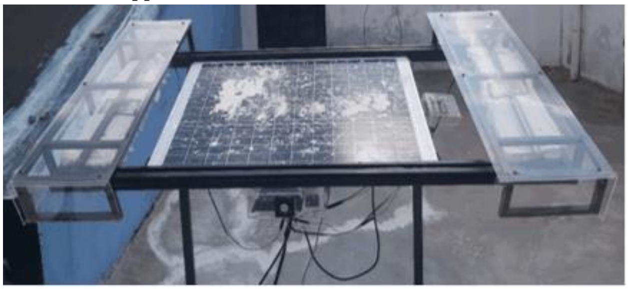


Figure 11. Dirty Solar Panels

A scenario is carried out so that maintenance conditions in the form of cleaning dust or dirt on the solar panels can be carried out so that the solar panels are made dirty, as seen in Figure 11. After collecting data for 30 minutes, the average value of light intensity and power obtained in the conditions above will be maintained in the form of dust or dirt cleaning by the system.

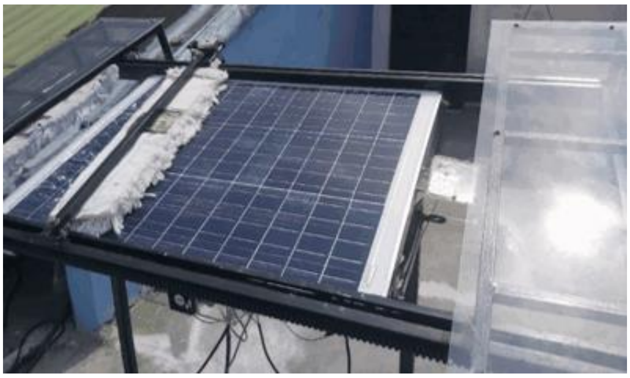


Figure 12. Solar Panel Cleaning Process

In Figure 12, you can see that the dust wiper is cleaning the surface of the solar panel so that sunlight absorption can be maximized.

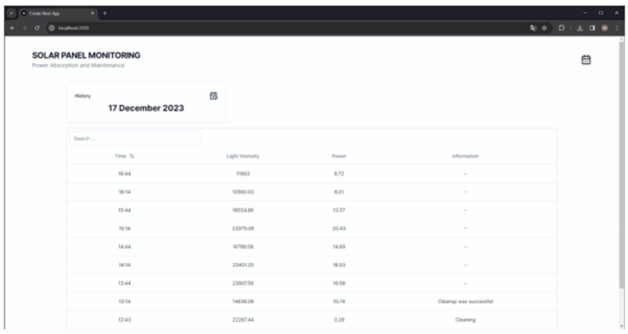


Figure 13. Cleaning Monitoring

Figure 13 shows that at 12.43, the average light intensity was 20,000 – 40,000 lux, but the power produced was only 3.9W. This causes cleaning to be carried out because the lower limit of the energy that must be generated in that range is 13W. After cleaning and data collection for 30 minutes at 13.14, it was stated that the cleaning was successful because the average light intensity was 10,000 – 20,000 lux. The solar panels produced power with an average of 10.74W, exceeding the lower limit of the range.

Figure 14. Wet Solar Panels

A scenario is carried out so that maintenance conditions in the form of helping dry the surface of the solar panel can be carried out so that the solar panel and rain sensor are wet, as seen in Figure 25. The condition is declared rainy when the analog value of the rain sensor is below 950.

Figure 15. Solar Panel Surface Drying Process

In Figure 15, it can be seen that the rain wiper helps dry the surface of the solar panel. Drying occurs when the analog sensor value, initially below 950, rises to above 950. The value of the lastCondition and currentCondition variables has a value of actual changes to the lastCondition, which has a true value, and the currentCondition has a false value. It is stated that the rain has just stopped, and drying is underway.

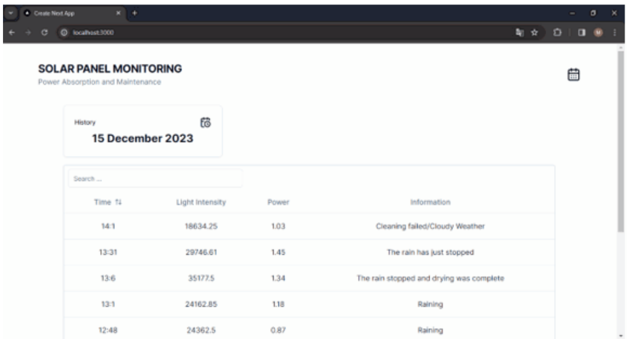


Figure 16. Monitoring Rain Conditions

In Figure 16, the rain conditions are monitored on the monitoring website. At 14.28, rain was detected, then at 13.06, the rain stopped, and drying was carried out on the surface of the solar panels. The drying process is carried out first, then the data is sent to the Firebase database.

