DESIGN OF THE MAXIMUM POWER POINT TRACKING PV SYSTEM BASED ON P&O ALGORITHM

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Abstract

The photovoltaic (PV) power system is one of the renewable energy power sources developing in Indonesia, while the utilization of fossil energy as the primary energy source for power generation decreases significantly. The maximum power point tracking (MPPT) controller can improve the PV power system efficiency. This study presents an experimental design of the Perturb and Observe (P&O) algorithm in the MPPT PV system comprised of a 90-Wp photovoltaic connected to a boost converter and resistive load. The components of the boost converter are determined based on the PV characteristic. The MPPT PV power system is implemented in Simulink MATLAB. The performance of the perturb and observe algorithm is compared to the PV system without an MPPT controller. The results show that perturb and observation algorithm can track the output power at the optimum power
Keyword: Photovoltaic; MPPT; P&O; Boost Converter

Electrical energy is energy that is needed to support human life today. At present, electrical energy can be said to be a primary need for Indonesian people, both those who live in big cities and those who live in remote or rural areas. Indonesia is a country that has many islands and mountains where some of these areas are remote areas and do not get sufficient electrical energy supply due to the difficulty of installation to distribute electrical energy from generating sources that are very far away. With these conditions, the government encourages efforts to develop the provision of electrical energy from renewable energy sources. These efforts, apart from reducing the electricity burden borne by the government, can also reduce pollutant emissions resulting from the use of fossil fuels to support the work of generating electricity (Bilgen, Keleş, Sarıkaya, & Kaygusuz, 2015) (Tükenmez & Demireli, 2012) (Xie, Yuan, & Yang, 2015). One of the major renewable energy sources is solar energy. The utilization of solar energy as a source of electricity generation has enormous potential because Indonesia is located in the tropics, which is crossed by the equator where the sun shines all the time. Solar cells are needed as a device to convert solar energy into electrical energy. Several researchers have attempted to develop a technique to increase this efficiency factor.

The DC-DC converter is implemented in the MPPT controller PV system converter, for instance, the boost converter (Kchaou, Naamane, Koubaa, & M'sirdi, 2017) (Palaniswamy & Srinivasan, 2016), the buck – boost converter (Kwan & Wu, 2017), SEPIC converter (Kiranmai & Veerachary, 2005) and others. The DC – DC power converter is usually used to maximize the output power. The output current and voltage from the photovoltaic are used as the input source of converter and the controller to produce pulse width modulation (PWM) to switch MOSFET. The DC-DC power converter is designed by calculating the capacitance and the inductance implemented in the converter. In order that the converter operates in the continuous current mode (CCM), the inductance value has to be higher than the calculation result. Otherwise, the DC-DC converter operates in the discontinuous current mode (DCM). The CCM will maintain the output voltage at a stable value. There are two capacitances, the input capacitance, and the output capacitance. The input capacitance is used to filter the input power from PV, while the output capacitance is calculated to maintain the voltage ripple within the acceptable specification.

This paper derives the calculation of the inductance and the capacitance for the boost converter connected to the PV module system. By using the simple equations, both input and output capacitance, the inductance for converter design are calculated. The perturb and observe is implemented as the algorithm for MPPT controller.

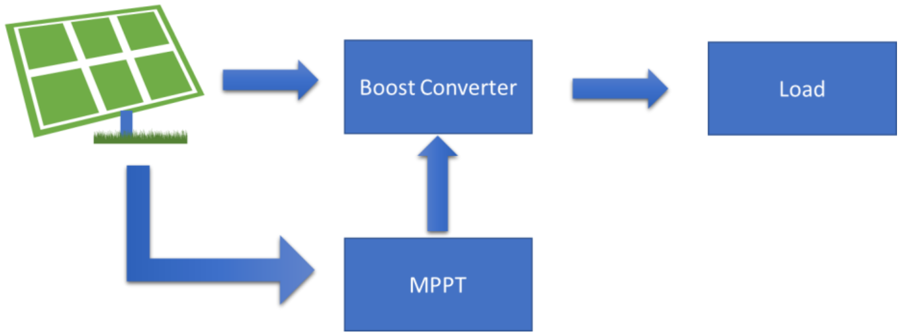

Figure 1. The MPPT PV system

Methods

The components modeling for the MPPT controller boost converter shown in Figure 1 consist of the PV model, the maximum power point tracking (MPPT) method, and the calculation of the boost converter components.

PV model

The PV model is one of the main components in the MPPT controller boost converter. The PV model has the function curve, such as the Current-Voltage characteristic curve of the PV system. The product of the current and the voltage is the Power – Voltage P-V characteristic curve. The Canadian solar 90WP is considered as the PV module for simulation in Simulink MATLAB 2020.

