MATLAB / SIMULINK SIMULATION OF PV SYSTEMBASED ON MPPT IN VARIABLE IRRADIANCE WITH EV BATTERY AS LOAD

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Abstract

The PV panels have become a ubiquitous renewable resource as it produces clean energy and needs less maintenance. However, in changing environmental conditions less power output is generated. The operating point shifts from the maximum power point (MPP) to some other point. The MPP Tracking (MPPT) controller is designed for the panels to track the changing irradiance and maintain operating point at MPP. The MPPT controller uses an algorithm which generates a dynamic duty ratio for the dc-dc converter. MATLAB simulation of the MPPT PV system using perturb and observe (P&O) algorithm is shown in this paper. In the simulation model, irradiance changes are considered while the temperature remains unchanged. A comparison between non-MPPT and MPPT output is analysed. The result verifies that MPPT algorithm boosts the efficiency of the system in changing climatic conditions and performs better than the non-MPPT system.

Keywords: *dc-dc Converter, Maximum Power Point Tracking (MPPT), Photovoltaic (PV) Cells, Perturb and Observe (P&O) Algorithm*

Introduction

The production of electric power with the renewable energy is essential to meet the increasing future demand and decreasing generation resources. Among various renewable sources, the most popular are solar and wind generating plants. Due to the omnipresence of solar energy, its applicability is higher. The photovoltaic (PV) cells convert the radiations from the sun into electricity. A single cell cannot generate sufficient electricity .Therefore these cells are connected with each other to form PV panels [1]. The electricity produced by these panels depends on the intensity of radiation falling on the panel and temperature of surroundings.

The irradiance is fluctuating in nature and never remain constant. The V-I characteristics of PV panels are non-linear, and P-V characteristics show that for a particular irradiance only single maximum power point (MPP) exists. The variation in irradiance and temperature changes the value of current and voltage respectively. The operating point of PV panel depends on the load characteristics. The point at which load curve intersects the IV curve is the operating point of the system. The MPP vary with the variations in irradiance and temperature .The operating point also shifts according to changing climatic conditions. Thus, the operating point is not always the MPP but at some other point. If the system operating point deviates fromthe MPP there are more losses. Due to changing climatic conditions, the efficiency of PV system is not optimum [2], [3].

PV System with MPPT Controller

The efficiency of PV system is less due to its suboptimal conversion rate. For better conversion, the operating point should be adjusted to MPP with changing irradiance. In circuit theory, the maximum power transfer theorem states that if the source and load impedance are matched then maximum power is transferred. The matching of source and load impedance is implemented with the power converter. The converter used in this model is shown in Fig. 1. A boost converter with a battery as a load having some internal resistance (Rl). The converter operates in continuous current mode. The correct component selection of the converter is most important for the betterperformance of PV system. The current in the circuit increases with decreasing inductance so inductance should always be chosen with a current rating higher than maximum current. Theselection of inductor can be by the following equation

$$L = \frac{V_{pvi} \times (V_{output} - V_{pvi})}{\Delta I_{Li} \times f_{switch} \times V_{output}}$$

ΔI_{Li} = ripple current through inductor f_{switch} = min. switching frequency V_{output} = output voltage across load $_{output}$ = max. output current necessary for application purpose For switching circuit operating at higher frequencies, Schottkydiodes perform better. The forward current rating should beequivalent to max. output current. The power dissipation ofdiode (P_D)is given by

$$P_D = I_F \times V_F$$

I_F = average forward current of diode V_F = forward voltage of diode

For power converter, it is convenient to apply a lower equivalent series resistance (ESR) capacitors to minimize the ripple on the output voltage. The capacitor having capacitance (C) produce desired output voltage with external compensators I_{output} should be maximum output current of application.d = duty ratio of the pulse

The duty ratio of the converter is keep on varying to match the input and output circuit impedances. A static duty cycle is not capable of operating at MPP in changing climatic conditions. A block diagram of solar panel with MPPT isillustrated in Fig. 2 [4]–[7].

The efficiency of the system can be increased by either changing to better hardware or by using some algorithm to match impedance in varying environmental conditions. The duty cycle has to be adjusted such that system always operates at MPP; this can be achieved by applying MPPT algorithm. Now, there are various algorithms which can be used in MPPT controllers. Some parameters of PV systems are measured and given to MPPT controller. The controller generates a dynamic duty ratio for a converter which improves the performance of the system [8].

