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ENERGY EFFICIENY OF ELECTRIC KNAPSACK TYPE SPRAYER POWERED BY SOLAR PANEL 20 WP

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ABSTRACT

Indonesia, as an agricultural country that relies on the agricultural sector as a source of livelihood, is increasingly providing quality human resources to encourage progress in the agricultural sector. In an effort to advance the agricultural sector, various aspects need to be improved, one of which is the quality of even spraying of plant seeds. Therefore, the development of sprayers is a very relevant innovation. A sprayer is used by farmers to control pests and plant diseases. A sprayer is one of the agricultural equipment used by farmers to spray pesticides on plants to eradicate pests. The development of solar-powered sprayers has an impact on the environment and is a substitute for renewable energy. Then a test was carried out between the power produced by the solar panels and the power used by the pump. The first measurement was carried out and produced power on the solar panels with a total power of 1874.27 watts. The power used in the pump DC is 882.54 watts. Based on the power produced by the panel and the output of the sprayer, with a 20 wp solar panel in sunny conditions, you do not need a battery to drive the sprayer, but a battery is needed when the weather conditions are cloudy.

Keywords : Sprayer; Pump DC; Solar Cells.

I. INTRODUCTION

A sprayer is a piece of equipment used to spray pesticides to eradicate pests on plants[1]. Commercially farmers still use conventional spraying using manual pumping[2]. Recently, farmers have been using battery-powered sprayers. This sprayer has a drawback, namely that when the sprayer battery is used, it will empty and must be filled with an electricity source [3]. The need for electrical energy is increasing, which is inversely proportional to the amount of fossil fuels used to generate electrical energy [4]. o we look for resources that are renewable and safe for the environment [5].

One of the potential renewable energies is solar energy [6]. According to the Ministry of Energy and Mineral Resources (ESDM), the potential for solar energy in Indonesia is very large; it is recorded that Indonesia has a solar energy potential of 207,898 MW (4.8 kWh/m2/day). Currently, the use of solar energy in Indonesia has only reached 0.05% of the potential installed capacity for a 100 MW solar power plant. Solar panels are a system used to produce electrical energy by utilising sunlight energy through a photovoltaic process [7]. There are several main factors in solar panels that influence their performance, namely the intensity of the sun and the temperature of the cells, which cause panel efficiency to decrease[8]. The output of solar panels is greatly influenced by environmental conditions because of the nonlinear current-voltage (I-V) relationship, which causes power fluctuations in the load[9]. On the curve (V-I), the horizontal axis is voltage and the vertical axis is current. The symbols on the curve, namely maximum voltage (Vmp), maximum current (Imp), no-load voltage (Voc), and short circuit current (Isc), are seen in Figure 1 [10].

Solar cells are made from semiconductor material, namely silicon, as an insulator at low temperatures and a conductor in the presence of energy and heat. When sunlight hits the solar panel, the valence electrons in the solar cell move from N to P, thus producing electrical energy. Using solar panels on pumps has the advantage of saving energy costs and making it a practical and efficient tool for farmers. Using solar power and batteries is an efficient way. The output from the panel converts the energy charging in the battery cycle [11]. The use of solar energy is influenced by the intensity of the sun. If the intensity of the sun is intense, the power produced will also be weak [12]. Therefore, it is necessary to carry out this research so that it can be effective in using and increasing the efficiency of the energy produced. In research, DC pumps can work continuously as long as the solar panels produce energy without recharging separately [13].

This research uses Pulse Width Modulation (solar control) as a charging controller in the form of electrical pulses to the battery [14]. In measuring voltage and current on panels and DC pumps using the INA219 sensor[15]. The results of measuring the current and voltage values are sent to the Arduino Uno microcontroller via the SCL and SDA pins, the energy source from the battery to the power jack on the Arduino [16]. The HC-05 Bluetooth module plays a role in exchanging data between laptops, cellphones, and others [17].

