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ENERGY MONITORING OF SMALL-SCALE IRRIGATION SYSTEM USING FLOATING SOLAR PHOTOVOLTAIC

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Abstract

In agriculture, it is crucial to use the appropriate irrigation method. Farmers in agriculture face many problems in pouring water into their field, especially in summer, to keep their crops green. Because they did not have a good idea of the availability of power, they must wait for the field to be adequately irrigate even if it is available. Solar energy is the best way to generate electricity for supplying power to the water pump. Floating solar PV cells are used for this project. Photovoltaic electricity (PV) is due to its ubiquity and reliability, one of the world's most popular renewables. Photovoltaic (PV) energy is one of the most promising renewable energies globally due to its ubiquity and sustainability. Floating solar PV is used because the solar equipment has a passive cooler that cools down the system. The panels produce electricity in hot climates more efficiently than they could otherwise. Floating solar PV is used because it has a passive cooling agent that can cool down the solar equipment. This means the panels produce electricity at higher efficiencies in hot climates than they might otherwise. The information about energy from the floating solar PV system is monitor by using IoT based. This irrigation system is designed with a sensor for temperature and a soil humidity sensor. The microcontroller's use is to monitor the entire system, and it also comes with a PV solar energy monitoring system. The microcontroller is also used to control the irrigation system.

Keywords: Energy monitoring, Floating, Solar Photovoltaic, Irrigation System, internet of thing (IoT)

1.0 INTRODUCTION

With the ever-increasing population, the demand for energy, agricultural land, and shelter has risen dramatically. Most regions across the world have at least one commercially viable renewable energy source (wind, sun, hydro, geothermal), and some have many renewable energy sources. Solar energy is usually recognized as the planet's most abundant and endless energy source [1]. Ancient civilization already used sunlight as an energy resource [2]. Solar power has become the best way to cut the costs. It is a renewable power worthy of recognition owing to reliability, lower production costs and lower maintenance costs. The PV device is an easy to access and easy to install system. The source factor for its adoption in order to meet the growing demand for electricity in the world is the abundance of solar energy [3]. Since then, a lot of ingenious technologies and enhancements were implemented in this field. The main example of sunlight energy conversion is solar panel.

Solar photovoltaic cells past initiated by Edmond Becquerel's discovery in photovoltaic effects in 1839 [4]. After 50 years, the first solar cells from gold coverings and selenium wafers were invented by Carles Fritts and photovoltaic being altered to silicon in

20th century. The results conclude that global warming and greenhouse gas are beginning to take responsibility for damage [5]. Solar power facilities are frequently constructed on agricultural and wastelands, which is not a completely sustainable use of land. PV panels have a negative temperature coefficient, which indicates that when the temperature decreases, the panels' sunlight to energy conversion ability improves [6]. Floating solar PV (FPV) is a unique application in which solar arrays are installed above bodies of water to take use of the solar module's negative thermal coefficient [7]. Module for solar pumping and automatic irrigation. A solar panel of the required specification is installed in the solar pumping module near the pump set. The water outlet valve of the tank is electronically controlled by the automatic water irrigation module by the soil moisture sensor circuit [8].

2.0 METHODOLOGY

This study was focus on monitoring the energy from solar PV and irrigation system. The energy sunlight was utilized to charge a 12V battery thru PV panel and solar controller. The main function of battery is to power up the ESP8266 Arduino controller board which is the brain of the system. Once the controller power up, it able to perform as monitoring system. The energy that received from solar PV will be monitor and the data will send to Adafruit IO and will be stored. For irrigation part, the temperature and moisture of soil will be monitor by this system. The soil wetness will be detected by the moisture sensor. The water pump will run to irrigate the land according to the moisture percentage that has been established. The power usage of the water pump will be monitored, and the information will be communicated to Adafruit IO. The development of the system comprises of three part which is software development, hardware development and interface input output (IO).

Software Development

The process of simulation of the system start with designing the prototype of monitoring system using floating solar using Catia. This is due to analyze

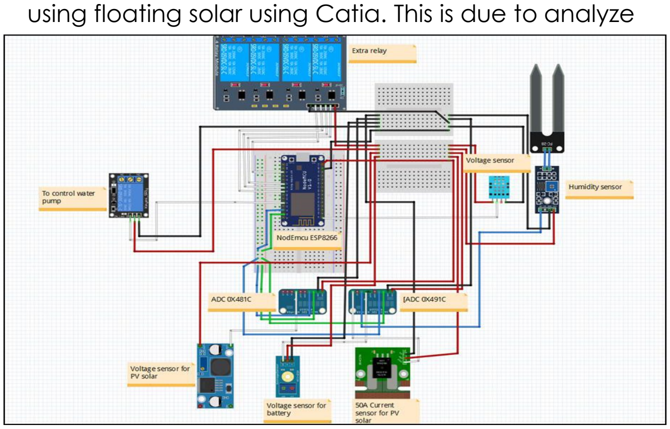


Fig. 1. Schematic diagram of monitoring system of irrigation system using Arduino

the capabilities of the proposed system in the actual site. The designs are based on the actual size of all the component used. Each part of the hardware is designed using Catia and then assembled to results in the overall design of the hardware. Before constructing the real circuit, the circuit need to be simulated first using simulator. In this study, Fritzing application was selected to design and simulate the solar system circuit. The circuit design is shown in Fig. 1 where it completed with relays, note MCU, several sensors as input and motor for the output of the system.

