Performance enhancement of solar powered floating photovoltaic system using arduino approach

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ABSTRACT

This paper presents Performance Enhancement of Solar Powered Floating Photovoltaic System using Arduino Approach. In the project, an Arduino nano as a main controller of the system. The objective of this project to monitor performance of the voltage, current and power output respectively. Furthermore, the prototype of the research is testing in two conditions: on water surface and on a land area. Based on the results, the power of the photovoltaic on the water surface is increased compared on the land area. The conclusion for this project is it can generate electricity using floating photovoltaic and the same time to monitor output of the system.

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1. INTRODUCTION

A solar technology is not a recent development, it stated on the mid 1800's to the industrial revolution when solar plants were developed a heat water is produced a steam to drive machinery [1]. Thorough, renewable energy technologies need the use of large land spaces in order to produce electricity. Definitely, for photovoltaic (PV) systems, great surface areas are required because of low density power of solar energy. A solar energy is energy formed by sun created over a thermonuclear process and this process creates heat and electromagnetic radiations. These electromagnetic radiations have the energy that reaches the earth. A floating PV refers to the installation of photovoltaic on water surfaces, such as lakes, pond, reservoirs, hydroelectric dams and other often under-operated water surface, with PV panels usually attached upon a pontoon-based floating structure. A floating PV has massive market potential. It is estimated to become the third major sector for PV development after ground attached and rooftop PV. Nowadays, the use of photovoltaic system has expanded quickly the last period and today's market contains several different solar exploitations, where floating PV is some of them [2]. Earlier studies have exposed how floating PV system rise the photovoltaic panel productivity and at the same time decrease the water evaporation. A floating photovoltaic energy system offer numerous advantages over systems mounted on land. Firstly, a floating photovoltaic are installed on water surface, the land can be preserved and used for other purpose. Secondly, a floating photovoltaic deliver energy generation efficiency since the ambient temperature of water is comparatively low. Finally, evaporation from the water surface could be reduced when a floating photovoltaic system is installed in a lake or reservoir.

A solar photovoltaic not only protects productive land, but also protects valuable fresh water for generations to come. The simulated outcomes showed how the situations considering floating photovoltaic system created a higher reliability than the situations considering ground-mounted photovoltaic system [3]. A module cleaning has a major effect on the overall performance of utility-scale, ground-mounted PV projects. It requires adequate good quality water in the vicinity of the project. A floating PV panels are installed in low dust locations and can always use sprinklers to clean themselves, the systems have the potential to reduce evaporation up to 70 per cent [4]. The usual ambient temperature on water surface is lower than that on land due to the water-cooling effect, which enhances the presentation of floating PV modules. The project can be commissioned faster than utility-scale project of similar capacity since it does not involve movement of any heavy equipment at site. A floating photovoltaic panel technology has been achieved traction as a satisfactory and cost-effective alternative to the land-based PV systems. A revolution to renewable energy, the floating solar system market attitudes as one of the top potential equipment in the go green scene. As more and more states gradually be aware of the effective consumption of water bodies over the land space, the floating solar panel market is predictable to gain a further edge across numerous geographies. In paper [1] discusses the floating photovoltaic systems stand as development of technology that suitable for large energy power plants especially for non-usage water pond or lake.

The projects are collaborating with a Compressed Air Energy Storage (CAES) system into floating photovoltaic system using the pipes, that use as modular raft structure to added buoyancy. In paper [2] are discusses on thirteen floating photovoltaic power plants in Korea that have been installed from 2009 to 2014. The floating photovoltaic system has increased interest in Korea country as one of the best renewable energy alternatives. Next, in paper [3], a photovoltaic generating plant will require a great land area compared to other generating methods. A small panels of photovoltaic system development will only involve floatation in a small depth of water, it may be installed in a pond, lakes or wherever needed. The increasing in generating capacity could be considerable. A platform for floating must be made of a hollow sections' material for an effective buoyancy to self-weight ratio. The platform material will be designed to any desired form and can be attached together by chemical bonding. In paper [4] shows a study about canal top solar system with plane reflectors for the attention of the energy from sunlight has been done. The key parameters that affect the floating photovoltaic performance is amount of solar radiation, temperature and shading area which is adjusted. Additional cooling system is not compulsory for this floating PV system due to the occurrence of water inside canal which will condenses to provide a cooling effect to the system.

The water evaporation loss may reduce and an additional of a solar radiation will get on the solar panel by the consumption of reflector. This paper [5] discusses a good potential for Floating Solar PV (FSPV) are installed on reservoirs. A floating solar photovoltaic is used with pumped hydro energy system storage and hydroelectric in the existing reservoirs. This research is estimate and analysis of potential in India for the model in the present and future. In paper [6], it states that in order to decrease the reservoir shading area on the water surface, a greater fitted power per panel was selected. It was equal to 103.5 kWp, equivalent to about 300 panels are fitted on 46 structure of floating panel in area about 1.5. In paper [7] discussed a floating solar photovoltaic system at Kota Barrage and Kishore Sagar lake Kota in Rajasthan. This paper concentrate on floating photovoltaic technology, describing on types of floating photovoltaic plant along with research that being carried out on some floating solar plant.