Various studies have been carried out to explore the development of solar-powered sprayers, with a focus on knapsack sprayers at an inclination angle of 25 degrees. One study used polycrystalline solar panels, with the flowing current measured[18]. A follow-up study regarding a solar-powered mini sprayer involved the use of a 17.2 V solar panel. The test results using a mini misting sprayer showed success, as reported in Fathurrohman's research in 2023 entitled "Design of a Sprayer Using a Mini Misting Sprayer Powered by Solar Panels" [19]. This research involves assembling a mini mist sprayer with a mini steam pump and identifying a solar panel array system.

Further research related to water pumps and lighting revealed the use of 10 Wp solar panels. In this study, battery efficiency with a load on the pump reached 96.45% [20]. In research conducted by Sarwono 2022, "Solar Powered Pesticide Sprayer" explains sprayers using DC pumps. This research focus makes an important contribution to the understanding of the efficiency of energy entering the sprayer, helping to optimise the efficiency of energy received by the battery and supplied to the load.

Therefore, this research was designed regarding " Energy Efficiency of Electric Knapsack Type Sprayer Powered by Solar Panel 20 WP ". It is hoped that this research can increase the efficiency of the energy produced. Farmers do not need to use electricity from PLN to charge sprayers where their gardens are far from electricity sources.

II. METHOD

This research is a type of engineering research. This research is designed for something new or to improve performance. Engineering research must have increased benefits in terms of the process or be superior to previous products [21]. In this research, the design and construction method was used. This discusses the tool system and the components used in the system.

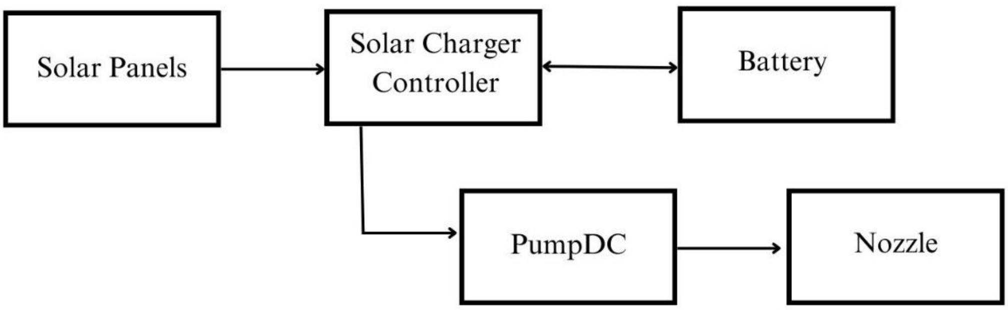

Fig. 2. Pump system block diagram

Based on Figure 2, there are solar panels to catch sunlight. The energy received by the solar panels goes to the Solar Charge Controller (SCC), which functions to protect the battery during overcharging and overdischarge. Then the battery will provide energy to the 12 V DC motor pump. Next, the 12 V DC motor regulates the water volume output. When sunlight is shone onto the solar panel, the process in the block diagram can occur continuously.

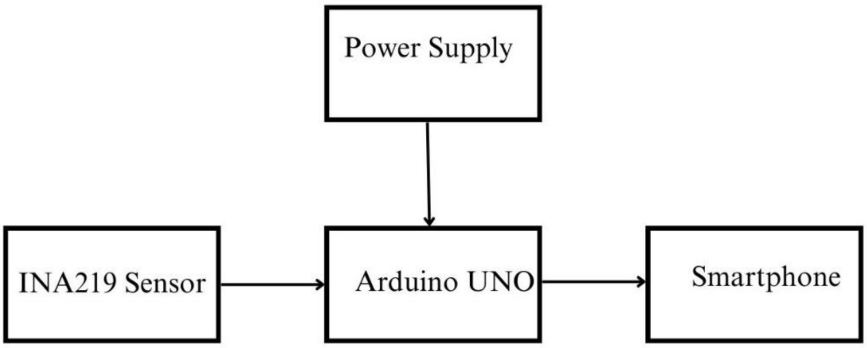

Fig. 3. Block diagram of a measuring device

Measuring the power used in the system using the INA219 sensor. The use of measuring instruments affects the quality of data in a study, which aims to obtain quality and empirical data [22]. The INA219 sensor measures current and voltage in real time, which is processed by the Arduino UNO. The data will be displayed on a smartphone connected via Bluetooth.