Interface IO Development

The Adafruit IO apps is used in this study to develop the user-friendly input output interface of the system. The interface able to check the current condition of their project system with the smartphones thru the internet of things configuration. Fig. 2 shows the interface design for monitoring system of irrigation using floating solar PV. The application was designed with capable to send notifications to user when there are triggering something happens with the performance of the solar performance.

Fig.2 Interface of Monitoring system

Hardware Development

The hardware selection is important in hardware development process. Each equipment parts are important to be viewed first before chose to be used in this project. The component specification is imperative to be explore and researched first. The components selection is indicated according to advantages and characteristic of the component to satisfy the functionality of each part used.

A wire connection between interfacing devices must be obtained before creating an actual circuit design on a breadboard. The cable connection for this project is initially designed using the Fritzing software. Based on the research carried out, the circuit construction is shown in Fig. 3.

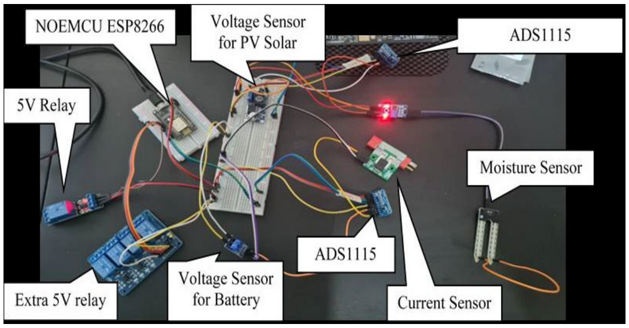


Fig.3 Interconnection of monitoring circuit

The coding is written based on the choice of sensor used in this study. The coding for monitoring the system is created and the formula used to get the data. For this study, the coding was developed and verified by Arduino IDE to check if the coding has no error and can compile to the ESP8266.

Floating Solar PV Model

Before creating a real floating PV solar, design for floating PV solar must be done to ensure the dimension is suitable to the PV solar. The size of piping that use to make the float floating. Besides that, the structure of floating PV solar must be considered to make the hardware strong enough.

For this equipment, designs were created and plan using Catia software. The floating PV solar construction shown in Fig. 4.

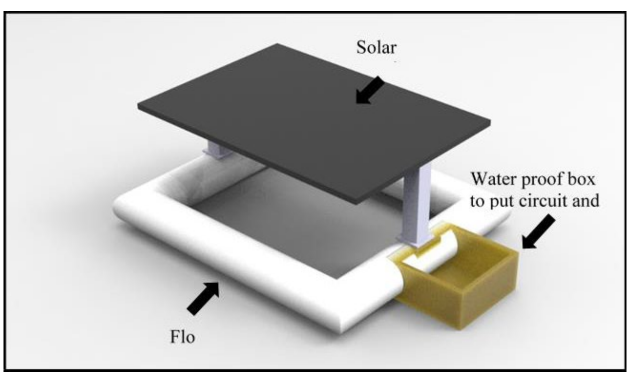
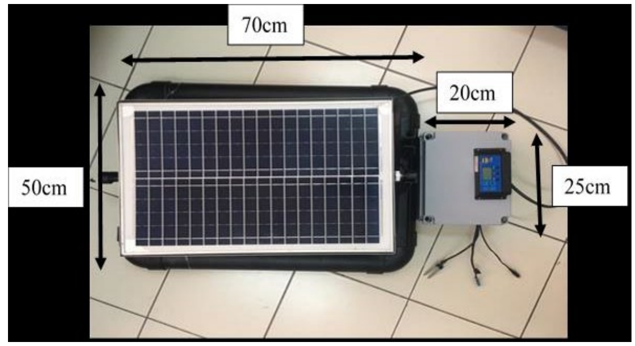


Fig.4. Floating Solar Model

The floating PV solar is placed in the middle of the floating body to balance the weight of PV solar. The box for electronic part is separately from the floating PV solar, it is because the weight of the box is heavy and can make the floating out of balance. Beside that it also can prevent the part of electronic expose to water that can damage the electronic part. Fig. 5 shows the complete set of floating solar PV system with their dimensions.

