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Performance Comparison of Monocrystalline PV Module Using Floating and Non-Floating Method

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Abstract: This project explains the concept of comparative performance of monocrystalline PV modules in grasslands and floating lakes, where the performance efficiency of the two types of methods installed is being analyzed. The floating PV modules are installed on the surface of the water and the other one is installed on the grassland. The main objectives of this paper are to design a floating lake PV system to float on the water surface, to develop an algorithm that can automatically get a proper reading of the parameter required, and to design a prototype for the development of the floating lake PV system where the water is used as natural cooling effects. In this project, Arduino UNO is selected to program the system as a microcontroller, while sensors such as a voltage sensor, a current sensor, and a temperature sensor are used to initiate data reading for system data logger 1 and system data logger 2. The system has been built accordingly and the performance of the system is tested. The result shows that the system can run with the aid of solar energy and the overall concept of the system can be implemented for the real application system.

Keywords: Monocrystalline PV Module, Arduino UNO R3, PV Sizing, Renewable Energy, Solar Energy

1. Introduction

Solar energy is considered one of the most promising energy alternatives due to its ubiquity and sustainability. The best way to use solar energy is the PV system. Photovoltaic is the process of converting sunlight directly into electricity using solar cells [1]. Photovoltaic (PV) modules are the most effective, sustainable, and eco-friendly products in the field of renewable energy. The performance of

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the photovoltaic module parametrically depends on the climatic condition, operating electrical parameter, and design parameters such as ambient temperature, solar irradiance, modules temperature open-circuit and short-circuit current, etc. A common photovoltaic module can convert 4-17% of solar radiation into electrical power, upon these above parameters [2].

However, the photovoltaic module also has its inevitable weakness. One of the main problems in the use of PV modules as a source of renewable energy is the low efficiency of energy conversion obtained [3]. Besides, in the long run, the PV panel tends to experience a further decrease in efficiency due to the increase in the panel operating temperature which exceeds a certain limit. A high working temperature can cause shortening PV panel life expectancies. One way to reduce this impact is by cooling down the PV panel while the operation is running [4]. The problem for PV does not stop with low efficiency. However, installation of PV is a burden in the high land use which will always be a scarce commodity. This technology uses a large area for plant installation and production concentration in a period of shines. Despite the above mention problems since it is an ecologically pure source, with an unlimited and free source, this technology increasingly more present every day [5].

To save on the use of scarce land, the installation of PV can be changed to water bodies such as the sea, lake, reservoir, or water bodies with minimal use on the surface, by using the concept of floating techniques which is where installation can be a promising choice. Due to the cooling effect of water on both the panels and the equipment, all water resistance, floating solar plants are expected to deliver higher power output than conventional solar installation.

2. Methodology

To ensure this project is successful, several studies have been conducted through the study papers. To achieve this objective, several procedures need to be followed. The first step is to study the types of PV modules that will be used before starting the experiment and find the ways of ideas to gain information and idea to conduct this project by referring to the book, conference paper, journal, and proceeding paper. In addition, it also assists in the understanding and selection of appropriate components for use in circuits. Then, the determination of the accuracy of components such as sensors is done in the project laboratory, Faculty of Electrical and Electronic Engineering (FKEE). A suitable procedure has been identified to proceed with the experiment.

2.1 Flowchart of the overall project

The flowchart in Figure 1 shows the flowchart of the overall methodology for the study of performance comparison of the monocrystalline PV module on grassy land with a lake floating.