The floating photovoltaic plant can be set up on a pond, lake, reservoir, or on any other water surface. 1MW floating plant in Kota barrage can made up to 18,38,519 kWh electrical energy per year and might save 37 million liters of water and about 1,714 tons of emissions can be reduced annually. For Kishore Sagar lake Floating plant, 1MW floating pv plant mightharvest 18,58,959 kWh energy annually and can save up water to 37 million liters and reduce about 1,733 tons of emissions yearly. The objectives of this project to design of floating photovoltaic to generate electricity, to monitor the voltage and current performance of floating solar system and to evaluate the effectiveness of system at on water surface.

2. RESEARCH METHOD

The main components of this project are the photovoltaic panel, the charge controller circuit, a LCD display and a rechargeable battery as shown in Figure 1. Next, the Figure 2 shows the block diagram of a solar charger controller to the load. A photovoltaic panel is function to transform solar energy into electrical energy. Then the energy will be stored inside a battery so that the electrical energy supply will continue while at night. An electrical energy is saved at an enormous level by consuming the solar to power up the load while solar charge controller function is to protect the charging battery against excess current. The floating material development in the other hand is more important in this project even it is not stated in the process of project because the photovoltaic panel will be placed at the floating material [8-13]. The project is depending on the strength of the floating material to withstand the solar panel to supply energy.

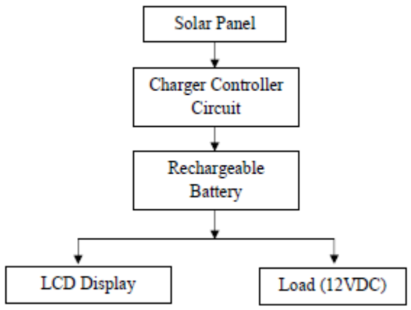


Figure 1. Block diagram of the project

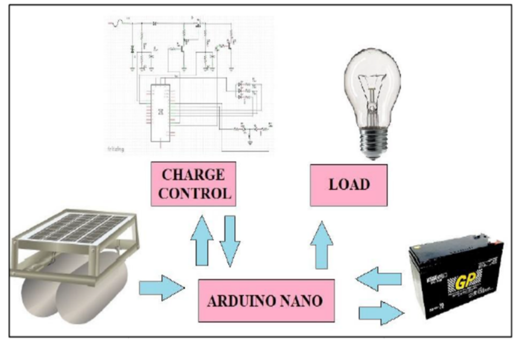


Figure 2. The complete circuit of the project

2.1. Component of project

This section discusses the main components in this research such as a solar module, a lead aced rechargeable battery, an arduino nano, an LCD display and a converter power module.

2.1.1. Solar module

The type of solar module is a polycrystalline, 12V as a voltage output with a power rating of 10W. The solar panel a design with a frame in order to used for outdoor application. It is suitable designed for charging 12V lead acid battery through solar charging controller. A Figure 3 shows the polycrystalline 12V solar module and specification of solar panel as tabulated in Table 1 [14-18].

Figure 3. The polycrystalline 12V solar module

Table 1 The Specification of solar panel

Variable	Type	polycrystalline 12V solar module
1.	Rated	10W, maximum output can reach
2.	Efficiency of solar cell	~16.5%
3.	Dimension	36cm x 24cm
4.	Weight	1.5 kilogram
5	Thickness	17mm

2.1.2. Lead acid rechargeable battery

A 12V rechargeable battery seal lead acid (SLA) as shown in Figure 4. The specification of a battery as tabulated in Table 2. The advantages of battery are robust, cheaper, and required a less of maintenance [20]. A DC power supply can be used to charge the battery as long as it delivers the accurate voltage amount to the battery. This battery use is capable for most of motors, 12V controllers, or any other circuit or appliances [21]:

Figure 4. 12V lead acid rechargeable battery

Table 2. Specification of 12V lead acid rechargeable battery

Variable	Item	Value
1.	Voltage	12V
2.	Capacity	1.2 Ah
3.	Size	95mm x 42mm x 52mm
4.	Origin	Malaysia
5.	Weight	0.7kg

2.1.3. Arduino Nano

The Arduino Nano in this project is a compact, complete, small, and breadboard friendly board where constructed on the ATmega328P (Arduino Nano 3.x). It has relatively the similar functionality of Arduino Duemilanove, but in a dissimilar set. This Arduino Nano as a brain for this project because all the coding process for the project is uploads inside this small arduino nano. Figure 5 shows the Arduino Nano Board and the specification of the Arduino Nano as tabulated in Table 3 [22-25].

