Artificial Light Energy Harvester Using Low Start Voltage Solar Cell

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Abstract. Solar cells are widely used as an alternative renewable energy. On future, the trend of electric car will demand more solar cells mounted on the roof to support main electric source. The solar cells work optimally during the day because it convert sunlight onto energy to produce usable power. Meanwhile, the intensity of ambient light decreased at night, except from artificial light such as street light. In fact, this condition makes solar cells capable of generating enough voltage and electric current relatively. In this study, an experiments for 12 street lights with standard illumination were conducted and reported to measure the voltage and current generated by a 10 WP Polycrystalline solar cells at night. The average power obtained from them are 67.06 W. The energies which are generated can be harvest and store on smart batteries or used directly by a microcontroller system. We conclude that our system can be as efficient as energy harvester system when optimized by low start voltage solar cells to generate more energy from artificial light mounted as street lights. These findings shows our ideas potential and further research needed to get usable energy for other electric dependent system.

1. Introduction

Solar panels produce power at noon and produce less power during the night [1]. At night the intensity of light received is not as big as during the day [2]. Therefore a relatively small power at night will be utilized. One way of utilizing solar panel power at night is the application of solar panels on the electric car [3]. So cars that use solar panels can generate power through street lighting at night. This is applied because some of the existing street lighting in Indonesia began to be replaced type LED lights [4]. By utilizing the light from the street lighting and solar panels on the car, the power generated at night can be stored [5].

Small solar panels suffice to ensure continued operation, and several photovoltaic (PV) harvesting circuits have been recently proposed for this purpose [6]. One of the great strengths of the polycrystalline thin films is that they do not exhibit any sort of light-induced instability [7]. At night solar panels have voltage breakdown, because it produce small voltage to charge batteries. Instead of produce power, solar panel will consume power from batteries [8, 9]. To optimize this research, it will need to utilize the small amount of power with low voltage harvester system [10]. Thus will proved that solar panels can produce usable power from artificial light at night. The integration of solar cells on the same chip with

the sensor circuitry is an appealing solution since it reduces system integration costs, parasitic effects, and overall size [10].

2. System design

To build this harvesting energy system we make the prototype based on block diagram as shown in Figure 1.
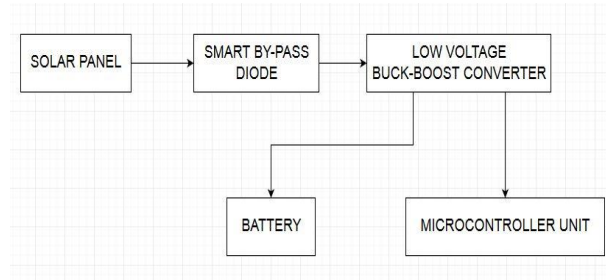

Figure 1. Block diagram system.

The solar panels absorb energy from artificial light, which is happen during the night and have a low voltage to harvest. In that case we use smart by-pass diode to minimize the voltage consumed by diode. The voltage flow to smart by-pass diode which is have small forward voltage, then we can harvest the voltage with DC-DC converter buck-boost type, this converter will set the value of voltage that will be needed. Either that will be stored on battery or used directly on microcontroller unit (MCU).

3. Implementation

In the next 15 to 20 years, electric car will be widely used for public transportation. Solar panel will mounted on the roof the car to provide energy. At night this future this future electric car can produce own power from artificial light. This is the possibility of self-sustaining energy distribution.
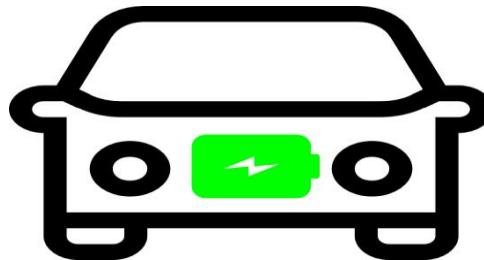
Figure 2. Electric car.

4. Materials

These are the important components to make this harvesting energy. There are some explanation below.

4.1. Solar panels

Solar panel is a set of photovoltaic modules, which is a silicon cells that can collect the rays of light. Thus the light that absorbed by solar panels will generate the electricity power based on the peak power (watt-peak/WP) of its panels. The greater the value of WP then the value of power produced is greater [11].

While designing sources which scavenge solar energy, factors such as availability of day light, periods of dense cloud and snow cover, effects of operation at higher latitudes, characteristics of the photovoltaic cell used, the intensity of the incident light, power supply requirements are to be considered [12].

In this experiment we use 10 WP Polycrystalline solar panels. We use 10 WP because it has small cross-sectional area. The smaller one has more efficiency to absorb artificial light at night. At night light

exposure is limited to certain areas, so it will become useless if we use the larger cross-sectional area of solar panels. Later on this solar panel will be mounted on the roof of the car to collect artificial light. This will be from street or from the street junction when the car stopped for street lamps.

Figure 3. 10 WP polycrystalline solar panels.
(Source: https://www.tokopedia.com/862616/solar-panel-panel-surya-solar-cell-sunlite-10wp-poly)

4.2. Diode
Diode is a semiconductor material made from silicon or germanium. It has 2 terminal that attached to its side. The function of diode is to allow electricity to pass in one direction not the other direction [13] [14]. In the solar panels system we used diode either as blocking or by-pass diode. When at night the solar panels produce smaller voltage than the voltage of battery, so it is important to use diode as blocking equipment.