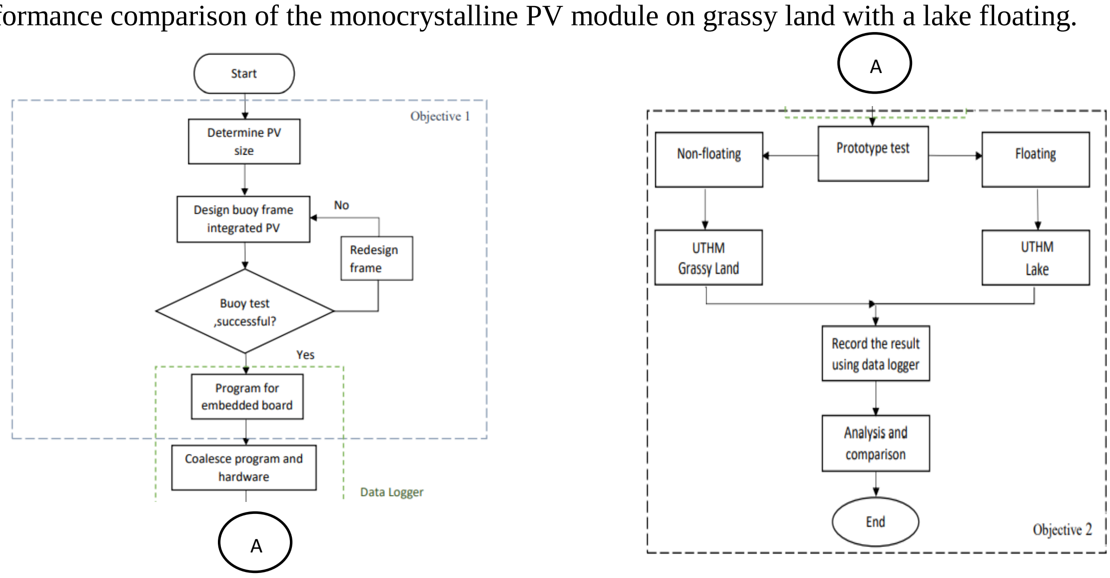


Figure 1: Flowchart of the overall methodology

2.2 Component of project

The main components of this project are monocrystalline PV panels, UNO Arduino, SD card shield, current sensor, voltage sensor, and LCD. From the monocrystalline PV panel, it converts solar energy to electronic energy and readings will be recorded in SD card storage. The battery function of this project is to turn on the circuit to read and record the readings taken through the sensors contained in the circuit. For the material for the development of a floating structure, it is designed using a G-412 buoy that is fastened to an aluminum rod along the length of the solar panel, the buoy fastened with an aluminum rod mounting on the monocrystalline PV panel.

2.2.1 PV module

This project uses a monocrystalline PV module with an output voltage of 18V with a power rate of 100W as mentioned in Figure 2. This PV module is designed with custom frames for outdoor use. Monocrystalline PV modules have been selected for this project because they have a high-efficiency rate compared to polycrystalline PV modules according to the project.

Table 1 Specification of PV module

No.	Specifications	Value
1	Rated	100W
2	Tolerance	3%
3	Max current	5.56A
4	Max voltage	18V
5	Open circuit current	22.3V
6	Short circuit voltage	6.05A
7	Dimension	100.5x66.5x3cm

Figure 2. Monocrystalline 100W PV module

2.1.2 Battery 12V(Lead-acid)

The battery with 12V capacity, as shown in Figure 3, is used in this project. Table 2 shows the specifications for the battery. Because the project uses two data loggers, the number of batteries used in this project is 2. This battery is used because it is robust, cheap, and requires less maintenance. Furthermore, the in-battery can also be powered by motors, 12V controllers, or any circuit or circuit. Furthermore, the in-battery can also be powered by motors, a 12V controller, or any circuit or device. As long as it can deliver the right amount of voltage, a battery with a DC source can be used for charging.

Figure 3. 12V lead-acid battery

Table 2. Battery specifications

No.	Specifications	Value
1	Voltage	12V
2	Current capacity	5Ah
3	Size	113mm x 85mm x 70mm
4	Origin	Thailand
5	Weight	0.95kg

2.1.3 Arduino UNO

Arduino is an open-source electronics platform that is widely used for several purposes. It enables the users to develop the software without any charge applied. In this project, Arduino UNO is selected as the microcontroller for the system due to its simplicity. Arduino UNO is a microcontroller board based on the ATmega328P. It technically has 14 digital input or output pins, six (6) analog input pins, 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. The Board of the Arduino UNO is shown in Figure 4. Table 3 lists Arduino UNO specifications.

Figure 4. Arduino UNO board

Table 3. Arduino UNO specifications

No.	Category	Details
1	Microcontroller	AVR
2	Recommended I/P voltage	7-12V
3	Analog I/O pins	6(A0-A5) loader
4	Digital I/O pins	14 (6 provide PWM output)
5	DC I/O pins	40mA
6	DC on 3.3V pin	50mA
7	Flash memory	2KB
8	EEPROM	1KB
9	Frequency (Clock speed)	16MHz

3. Results and Analysis

The analytical results for hardware and software will be discussed in this section.

3.1 Development of the prototype

The results testing for of hardware of the prototype structure circuit and the complete project circuit are discussed in this part.

3.1.1 Data logger

Before going to the soldering process, the data logger circuit tested for each component to be functioning. The entire connection is completed, then the coding is embedded into the Arduino UNO board. The data logger is equipped with an LCD 20x4 (I2C) char for the display monitor. The LCDs the output that coming from the panel such as voltage (V), current (A), power (W), environment temperature (Celsius), date, and time. An Arduino UNO, current sensor, voltage sensor, and temperature sensor are using a 5V supply from the Arduino UNO board. Figure 5 and Figure 6 show the data logger 1 is for the Floating PV system and data logger 2 is for the non-floating PV system that is used to compare the performances of the grassy land and floating PV system.

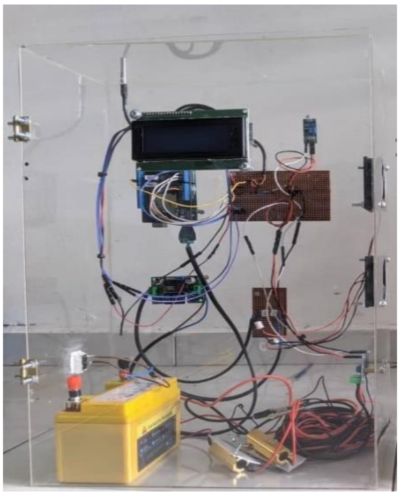


Figure 5. Data logger 1 for floating PV system

Figure 6. Data logger 2 for non-floating PV system

The result can be summarized through the LCD Display as Figure 7. All the display reading was being measured using a connected sensor from the PV panel to the data logger box.

