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Design and Realization of Solar Power Systems Using Photovoltaic Cells for Smart Plantation Watering Systems

Rezky Maruli Purba[1], Suratun Nafisah[2], Uri Arta Ramadhani[3], Kisna Pertiwi[4], Muhammad Redho Kristianto[5]

[1, 2, 3,5]Electrical Engineering Study Programme, Institut Teknologi Sumatera

[4]Automation and Instrumentation Engineering Study Programme, Institut Teknologi Sumatera

Corresponding Author: Uri Arta Ramadhani uri.ramadhani@el.itera.ac.id

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A B S T R A C T

The development of plants on a plantation is highly dependent on providing sufficient water for the plants.Hence, it is needed to have a optimal smart watering for plantation that is able to distribute water for plants efficiently. In this work, we developed an off-grid solar power plant to support a smart watering system. This solar power plant uses polycrystalline panels that function to absorb solar energy. Second, there is the SCC (Solar Charge Controller) which is used to charge the battery and regulate power from the battery to the load to keep the battery from overcharging. Then there is a 500 watt psw inverter. The battery is also used as a storage of the power that has been generated. The power that has been stored in this battery still be used to turn on the pump to water the plants, and it is also useful to turn on the existing sensors which will be input to the microcontroller then give the command to turn on the pump. Based on the collected data, it is known that the system requires an average power of 783.56 W for one hour

INTRODUCTION

Electrical energy plays an important role in supporting various daily human activities, but in several areas, there are problems with the continuity of electrical energy supply due to rolling blackouts. Energy independence is very necessary to overcome this, by utilizing new and renewable energy (Agustiawan, 2021). Renewable energy will not be diminished even if used on a large scale. One of the EBT power plants that is familiar and often encountered is the solar power plant. This type of power plant has been widely applied in various sectors, such as education, industry, and agriculture. In Indonesia, the agricultural sector is a vital sector, because most of the population's main livelihood is farming, which is why this country is nicknamed an agricultural country (Sukmajati & Hafidz, 2015).

As environmentally friendly technologies spread and in line with the government's "Agriculture 4.0" initiative, various tools have been developed to make it easier for farmers to carry out their tasks (Afandi, Fadlika, Gumilar, Andriansyah, & Mistakim, 2021). One of the important products in applying technology in the plantation sector is the Smart Watering System for Plantation (SWAP). This product is operated using electricity obtained from solar energy as the main source of power. The charging process for this system involves a 120 Wp solar panel, solar change controller, battery, and inverter which can change DC 12 V voltage to AC 220 V (Faturrahman, 2021).

METHODS

The research method applied in this research includes testing the system that has been designed, with a focus on observing the voltage produced by the solar panel and the amount of current entering the battery (Wandira, Notosudjono, & Rijadi). This testing is divided into two stages, namely:

A. Testing on Solar Panels
   1. Collect current and voltage data during the hot sun from 09:00 to 16:00.
   2. Taking temperature data on production results (Simanjuntak, Heryanto, Rahmawaty, & Manurung, 2021).

B. Battery Testing
   1. Retrieval of current and voltage data entering the battery (Perdana).
   2. Retrieve data related to the duration of charging the battery to full (Simanjuntak & Dahlia, 2013).

After carrying out the series of procedures above, data is then collected which includes the voltage of the solar panel when the circuit is open (Voc) and the short circuit current produced by the system (Naim, 2020).

RESULTS AND DISCUSSION

A. Implementation

The implementation was carried out in the ITERA botanical garden, precisely in front of parent A. The solar panel used was of the Polycristaline type measuring 330 Wp which was supported by 4 legs made of light steel and perforated angles. The solar panel is then connected to the SCC at the bottom of the solar panel. Then the SCC is connected to 2 batteries, each of which has a capacity of 100 Ah and will be connected in parallel so that the current increases according to needs.