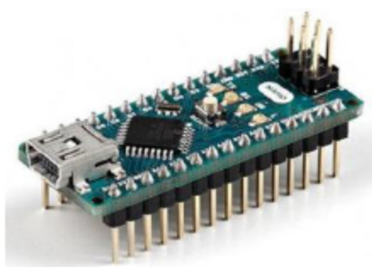


Figure 5. Arduino nano board

Table 3. Specification of the arduino nano

Variable	Microcontroller	ATmega328
1.	Architecture	AVR
2.	Operating Voltage	5V
3.	Flash Memory	32KB of which 2KB used by boot loader
4.	SRAM	2KB
5.	Clock Speed	16MHz
6.	Analog IN Pins	8
7.	EEPROM	1KB
8.	DC Current per I/O Pins	40mA (I/O Pins)
9.	Input Voltage	7-12V
10.	Digital I/O Pins	22 (6 of which are PWM)
11.	PWM Output	6
12.	Power Consumption	19mA

3. RESULTS AND ANALYSIS

This section provides the details about the hardware and software results and analysis. It discusses the circuit design of the project.

3.1. Prototype development

This part discusses on the result of hardware testing for the solar charger controller circuit, the prototype structure and the complete circuit of the project.

3.1.1. Solar charger controller monitoring circuit

In this part, the solar charger controller circuit are testing on a breadboard before go to the soldering process. After all the connection in done, the coding is then being uploaded into the arduino nano board. A LED is used as an indicator for the circuit for charging condition with solar energy as a voltage supply. The I2C LCD 20x4 char is used to monitor the voltage from the solar panel, V_S and from the battery, V_B, the temperature (Celsius), the charging indicator, Current (A), Power (W) and Energy (WH) of the project. An arduino nano, a current sensor and a temperature sensor using a 5V as a voltage supply. A DC-DC Adjustable Step Down module are function to step down a 12V to 5V and as voltage supply to the three components as shown in Figure 6. Figure 7 shows the I2C display with symbols of solar panel (V), the battery symbols (V), a current reading (A), and a power reading in watt (W). Next, there are three (3) sensors that are used to take reading for displaying it on the LCD that are a Voltage Sensor, Current Sensor and Temperature Sensor.

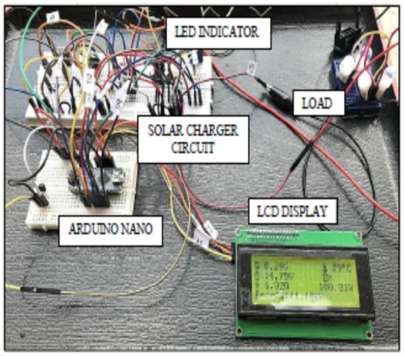


Figure 6. Circuit testing using a breadboard

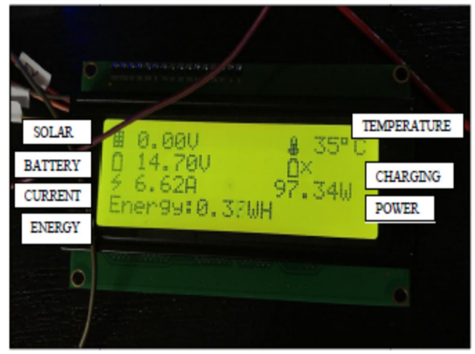


Figure 7. I2C LCD display output of project

Figure 8 shows indication of LED that will show the battery state of charge. It is important part to show the state of charge to describe the energy content inside a battery. A RGB LED is used to show the battery state of charge. Table 4 tabulated the state of charge in battery. For the load LED, A bi color (red/green) led is used for indication.

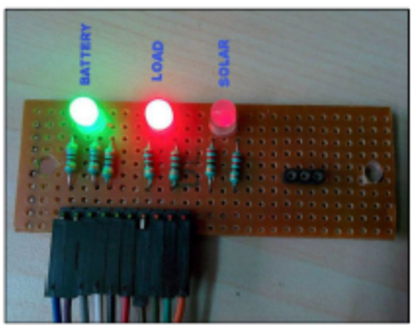


Figure 8. Battery status using LED indicator

Table 4. Status of battery

LED Colour	Status of Battery	Voltage
Red	Low	< 10.5V
Green	Medium	10.6V ~13.5V
Blue	Full	13.6V

3.1.2. Floating photovoltaic prototype development

This part explains the result of prototype for the floating photovoltaic system. The prototype was tested to observe the performance of the floating solar material on water bodies and measure the power output from a solar panel. The setup of the overall configuration is shown in Figure 9 and 10.

