Solar Panel as Alternative Energy Source for Water Pump Control System at the Floating House in the Palembang Musi River Bank

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ABSTRACT
Solar energy is a renewable energy and has unlimited availability. Indonesia is one of the countries traversed by the equator and has a tropical climate and sunshine throughout the year. Solar panels are a system that can convert sunlight energy into electrical energy by utilizing the photovoltaic effect. Based on data from the BMKG Climatology Station Class I South Sumatra, Palembang City has an average of 3.75 hours of radiation during February and May 2021.
The house, which is located on the banks of the Musi River in Palembang, has very good potential for the construction of a solar panel system in the area, because the area has an open area so that the lighting is needed by solar panels. Based on measurements made in the area, the average light intensity ranges from 50000 Lux – 70000 Lux with a voltage generated of 38 – 43 Volts on 22 and 25 July 2021. The solar panel system built will be used as alternative energy in the control system. AC water pump in a floating house along the Musi River, Palembang. Therefore, a solar panel system was built which is expected to be able to replace the role of conventional electricity used today.
The solar panel system that is built must be controlled and monitored properly so that its use becomes more optimal. The control system is built using several sensors including the ACS712 Current Sensor, Voltage Sensor, and the PZEM-004T AC power sensor with an accuracy level for each sensor.

Keywords: *Solar Intensity, Solar Panel System, Control System, Alternative Energy*

1. PRELIMINARY

Solar energy is a renewable energy and has unlimited availability. The increase in the use of renewable energy is very significant around the world. Indonesia is one of the countries that is crossed by the equator (Equator) and has a tropical climate with sunlight throughout the year. Sunlight is a renewable energy that can be converted into electrical energy by a device called a solar panel.

Solar panels are a system that can convert sunlight energy into electrical energy by utilizing the photovoltaic effect. In each solar panel module, there are between 24-36 solar cells. Besides being able to convert sunlight energy into electrical energy, solar panel systems can also save on conventional electricity bills that we often use, and do not have pollution that makes solar panel systems environmentally friendly.

In a solar panel system, there are at least 4 items needed in building a solar panel system, including solar panels as input, Solar Charge Controller, Batteries and Inverters.

Based on data obtained from the BMKG official website (Climatology Station Class I South Sumatra, throughout May 2021, the city of Palembang has an average of 3.2 hours / day for the length of solar radiation with the highest solar radiation duration occurring on May 11, 2021 for 9.4 hours and has the lowest duration of solar radiation for 0 hours on May 19 and 23. The city of Pelembang has a duration of irradiation above 5 hours, as many as 18 days, in June 2021. In February 2021, the city of Palembang has an average length of solar radiation for 4.73 hours/day. The highest solar irradiation time will occur on February 15, 2021 with a solar irradiation duration of 8.6 hours and the lowest irradiation time of 0 hours on February 27, 2021. as many as 13 days, in February 2021. Based on this data, it is suitable to build a solar panel system in the Palembang city area trumpet.

The floatinghouse which is located on the banks of the Musi River in Palembang, has good potential for the construction of a solar panel system, which is located on the bank of the river, and the area is an open area so that the lighting needed by solar panels is optimal. The solar panel system built will be used to power several household appliances, one of which is the AC Water Pump. The water pump will be used to move water from the Musi River to a water reservoir which will later be used for clean water needs around the Palembang Musi River Floating House.

Many studies on the design of solar panel systems in Indonesia have been carried out, such as Albert Gifson, et al[1], designing an on-grid solar power plant in the Ancol ecopark. The research they carried out used an on-grid generating system, in which the use of this system was still dependent on PLN, because it did not have sufficient storage power. In the event of a blackout, the electricity will also go out.

The design of a solar panel system has also been carried out by Muhammad Irwansyah[2], designing a solar panel system to turn on the load in the form of an aquarium water pump. In the tool made by him, it produces very small power, small capacity and small load, which is 20 Watt AC.

