ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 4, April 2023

System Implementation of Solar Panel Optimization by Adjustment of Tilt Degrees and Cooling System Integrated Internet of Things

[1] Khairul Umurani, [2] Abdullah*, [3] Maharani Putri, [4] Juli Iriani, [5] Fitria Nova Hulu, [6] Cholish

[1] University of Muhammadiyah Sumatera Utara, Medan, Indonesia
[2] [3] [4] [5] [6] Politeknik Negeri Medan, Medan, Indonesia
Corresponding Author Email: [1] khairulumurani@umsu.ac.id, [2] abdullah@polmed.ac.id, [3] maharaniputri@polmed.ac.id, [4] juliiriani@polmed.ac.id, [5] fitrianova@polmed.ac.id, [6] cholish@polmed.ac.id

Abstract— *As a result the need for energy continues to increase, so that the use of alternative energy is required, one of this is the use of solar panels. Solar panel will work optimally if it get maximum sunlight and work in the working temperature range of solar panel, so needed to implement a solar panel optimization system by adjusting the degree of tilt and an integrated cooling system for the Internet of Things. The method used is setting the degree of inclination so that the movement of the solar panels is at the maximum slope of sunlight and utilizing the Peltier effect on water as a surface cooling system for solar panel. To ensure the system works properly, all parameters are monitored using Internet of Things-based technology in real-time. From the tests that have been carried out, the system can work well as a solar panel optimization system that has been integrated with the Internet of Things, which shows an increase in power from setting the degree of tilt of 35.19% and tilt angle settings and cooling system by 44.16% between solar panel without system and solar panel with system.*

Keywords: Solar Panel, Optimization, Internet of Things, Implementation, Energy.

I. INTRODUCTION

The use of alternative energy has become a global issue as a way to anticipate the increasingly limited energy sources derived from fossils [1]. The use of renewable energy is in the spotlight as the use of alternative energy because it is abundantly available and environmentally friendly [2]. One of them is the use of alternative energy sourced from solar energy, this occurs because the need for electrical energy has increased every year inversely proportional to the availability of fossil energy sources which are decreasing or limited, so that it becomes a serious problem that must be addressed immediately [3], one way to take advantage of solar energy sources is to utilize and optimize the work of solar panels [4].

Solar panels work on the principle of the photovoltaic effect, namely converting sunlight energy into electrical energy. Optimization of the electrical energy generated by solar panels in the form of voltage and electric current is strongly influenced by two main factors, namely the level of intensity of sunlight and the temperature of the solar panels. Where if the lower the level of intensity of sunlight received by the solar panels, the electrical energy in the form of current and the resulting electric voltage will also be lower. The high temperature on the surface of the solar panel as a result of the sun's continuous exposure to the surface of the solar panel results in a decrease in the generated electric power, i.e. 1ºC (starting from 25ºC) will reduce the output power generated by solar panels by about 0.5% [5]. From these problems, in this study a system was designed with the concept of optimizing solar panel work, namely the implementation of a solar panel optimization system by adjusting the degree of tilt and an integrated cooling system Internet of Things by maximizing the level of intensity of sunlight that can be absorbed by solar panels by adjusting the degree of tilt of the solar panels which have been integrated through a light sensor combination algorithm to get maximum sunlight points and cool the surface temperature of the solar panel to match the working temperature of the solar panel through the use of the Peltier effect as cooling water which will flow evenly to the surface of the solar panel which is communicated through the temperature sensor on the panel solar panels as well as monitoring features for all solar panel parameters to ensure the system works properly using Internet of Things-based technology in real time.

In this monitoring application, the main parameters taken from this study will be displayed, namely the analog voltage data of the two LDR light sensors, the angle of inclination of the solar panel movement, the temperature of the solar panel, the water temperature, output indicators such as east side pump work, west side pump, peltier 1 and peltier 2, displays weather information and the direction of movement of the solar panel and most importantly the voltage value, current and output power of solar panels on a comparison of standard solar panels (without system design) with solar panels by system design.

IFERP connecting engineers...developing research

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 4, April 2023

II. LITERATURE REVIEW

Energy has become a serious problem almost all over the world so that energy is one of the most important factors for a country's economic growth. Serious problems regarding energy are getting stronger at a time when the demand for energy is increasing. This causes the supply of energy reserves to decrease. The problem of the need for energy that continues to increase is inversely related to human awareness to create environmental conditions that are clean and free from pollution [3]. So that from these problems it is necessary to develop alternative energy sources as a solution to the problem of scarcity of energy reserve supplies.