Figure 1. Solar Panel Installation

Figure 2. Solar Charge Controller


Figure 3. Battery and Inverter

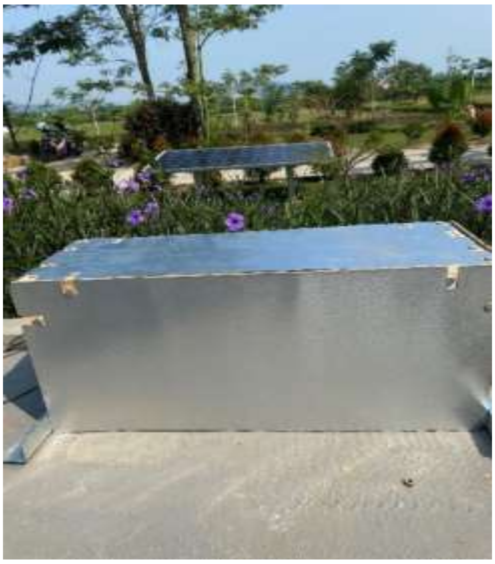

Figure 4. Battery Cover

B. Testing

Testing of the power subsystem installation with a 350 W water pump load of 2 pumps is part of the SWAP II product. The solar power plant is designed to be the main energy source to run the entire system for the SWAP II product. By carrying out testing, the performance of the installed power subsystem can be determined. The tests are carried out through a calculation and measurement process. Power subsystem components include solar panels, SCC, batteries and inverters.

1. Battery charging testing

Testing solar panels to charge batteries aims to determine the duration to charge a 200Ah capacity battery. Observations were carried out every 1 hour periodically. Testing will be conducted from 09:00 to 15:00.

Table 1. Data Collection I

Time	**Voc (V)**	**Vsc1 (I)**	**Isc1 (A)**	**Temperature (˚C)**	**Weather**
09.00	39,8	12,8	1,8	30	Cloudy
10.00	40,2	13,7	4,6	35	Sunny
11.00	40,1	13,5	4,6	35	Sunny
12.00	39,8	13	2,1	35	Cloudy
13.00	41	14,1	6,8	38	Sunny
14.00	41,3	14,4	7,1	40	Sunny
15.00	39	13,1	2,1	34	Sunny

Table 2. Data Collection II

Time	Voc (V)	Vsc2 (I)	Isc2 (A)	Temperature (˚C)	Weather
09.00	39,8	12,5	1,5	30	Cloudy
10.00	40,2	12,6	4,2	35	Sunny
11.00	40,1	12,7	4,2	35	Sunny
12.00	39,8	12,7	1,7	35	Cloudy
13.00	41	12,8	6,3	38	Sunny
14.00	41,3	13,1	6,8	40	Sunny
15.00	39	13,2	1,7	34	Sunny

Table 3. Data Collection III

Time	Voc (V)	Vsc1 (I)	Isc1 (A)	Temperature (˚C)	Weather
09.00	39,1	12,7	1,4	33	Cloudy
10.00	39,5	13,1	4,1	34	Cloudy
11.00	41,1	14	7,2	38	Sunny
12.00	41,6	14,3	7,6	39	Sunny
13.00	39,8	13,5	6,6	35	Cloudy
14.00	39,2	13,2	4,2	33	Cloudy
15.00	39,1	13	1,8	33	Cloudy

Table 4. Data Collection IV

Time	Voc (V)	Vsc2 (I)	Isc2 (A)	Temperature (˚C)	Weather
09.00	39,1	12,4	0,8	33	Cloudy
10.00	39,5	12,4	3,7	34	Cloudy
11.00	41,1	12,5	6,6	38	Sunny
12.00	41,6	12,7	7,1	39	Sunny
13.00	39,8	12,8	5,8	35	Cloudy
14.00	39,2	13	3,7	33	Cloudy
15.00	39,1	13	1,2	33	Cloudy

Table 5. Data Collection V

Time	Voc (V)	Vsc1 (I)	Isc1 (A)	Temperature (˚C)	Weather
09.00	40,2	13,8	3,5	34	Cloudy
10.00	40,6	14	6,6	36	Sunny
11.00	41,1	14,3	7	40	Sunny
12.00	41,8	14,6	7,8	40	Sunny
13.00	41,6	14,4	7,2	39	Sunny
14.00	40,8	14,1	6,8	37	Sunny
15.00	39,9	13,6	2,6	33	Cloudy