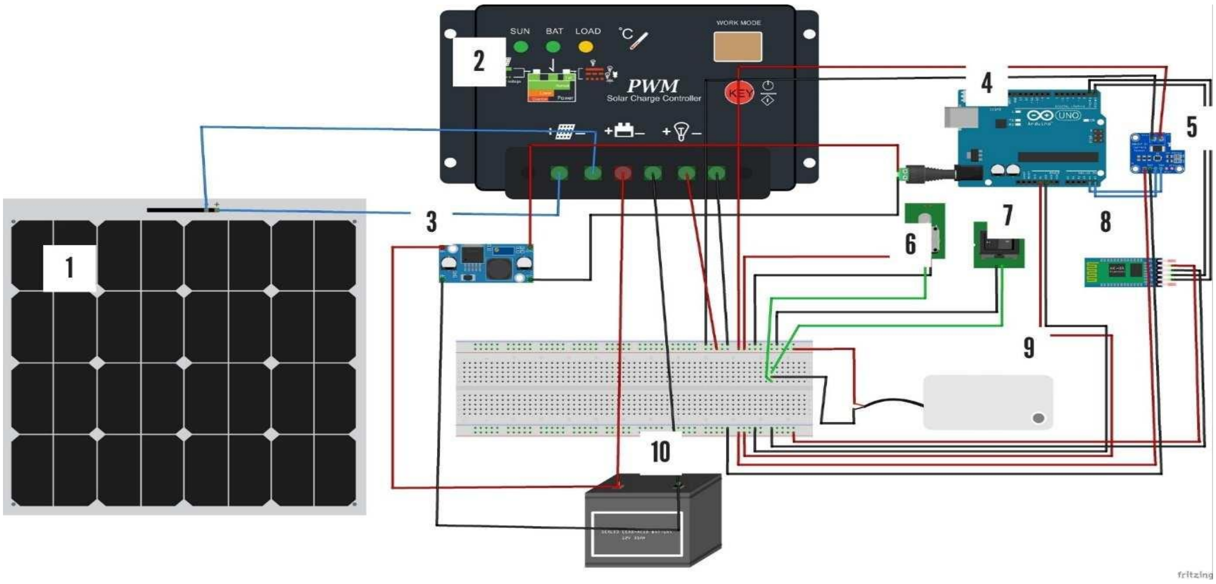

Fig. 4. Electronic circuit

Figure 4 is a picture of the circuit and components used in the system. In this system, the solar panels are connected to the solar charger controller. The energy produced by the solar panels is controlled by the solar charger controller on the battery. The solar charger controller output is connected to a switch and potentiometer. The switch and potentiometer are connected to the DC pump, functioning to regulate the output of the DC pump. Step down is connected in parallel with the battery. The stepdown output will be connected to the Arduino UNO. Then the INA219 sensor has a VCC pin connected to the 5 V pin on the Arduino, the ground pin is connected to the ground pin on the Arduino, the SCL and SDA pins on the sensor are connected to pins A4 and A5 on the Arduino. The Vin+ and Vin- INA219 sensors are connected in series to the panel if measuring power on the panel, if measuring DC pump power they are connected in series. On the Bluetooth module there are VCC pins, GND pins, TX pins and RX pins.

When the sprayer is used, the data displayed is voltage and current, which are displayed on a cellphone connected to Bluetooth. data displayed for 2 days from 11 a.m. to 2 p.m. On the first day, the solar panel power data was produced, and on the second day, the output power data from the DC pump.