Therefore, to utilize the solar panel system as a renewable alternative energy, the authors apply the Solar Panel System to the Floating House on the banks of the Musi Palembang river as a source of electricity to drive the water pump, where the city of Palembang has good sunlight intensity and the floatinghouse has an open area, making it suitable for designing a Solar Panel System as an alternative energy source in that place.

2. LITERATURE REVIEW

2.1. Solar Cell

Solar cells or Solar Cells are able to convert sunlight directly into electricity. Besides being used as a tool to maximize the potential of solar energy, solar cells can also maximize heat energy from the sun through a system called the Solar Thermal System [3].

Solar cells are made of semi-conductor material which is composed of positive and negative poles. The working principle of solar cells utilizes the photovoltaic effect, which is able to convert sunlight into electrical energy directly. Solar cells are formed from a single-crystal silicon base material which is then purified to form an atomic element. With the formation of these atomic properties, an electromagnetic field is formed which can cause the photovoltaic effect.

Figure 1 Solar Cell Module

2.2. Solar Charge Controller

The Solar Charge Controller is one of the most important components in the solar power generation system, which has a function as a battery charging control device, and functions as a regulator of the incoming electric current from the solar panel and the outgoing load current. The Solar Charge Controller usually consists of 1 input (2 terminals) connected to the solar panel output, and 1 output (2 terminals) connected to the battery or battery, and 1 output (2 terminals) connected to the load.[4].

The main role of the Solar Charge Controller is to protect and automate battery charging. It aims to optimize the system as well as to keep the battery life can be maximized.

Figure 2 Solar Charge Controller MPPT

2.3. Inverter

Inverter is a device that can convert direct voltage into alternating voltage (DC to AC) and adjustable frequency [3]. There are 3 types of output waves generated by the inverter, namely in the form of waves in the form of sine (Sine Wave), square (Square Wave), and modified sine (Sine Wave Modified).

Figure 3 Inverter

2.4. Accu/Battery

An electric battery is a device consisting of 2 or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell in the battery has a positive pole (cathode) and a negative pole (anode). The positive pole means that it has a higher potential energy than the negative pole, while the negative pole is a source of electrons which, when connected to an external circuit, will flow and provide energy to electronic devices.[5]. Based on the main material's capabilities, there are only 2 types of batteries, namely Single-use Battery) or batteries that can only be used once, and Rechargeable Batteries or batteries that can be recharged.

Figure 4 Accu/Battery

2.5. Water Pump

A pump is a machine/tool used to move fluid from a lower surface to a higher surface, or move fluid from a lower pressure to a higher pressure. Pumps work by utilizing mechanical energy from an external energy source to the fluid flowing through it[6].

Figure 5 AC Water Pump

2.6. Current Sensor ACS712

Current measurement usually requires a resistor that is a resistor that is connected in series to the load and then converts the current flow into voltage. The voltage is usually fed to the current transformer first before entering the signal conditioning circuit[7].

The Hall Effect technology applied by Allegro replaces the function of the shunt resistor and Current Transformer into a sensor with a relatively much smaller size. The flow of electric current creates a magnetic field that induces the Dynamic Offset Cancellation portion of the ACS712.

Figure 6 Current Sensor ACS712

2.7. Voltage Sensor

The voltage sensor uses a voltage transformer to lower the voltage from 220 to 5 volts AC then rectified with a diode bridge to get a DC voltage, then filtered using a capacitor and enters a voltage divider circuit to lower the voltage. The resulting voltage is not more than 5 volts DC as input to the microcontroller.

Figure 7 Voltage Sensor

2.8. Sensor PZEM_004T

The PZEM-004T sensor is a sensor that can measure rms voltage, rms current, and active power that can be connected via Arduino or other operating source platforms. The PZEM-004T measures 3.1 cm x 7.4 cm. The PZEM-004T module is bundled with a 33 mm diameter current transformer coil which can be used to measure a maximum current of 100A[8].