Table 6. Data Collection VI

Time	Voc (V)	Vsc2 (I)	Isc2 (A)	Temperature (°C)	Weather
09.00	40,2	12,4	2,8	34	Cloudy
10.00	40,6	12,5	6	36	Sunny
11.00	41,1	12,7	6,2	40	Sunny
12.00	41,8	12,9	7,1	40	Sunny
13.00	41,6	13,1	6,8	39	Sunny
14.00	40,8	13,2	6,1	37	Sunny
15.00	39,9	13,2	1,8	33	Cloudy

From the data above, it can be represented in the graph shown in Figure 5 to Figure 8 to see the comparison of the current and voltage curves from the first day of testing to the third day.

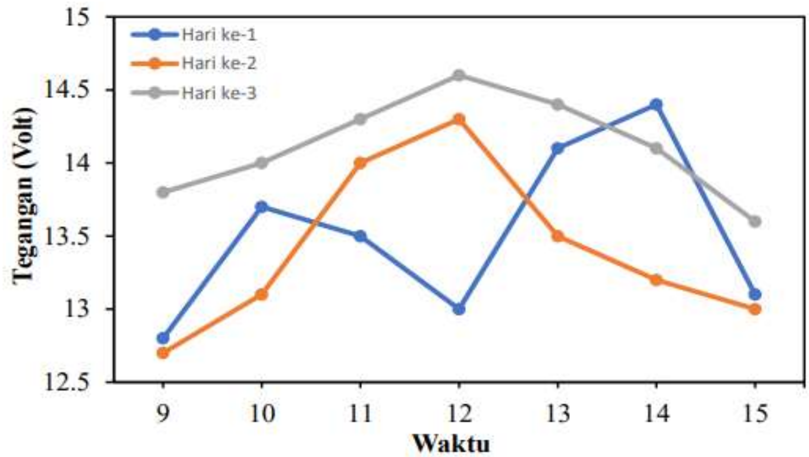

Figure 5. The Solar Panel Voltage Curve

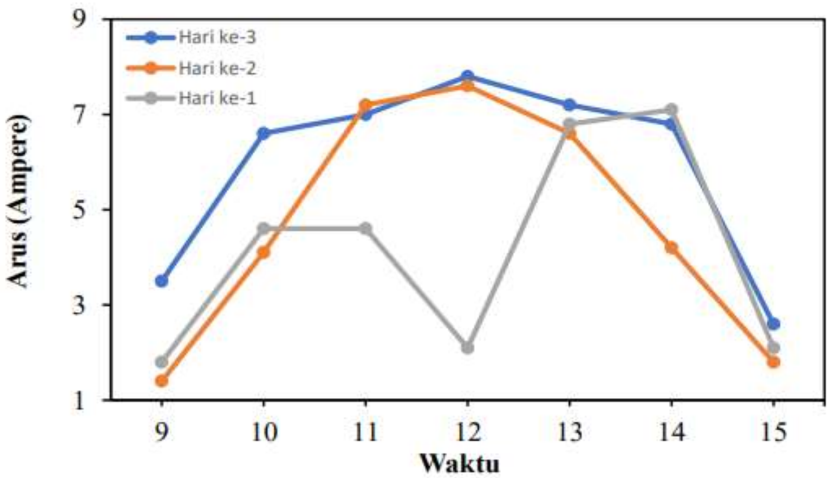

Figure 6. Solar Panel Current Curve

From the graph above, it is known that the results of testing on the 1st day with predominantly sunny weather got the highest voltage at 14:00 worth 14.4 V with a current of 7.1 A. Then on the 2nd day of testing, we got the highest voltage results at 12:00 worth 14.3 V with a strong current of 12.5 13 13.5 14 14.5 15 9 10 11 12 13 14 15 Voltage (Volts) Time 1st Day 2nd Day 3rd Day 1 3 5 7 9 9 10 11 12 13 14 15 Current (Amperes) Time of Day 3rd Day 2nd Day 1 22 7.6 A. And on the 3rd day of testing the highest test results were obtained at 12:00 with a voltage of 14.6 V and a current of 7.8 A.