III. RESULTS AND DISCUSSION

Measuring instrument performance specifications are an identification or description of the function of each part that forms the system, where it is necessary to test the instrument and analyse the instrument so that it can be seen whether the system is working well [23] The performance specifications consist of a power supply circuit, an INA219 sensor circuit, and a sprayer output.

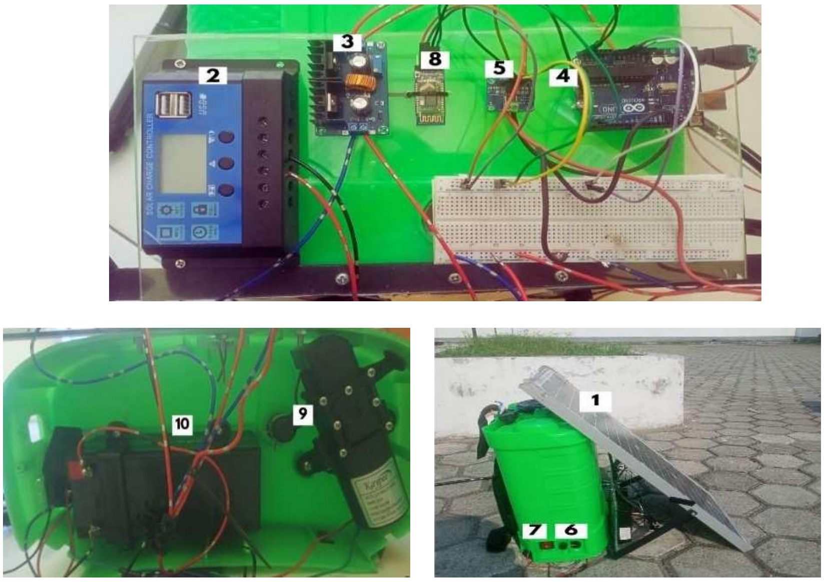

Fig. 5. Circuit design results

This research is on a series of solar-powered sprayers. In the system for the power supply circuit, there is a 20 Wp solar panel producing power. This system uses a Solar Charge Controller (SCC) to act as a battery charging controller. The power supply circuit uses a stepdown for safety in the measurement system.

In the measurement system using the INA219 sensor, which is controlled using an Arduino UNO, this sensor can measure the output power from the panel and 12 V DC pump. This sensor has 4 pinouts, namely ground (GND), VCC pin, SCL, and SDA data communication pins. The VCC pin on the INA 219 sensor is connected to the 5 V pin on the Arduino, the ground pin is connected to the ground pin on the Arduino, and the SCL and SDA pins on the sensor are connected to pins A4 and A5 on the Arduino. Vin+ and Vin- are connected in series to the panel if measuring power on the panel, if measuring DC pump power, it is connected in series with the INA219 sensor.

The 12 V DC pump output is controlled by a switch and potentiometer. The switch controls the on or off of the DC pump, and the potentiometer controls the power used on the DC pump. This affects the measurement results displayed on the Bluetooth module. In the data logger system, install the TX and RX pins on the Bluetooth module on the Arduino board, then connect the Bluetooth module to the Bluetooth on the smartphone.

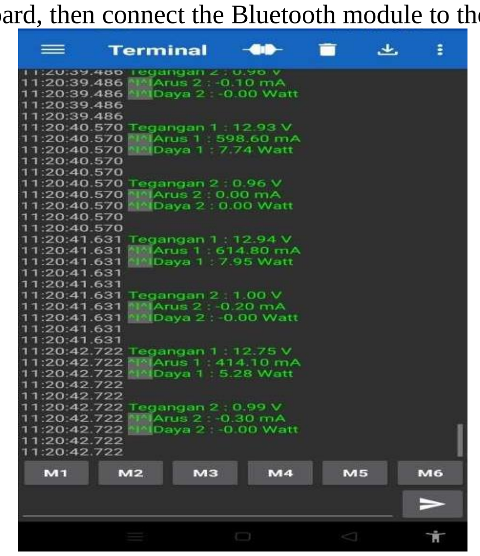

Fig. 6. Data display

Figure 6 shows the design of a data logger using a Bluetooth module to send data to a smartphone screen. When retrieving data, make sure that Bluetooth connectivity can still be reached by the smartphone. This system can take measurements from the sensors used in real time. The data displayed is voltage, current, and power data.

