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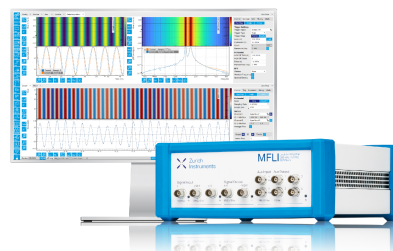
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A Maximum Power Point Tracking Technique Using Modified Hill Climbing (MHC) Method In DC Microgrid Application

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Abstract. Solar energy is one alternative energy that can be used as a source of electrical energy that is converted through solar panel media. The output power in the solar panel varies according to solar irradiation and ambient temperature. To optimize the performance of the Solar Panel, the Maximum Power Point Tracking (MPPT) method is used. Output voltage regulation of the solar panel will be regulated by a parallel buck converter. The algorithm used in this paper is Modified Hill Climbing (MHC) which is used to find the maximum power point quickly and accurately. With the existence of MPPT MHC, the average power is 90.16 W which shows an increase power compared to without MPPT which is equal to 55.78 W.

INTRODUCTION

As the community's need for electricity increases, alternative energy is needed to supply those needs. Solar energy is an alternative energy because this energy can be converted into electrical energy through the media of solar panels or solar cells. Solar panels have the advantage of not requiring fuel oil, producing no pollution, low maintenance costs and not producing noise. In addition, given that Indonesia is a tropical country, solar panels are very appropriate to use. However, the efficiency of this solar panel is still low so that the Maximum Power Point Tracking (MPPT) method is needed in order to produce optimal power [1-4].

The goal of this research is to get the maximum power produced by solar panels. The MPPT method used in this study is Modified Hill Climbing (MHC). This method is a development of the Hill Climbing or Classic Hill Climbing (CHC) method which has been widely used before. The existence of this MHC method is expected to accelerate the maximum power tracking process.

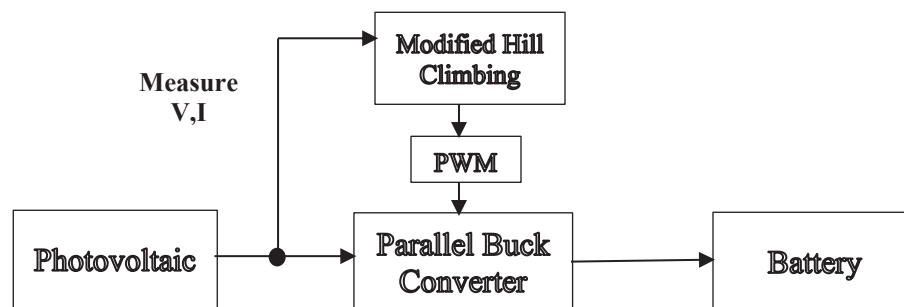


FIGURE 1. Block Diagram System

Figure 1. block of a solar garden lighting system using MPPT control where the solar cell is connected to a parallel buck converter which functions to regulate the output voltage of the battery to be constant and in accordance with the voltage needed to charge a 12 Volt battery that is 14 Volts [5]. The output voltage of the parallel buck converter is regulated by the MPPT technique using the modified hill climbing method through a microcontroller [6-9].

Furthermore, the battery is directly used to supply DC loads. If the battery does not reach the specified voltage level/the battery is not fully charged, the microcontroller will work to activate the relay contact so that the battery will be filled with PLN.

Mathematically, to find the maximum point on a parabolic curve that is the first derivative $f'(x)$ is equal to zero. This derivative is the value of the slope (gradient) of the tangent on a parabolic curve. The gradient will be positive when the curve goes up ($f'(x) > 0$) and will be negative when the curve goes down ($f'(x) < 0$). When at maximum conditions, the gradient is parallel to the abscissa axis (x)[10-15]. In the MPPT concept, this gradient is called slope (S). So to determine the maximum power point or Maximum Power Point (MPP) obtained at the state S equal to zero. S is the ratio of the change in power (dP) to the change in voltage (dV)[16-20]. The working principle of the MPPT is shown in Fig. 2.