A. Solar Panels

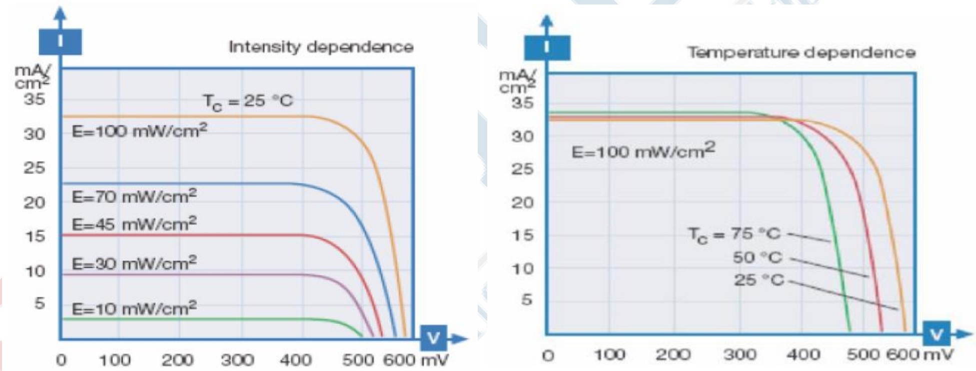
Solar panels are components consisting of semiconductor materials that work as a processor for converting solar energy into electrical energy with the concept of how photovoltaic works [6]. When sunlight hits the surface of the solar cell, photons will be formed which will give their energy to the valence electrons of the semiconductor material so that the spectral distribution of light occurs. When the solar energy is getting bigger, there is a potential difference that can produce an electric current [7]. In solar panels there is the term "Parameter Fill Factor (FF)" in which this parameter determines an efficiency value on the solar panel. Where to find the Fill Factor (FF) value can be calculated using the following equation:

$$FF = \frac{Imp\,.Vmp}{Isc\,.Voc}$$

Where:

FF = Fill Factor is the value of solar panel efficiency
Imp = Maximum panel current
Vmp= Maximum panel voltage
Isc = Current in short circuit condition
Voc = Voltage in open circuit condition

To get the voltage and current values you can use the equation: V=IR, where V is the voltage value, I is the current value and R is the resistance value, as well as to get the power value you can use the equation: P=VxI, where P is the electrical power [7]. The working principle of photovoltaic or often called solar cells consists of type-p and type-n semiconductor material connections (pn-junction semiconductors) where there will be a flow of electrons when exposed to sunlight; this flow of electrons is called the flow of electric current. The characteristics of a solar cell consist of two in general [8], ie:



(a) (b)

Figure 1. (a) I-V curve for irradiance, (b) I-V curve for temperature

B. Internet of Things

Internet of Things use computing techniques that are connected using the use of the internet network and are able to identify themselves from one device to another, so that long-distance communication occurs without wires. The most common thing to use Internet of Things technology is for the needs of a monitoring system so that a device that you want to monitor is simply done easily via a smartphone or laptop without having to go directly to the place you want to monitor, with this Internet of Things capability, the process of transferring information/data can be quickly done [9].

C. Control System

The control system is the most important part of the system. Without a control system, the designed system will only be like an inanimate object (the system cannot function). The control system for implementing a solar panel optimization system by adjusting the degree of tilt and integrated cooling system Internet of Things consists of three main parts: mechanics, hardware, and control algorithm [10]. At this mechanical stage, a mechanical design is designed that supports the tilt degree adjustment system with a single axis tracking mechanical concept, the solar panel cooling system utilizes the heatsink design attached to the back of the solar panel and the Peltier effect as cooling water which will flow evenly to the surface solar panels. At the hardware stage, electronic requirements are designed and at the control algorithm stage, software requirements are prepared in the form of programming to control the entire system, from this control algorithm the mechanical and hardware systems can work automatically according to the desired function.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 4, April 2023

III. RESEARCH METHODOLOGY

The research method for implementing a solar panel optimization system with tilt adjustment and an integrated cooling system for the Internet of Things is to combine hardware and software parts.

A. Hardware Design

Hardware design consists of two main parts, namely mechanical system design and electronic system design. The mechanical design consists of the physical form/design of the system, while the electronic design consists of the system design of electronic requirements such as controllers, sensors, motors and others. Figure 2 shows the mechanical design of the designed system.

Figure 2. System mechanical design

In the above mechanical design the main materials used, namely hollow iron, plate iron, aluminum plate and hydraulic DC motor, the mechanical material was chosen because this material is strong and easy to shape according to system requirements.