This experiment still used factory diode which is 6A10 MIC to test for samples. However we need smaller forward voltage diode to allow small harvested voltage flow to converter. And to increase power dissipation to maximize the energy harvesting. So we use smart by pass diode SM74611 which has 26 mV of forward voltage.

Figure 4. SM74611 smart by pass diode.
(Source: http://www.ti.com/lit/ds/symlink/sm74611.pdf)

4.3. DC-DC converter
It is an electronic circuit that is used to convert the level of voltage to another level of voltage. This electronic circuit highly used to charge battery, so the voltage input of battery can be stabilized [13-15].

Buck-Boost Converter is a type of switched mode power supply that combine the work function of Buck Converter and Boost Converter [14]. This is used to maintain the initial voltage from by-pass diode to charge battery or used on MCU. If the initial voltage is lower than the battery or MCU, then the Boost Converter is on. On the other side if the initial voltage is higher than battery or MCU, then the Buck Converter is on.

5. Experiment
Our research focused on the value of energy that can be harvested from solar panels at night, with the source of artificial light. So we take samples of 12 street lamps with 45 seconds of measurement time for each lamp. And 3.5 meters of length between the lamp and solar panel. With the circuit of solar panel is shown in Figure 5.
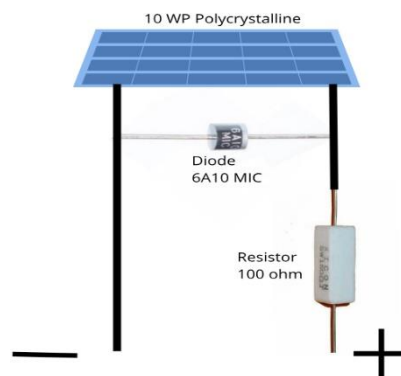
Figure 5. Circuit of solar panels.

5.1. Methods
We take solar panels directly to its centre of lamps light exposure. This means to improve the amount that can be absorbed by solar panels. After 45 seconds we take the value from the solar panels circuit. In Figure 6 is shown the illustrated methods of taking samples.

Figure 6. Method of taking samples.

5.2. Results and discussion
From the experiment above we get value of electric current that generated by solar panels. Which is shown in Figure 7.
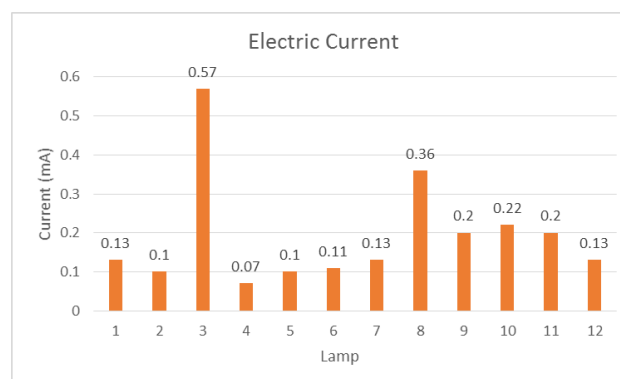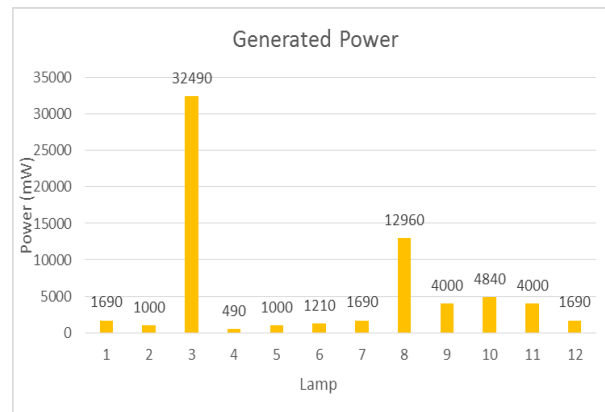

Figure 7. Generated electric current.

With that data we can get the value of power that generated by solar panels with the equation of:

$$P = i^2 . R \qquad (1)$$

The value of i is a generated electric current by solar cells that shown in Fig. 7 and the value of R is shown in Figure 5 which is 100 ohm. And P is the value of power by calculating from the equation (1), thus we get in Figure 8.

Figure 8. Value of power.

6. Conclusions and future extension
From this research we conclude that
- The highest energy is 32.49 W and the lowest energy is 0.49 W.
- Total energy that generated by solar panel with 12 samples of street lamps for 45 seconds is 67.06 W.
- The average value of power is 5.58 W with 12 samples of street lamps.

With that value of power it is possible to be used for charging battery or used directly on MCU. Thus we need a low voltage Buck-Boost Converter to maintain the value of voltage that generated by solar panels. The Buck-Boost Converter specification in this research should have low voltage input to harvest energy. The minimum requirement is 250mV and the maximum is 15V to harvest artificial light. With the output requirement will have variable value either to charge battery or used directly on MCU.

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