Table 1. The PV characteristic

Characteristic (Canadian solar 90M)	Value
Maximum Power (Watt)	90
Open circuit voltage Voc (V)	22.2
Voltage at maximum power point V_{mp} (V)	18
Cells per module (Ncell)	36
Short-circuit current I_{sc}(A)	5.4
Current at maximum power point I_{mp} (A)	4.99

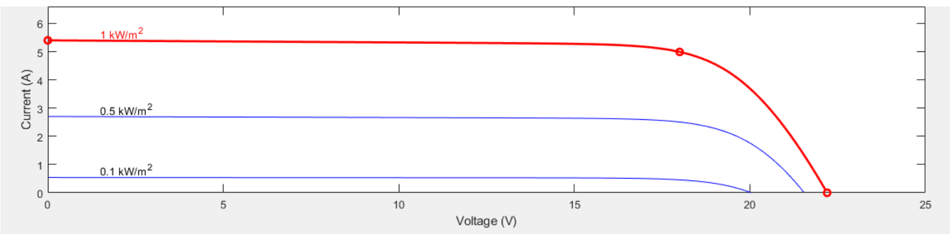

Figure 2. The I-V characteristic curve

The MPPT method

The perturb and observe (P&O) algorithm operates in the P-V characteristic curve, in which there is the optimum power point. This P&O algorithm can maintain the operating power point at the range of the maximum power point (MPP). Figure 3 explains how the P&O maintains the optimum power.

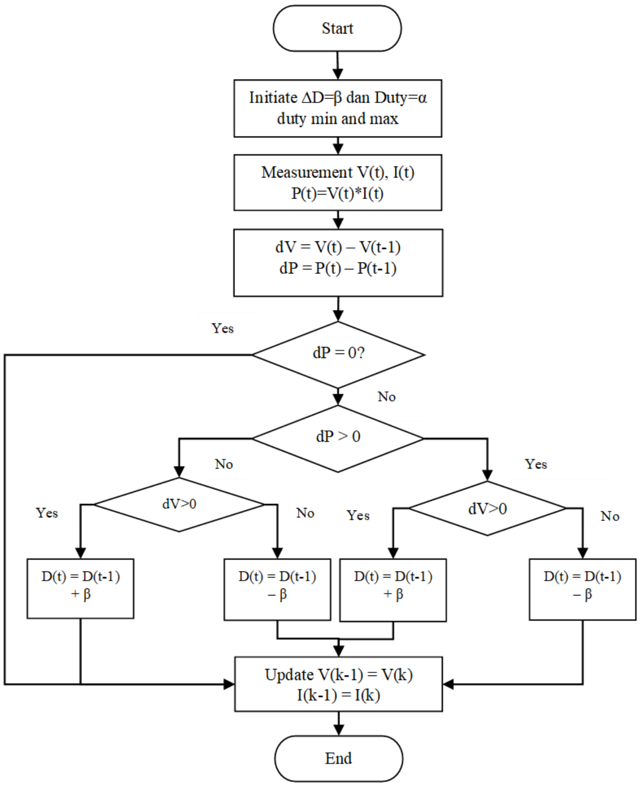

Figure 3. The flowchart of P&O algorithm

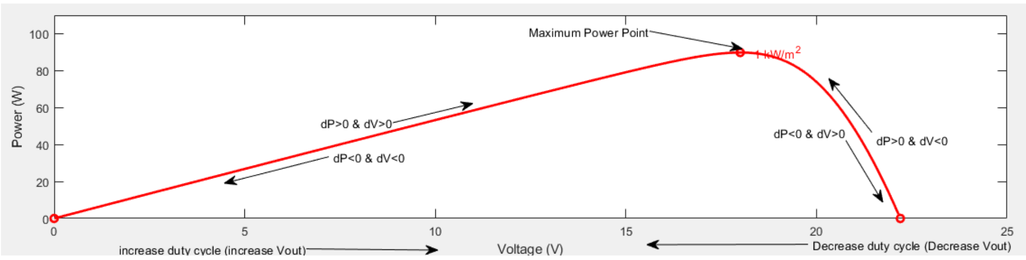

Figure 4. The P-V characteristic curve

First of all, the voltage and current from the PV module are sensed, following calculation the change of the power and voltage. When there is no power change, the duty cycle is not changing. The power increase while there is an increase of the voltage, the duty cycle will be added by β. Otherwise, its duty cycle decrease. A decrease of the power and the voltage leads to a decrease of the duty cycle, on the other hand, the duty cycle increase as shown in Figure 4.

The Boost Converter

The design of the boost converter is the main component of the MPPT PV system. The boost converter can operate in on-state condition and off-state conditions. These operation conditions are based on the switching of PWM produced by the MOSFET driver. The comparison of the output voltage V_0 and the input voltage V_{in} is explained in the following equation to generate the duty cycle D.

$$\frac{V_0}{V_{in}} = \frac{1}{1-D} \quad (1)$$

In order to the operating CCM condition, the inductance is calculated using equation 2. Where: R is the resistive load and the f_{min} is the minimum frequency (Daniel, 1997).

$$L_{min} = \frac{D(1-D)^2 R_{max}}{2 f_{min}} \tag{2}$$

To filter the output voltage in the stable voltage, the boost converter needs to calculate the minimum capacitance.

$$C_{min} = \frac{D}{\%V_r . R . f_{min}} \tag{3}$$

Where $\%V_r$ is desired output ripple.