Proposed Model

In this model, a MATLAB simulation of an MPPT controller is compared with non-MPPT controller. The algorithm which is mostly used in practical applications is perturbed and observe (P&O). In this manuscript, P&O algorithm is applied to the PV system with varying irradiance [9]. In this algorithm, the value of power is calculated after every perturbation

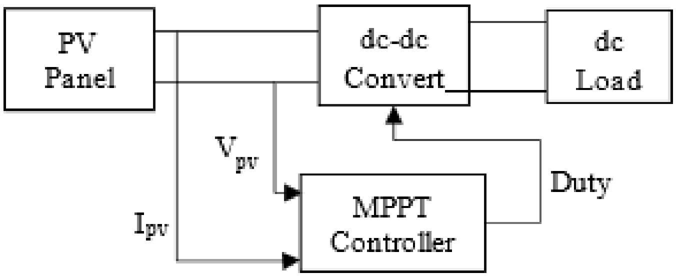

Figure 2 Block Diagram of Photovoltaic System with MPPT Controller

The controlled variable for next iteration is calculated by

$$f_{new} = f_{prev} + \Delta f \times \varphi$$

The controlled variable (f) can be current, voltage or duty ratio of signal depending on application. The value of variable for next iteration depends on change in variable value (Δf) and its previous value. The change in variable can be either added or subtracted depending on direction of perturbation (φ) value.P&O algorithm for MPPT controller,

Step 1: Sense the value of voltage and current from PV panel

Step 2: The value of PV power generated is calculated

Step 3: The variation in values of power and voltage is calculated

Step 4: Check if variation in power is positive or negative

Step 5: Check if the control variable i.e. voltage value has increased or decreased

Step 6: If change in power is positive and voltage is increasing, then duty is given by equation

A perturbation is given to the voltage of the system with δ steps to observe variations in the power of the system. The voltage (V) and current (I) of the system are measured by sensors. Then the PV power is calculated by multiplying V and Now, the change in power is observed. If the power is increasing with increasing voltage, then next perturbation is in the same direction [10], [11]. Otherwise, the direction of perturbation is reversed. The duty cycle of the power converter is calculated by following equations,

$$d \text{ (Duty Cycle)} = d_{n-1} \text{ (Previous Value)} + \delta$$

$$\text{or } = d_{n-1} \text{ (Previous Value)} - \delta$$

For initialisation of the algorithm, the duty cycle is set at 0.8. As the irradiance varies, the value of PV power output also changes. Hence, the value duty cycle changes.

Results

The model for MPPT is illustrated in fig.3. The irradiance is altered by using signal builder block. However, the temperature remains constant at 25C. The dc-dc converter match impedances and controls the PV output. A MOSFET is used for switching power converter due to its minimal losses at higher switching frequencies. The voltage and current values measured from the PV are given to MPPT block. The filtered values of voltage and current are multiplied to get PV output power generated [12]. After which P&O algorithm track the MPP. The output of the algorithm produces a duty cycle which controls power converter. Thus, the more efficient output is produced. The graph in Fig. 4 shows irradiance given to the PV panel.

In Fig. 5 to 8 a comparison between the power output of MPPT with non-MPPT controller systems are illustrated graphically. The graphs show that output power produces by MPPT is stable compared to non-MPPT.

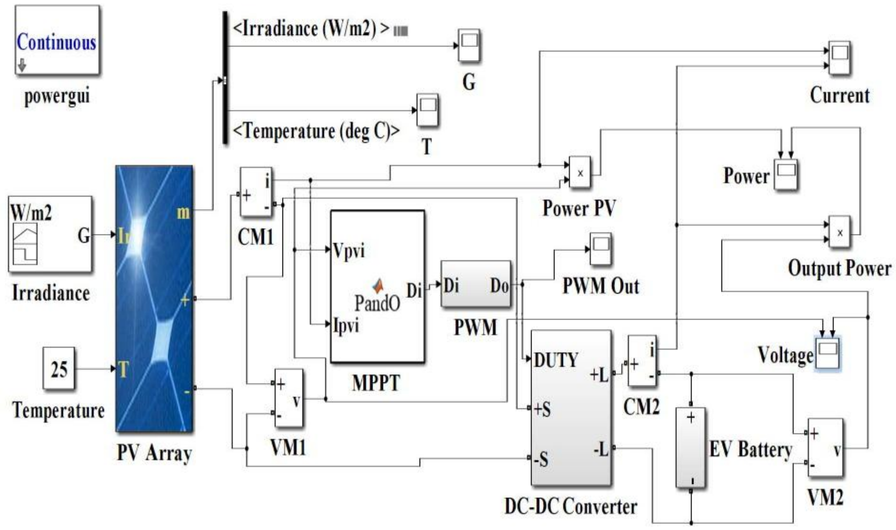

Figure 3 PV System with MPPT Controller Simulation Model in Simulink

The power given by MPPT controller to the load is higher than non-MPPT controller. Different parameters pertaining to systems are compared in Table 1. The mean value of power output with MPPT is 68.85 W and non-MPPT system is 40.37 W. The system with MPPT provides 70.54% more power to EV battery