Figure 8 Sensor PZEM-004T

2.9. Microcontroller ATMega328

The ATMega238 microcontroller is an 8-bit AVR family of microcontrollers. several other microcontrollers with the same type include ATMega8535, ATMega16, and ATMega32, and what distinguishes these types of microcontrollers include memory size, many I/O pins and peripherals (USART, timer, counter, etc.). In terms of physical size, this type of ATMega has a smaller size, but has a memory size that is not inferior to the type of microcontroller above.[7].

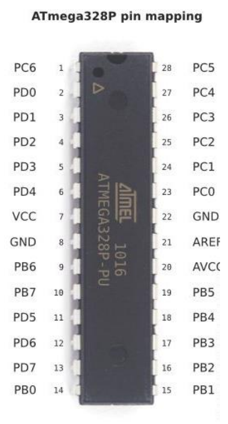

Figure 9 Microcontroller ATMega328

2.10. Liquid Crystal Display (LCD)

LCD is one of the output devices that can display text which is now very popularly used. LCD is starting to be felt to replace the function of the CRT (Cathode Ray Tube) which has been used by humans for decades[7].

Figure 10 *Liquid Crystal Display*

3. SYSTEM DESIGN

The system design consists of the design of the Solar Panel System and Monitoring Control System. In Figure 11 it can be seen the block diagram of the Solar Panel System, and in Figure 12 it is a Monitoring Control System.

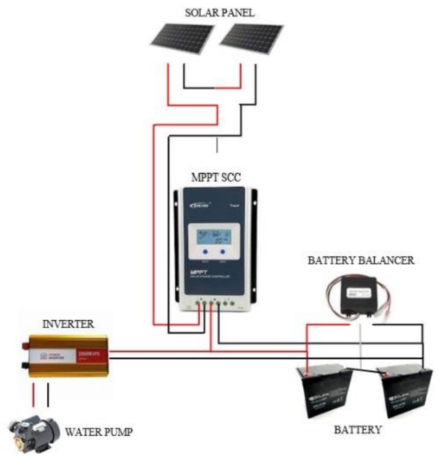

Figure 11 Solar Panel System

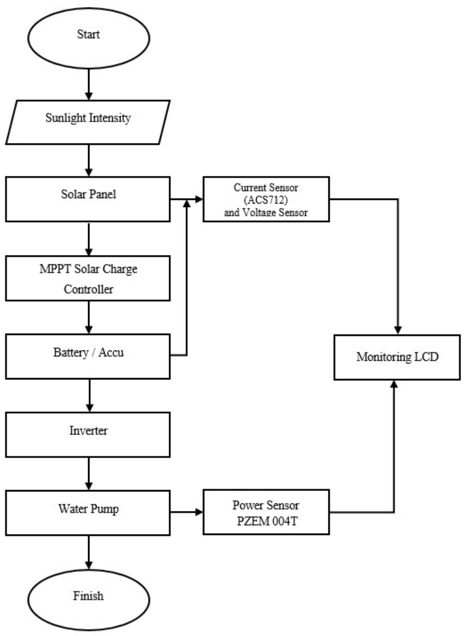

Figure 12 Solar Panel Monitoring Control System

3.1. Hardware Design

Hardware design consists of electronic design and mechanical design.