B. Research Stages

The research design to be carried out is that Arduino Mega as a data processing center will receive input in the form of an LDR light sensor, temperature sensor, GY-302 lux sensor and INA-219 module, controlling a DC motor through a DC motor driver as a movement system for setting the degree of tilt to carry out the movement process of the solar panels to stay focused following the direction of the sun. Peltier control through a peltier driver as a water cooling system that will flow evenly to the surface of the solar panels is regulated as needed with the concept of Pulse Width Modulation. The design of this system is also equipped with an LCD display and monitoring through the integrated application of the Internet of Things. This monitoring application functions to display important parameters in the system, so that the system can work and be monitored properly. The overall system design diagram is shown in the following figure 3:

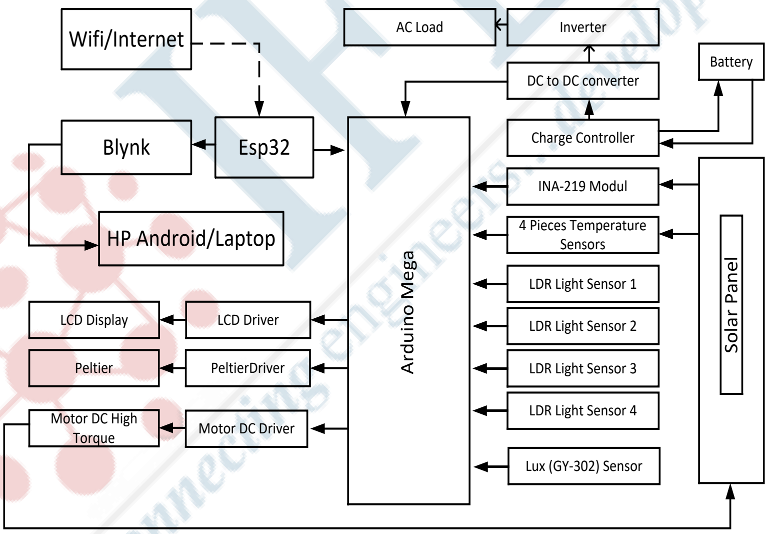


Figure 3. Hardware block diagram as a whole

Based on the design diagram above, it can be explained the requirements for the core components of the designed system, namely Arduino Mega, namely as a center for input / output processing and communication for reading the ESP32 WiFi module, 100 WP Solar Panel, High Torque DC Motor functioned to move the solar panel according to sensor instructions LDR light, Peltier as a water cooling system works according to temperature sensor instructions, DC Motor Driver functions to control the movement of the DC motor both direction and rotational speed, LDR light sensors (4 pieces) which function as sun focus detectors work based on changes in resistance to light about it, DS18B20 temperature sensor for measuring the temperature of solar panels with range specifications -55ºC – 125ºC, The GY-302 Lux sensor functions as a light intensity meter in units of Lux with a resolution : 0 – 65535 lux, The INA219 module is used to measure current and voltage on solar panels with a monitor voltage range: 0 - 26 V and operating voltage: 3 - 5 V, ESP32 functions as a WiFi module in the IoT design, 20x4 LCD Display (1 piece) functions as a display to display monitoring results placed on the system in the form of 20 columns and 4 rows, 12 Volt 20 Amp power supply (1 unit) functions as a voltage source for system needs , Deep Cycle type battery for storing power from solar panels, Charge Controller as a

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 4, April 2023

voltage and current controller to be supplied to the battery, DC to DC converter as a conversion of the DC input voltage level to a different dc output voltage level as needed, inverter as a DC voltage conversion into AC voltage to activate the AC load used.

C. Research Stages

The stages of implementing the research carried out can be seen in the flowchart as follows:

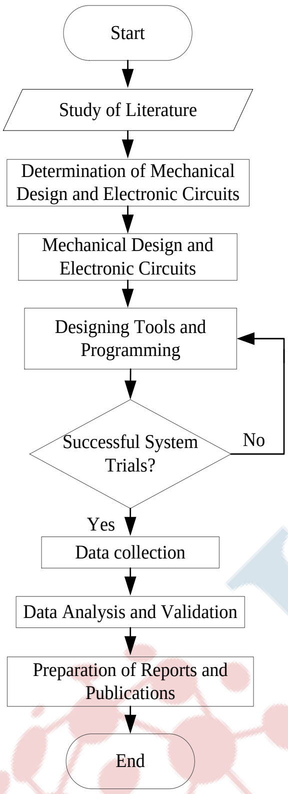


Figure 4. Research stages flowchart

Based on the flowchart above, the stages of the research implementation started from conducting a literature study regarding research supporting references, references to the use of components needed in system implementation, after obtaining references, determining and designing the mechanics and circuit modules needed by the system, such as mechanical design to be made, the need for circuit modules, some of which are controllers, sensors and circuit modules used, types of DC motors and drivers, indicator displays and WiFi modules used to integrate Internet of Things-based systems, after mechanical design and circuit modules If this is done, testing will be carried out to ensure that all mechanical designs and circuit modules can work properly. Then proceed with connecting the entire series according to system requirements, followed by software design by making program algorithms, then after the program algorithm is complete then proceed to upload it to the controller as the input and output control center, the next stage is to test the tool, ensure the designed system is appropriate or no, if there are still problems, they will be repaired again according to the problems that occur, but after being in accordance with the research, the system design/manufacturing stage has been completed, followed by data collection, report preparation and publication.

D. Software Design

The software design uses the C programming language with the Arduino IDE software as the main software for system controller programming such as for process control and monitoring processes and uses the Blynk application as an Internet of Things interface design. The software display can be seen in Figure 5, as follows:

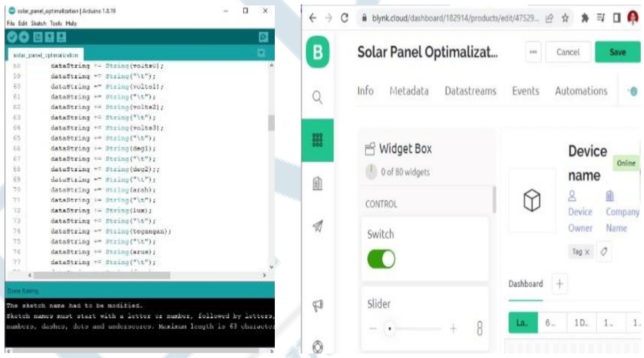


Figure 5. Display of the software used on the system

IV. RESULTS AND DISCUSSION

The results and discussion of the research on the implementation of the solar panel optimization system by adjusting the degree of tilt and the Internet of Things integrated cooling system consist of five tests, namely testing the system for adjusting the angle of the solar panel, testing the output power of solar panels between static solar panels and solar panels with the system setting the tilt angle, testing the solar panel cooling system and testing the solar panel optimization system between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle adjustment and cooling systems as well as testing the entire Internet of Things integrated system using the Blynk application. The following is the result of the overall system design.

Figure 6. Display of overall system design results

IFERP
ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 10, Issue 4, April 2023

A. Testing the solar panel tilt angle adjustment system

Design Testing of the system for adjusting the tilt angle against the direction information of the solar panel is carried out to show how the motor moves in adjusting the tilt angle with the single axis concept, where the DC motor that uses hydraulic mechanics has worked well, namely moving in the direction specified as the maximum movement of sunlight . This test can be seen in Table.1 and the graph in Figure 7.

Table 1. Testing of the solar panel tilt angle adjustment system

Time (Western Indonesian Time)	LDR Sensor Analog Voltage (Volt)		Solar Panel Tilt Angle (°)	Description of Solar Panel Direction
	LDR_1 Sensor	LDR_1 Sensor		
08.00	0,2	0,17	51	East
09.00	0,23	0,19	56	East
10.00	0,27	0,23	67	East
11.00	0,29	0,25	72	East
12.00	0,32	0,31	88	Vertical
13.00	0,35	0,33	92	Vertical
14.00	0,33	0,29	102	West
15.00	0,31	0,27	108	West
16.00	0,28	0,25	113	West
17.00	0,26	0,22	120	West

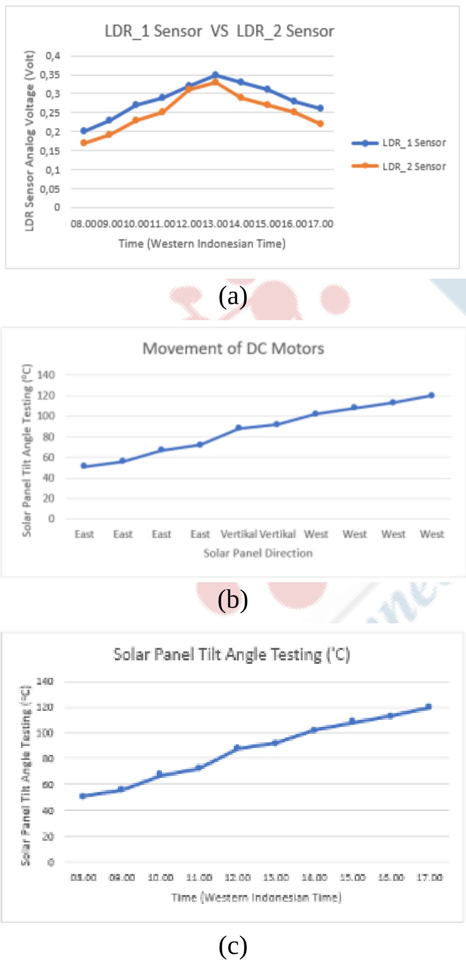


Figure 7. Graph of solar panel tilt angle setting system (a) LDR sensor _1 VS LDR sensor _2 with to time, (b) Tilt angle of solar panel with to time and (c) DC Motor movement with to direction