Design specifications were obtained from the results of measurements carried out during the research. The data obtained is taken from data logger storage. In the design specifications, sensor characterization of the system is carried out. Sensors are used in solar panel and sprayer measurements.

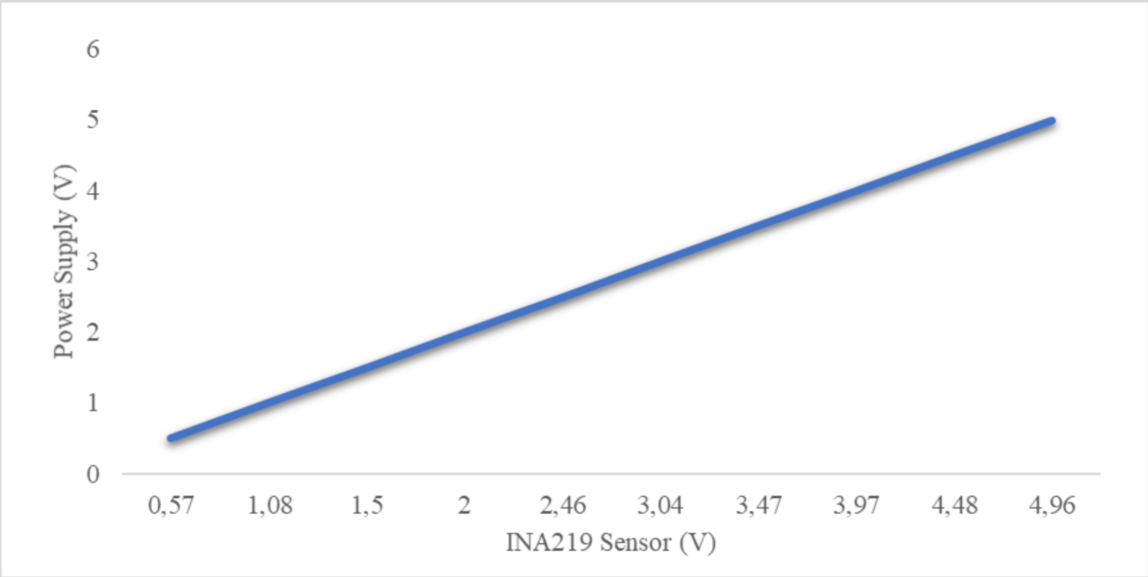

Fig. 7. INA 219 sensor characterization (voltage)

Figure 7 is a test graphic of the characterization of the INA219 sensor. Based on the graph, the sensor output value is directly proportional to the power supply. The graph indicates that the measurements for these voltage parameters are good. The R-square value obtained in the INA219 sensor linearity test is 1 for the voltage parameter.

