An efficient use of electric power controller from MPPT solar charge

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Abstract. The use of the MPPT algorithm in harvesting solar cell energy has been developed by various methods and has been used in the market. The use of this system has high efficiency and is stable in harvesting and storing electrical energy. However, the use of solar cell energy has the problem of controlling excessive energy consumption by electrical equipment, causing problems in the system and shortening the life of the system. For this reason, a study was conducted to control the optimization of the MPPT system and the use of energy from solar energy storage. The method used is optimization of the MPPT system using microcontroller control and integrated with current limiting control for the output load. From the results of these studies, it is found that the power harvested from solar cells is at the maximum point and a balance between the stored power from absorption from solar cells with power consumption by electronic equipment. These results can increase the efficiency and effectiveness of the absorption and use of solar energy based on solar cells. With this balance, it will reduce the factors that cause system failure and ensure a long battery life.

1. Introduction
Electrical energy is the main need for humans in carrying out daily activities, the level of electrical energy needs continues to increase because every human activity is supported by energy. The motivation to search for new energy is getting higher because of the global situation which indicates that fossil energy reserves are decreasing due to its non-renewable nature [1][2]. In addition, the energy price continues to increase due to the following reasons: high world oil prices and energy price adjustments towards its economy (subsidy removal). Solar energy is one of the alternative and renewable energies which has enormous value. Therefore, proper management is needed to carry out the harvesting and use of this renewable energy.

Energy management according to the Energy Law (UU) No.30 / 2007 and Government Regulation (PP) on energy conservation, the definition of energy conservation is a systematic, planned and integrated effort to conserve domestic energy resources and increase the efficiency of their utilization. It should be noted that the problem of energy waste in general is about 80 percent by human factors. Using energy efficiently does not mean that energy usage has to sacrifice comfort, for example reading a book in a dark room to save lights or turning off all air conditioning in the building to save electricity costs. For this reason, energy management is needed in increasing the efficiency of electricity consumption[3].
The successful use of energy efficiently is strongly influenced by behavior, habits, discipline and awareness of energy saving. For that we need a system that can work without direct human touch. The systems that have been developed to date are electronic equipment made using components that absorb small amounts of energy but still produce the same output, for example, the development of LED lights, LED and LCD-based televisions, air conditioners with dual inverters, and others. But the energy-efficient equipment is not enough because of human behavior who often neglects the use time of the electronic equipment.

Seeing this problem, the researchers tried to develop a system that can control electronic equipment that remains active but with reduced energy when it is not used optimally, namely the safety dimmer system. This system works to limit the flow of electric current to electronic devices if not used optimally, this system will be connected through an energy source from solar cells with optimal energy absorption through the MPPT system\cite{4}. Through a combination of safety dimmer and MPPT systems on solar cells, it is hoped that the use of electrical energy will be more effective, and the efficiency of using electrical energy will increase\cite{5}.

The MPPT system on solar cells is a system that has been commonly used and researched in the last decades, this system is very supportive of increasing the efficiency achievement of solar cells. In general, the work process of this MPPT is to find the maximum power point on the solar cell by looking at the current factor and the voltage of the solar cell. MPPT development can be carried out using various methods, one of which is perturb and observe, which is to treat one of the components and see the results. This method can be used using several combinations of electronic components. The circuit has been supported using the IC ir2104 as the schematic system in Figure 1.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{DC_to_DC_converter_circuit.png}
\caption{DC to DC converter circuit}
\end{figure}

Based on the ranking image, it can be seen that changes in power points are carried out by changing the pulses flowing at the output of the solar cell or changing the DC voltage level generated by the solar cell. Thus, the current level will also continue to change, so that it is expected that the bias reaches the maximum power point\cite{6}.

The energy management instrumentation system is an integrated program that is planned and implemented systematically to utilize energy and energy resources effectively and efficiently. The use of solar cells has been widely used in several countries in Central Asia and Europe, due to the large energy needs and very limited fossil energy sources, solar cells have very good prospects for use, especially in the tropics, solar cells are also an environmentally friendly energy source, which is an alternative to existing energy sources \cite{7}. Research related to solar cells is being developed in several Asian countries such as India and several other European countries \cite{8} \cite{9}.

\section{Research Methods}
Research and development of energy management tools using the MPPT method and safety dimmer from the absorption of solar cell energy are continuously being carried out by experts, given the increasing need for renewable energy\cite{10}. In the early stages of this research, an analysis of the demand for renewable energy in Indonesia has been carried out \cite{11} \cite{12}. 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 areas in Indonesia will be able to enjoy electricity
with the development of power plants from solar cell energy [13]. From the results of the study on several sources an energy management system with the safety dimmer method can be developed in Indonesia. The development process starts from determining the characteristics of the electronic system to be used, assessing the right sensor and measurement system, designing tools from predetermined components and equipment, making tools, testing tools and seeing the performance of the capabilities of the tools, seeing the characteristics of the measurement results, and the final goal. produce a system that can increase the efficiency of electrical energy expansion.

The work system technique of the dimmer system for solar cell energy based on MPPT was developed based on the current and voltage (I-V) characteristics of solar cells, which is a technique for harvesting solar energy through an electronic system that can track the maximum power points that can be released by a solar cell. The I-V characteristics of solar cells are very nonlinear which always changes with radiation and the surface temperature of the solar cells. In general, there is a maximum power point that can be seen on the I-V curve and the V-P curve. Where at this point, the voltage and current of the solar cell can work with maximum efficiency and produce the highest output power [13]. Besides, the safety dimmer is developed from limiting the current that enters an electronic device, with current limitation to a certain limit it will reduce power consumption without eliminating the function of the electronic device. From the system controlled via microcontroller software. The system built will clearly display the maximum power that can be generated by solar cells in various conditions and at high energy usage levels. The MPPT based safety dimmer system can work and produce maximum power and can control the use of this energy in electronic loads.