Fig. 5. Complete set of floating solar PV system



3.0 RESULTS AND DISCUSSION

After the device was completed, it was tested for functionality by submerging it in water. The device was then put to the test to see if it could float or not. After the testing was completed successfully, the completed device was taken to Uniciti Alam to collect data for grounded PV solar and to Tasoh Lake to collect data for floating PV solar. Then, the device is tested on field (Fig. 6) to collect data received from solar panel and battery charging data.

Fig.6. Floating Solar

To evaluate the solar panel performance and efficiency, two different conditions were selected to compare the reading taken on different days and at the different places. The first experiment was conducted at Uniciti ALAM on 10 December 2020 from 8 am until 6 pm. Furthermore, the second experiment was conducted at Tasoh Lake, Perlis on 11 December 2020 from 8 am until 6 pm. The solar panel is tested in two conditions, which are grounded and floating condition. For grounded condition, experimental was taken at Uniciti ALAM, and for the floating condition was taken at Tasoh Lake, Perlis.

The comparison of voltage for these two situations shows in the graph in Table 1. Meanwhile, line graph is obtained from the data collected and shown in Fig. 7.

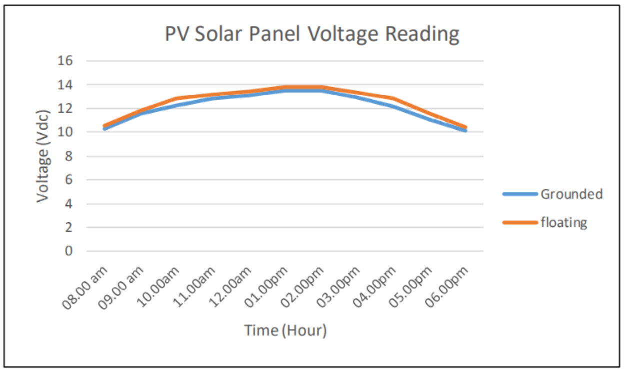


Fig. 7. Graph voltage grounded versus floating solar PV.

The voltage reading is slightly increase from 8.00am until 2.00pm. It is because the sun is rising but from 2.00pm until 6.00pm the voltage slowly decreases because the sun is turn to sunset. Equation 1 for grounded PV solar and equation 2 for floating PV solar shown the average data.

[10.3+11.5+12.2+12.8+13.1+13.5+13.5+12.9+12.1+11+10.1] Vdc ÷ *11 = 12.09Vdc* (1)

[0.5+11.8+12.8+13.2+13.4+13.8+13.8+13.3+12.8+11.5+10.4] Vdc ÷ *11 = 12.48Vdc* (2)

The comparison of current for these two situations shows in the graph in table 2. Meanwhile, line graph is obtained from the data collected and shown in Fig. 15

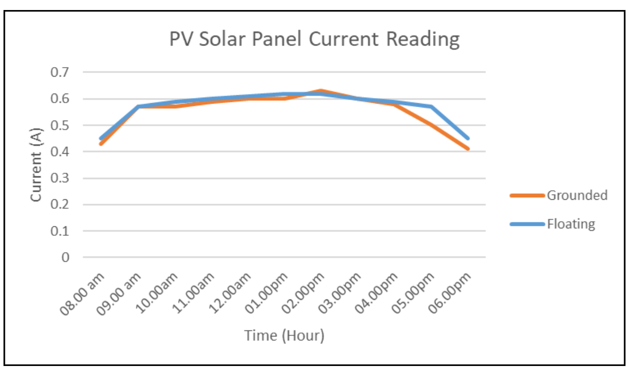


Fig. 8. Graph current grounded versus floating PV solar

Water pump is use as a load to get the current reading. The current reading is slightly increase from 8.00am until 2.00pm. It is because the sun is rising but from 2.00pm until 6.00pm the current slowly decrease because the sun is turn to sunset. Equation 3 for grounded PV solar and equation 4 for floating PV solar shown the average data.

[0.43+0.57+0.57+0.59+0.60+0.60+0.63+0.60+0.58+0.50+0.41] *A ÷ 11 = 0.552A* (3)

[0.45+0.57+0.59+0.60+0.61+0.62+0.62+0.60+0.59+0.57+0.45] *A ÷ 11 = 0.570A* (4)

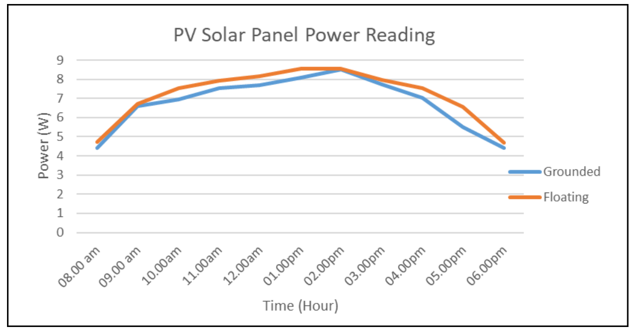


Fig. 9. Graph power grounded versus floating solar PV

The comparison of power for these two situations shows in the graph in table 3. Meanwhile, line graph is obtained from the data collected and shown in Fig. 9

The power reading is slightly increase from 8.00am until 2.00pm. It is because the sun is rising but from 2.00pm until 6.00pm the power slowly decreases because the sun is turn to sunset. Equation 5 for grounded PV solar and equation 6 for floating PV solar shown the average data.