From the tests shown in Table 1 and the graph in Figure 7, it shows the work of the DC motor movement in determining the position of the solar panel, namely the movement of single_axis. It can be seen that the movement of the motor has worked well through the combination of the two LDR light sensors in determining the angle of inclination and direction of the solar panels. Where does the LDR light sensor work, which is divided into two, namely the LDR_1 sensor in the top position and the LDR sensor _2 in the lower position, if the LDR sensor analog voltage value_1 greater than the analog voltage value of the LDR sensor _2 then the hydraulic motor will continue to move the solar panel towards the east otherwise if the analog voltage value of the LDR sensor _1 smaller than the analog voltage value of the LDR sensor _2 then the hydraulic motor will continue to move the solar panel towards the west, but if the analog voltage value of the LDR sensor _1 almost the same (within 3 degrees) between the analog voltage values of the LDR sensor_2 then the hydraulic motor will stop, to determine the degree of tilt position of the solar panel will be read by the Accelerometer & Gyroscope sensor.

B. Testing the output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system

Testing the output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system shows how the process of optimizing the performance of solar panels can be increased by adjusting the tilt angle compared to static solar panels. This test can be seen in Table 2 and the graph in Figure 8.

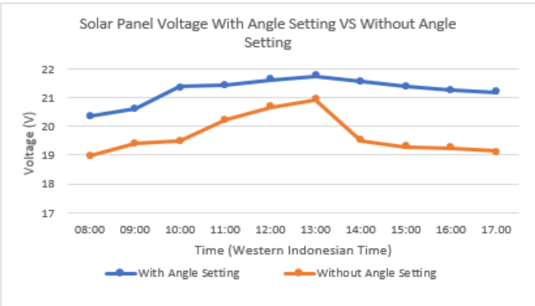
ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

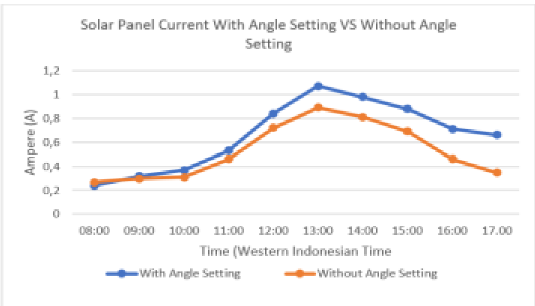
Vol 10, Issue 4, April 2023

Table 2. Testing the output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system

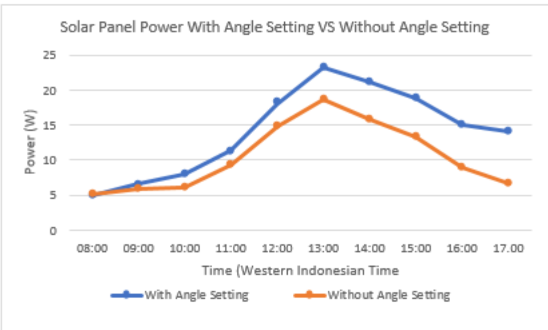
Time	Solar Panel with Angle Setting			Solar Panel without Angle Adjustment			Weather Conditions
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (Watt)	
08:00	20,34	0,24	4,88	18,96	0,27	5,12	Bright
09:00	20,62	0,32	6,60	19,42	0,30	5,83	Bright
10:00	21,37	0,37	7,91	19,49	0,31	6,04	Bright
11:00	21,43	0,53	11,36	20,21	0,46	9,30	Bright
12:00	21,62	0,84	18,16	20,67	0,72	14,88	Bright
13:00	21,75	1,07	23,27	20,93	0,89	18,63	Bright
14:00	21,57	0,98	21,14	19,50	0,81	15,80	Bright
15:00	21,38	0,88	18,81	19,30	0,69	13,32	Bright
16:00	21,26	0,71	15,09	19,25	0,46	8,86	Cloudy
17.00	21,19	0,66	13,99	19,13	0,35	6,70	Cloudy



(a)



(b)



(c)

Figure 8. Graph of (a) voltage to the time (b) current to the time and (c) output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system

Based on testing the output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system, the total power of solar panels with a setting system is 141,21 W and solar panels without an angle setting is 104,46 W, so the difference in power can be calculated:

Difference Ptotal	=	Ptotal with angle adjustment system tilt – Ptotal without tilt angle adjustment system
	=	141,21 Watt – 104,46 Watt
	=	36,75 Watt
% Increase in P	=	(Difference in total P system / P total without system) x 100
	=	(36,75 / 104,46) x 100
	=	35,19 %

The percentage increase in panel output power is 35,19%.