3.1.1. Electronic Design (Monitoring)

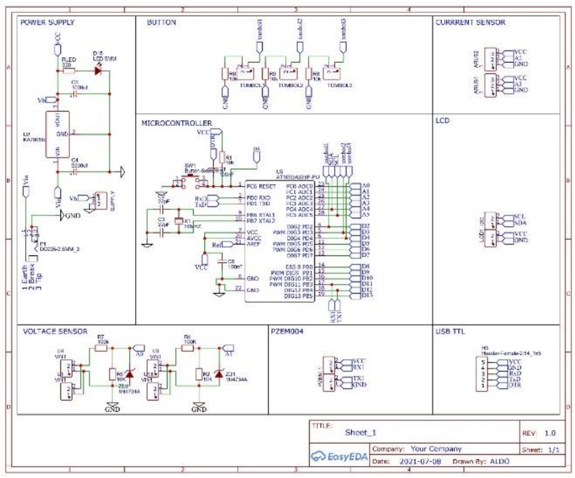

Figure 13 Schematic of the Solar Panel Monitoring Control System Circuit

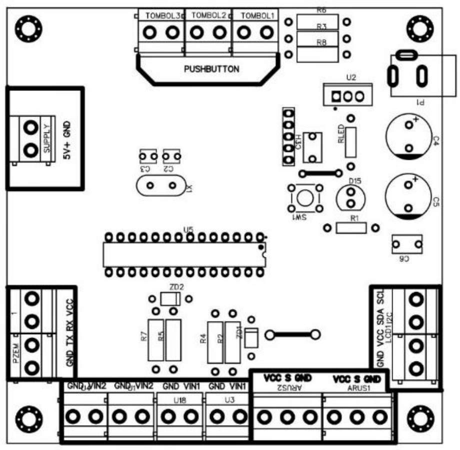

Figure 14 Component Layout

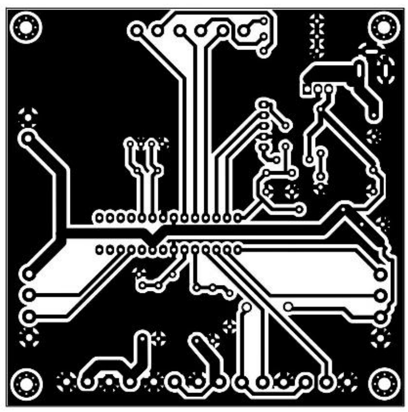

Figure 15 PCB Layout

The Monitoring Control System circuit uses 3 sensors as inputs, the ATMega328 microcontroller as the brain of the system, and a 20X4 LCD as the display output on the system. The electronic circuit above uses a power supply as a voltage source, which source will be taken from the built Solar Panel System.

3.1.2. Mechanical Design

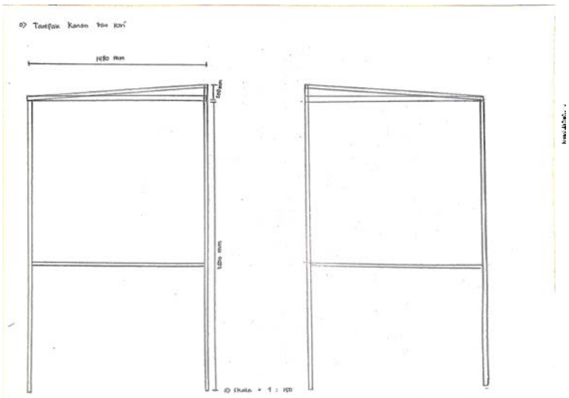

Figure 16 Solar Panel Tower Mechanical Design

3.1.3. Required Solar Panel Design

1. Water Pump = 125watt
2. Lamp = 10 watt
3. Water Reservoir = 500 liter

4. RESULT

In this result and discussion, a test is carried out with the parameters of the voltage, current, and active power values in the Solar Panel System. The readings of voltage, current, and active power on the Solar Panel System are carried out by the Monitoring Control System that is built.

4.1. Voltage Rated Test

The test is carried out by comparing the voltage value read by the voltage sensor with a standard measuring instrument. The voltage is sourced from the solar panel and the unit used is Volt (V).

Table 1 Voltage Rated Test

No.	Volt (V)		Error Percentage (%)
	Multimeter	Voltage Sensor	
1.	3	3.2	6.66
2.	40.2	40.3	0.25
3.	42.8	42.8	0
4.	43.3	43.3	0
5.	44.8	44.7	0.22
6.	47.3	47.2	0.21
7.	53.8	53.9	0.19
8.	49.6	49.5	0.20
9.	49.7	49.5	0.40
10.	43.5	43.7	0.46
11.	45.6	45.6	0
12.	44	43.9	0.23
13.	14.3	14.4	0.70
Average			0.732308

From the test data, the voltage generated by the solar panel ranges from 3-54 Volts, with the difference between the data read by the voltage sensor and the multimeter is not too far away, which only has an average error percentage of 0.73%.