After determining the mechanism modeling and testing planning to be carried out, the next step is to design how to realize the design or design of the tool. Testing will be carried out after the mechanism has been completed. The mechanism must run according to the model, otherwise re-analysis is required, and then changes to the test plan and mechanism. Improvements will continue to be made until conditions that are very close to the initial modeling are achieved.

If the mechanism has met the initial modeling, data collection on the characteristics of energy management with a safety dimmer system can be done. Various variations to be carried out are the maximum power from solar cells, the length of time using electronic equipment through the safety dimmer system, and the resulting efficiency analysis. Thus, it can be seen that the power absorbed by the solar cell and processed with a series of instrumentation systems can determine the efficiency and effectiveness of the instrumentation system.

The process of designing a safety dimmer instrumentation on solar cells begins with three main stages, namely the first process of understanding and analyzing the characteristics of solar cells, the process of measuring the energy of these solar cells. The second process involves designing and manufacturing electronic systems related to processing energy from solar cells. The third process is by conducting an experimental process to increase the effectiveness and efficiency of the instrument system that has been built.

3. Results and Discussion
The results of designing electronic instrumentation with two main systems, namely hardware systems and software systems. The hardware system has been designed through the creation of a system circuit consisting of current sensor components, voltage sensors, microcontrollers, IC timers, mosfets and other supporting components. The results of implementing a series of systems can be seen in the series of Figure 2.
System data retrieval can be carried out as a whole if all electronic systems and mechanical systems are combined as a whole. Merger system consisting of hardware that is formed in electronic circuits and controlled via a microcontroller. Then from the electronic system it is connected to solar cells and the output is a battery and electronic load.

Testing the results of the implementation of energy management with the safety dimmer method is carried out in four stages of testing. The first test is testing the function of each component used. The second test is to test the accuracy of the absorption of solar cells. The third test is measuring the current and voltage of solar cells with the MPPT system. And the fourth test is to compare the value of the output power of solar cells in energy management with the safety dimmer method with solar cell power with standard conditions.

The third and fourth test processes are carried out at the same time with the aim of the same sunlight intensity. This test is carried out for six (6) hours, starting at 09.00 when the sun is leaning towards the East to 15.00 when the sun is inclining to the West. Meanwhile, data collection is carried out every half hour.

From the system testing experiment, the total power produced by solar cells with energy management with the safety dimmer method, the absorption power generated by the system through the system and without going through the system, can be seen in the comparison in the graph in Figure 3.

Based on the graph of the output power of solar cells, by varying the output load, there is a change in the output power of solar cells, where in normal conditions the maximum output power from solar
cells occurs at a load of 35 ohms to 50 ohms. The output power of solar cells without the MPPT system will produce power that is almost the same as solar cells with energy management with the safety dimmer method, but at loads smaller than 35 ohms and greater than 50 ohms, you will see that the power will be more stable using the system.

The output power of solar cells with the MPPT system and safety dimmer is greater than that of static solar cells before 11.30 WIB and after 13.00 WIB. Because sunlight comes at an angle to the surface of the solar cell. The morning and the afternoon, the static solar cell output power is smaller, while the solar cell output power with the MPPT system and safety dimmer is more stable according to the radiation emitted by the sun.

Testing of the control of absorption of electronic equipment is carried out with a safety dimmer system in which the current entering electronic equipment is adjusted to the use of the equipment. Power control data can be seen in Figure 4.

![Graph](image1.png)

**Figure 4.** Load Force (a). 9 watts, (b). 50 watts.

Based on Figure 4. It can be seen that the difference in the value of the power absorbed by the load / electronic equipment through the safety dimmer system and without the safety dimmer. This data uses electronic equipment, namely LED lights. In figure 4a. power will be more stable if through the system shown in the red line on the graph, while the blue line shows the degree of fluctuation of
absorption. Whereas in Figure 4b it can be seen that there is a surge in the absorption power of the LED lamp after 20 minutes of use, this is because the high current factor causes the lamp to become hotter and the absorption capacity is greater, whereas if it is through a safety dimmer system, absorption becomes more stable.

Based on the graph of the change in voltage and changes in the output current of the MPPT driver, it can be seen that the MPPT driver output power will remain stable even though by varying the value of the output voltage and current, but the MPPT system still produces maximum power. MPPT driver control includes controlling the maximum power generated by solar cells, and controlling the process of absorption by electronic equipment / loads. Overall, testing the MPPT solar cell system and safety dimmer produces a greater output power than static solar cells. Based on the calculation of the average power of solar cells with the MPPT system and safety dimmer, it increased 12.07% compared to standard solar cells.

4. Conclusion

Based on the results of the design and testing of the system, it can be concluded that the use of an energy management system at the output of solar cells before being stored and used on electronic equipment is very important. Where, with the use of an MPPT-based system and a safety dimmer, it can increase the efficiency of the absorption of energy produced by solar cells by up to 12.07%. If used on a large scale, the efficiency of energy use is much greater and the maintenance or life of solar cells and other equipment can be longer because it avoids overloading.

5. References

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