Journal of Physics: Conference Series

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To cite this article: Mairizwan *et al* 2020 *J. Phys.: Conf. Ser.* **1481** 012007

IOP Conf. Series: Journal of Physics: Conf. Series **1481** (2020) 012007 doi:10.1088/1742-6596/1481/1/012007

Optimization of harvesting solar cell energy based on MPPT to be applied during the rainy season in the tropics

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Abstract. Energy harvesting systems in solar cells require control to get maximum power, the maximum power control system is maximum power point tracking (MPPT). Energy efficient and effective harvesting is needed to avoid the energy absorbed by the control system. MPPT method with the Perturb and Observe (p&o) algorithm system. P&O method is a change in the value of a certain voltage and looking at the current value, this method is very effective to get the maximum power produced by solar cells. Energy that is absorbed by solar cells during the rainy season is very limited because the intensity and duration of sunlight to the surface of the solar cells is very small, therefore harvesting energy with the MPPT system can produce effective energy.

1. Introduction

Electrical energy is the main requirement for human life in living life and activities, the level of need for electrical energy continues to increase because every human activity is supported by energy. In Indonesia the growth of total electricity consumption is 6.84% every year in the next 10 years, this forecast is based on economic growth, growth in the number of customers and growth in electricity consumption of customers [1], the availability of electrical energy depends on the conversion of other energy sources such as water, solar and others [2].

As an alternative to the limitations of fossil energy, humans try to create some equipment for energy harvesting [3]. Energy Harvesting is a process where energy comes from external sources (solar power, heat energy, wind energy, potential energy, and other kinetic energy), captured, and converted to electrical energy, energy harvesting techniques appear as an environmentally friendly energy source, which is an alternative for existing energy sources. Concerning the search for energy, with reason and mind humans continue to try to respond to all the problems that arise due to the limited carrying capacity of the earth as efficiently and effectively as possible. Starting from solar cells that try to harness the abundant solar energy to become electrical energy, windmills that use wind gusts to spin a giant windmill that is connected to an electric generator. Not to forget, the potential of the sea which covers 2/3 of the earth has also been utilized.

Solar cells have a very good prospect for use in the tropics, where sun insulation does not fluctuate too high throughout the year and shine for up to 12 hours a day. Therefore, the use of solar cells for electricity generation in areas not yet reached by the State Electricity Company (PLN) has great potential to be developed. Some of the outermost regions in Indonesia will be able to enjoy electricity by developing Power Plants from energy harvesting.

Solar cells are an excellent renewable energy source that offers many advantages such as not requiring fossil fuels, only a small amount of pollution, small maintenance costs. The problem that will occur in the use of solar cells is the power generated by small electric power, especially in conditions of low solar radiation. Of what has been achieved to date no more than 20%, still on a laboratory scale. With the amount of electricity generated will change periodically along with changes in the intensity of the sun. The characteristics of the output power of solar cells are strongly influenced by solar radiation, the position of the solar cell against the sun and the temperature on the surface of the solar cell. Therefore, we need an algorithm to find the maximum power point known as Maximum Power Point Tracking (MPPT) [4] [5].

MPPT is a method of finding maximum points from power characteristic graph and input voltage (P-V) for solar panel applications. The Maximum Power Point Tracker (MPPT) system connected to the dc-dc converter can be used to control the amount of output voltage on the solar panel, to be able to force the solar panel to produce maximum power at various levels of light intensity [6]. By analyzing the input energy from the conversion of solar panels and utilizing the ability of peak power capacity resulting from the characteristics of the panel, the expected efficiency of the output power to the load can be maximum [7] [8].

There are many MPPT algorithms that have been found and published in international scientific journals, namely Perturb and Observe, Dynamic Approach, Temperature Methods, Incremental Conductance, Artificial Neural Network methods, Fuzzy Logic methods, etc. [9] [10] [11]. All these algorithms have different strengths and weaknesses in several aspects including speed, hardware implementation, cost, effectiveness, sensors needed, and parameters needed [12] [13].

In this study an optimization of the use of the MPPT system on solar cells with low sunlight intensity, where when the intensity of sunlight is low, the energy absorbed by small solar cells, if without the MPPT system, the energy absorbed by solar cells will be difficult to be stored in batteries or exploited by other electronic devices. Therefore, an MPPT system is designed that requires only a small amount of energy to operate and can work at small voltages and currents.