C. Testing the solar panel cooling system

Testing the solar panel cooling system shows how the work process of the solar panel surface cooling system is carried out on optimizing the performance of solar panels to get an increase in solar panel output power. This test can be seen in Table.3.

Table 3. Testing of solar panel cooling systems

No.	East Side Pump Status	West Side Pump Status	Cooling Water Temperature (°C)	Time	Solar Panel Direction
1	ON	OFF	18	10.03	West
2	ON	OFF	21	11.05	West
3	ON	OFF	22	11.59	Vertikal
4	OFF	ON	22	13.11	East
5	OFF	ON	24	14.38	East

IFERP connecting engineers...developing research

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 4, April 2023

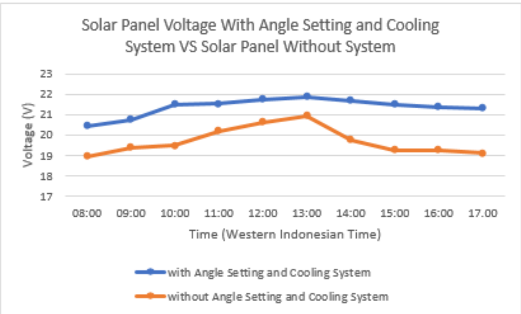
Based on Table 3 shows the work of the solar panel cooling system, where the cooling system process will work if the temperature of the solar panels is at temperature ≥ 35ºC and the cooling system shutdown process is at a temperature 25 ºC-30 ºC. This cooling system works by flowing cold water to the surface of the solar panel, the water flow process uses two pumps which are divided into the east and west sides, the east side pump will work if the solar panel faces west and the west side pump will work if the solar panel faces east. The cooling water temperature will be maintained by utilizing the Peltier effect to cool the water between 15 ºC to 25 ºC.

D. Testing of the solar panel optimization system between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle settings and cooling systems

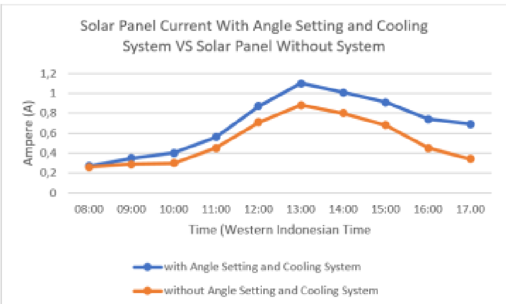
Testing of solar panel optimization systems between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle adjustments and cooling systems shows how the process of optimizing solar panel performance can be increased by adjusting the tilt angle and cooling system compared to solar panels without tilt angle adjustments and cooling system. This test can be seen in Table 4 and the graph in Figure 9.

Table 4. Testing of solar panel optimization systems between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle settings and cooling systems.

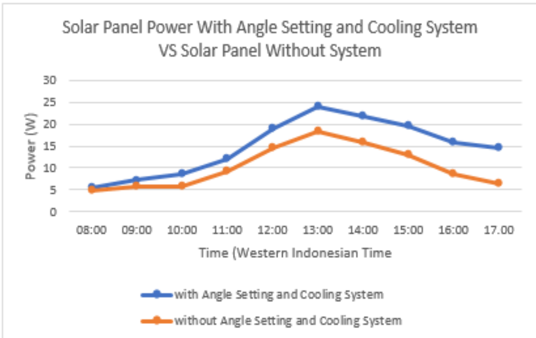
Time	Solar Panel With Angle Setting + Cooling			Solar Panel With Angle Setting + Cooling			Weather Conditions
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	
08:00	20,45	0,27	5,47	18,93	0,26	4,92	Bright
09:00	20,73	0,35	7,20	19,39	0,29	5,62	Bright
10:00	21,48	0,40	8,54	19,46	0,3	5,84	Bright
11:00	21,54	0,56	12,01	20,18	0,45	9,08	Bright
12:00	21,73	0,87	18,85	20,64	0,71	14,65	Bright
13:00	21,86	1,10	23,99	20,9	0,88	18,39	Bright
14:00	21,68	1,01	21,84	19,72	0,8	15,78	Bright
15:00	21,49	0,91	19,50	19,27	0,68	13,10	Cloudy
16:00	21,37	0,74	15,76	19,22	0,45	8,65	Cloudy
17.00	21,30	0,69	14,64	19,1	0,34	6,49	Cloudy