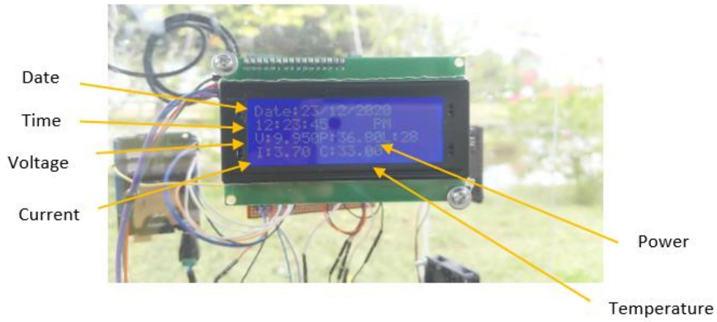


Figure 7. LCD output

3.1.2 Structure for floating based

This section describes the results for the prototype of the floating PV system. The floating structure in this project uses the G-412 buoy was paired with the PV panel and then tested to record the output readings. The overall configuration of the setup is shown in Figures 8 and 9.

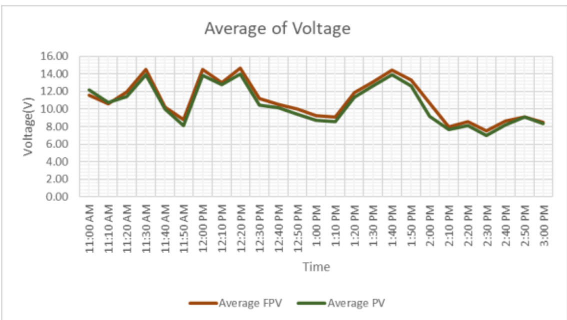
Figure 8. G-412 buoy with aluminum rod

Figure 9. Buoyancy test

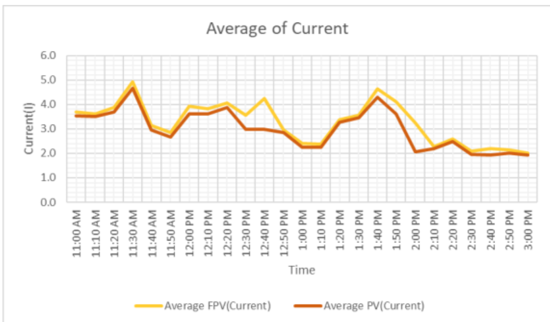
For the floating PV system, a buoy of 12nos is used to screw the mounting structure. Aluminum is selected for the based structure because it is lightweight, not rust after its contact with water directly. The prototype is floating, making the panel touch the surface of the water bodies as well as the usual PV panel on the grass side.

3.1.3 Voltage, current, and power output

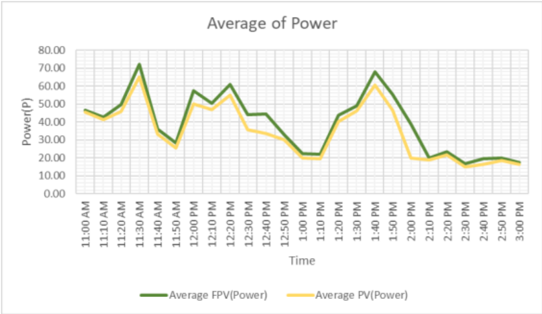
The project was carried out at Lake Tun Hussein Onn Malaysia University, Johor, for three consecutive days beginning on 21, 22, and 23 December 2020. This analysis starts at 11.00 am until 3.00 pm as it is the peak time where the sun is very strong. Record reading from output is taken every 10 minutes. This study is intended to test the output of PV systems based on solar energy. In this study, the radiation factor from sunlight affects the output emitted from the PV panel. Figure 10 shows the average output for voltage versus time graph, current versus time, and power versus time on 21,22, and 23 December 2020. The output in Figure 10(a)(b) and (c) shows the highest values at 11:30 a.m., 12:00 p.m., 12:20 p.m. and 1.40 p.m. The displayed graph looks unstable due to the weather factor in December in Malaysia at that time it was a rainy season. Indefinite weather changes affect the output and formation of graphs. The highest reading was on the second day of 15.49V and the current of 5.3A floating PV panel output was higher than the PV panel on land.



(a)



(b)



(c)

Figure 10. The Graph of (a) Voltage (b) Current (c) Power Output Average measurement of three consecutive days measurement

4. Conclusion

In conclusion, the performance comparison between the monocrystalline PV using floating and non-floating systems were successful in achieving all the objectives. Arduino as a microcontroller for measuring, storing, and displaying data output such as voltage, current, and power. The main objective is to design a floating PV system that is comparable to the conventional PV system. The structure of the floating base was successfully constructed to support the floating PV panel on the surface of the water. The second objective is to analyze the voltage, current, and power performance of both systems. This system was successfully implemented and the output parameters, voltage, current, power, and temperature, were correctly displayed via the LCD.

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