2. Research Methods

Analysis of the study of the characteristics of solar cells is done by looking at the range and maximum and minimum limits of energy harvesting. The design of the MPPT Driver system system for harvesting solar cell energy depends on the components used, the components used consist of solar cells that harvest solar energy, and electronic components that experience changes in value based on the expected level of voltage and current rise as well as measuring devices that function to calculate and displays the results of measurements of current and voltage. So this system is useful for displaying clearly the maximum power harvested by solar cells. This MPPT driver is designed to work and produce maximum power so it must meet certain specifications.

This driver design with a framework consists of making a driver using a PCB and all components needed, this driver consisting of; a) current and voltage sensor circuits at the driver input and output driver, b) buck boost converter circuit to increase and decrease the output voltage as needed, c) control the maximum power that can be generated, d) and then this circuit will be connected to the cell solar to harvest energy and microcontrollers to control the output power produced. After knowing that the MPPT driver can work well to increase the voltage in accordance with the duty cycle, then the MPPT driver is connected with photovoltaic. Photovoltaic is filtered from sunlight with the assumption of high insulating solar irradiation conditions. In this system the MPPT driver is not controlled based on the output voltage, but based on the output power. According to its purpose to find the maximum power point with MPPT Control.

After determining the modeling mechanism and planning of the test to be carried out, the next step is to design how to realize the design or design of the tool. Testing will be done after the mechanism has been completed. The mechanism must run according to the model, if not then re-modeling is needed, and then make changes to the test planning and the mechanism. Improvements will continue until conditions are reached that are very close to the initial modeling.

IOP Conf. Series: Journal of Physics: Conf. Series **1481** (2020) 012007 doi:10.1088/1742-6596/1481/1/012007

If the mechanism has met the initial modeling, then the data collection in the form of voltage and current can be done. Various variations to be made are the type of power from the solar cell, the irradiation time and the intensity that reaches the solar cell. Thus, it can be seen the power absorbed by solar cells and that is processed by a driver circuit, so that the efficiency of solar cells and MPPT drivers can be known.

3. Results and Discussion

3.1. Results

MPPT driver testing is done by connecting the MPPT driver to the solar cell. The solar cells used in this study are with the following specifications: The design MPPT driver will be operated directly by connecting to the source (solar cell) to determine the operational characteristics of the driver. Testing the MPPT driver electronic system is done by connecting the MPPT driver at the input to the solar cell and at the output to the 12 volt battery. So that the MPPT driver performs the process of finding the maximum power of the solar cell and then controls the battery charging process. At the top of the surface of the solar cell is given a light filter that serves to reduce the intensity of sunlight reaching the surface of the solar cell, this aims to find out the characteristics of the system when the sun is low.

The maximum power measurement experiment is carried out with two main stages: Connecting solar cells directly with the load resistance in the form of a power resistor that varies the value of the resistance. This is done in order to find out the maximum power of solar cells with manual tracking. Then the second stage by connecting solar cells through the driver before entering the load resistance.

Based on the graphic characteristics of the I-V solar cells above, it can be seen that the voltage and current output of the solar cell will change according to changes in load. This, will result in changes in the output power of solar cells that enter the circuit. The same light intensity conditions can be known the maximum power of solar cells is at a load of 40 ohms - 50 ohms, namely with a voltage of 16.9 volts and a current of 1.45 Amperes, and the output power reaches 24 watts.

In the measurement of solar cell output power through the MPPT driver and connected to the load in the form of a resistor, the measurement of solar cell power passes through the MPPT driver, by varying the value of the load resistor resistance, it can be taken from the measurement data of solar cell output power. MPPT driver then obtained a graph of the relationship between changes in load resistance to the output power of solar cells as shown in Figure 1 :