(a)



(b)



(c)

Figure 9. Graph of (a) voltage to the time (b) current to the time and (c) output power of solar panels with tilt angle settings and cooling systems with without system

Based on testing of the solar panel optimization system between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle settings and cooling systems, the total power of solar panels with tilt angle settings and cooling systems obtained is 147,81 W and solar panels without tilt angle settings and a cooling system of 102,53 W, so that the power difference can be calculated.

ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 10, Issue 4, April 2023

Difference Ptotal	=	Ptotal with adjustment of tilt angle and cooling system - Ptotal without adjustment of tilt angle and cooling system
	=	147,81 Watt – 102,53 Watt
	=	45,28 Watt
% Increase in P	=	(Difference between Ptotal system / Ptotal without system) x 100
	=	(45,28 / 102,53) x 100
	=	44,16 %

The percentage increase in panel output power is 44,16%.

E. Testing the entire integrated Internet of Things system using the Blynk application

This testing design for an integrated Internet of Things system shows how the concept of remote monitoring using IoT technology can be carried out on a solar panel optimization system between solar panels with tilt angle adjustments and a cooling system with integrated Internet of Things solar panels using the Blynk application. Some of these tests can be seen in Figure 10.

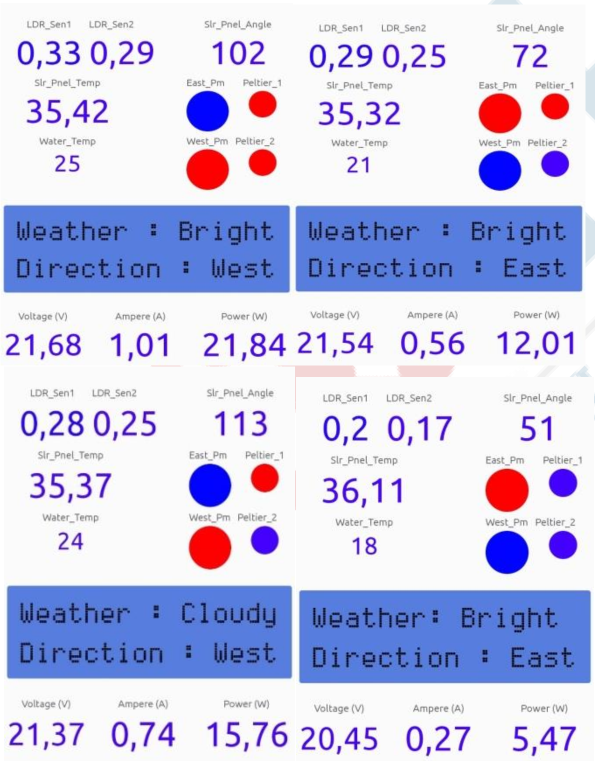


Figure 10. Testing the entire integrated Internet of Things system using the Blynk application

From tests carried out all monitoring data, both the second analog voltage data, the tilt angle of solar panel movement, solar panel temperature, water temperature, output indicators such as east side pump work, west side pump, peltier 1 and peltier 2, display weather information and directions the movement of solar panels and most importantly the value of voltage, current and output power of solar panels can be monitored properly in one Blynk application that has been integrated with the Internet of Things.

V. CONCLUSION

The conclusion of this study is that all system settings are carried out automatically in one system that is equipped with realtime monitoring application features integrated with the Internet of Things, in which there is second analog voltage data, tilt angle of solar panel movement, solar panel temperature, water temperature, output indicators such as the work of the east side pump, west side pump, peltier 1 and peltier 2, display of weather information and the direction of movement of the solar panel as well as most importantly the value of the voltage, current and output power of the solar panel, so that if there is an error in the movement of the position or variable value the not suitable can be resolved immediately. From the tests that have been carried out, the system can work well as a solar panel optimization system that has been integrated with the Internet of Things, which shows that the solar panel tilt angle adjustment system has worked well through input from a combination of light sensors for the movement of the tilt angle and direction of the solar panels over time, testing the output power of solar panels between static solar panels and solar panels with a tilt angle adjustment system obtained an increase in power of 35,19%, cooling system that has worked well in activating solar panel surface watering pumps on solar panel surface temperature, water temperature and solar panel direction information, Testing of solar panel optimization systems between solar panels with tilt angle settings and cooling systems with solar panels without tilt angle settings and the cooling system obtained an increase in power by 44,16% and this testing of the Internet of Things integrated system shows how the concept of remote monitoring can properly monitor all system parameters in one Blynk application that has been integrated with the Internet of Things.