4.2. Current Rated Test

The test is carried out by comparing the current value read by the ACS712 sensor with a standard measuring instrument. The current measured is the current flowing in the battery charging. The unit used in this test is Ampere (A).

Table 2 Current Rated Test

No.	Current (A)		*Error Percentage* (%)
	Multimeter	Sensor *ACS712*	
1.	0.21	0.22	4.76
2.	0.48	0.48	0
3.	0.37	0.36	2.7
4.	0.47	0.46	2.13
5.	0.46	0.48	4.35
Average			2.788

From the test data, the current flowing into the battery ranges from 0.21A-0.48A, with the difference between the data read by the voltage sensor and the multimeter is quite far, which only has an average error percentage of 2.79%.

4.3. Active Power Value Test

The test is carried out by comparing the active power value read by the PZEM-004T sensor with a standard measuring instrument. The unit used in this test is Watt (W).

Table 3 Active Power Value Test

No.	Power (W)		Error Percentage(%)
	Wattmeter	Sensor PZEM-004T	
1.	165.034	175.9	6.58
2.	161.891	166.8	3.0
3.	134.64	156.8	16.45
4.	132.454	135.1	1.99
5.	128.506	128.3	0.16
Average			5.4

Based on Table 3, the percentage of error between the two measurement instruments ranges from 0.16 to 16.45%. The average percentage error in the measurement between the two measurement instruments is 5.4%.

4.4. Battery Usage Time Against Load Used

Analysis of the length of battery use carried out by the load needs to be done in order to find out how long the battery can last to turn on the load.

Table 4 Load and Battery Capacity

No.	Load Used	Load Power	Volage Battery (V)	Voltage Drop Inverter (V)	Battery Capacity (Ah)
1.	AC Water Pump With Inverter 24V	125 W	24,6 Volt	22 Volt	100 Ah (2 pcs)

$$Battery\ Capacity = 22\ Volt\ \times 100Ah\ (2\ accu) = 2200\ Wh$$

$$Battery\ lifetime\ = \frac{2200\ Wh}{125\ W} = \ 17{,}6\ hour$$

5. CONCLUSION

From the results of testing the voltage rated test, current rated test and battery lifetime, it can be concluded as follows :

1. The percentage of errors that occur in DC voltage measurements is 0.7% with a sensor accuracy rate of 99.3%.
2. The average percentage of errors that occur in DC current measurements is 2.8% with a sensor accuracy rate of 97.2%.
3. The average percentage of errors that occur in AC Load Power measurements is 5.4% with a sensor accuracy rate of 94.6%.
4. The battery used in this system is capable of driving the water pump for 17,6 hours with a fully charged battery

REFERENCES

[1] A. G. Hutajulu, M. RT Siregar, and M. P. Pambudi, "Design of Solar Power Plant (Plts) on-Grid in Ecopark Ancol," *TESLA J. Electrical Engineering*, vol. 22, no. 1, p. 23, 2020, doi: 10.24912/tesla.v22i1.7333.

[2] M. Irwansyah, "Aquarium Water Pump Using Solar Panel," vol. 5, no. 1, pp. 85–90, 2013.

[3] A. B. Prasetio, "Comparative Analysis of the Output Power of a Solar Power Plant Using Reflected Mirror Light and Direct Sunlight," *Medan Univ. Muhammadiyah North Sumatera*, no. November 2017, pp. 1–11, 2006.

[4] E. Permana and A. Desrianty, "R Design of a Charger with Solar Panels (Solar Charging Bag) Using Quality Function Deployment (QFD)*," J. Online Inst. Teknol., vol. 03, no. 04, 2015.

[5] G. R. F. S. Sugeng Haryadi, "The design of solar panel utilization as a phone charger in public place," *Mechanical Engineering UNISKA*, vol. 02, no. 02, pp. 114–120, 2016.

[6] R. Tanuatmadja and F. X. S. Wijono, "T E S L A | VOL. 19 | NO. 2 | OCTOBER 2017 | Design of a Water Pump Monitoring and Controlling System Wirelessly Based on Android," vol. 19, no. 2, pp. 124–132, 2017.