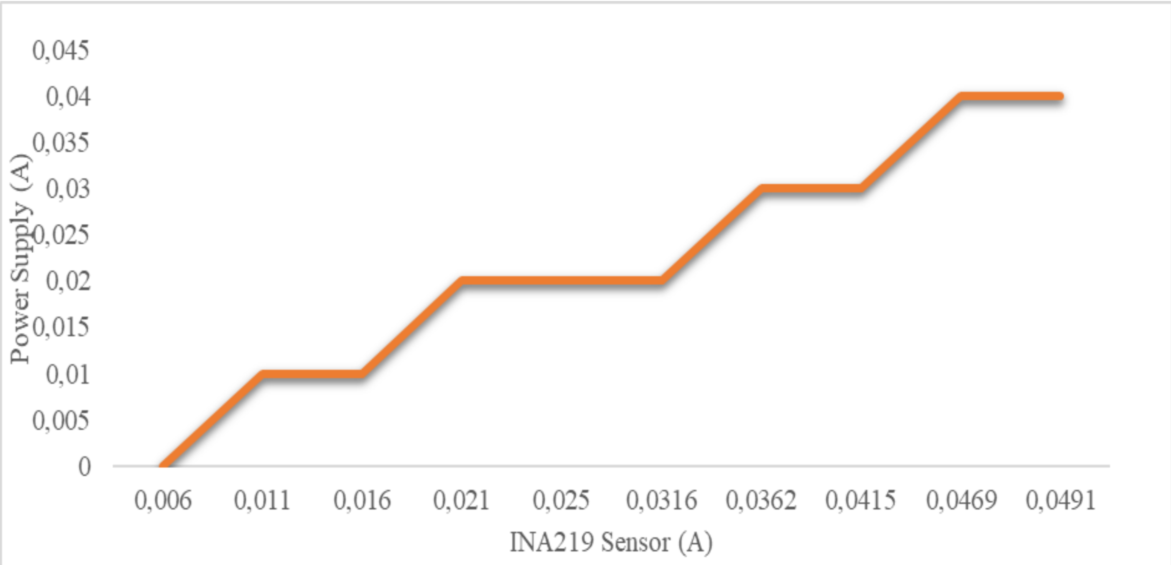

Fig. 8. INA 219 sensor characterization (current)

Figure 8 is a test graphic of the characterization of the INA219 sensor. Based on the graph, the sensor output value is directly proportional to the power supply. The graph indicates that the measurements for these voltage parameters are good. The R-square value obtained in the INA219 sensor linearity test is 0.9518 for the current parameter. The accuracy data of voltage and current can be found in Table 1.

Table 1. Measurement Accuracy

Multimeter (Volt)	**Multimeter (mA)**	**INA219 Sensor (V)**	**INA219 Sensor (mA)**	**Error % (V)**	**Error % (mA)**	**Accuracy % (V)**	**Accuracy % (mA)**
0,542	5,45	0,55	5,7	1,47	4,6	98,53	95,4

1,020	10,25	1,04	10,60	1,96	3,4	98,04	96,6
1,413	14,25	1,44	14,8	1,91	3,8	98,09	96,2
2,342	23,63	2,4	24,5	2,47	3,7	97,53	96,3
2,841	28,68	2,91	29,8	2,43	3,9	97,57	96,1
3,270	33,07	3,35	34,30	2,47	3,7	97,53	96,3
3,757	37,98	3,85	39,3	2,47	3,5	97,53	96,5
4,25	42,9	4,35	44,70	2,35	4,2	97,65	95,8
4,67	47,4	4,78	49,1	2,35	3,6	97,65	96,4
Average				2,22	3,79	97,78	96,2

The first design specification is the accuracy of the INA219 sensor used in the system. The accuracy value of the voltage measurement obtained in the accuracy test is an average accuracy of 0.98 with an average error percentage of 97.78%. Then, the accuracy value of current measurements obtained in accuracy testing is an average accuracy of 0.96 with an average error percentage of 96.2%. The prercision data of voltage and current can be found in Table 2.