Table 2. The boost converter specification

The input voltage (V_{pv})	18 V
The output voltage	30 V
The output current	4.99 A
Switching frequency	20kHz
R_L	$6 - 750\ \Omega$
Duty cycle	0.4
The output capacitor (C_{min})	20μF

Findings and Discussion

The MPPT PV system is designed and simulated in Simulink MATLAB 2020, Figure 5. The input of the converter is measured to the display of scope, and also the measurement of the output of the boost converter. Figure 6 depicts that the output of the boost converter is higher than the input voltage. This result shows that the boost converter operates at the desired output.

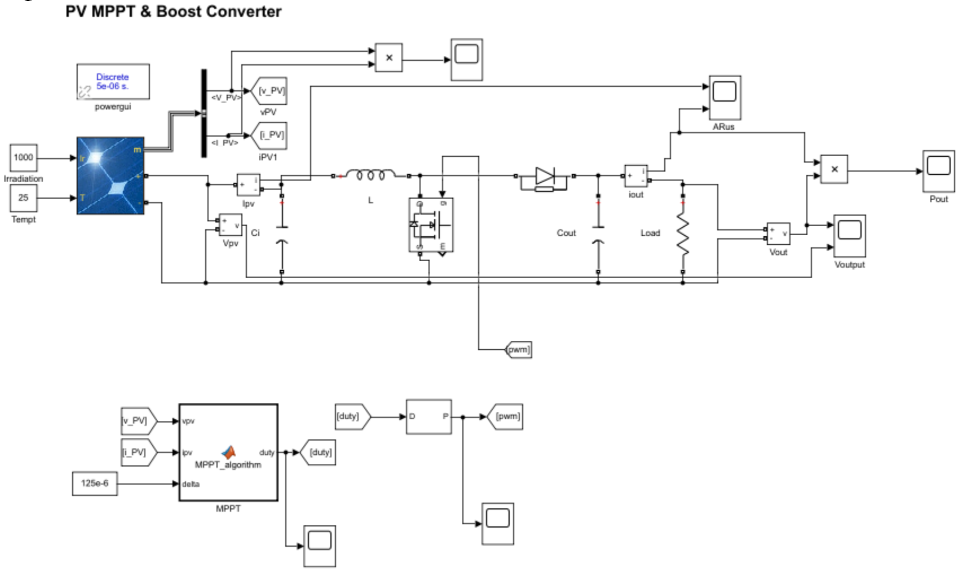

Figure 5. Simulink simulation of the PV MPPT system

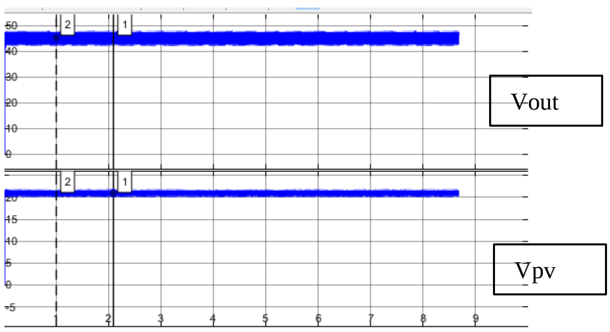

Figure 6. The comparison of the output voltage and the input voltage (Vpv)

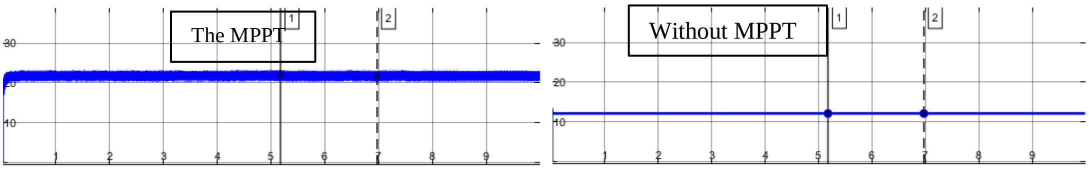

Figure 7. The output power for the MPPT PV and fixed PWM

The P&O algorithm in the maximum power point tracking PV can maintain the optimum power point as shown in Figure 7. The output power of the MPPT controller PV system is larger than the PV system without an MPPT controller or fixed duty cycle. The MPPT PV system using boost converter produces the output power of about 23 Watt with the resistive load, 100 Ω, compared to the output power of the PV system without the P&O algorithm is as average about 12 Watt.

Conclusions and Suggestions

The MPPT PV system consists of the PV module 90 WP, the DC-DC boost converter, MPPT controller, and the resistive load. The simulation results of the MPPT PV system based on P&O algorithm using a boost converter show a good performance, the output power about 23 Watt with the resistive load, 100 Ω, compared to the output power of the PV system without the P&O algorithm is at 12 Watt.

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