VI. ACKNOWLEDGMENTS

The author would like to thank the State Polytechnic of Medan for the funding provided through the Contract: (B/455/PL5/PT.01.05/2022) which comes from DIPA POLMED funds in 2022.

REFERENCES

[1] Dirwan, A, “Peningkatan Ketahanan Pangan dan Energi sebagai Bagian dari Perwujudan Ketahanan Nasional,” Mitra Manajemen Journal, vol. 4, no. 1, 2020.

[2] Azhar, M., & Satriawan, D. A, “Implementasi kebijakan energi baru dan energi terbarukan dalam rangka ketahanan energi nasional,” Administrative Law and Governance Journal, vol. 1, no. 4, pp. 398-412, 2018.

ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 10, Issue 4, April 2023

[3] Nasional, D. E. (2015). Ketahanan Energi Indonesia. Jakarta: Sekjen DEN.
[4] Elsherbiny, M. S., Anis, W. R., Hafez, I. M., & Mikhail, A. R, “Design of single-axis and dual-axis solar tracking systems protected against high wind speeds,” International Journal of Scientific & Technology Research, vol. 6 no. 9, pp. 84-89, 2017.
[5] Nadia, A.-R., Isa, N. A. M., & Desa, M. K. M, “Efficient single and dual axis solar tracking system controllers based on adaptive neural fuzzy inference system,” Journal of King Saud University-Engineering Sciences, vol. 32 no. 7, pp. 459-469, 2020.
[6] Shufat, S. A. A., Kurt, E., & Hancerlioğulları, A, “Modeling and Design of Azimuth-Altitude Dual Axis Solar Tracker for Maximum Solar Energy Generation,” International Journal of Renewable Energy Development, vol. 8 no. 1.
[7] Sitorus, T., Lubis, Z., Sembiring, F., Christopel, B., & JA, R. S, “ Utilization of peltier cooling systems driven by solar power for
[8] storing vegetables and fruits,” Paper presented at the IOP Conference Series: Materials Science and Engineering, (2020).
[9] Munanga, P., Chinguwa, S., Nyemba, W. R., & Mbohwa, C. “Design for manufacture and assembly of an intelligent single axis solar tracking system,” Procedia CIRP, pp. 91, 571-576, 2020.
[10] Suryanto, A., Hudallah, N., Andrasto, T., Adhiningtyas, C. F., & Khusniasari, S. A,”Optimalisasi Keluaran Panel Surya Menggunakan Solar Tracker Berbasis Kamera Terintegrasi Raspberry Pi,” Jurnal Nasional Teknik Elektro dan Teknologi Informasi, vol. 10, no.3, pp. 282-290.
[11] Hamdani, H., Pulungan, A. B., Myori, D. E., Elmubdi, F., & Hasannuddin, T, “Real Time Monitoring System on Solar Panel Orientation Control Using Visual Basic,” Journal of Applied Engineering and Technological Science (JAETS), vol. 2, no. 2, pp. 112-124, 2021.

BIOGRAPHY

Khairul Umurani Graduated from Strata 1 at Muhammadiyah University of North Sumatra in 1998 then Master degree at University of North Sumatra in 2013. Currently active in Research in the Energy sector.

Abdullah completed his undergraduate education at the University of North Sumatra in the Department of Electronics Instrumentation Physics in 2010 and completed his Masters degree at the University of North Sumatra in the Department of Electrical Engineering in 2014. Currently active in Research in the field of Control and Automation System, Embedded System, Renewable Energy and Internet of Things.

Maharani Putri Strata 1 at Syiah Kuala University in 2010 then Master Degree at the University of North Sumatra in 2014. Currently active in research in the field of Electrical Energy.

Juli Iriani Bachelor Degree at the University of North Sumatra in 1994 then Master Degree at the University of North Sumatra in 2011. Currently active in Research in the field of Electrical Engineering.

Fitria Nova Hulu Graduated as Bachelor Degree at Pembangunan Panca Budi University in 2011 then Master Degree at the University of North Sumatra in 2016. Currently active in Research in the Telecommunication sector.

Cholish Graduated from Strata 1 at Muhammadiyah University of North Sumatra in 2011 then Master degree at Syiah Kuala University in 2016. Currently actively managing Scientific Journals and Research in the fields of Control Systems, Renewable Energy, Power Electronics and Power Quality.