Table 2. Precision of Measurement

Measurement (V)	**Measurement (mA)**	**INA219 Sensor (V)**	**INA219 Sensor (mA)**	**Average (V)**	**Average (mA)**	**Δx (V)**	**Δx (mA)**	**Error % (V)**	**Error % (mA)**
1	1	5,03	24,10	5,03	24,12	0	0,02	100	99,98
2	2	5,03	24,30	5,03	24,12	0	0,18	100	99,82
3	3	5,03	24	5,03	24,12	0	0,12	100	99,88
4	4	5,03	24,20	5,03	24,12	0	0,8	100	99,92
5	5	5,03	24,10	5,03	24,12	0	0,02	100	99,98
6	6	5,03	24,10	5,03	24,12	0	0,02	100	99,98
7	7	5,03	24	5,03	24,12	0	0,12	100	99,88
8	8	5,03	24,10	5,03	24,12	0	0,02	100	99,98
9	9	5,03	24,10	5,03	24,12	0	0,02	100	99,98
10	10	5,03	24,20	5,03	24,12	0	0,08	100	99,92
Average								100	99,94

The second design specification is the precision INA219 sensor, which plays a crucial role in the system's performance evaluation. The voltage measurement precision value obtained in the test is 100%. Then the current measurement accuracy value obtained in the test is 99.94%. The resulting solar panel day graph can be seen in Figure 9.

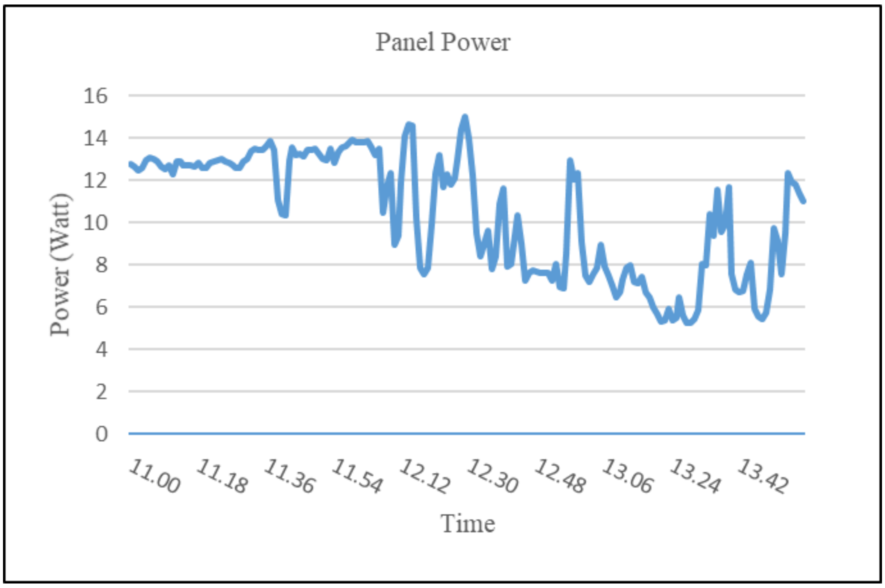

Fig. 9. Solar panel power

This research was carried out for two days. Based on the graph in Figure 9, data was collected on September 15, 2023, for 4 hours from 11.00 WIB to 14.00 WIB. When the INA219 sensor measures the panel voltage and current, the DC pump is on. Maximum power was obtained at 12:29 WIB with a power of 15.02 watts. The minimum power was obtained at 13:28 WIB with a power of 5.25 watts. The total power produced by the solar panels is 1874.27 watts. Figure 10 is a graph of the output power of a DC pump.