[4.43+6.60+6.95+7.55+7.68+8.1+8.5+7.74+7.02+5.50+4.41] *W ÷ 11 = 6.77W* (5)

[4.73+6.73+7.55+7.92+8.17+8.56+8.56+7.98+7.55+6.56+4.68] *W ÷ 11 = 7.18W* (6)

12.09/12.48 ×100% =96.88%

100%−96.88% =3.125% (7)

The average voltage from the grounded PV solar data reading is divided to average voltage from the floating PV solar data acquire the efficiency. The efficiency for floating PV is 3.125% higher to grounded PV solar in equation 7.

For this analysis is discuss about the time taken to charge the battery. The analysis is conduct for eleven hours at Uniciti ALAM, and Tasoh Lake from 8.00am to 6.00pm. During the test, both situations of PV solar is test. The initial percentage of the battery was from 35% to 65%, as shown in Table 4 and Table 5. From the observation, the increment of battery percentage is moderately increased by time. The range charging for grounded PV solar is between 10.0 V to 13.54 V, and for floating PV solar is between 10.4 V to 13.8. The average battery charging for grounded PV solar was at 12.09 V and for floating PV solar was at 12.48 V. The line graph from Fig. 10 shows that the percentage of batteries increases proportionally with time. The results will take 30 minutes to increase the battery percentage by 3% when the solar panel receives sufficient energy from the sun.

Table 1. Charging rate from grounded solar system

Time (Hour)	Voltage (V)	Battery Percentage
08.00 am	10.5	35%
09.00 am	11.8	37%
10.00am	12.8	41%
11.00am	13.2	42%
12.00am	13.4	45%
01.00pm	13.8	48%
02.00pm	13.8	51%
03.00pm	13.3	54%
04.00pm	12.8	57%
05.00pm	11.5	61%
06.00pm	10.4	65%

Table 2. Charging rate from floating solar system

Time (Hour)	Voltage (V)	Battery Percentage
08.00 am	10.3	35%
09.00 am	11.5	36%
10.00am	12.2	40%
11.00am	12.8	41%
12.00am	13.1	43%
01.00pm	13.5	45%
02.00pm	13.5	49%
03.00pm	12.9	52%
04.00pm	12.1	55%
05.00pm	11	58%
06.00pm	10.1	61%

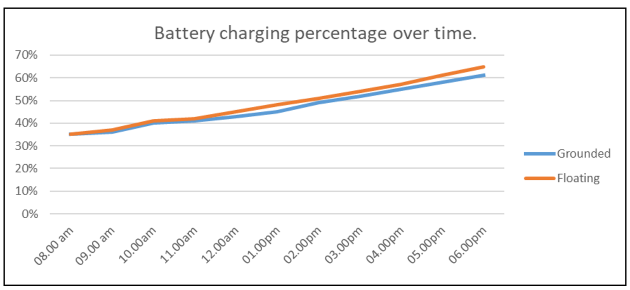


Fig.10. graph comparison charging rate between grounded versus floating solar PV

The water pump is detecting the percentage of the set point. The moisture is set with different value to analyze the time for water pump to watering the soil. Running to watering the soil. The percentage set point of moisture sensor is set. The water pump will be watering the soil until the moisture sensor. Table 3 below shown the time taken to watering the soil.

Table 3. Time taken to watering plant

Moisture (%)	Time (Second)
10%-20%	15
20%-30%	14
30%-40%	14
40%-50%	15
50%-60%	13
60%-70%	12

Water pump is running based on the set point percentage of soil moisture. Time is taken every 30 second to analyze the power consumption of water pump. Table 4 below shown the power consumption of water pump.

Table 4. Power consumption for pump

Time (Second)	Power (mWh)
30	52.35
60	104.80
90	157.50
120	209.60
150	261.99
180	314.39

4.0 CONCLUSION

This project focuses on the energy monitoring system for PV solar. The energy monitoring system was collected by IoT system, and all the data was store in Adafruit IO databased. For the irrigation, the moisture and temperature also can be monitor using IoT. The efficiency of PV solar can be effect because of the temperature on the PV solar panel. It can be proved by referring by data was collect using IoT. The efficiency of floating PV solar is higher than grounded PV solar. It is because the water itself can become the passive cooling agent to cool down the solar panel.

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