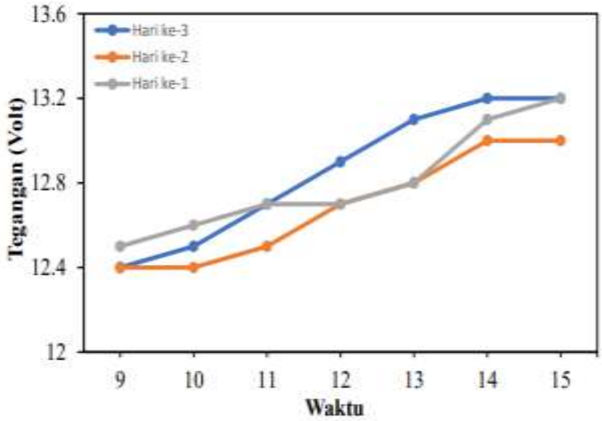

Figure 7. Battery Voltage Curve

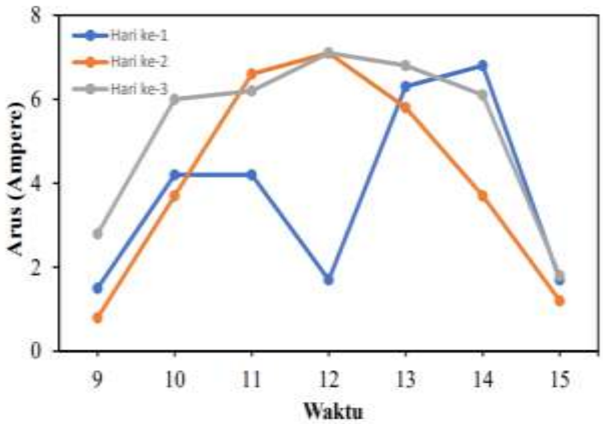

Figure 8. Battery Current Curve

Battery charging takes approximately 7 hours. On the second and third days of testing, it was found that the highest current entering the battery occurred at noon, namely 7.1 A.

2. Battery Testing

The test was carried out using 2 350 watt water pumps from a 200Ah battery alone without the help of solar panels. This test aims to determine the battery's ability to provide energy to the pump when there is no sun or the weather is not sunny. The results of the observation data can be seen in Table 7. Battery test.

Table 7. Observation Data for Battery Testing

Time (M)	Battery Voltage (V)	Battery Current (A)	Power (W)
1	11,5	73,6	846,4
5	11,4	72,2	823,08
10	11,3	72,1	814,73
15	11,2	72,1	807,52
20	11,0	72,3	795,3
25	11,0	71,9	790,9
30	10,8	71,8	775,44
35	10,7	72	770,4
40	10,6	71,9	762,14
45	10,6	72,2	765,32
50	10,5	71,9	754,95
55	10,4	71,8	746,72
60	10,2	71,9	733,38

The water pump load test using a 200 Ah battery was carried out for 60 minutes with a decrease in battery voltage of 0.01 to 0.2 V per five minutes as shown in Figure 8. This loading process experienced a voltage drop of 1.3 V, with an average current flowing to the inverter of 72.1 A with an average loading power for 60 minutes of 783.56 Wh.

3. Component Test

After carrying out a series of tests, the test results were obtained which can be seen in Table 8.

Table 8. Testing on Components

No.	Component	Component test result
1	Solar panel	A 330 Wp polycrystalline solar panel can produce a maximum voltage of 41.8 V with a maximum current of 7.8 A
2	SCC	The input voltage from the solar panel ranges from 12.8 to 14.6 V.
3	Battery	The battery functions quite well with a full battery capacity of around 13.4 V
4	Inverter	The inverter works quite well by converting DC to AC but sometimes overheats.