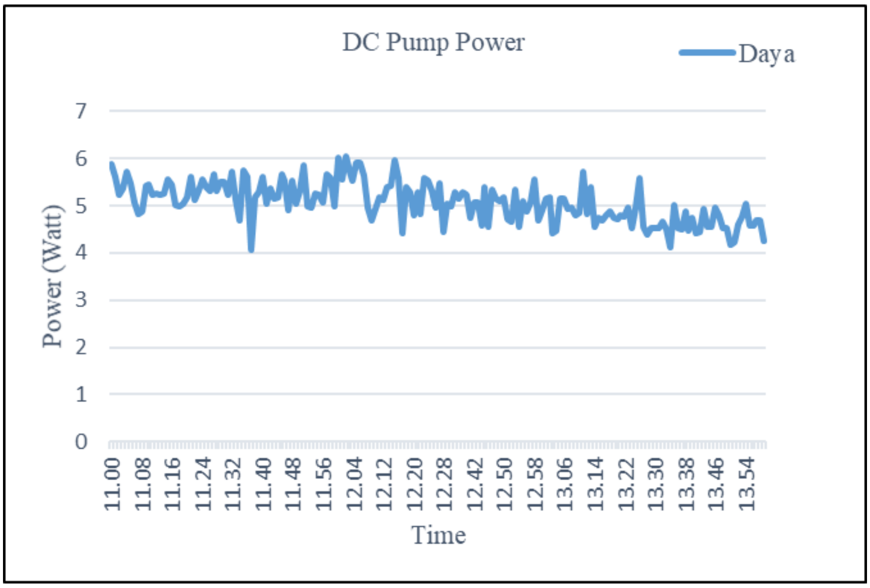

Fig. 10. Pump DC Power

Based on the graph in Figure 10, it explains that data collection was carried out on September 19, 2023, and was carried out for 4 hours, starting at 11.00 WIB until 14.00 WIB. When the INA219 sensor measures the voltage and current on the DC pump. The data is displayed via a cellphone connected to Bluetooth with a position still within reach of the Bluetooth module. The power data read by the INA219 sensor on the DC pump produces more stability. Maximum power was obtained at 12:02 WIB with a power of 6.03 watts. The minimum power was obtained at 11:37 WIB, with a power of 4.07 watts. The total output power measured on the sprayer is 882.54 watts.

In figure 9 and 10, the solar panels produce a total power of 1874.27 watts, with the maximum power at 12:29 WIB with a power of 15.02 watts. The minimum power was obtained at 13:28 WIB with a power of 5.25 Watts, and the DC pump produced a total power of 882.54 Watts with a maximum power at 12:02 WIB with a power of 6.03 Watts. The minimum power was obtained at 11:37 WIB with a power of 4.07 watts.

Based on the power produced by the panel and the output of the sprayer, with a 20 Wp solar panel in sunny conditions, there is no need for a battery to drive the sprayer. However, in cloudy weather situations, batteries are a necessity to maintain the performance of the sprayer. This is relevant to research on DC pumps that can work in bright conditions with solar panels without using batteries. [10].

The efficiency between conventional pest sprayers without a Photovoltaic (PV) module and variants equipped with a PV module. The results show an increase in sprayer performance of 42.86% when using a PV module. Sprayers using solar panels obtain a pump efficiency of 47.1%, this is influenced by weather conditions and temperature. [24].

IV. CONCLUSION

Results of measurement performance specifications by a series of sensors in the system. The INA219 sensor measures power on solar panels and DC pumps. The performance specification results consist of sensor characterization, sensor accuracy, and sensor precision. The characterization test was carried out on the sensor using standard tools, and the INA219 sensor linearity test had a linearity level of 1 for voltage and 0.95 for current. Furthermore, the accuracy value of the INA219 sensor with voltage parameters is 97.78%, and the accuracy value with current parameters is 96.2%. Then the precision value for voltage measurements is 100%, and the current parameters are 99.94%. Results of measuring the effectiveness of solar panels with DC pumps. The measurements produced power on the solar panels with a total power of 1874.27 Watts, with maximum power at 12:29 WIB with a power of 15.02 Watts. The minimum power was obtained at 13:28 WIB, with a power of 5.25 watts. Then, measurements were made of the power produced by the DC pump with a total power of 882.54 Watts, with the maximum power at 12:02 WIB with a power of 6.03 Watts. The minimum power was obtained at 11:37 WIB, with a power of 4.07 watts. So an efficiency value of 47.1% was obtained, which is in line with previous research. Based on these results, farmers do not need electrical energy from PLN, where the solar energy converted to produce electrical energy is greater than the output energy for DC pumps.

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