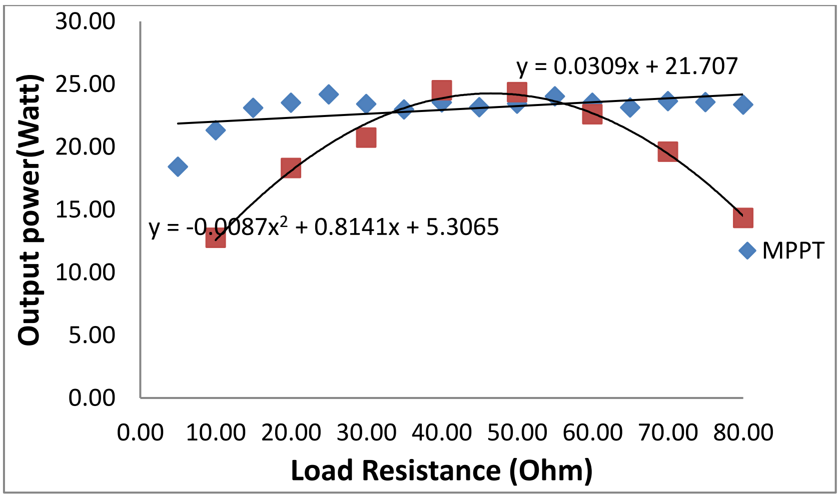

Figure 1. Solar Cells Output Power Directly And Through The MPPT

Based on the graph of solar cell output power with direct loading and loading through the MPPT driver, it can be seen that, the output power of solar cells tends to change at any given load change, where the maximum power is at a load resistance of 40 ohms. Meanwhile, if the load passes the MPPT driver, the output power of the solar cell will be more stable at 23 watts, as in Figure 2.

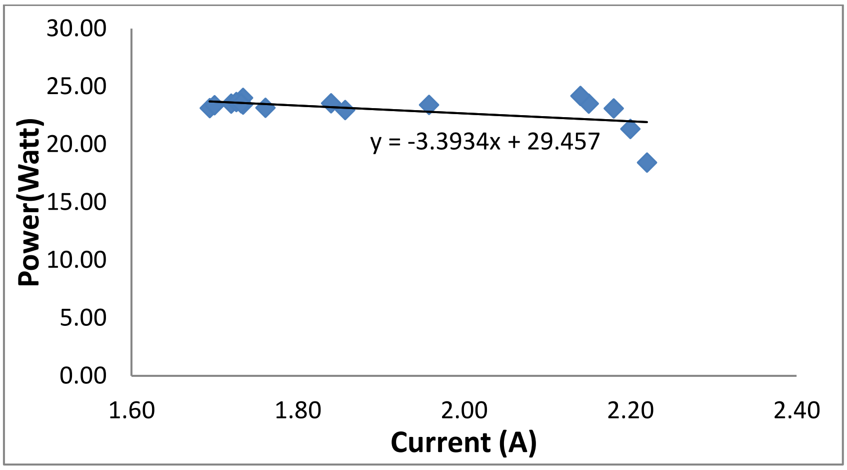

Figure 2. Graph of the Relationship between Power and Output Current of MPPT Drivers

Based on the graph of voltage changes and changes in the output current of the MPPT driver, it can be explained that the output power of the driver will remain stable even though when the load is varied it will vary the value of the output voltage and current, but the MPPT system will still produce stable power. Thus it can be seen that the use of MPPT drivers will make the output power of solar cells more stable under all conditions of change in load resistance given.

3.2. Discussion

Design and manufacture of MPPT drivers using component specifications in accordance with the maximum power capability produced by solar cells, with the aim of drivers can work optimally and avoid damage to solar cells, drivers and the output load to be connected in the form of batteries.

In addition to performing its main function, as an MPPT controller, controlling with this PWM also controls the DC-DC voltage converter. In the process, the MPPT control harvests energy from solar cells in light isolation conditions and controls the maximum power and emits it, on the other hand this controller converts the voltage from the MPPT control results to a certain voltage level required by the load or battery.

Control on charging the battery is done to keep the battery can do the optimum charging and disconnect charging when the battery is fully charged, marked with a current voltage sensor mounted on the battery charging circuit, so as to protect the battery from symptoms of damage that might occur. The control of battery charging is done by activating and disconnecting the PWM mosfet in the MPPT driver. Testing by using the driver as a search for the maximum power point of the solar cell is done by connecting solar cell output directly with the MPPT driver, it can be seen the changes in the output power produced.

5. Conclusion

From the MPPT driver test results that have been carried out will be compared with the theoretical basis that has been described, it can be explained that: Solar cells will produce different voltages and currents if given different resistance (loads). Solar cells will produce maximum power with certain conditions of light intensity at certain resistance (R). The MPPT driver output voltage can be adjusted using a mosfet on the DC converter by regulating PWM. The power generated by solar cells after passing the MPPT driver will be stable at maximum conditions even by varying the value of the voltage and current required by the load. The process of charging the battery from the solar cell MPPT driver takes place in a faster time compared to without passing the MPPT driver.

IOP Conf. Series: Journal of Physics: Conf. Series **1481** (2020) 012007 doi:10.1088/1742-6596/1481/1/012007

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