Table 9. Result of Components Testing

No.	Component	Test results	
		Good	Bad
1	Solar Panel	✓	-
2	SCC	✓	-
3	Battery	✓	-
4	Inverter	✓	-

Based on the data obtained, the electric voltage when charging the battery is maintained at 12 to 14 V. This is due to the settings made on the SCC with a limit of 14.9 V so as not to exceed the voltage on the battery. The maximum current obtained during the battery charging test was 7.8 A which occurred at noon to be precise at noon on the 3rd day of testing, while the lowest was on the 2nd day with a value of 1.4 A at 09.00.

From testing charging the battery for 7 hours per day, it was found that an average of 382.86 Wh per day or 15% of the total capacity that can be stored in the battery. 27 Based on battery calculations with an Isc specification of 24.2 A, it takes 8.26 hours using 4 100 Wp solar panels. With a different implementation using a 330 Wp solar panel with an average current during testing of 5 A, it takes 5 days to charge from empty to full battery. During this charging test, it took place in weather conditions that were more likely to be cloudy.

From the loading test data, it was found that the initial power required by the pump was 878.6. This power will decrease slightly as long as the water pump is on. For 60 minutes with a decrease in battery voltage of 0.01 to 0.2 V per five minutes, this loading process experienced a voltage decrease of 1.3 V, with an average current flowing to the inverter of 72.1 A with an average loading power for 60 minutes of 783.56 Wh.

CONCLUSION

After going through a series of tests and discussions, several conclusions can be drawn. First, system design is carried out by calculating the main load to ensure that the selection of components such as solar panels, solar charge controllers, batteries, and inverters is carried out correctly without errors or inability of components to deliver or accommodate current and voltage.

Second, the solar power plant in the Smart Watering System for Plantation (SWAP) II was implemented according to the design and placed in the Itera botanical garden, precisely in front of paranet A. Finally, it is known that SWAP II requires an average power of 783.56 W for 60 minutes or 1 hour.

REFERENCES

Afandi, A. N., Fadlika, I., Gumilar, L., Andriansyah, M. R., & Mistakim, E. (2021). Rancang Bangun Off-Grid System Pembangkit Listrik Tenaga Surya (PLTS) Sebagai Modul Pembelajaran Bagi Mahasiswa Univiversidade Oriental De Timor Lorosa'e (UNITAL). 351-352.

Agustiawan. (2021). Rancang Bangun Pembangkit Listrik Tenaga Surya Pada Pondok Tahfidz Hanifah. *Seminar Nasional Industri dan Teknologi (SNIT)*, 398-399.

Faturrahman, D. (n.d.). Implementasi Energi Terbarukan pada Produk Smart Watering System for Plantation (SWAP) Berbasis Panel Surya Polycrystalline. 2021.

Naim, M. (2020). Rancangan Sistem Kelistrikan PLTS Off Grid 1000 Watt di Desa Loeha Kecamatan Towuti. *Vertex Elektro*, 18-20.

Perdana, A. Y. (n.d.). Analisis Efesiensi Solar Charger Controller Tipe PWM dan MPPT dengan Metode Simulasi. 2020.

Simanjuntak, A. E., & Dahlia. (2013). Rancang Bangun Pompa Otomatis pada Penyiraman Tanaman dengan Solar Cell sebagai Catu Daya.

Simanjuntak, I. U., Heryanto, Rahmawaty, Y., & Manurung, T. (2021). Performance Analysis of VRLA Battery for DC Load at Telecommunication Base Station. *ELKHA : Jurnal Teknik Elektro*, 149.

Sukmajati, S., & Hafidz, M. (2015). Perancangan dan Analisis Pembangkit Listrik Tenaga Surya Kapasitas 10 MW On Grid di Yogyakarta. *Jurnal Energi & Kelistrikan*, 55-75.

Wandira, B. R., Notosudjono, D., & Rijadi, B. B. (n.d.). Rancang Bangun Sistem Keamanan Ruangan Berbasis Internet of Things (IOT) dengan Hybrid System PLTS Off Grid.