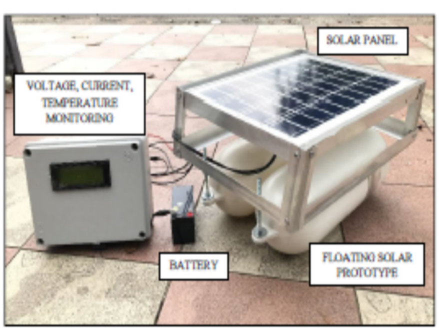


Figure 9. The setup of the overall project configuration

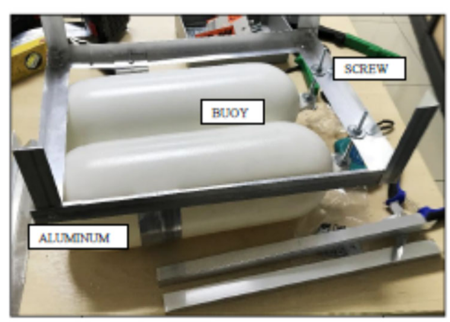


Figure 10. The body of floating solar panel

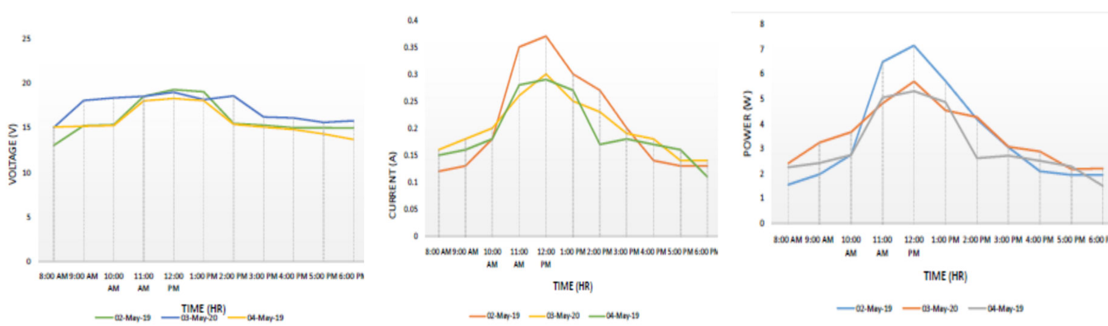
Figure 10 shows the floating material for this project. A 2nos of buoy is used for this floating solar project that been screw at the mounting structure. The material used for the mounting structure is aluminum. Aluminum is the best choice because it is lightweight and it can be used with contact with water without any rust. The prototype is floating at water bodies and also as a usual solar panel that are at land side shown in Figure 11 (a) and (b).

(a) (b)

Figure 11. (a) The Prototype on water surface (b) The Prototype on the land

3.1.3. Voltage, current and power output

The value of voltage and current outputs has a measured at the G3 Pool, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia area on 2nd May 2019, 3rd May 2019 and 4th May 2019. An analysis in the decision taken in 8.00am until 6.00 pm, it's taken an hour once. The objective is to test the functionality of the system towards solar energy. At the same time, the voltage produced by the solar panel varied with respect to the intensity of solar radiation from the sun. The result can be seen in Figure 12 (a), (b) and (c). From the results shows that at 11.00 am until 1.00 pm get the highest value of power with the fact the solar panel received maximum sunlight. The Figure 12(a) shown the performance of voltage versus time for three days: 2nd, 3rd and 4th May 2019. The maximum voltage is generating from 10.00am until 2.00pm for all the day. Next, the maximum of voltage is 19.30V at 12.00pm, 2nd May 2019. The Figure 11(b) shows the performance of current versus time for the same day with Figure 12(a). The highest performance of currents is on 2nd May 2019 with range value 0.2A until 0.37A. Next, the maximum of current is 0.37A, 12.00pm at the same day. The Figure 12(c) shows the performance of power versus time for three days are 2nd May, 3rd May and 4th May 2019. The maximum power produce is 7.14W at 2nd May 2019.



(a) (b) (c)

Figure 12 The Graph or (a) Voltage (b) Current (c) Power Output of three days measurement.

4. CONCLUSION

A development of prototype the floating photovoltaic system has achieves all objectives. The system is using an ArduinoNano board to measure and display data output such as a voltage, acurrent, and a power. The first objective is to design and construct the prototype a floating photovoltaic to generate electricity. The system using an ArduinoNano board to measure and display data output such as a voltage, acurrent, and a power. The second objective is to test and evaluate the effectiveness of the floating photovoltaic on the water surface. Lastly, determine a performance of the voltage and current output of a floating system. The data is collected successfully and the LCD that displays the voltage is working nicely. The floating solar system as a alternative technique to made save land usage and it more safe to use because it does not have any pollution.

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