If the Solar Panel voltage (V_{pv}) falls in the area to the left of the maximum voltage (V_{mpp}) or $V_{pv} < V_{mpp}$ or $S > 0$, then V_{pv} will be increased until it reaches V_{mpp} . Vice versa if $V_{pv} > V_{mpp}$ or $S < 0$, then V_{pv} will be lowered until it reaches V_{mpp} . After reaching V_{mpp} , automatically the output power on the Solar Panel will also be maximal (Pmpp). The duty to increase and decrease the voltage is a DC/DC converter[21-24].

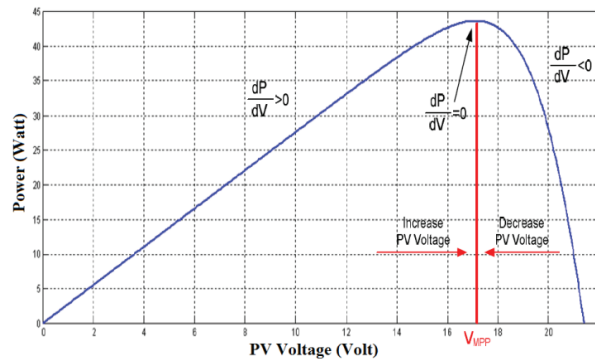


FIGURE 2. The working principle of the MPPT

In this method, finding the value of slope (S) is through a comparison of changes in power and changes in voltage. MPP is reached when the condition $S = 0$. In designing the MPPT system, it certainly cannot be separated from the converter topology used. The type of converter used is a dc - dc parallel buck converter. Fig. 3 shows a circuit of a dc-dc parallel buck converter.

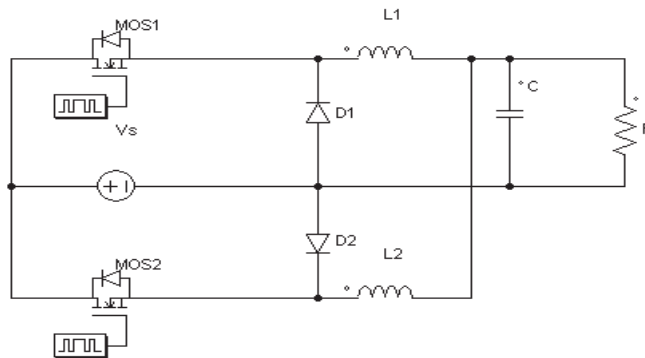


FIGURE 3. Parallel Buck Converter Circuit

To design a good parallel buck converter it is necessary to calculate the value of the right components. Because the component values are incorrect, it can cause output results that are not as desired. To design a parallel buck converter circuit, several parameters must be specified, namely: Input voltage minimum (V_s), Input voltage maximum, Voltage output parallel Buck, Current output parallel Buck, Load Voltage, and Switching Frequency. From the known parameters, it can be calculated the values of the components used, as follow

Duty Cycle Formula :

$$D = \frac{V_{out}}{V_{s\ max}} \quad (1)$$

Formula To get Inductor Value :

$$i_{L(avg)} = I_o = \frac{V_o}{R} \quad (2)$$

$$R = \frac{V_o}{I_o} \quad (3)$$

$$\Delta i_L = 0,2 \times i_{L(avg)} \quad (4)$$

$$L = \frac{1}{f} * (V_{S(max)} - V_o) * \left(\frac{V_o + V_f}{V_{s(max)} + V_f} \right) * \left(\frac{1}{\Delta i_L} \right) \rightarrow V_f = 1\ V \quad (5)$$