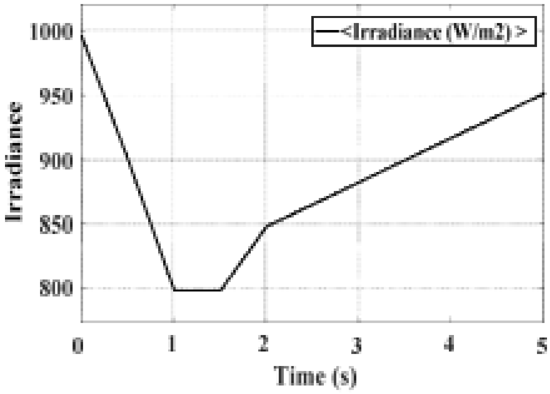

Fig. 4 Irradiance given to PV panel by signal builder

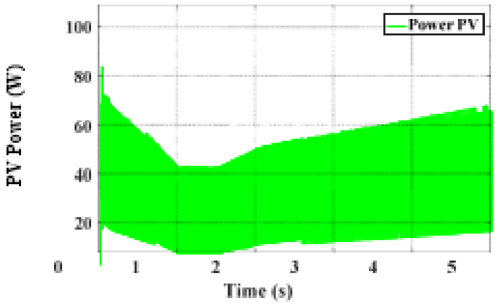

Fig.5 Power from PV panel without MPPT controller

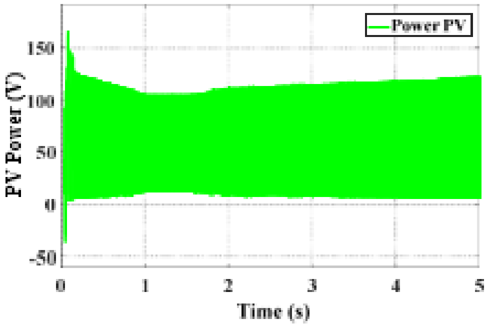

Fig.6 Power from PV panel with MPPT controller

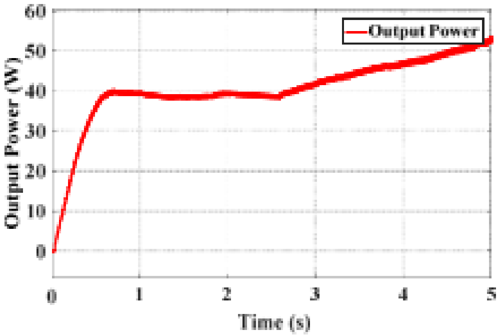

Fig.7 Power Output given to load without MPPT controller

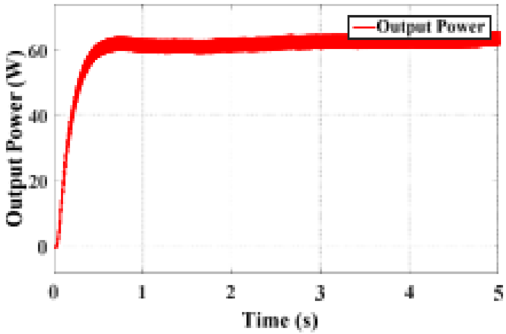

Fig.8 Power Output given to load with MPPT controller

Table 1 Comparison of Parameters for MPPT and Non-MPPT Systems with Variable Irradiance

Parameters	Output Power (W) with MPPT	Output Power (W) without MPPT
Maximum Value	1.009e+2	5.368e+1
Mean Value	6.885e+1	4.037e+1
RMS Value	7.199e+1	4.135e+1

Conclusion

In this paper, P&O based MPPT simulation in MATLAB is presented. The result predicts that changing environmental conditions changes the power output of the PV system. That change produces losses and reduces the efficiency. If MPPT controller generates a dynamic duty cycle, then the operating point of the system remain at MPP. Such operation of the system reduces oscillations and losses. Further, P&O has some limitations like oscillations near MPP and loss of tracking direction for fast-changing environmental conditions. This problem can be reduced by using the modified P&O algorithm. The perturbation steps are fixed in this simulation due to which there are some infinitesimally small oscillations. However, the overall losses in this system are less compared to a non-MPPTPV system.

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