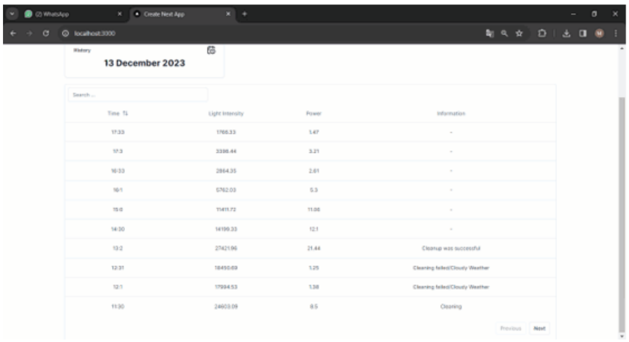


Figure 17. Notification Appear Conditions

A maintenance scenario was carried out by cleaning the solar panels from dust and dirt at 11.30, as seen in Figure 17. After cleaning and data collection were carried out for 30 minutes after washing, at 12.01, the scenario was that there was no increase in the power produced by the solar panels to generate notifications, as in Figure 18.

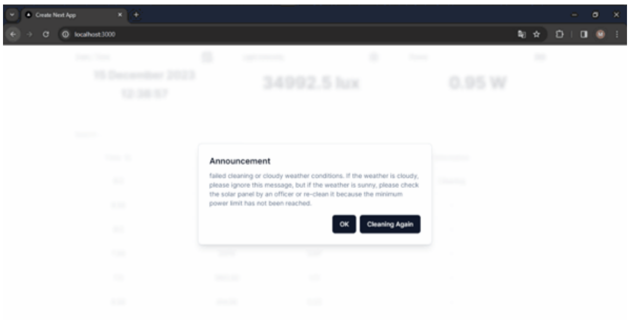


Figure 18. Notice to Officers

In Figure 18, you can see a notification for officers after sending data indicating that cleaning failed or the weather was cloudy. To carry out cleaning again within one minute, the officer must select the "Cleaning Again" button so that cleaning can be carried out again. In this test, no officer selected any button within one minute, so after one minute, the system retrieved data from the Firebase database and stated that there was no re-cleaning request. It can be seen in Figure 16 that at 12.31, data was sent with the same information because the previous notification had not been closed. Hence, the notification display remained the same and was not displayed again. In this situation, the officer selected the "Cleaning Again" button before taking the data for one minute, so after one minute of the data taken, the dust wiper was triggered to clean the surface of the solar panel. After re-cleaning and 30 minutes of data collection at 13.02, the cleaning was successful, and the average power absorption results increased again.

CONCLUSIONS

1. The system can determine the intensity of sunlight using the BH1750 light sensor, which is placed on acrylic installed next to the solar panel with a sensor accuracy level of 92% and determines the power produced by the solar panel using the INA219 sensor module which is placed in the system box with a level of accuracy sensor is 99.987%.
2. The system can carry out maintenance on solar panels in two conditions, namely maintenance after rain occurs by helping dry the solar panels with rain wipers and maintenance when

 https://doi.org/10.25077/chipset.5.01.40-48.2024

the power produced by the solar panels is inversely proportional to the light intensity at that time by cleaning the surface of the solar panels using dust wipers.

3. The system can monitor power absorption on solar panels via a monitoring website. Monitoring can be done not only on the power obtained but also on what the system does. It can also display the history of power absorption on the previous day or the selected date.
4. The system can notify officers by displaying a dialog alert when cleaning conditions do not increase power absorption on the solar panels. It's possible that this happened due to other disturbances or unfavorable weather conditions, so officers could ignore the notification, carry out their checks, and tell the system to clean again.

REFERENCES

[1] Rarumangkay, B. B., Peokoel, V. C., & Sompie, S. R. U. A. 2021. *Solar Panel Monitoring System*. Jurnal Teknik Informatika, 16(2), 211-218. Manado. Universitas Sam Ratulangi

[2] Sujana, P. A., Kumara, I. N. S., & Giriantari, I. A. D. 2015. Pengaruh Kebersihan Modul Surya Terhadap Unjuk Kerja PLTS. E-Journal Spektrum, 2(3), 49-54. Denpasar. Universitas Udayana

[3] Hidayanti, Fitria. 2020. "Aplikasi Sel Surya". Jakarta Selatan. LP_UNAS

[4] Sunenergy."Cara Merawat Panel Surya". sunenergy.id. https://staging.sunenergy.id/blog/cara-merawat-panel-surya/

[5] Kusuma, M. R. W., Apriaskar, E., & Djunaidi, D. 2020. Rancang Bangun Sistem Pembersih Otomatis Pada Solar Panel Menggunakan Wiper Berbasis Mikrokontroler. Techné: Jurnal Ilmiah Elektroteknika, 19(1), 23-32. Semarang. Universitas Negeri Semarang

[6] Purba, J., Uyun, A. S., Sugiyanto, D., & Ramdan, M. I. 2022. Perancangan Prototipe Alat Pembersih Panel Surya Dengan Sistem Gerak Otomasi. Jurnal Kajian Teknik Mesin, 7(1). Jakarta. Universitas Darma Persada Jakarta

[7] Talawo, D. C. P., Ilham, J., & Amali, L. K. 2022. Pengaruh Polutan pada Permukaan Panel Surya Terhadap Kinerja Panel Surya Kapasitas 10 Wp. Jambura Industrial Review (JIREV), 31-38. Gorontalo. Universitas Negeri Gorontalo

[8] Hiscocks, Peter D., 2011. Measuring Light. Toronto. Ryerson University.

AUTHOR(S) BIOGRAPHY

Melly Wasilah Ananda

Born in Batusangkar, West Sumatra, on 14 October 2001. He attended SDN 20 Sukarami, SMPN 11 Padang and SMAN 4 Padang. Then studied at the Department of Computer Engineering, Faculty of Information Technology, Andalas University.