Maximum Inductor Current :

$$I_{max} = i_L + \frac{\Delta i_L}{2} \quad (6)$$

Formula To get Capacitor Value :

$$\Delta V_o = 0.1\% \times V_o \quad (7)$$

$$C = \frac{\Delta i_L}{8 \times \Delta V_o \times f} \quad (8)$$

RESULTS AND DISCUSSIONS

In this test using 135 WP solar panels as a source while the load used is a 12 V / 45 Ah battery with a state of being charged as much as 40%. The test method is to set the duty cycle with a constant value so that the tracking process does not occur. Table 2 shows the system integration testing data without MPPT. From this table it can be seen that the average value of the output power of the solar panel (P_{in}) is 52.24 W. Because the output power of the solar panel is affected by the intensity of the light, measurement of these parameters is needed. The voltage and current that comes out of the converter is used for the battery charging process. The output voltage and current are respectively used as the charging voltage and current. From the test data it can be seen that the value of the output voltage has reached the charging voltage value.

The existence of MPPT is very useful because to get the maximum output power of the solar panel does not need to use the manual method. MPPT can track the maximum power point itself with various algorithms. In this final project MPPT Modified Hill Climbing (MHC) method is used. From testing the output data of solar panels, it is known that the power of solar panels using MPPT Modified Hill Climbing algorithm method has increased. To find out the value of the percentage increase in solar panel power can be obtained through the equation.

$$\% _ (\text{increase in power}) = (P_{mppt} - P_{without\ mppt}) / P_{mppt} \times 100\% \quad (9)$$

With the above equation, it is known that the increase in solar panel power. The amount of increase in solar panel power varies with each condition, depending on the weather at the time of testing. The magnitude of the increase in solar panel power between the MPPT control and no control is shown in Table 1.

TABLE 1. Increased Power Result

Waktu	P without MPPT (Watt)	P with MPPT (Watt)	Increased Power (%)
10.45	54,16	76,818	29,49
11.00	54,60	83,62	34,70
11.15	60,17	98,739	39,06
11.30	62,66	101,992	38,57
11.45	58,53	97,97	40,25
12.00	57,83	97,083	40,43
12.15	56,48	95,344	40,76
12.30	54,40	91,728	40,69
12.45	53,23	81,536	34,72
13.00	45,72	76,818	40,48

From the test results it is known that the average power that can be produced by solar panels with a system without MPPT is 55.78 Watt while the system with MPPT obtained an average power of 90.16 W. Testing is done by observing changes in the charging current at each time unit. This charging current is the current that comes out of the parallel buck converter. The charging test data is shown in Fig. 4.

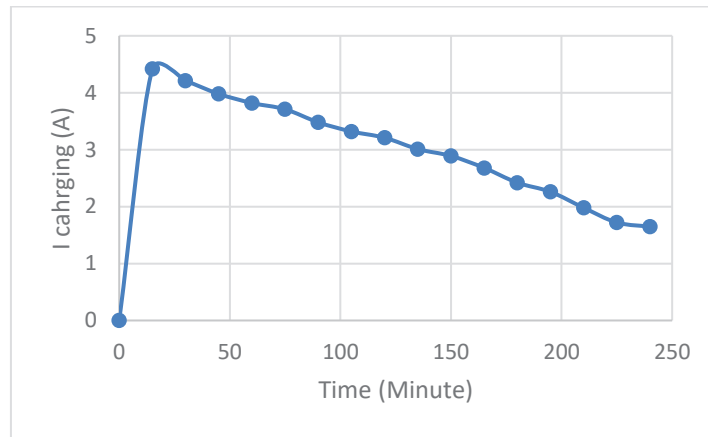


FIGURE 4. Charging Process Battery with MPPT MHC

In Fig. 4 is the 12/45 Ah battery charging process curve, the curve can be seen that the longer the charging current decreases, this indicates the process of charging the battery, the smaller the charging current the charging process will approach the full charge condition

SUMMARY

Based on the data obtained from all the tests that have been carried out, it can be concluded that the MPPT-Modified Hill Climbing (MHC) method, parallel buck converter can reduce the voltage of the solar panel 43.4 V - 48.8 V to 13.98 V used as a 12V / 45Ah battery charging voltage. Testing the integration of the system without MPPT produces an average power of 55.78 W and with the MPPT MHC method of 90.16 W so that the average increase in solar panel output power can reach 38.14%.

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