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P&O MPPT Using Sliding Mode Controller

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A B S T R A C T

This paper proposes a simulation of P&O MPPT using sliding mode controller (SMC) for extracting the maximum power in solar PV system under different irradiation conditions. Conventional perturb and observe MPPT is limited for constant irradiation that is the main drawback of the P&O MPPT algorithm. The difference between conventional perturb and observe MPPT and this system is this can be used for different irradiation conditions also. This paper gives the brief information about the P&O MPPT and sliding mode controller and how the proposed simulation works. In this system optimal gain values are given to the sliding mode controller which continuously measures the difference between the power and voltages and it provides the change in duty cycle (ΔD) to the MPPT controller that will keep the pv panel at a voltage which gives the maximum power under different irradiation levels also.

Keywords: Maximum power point tracking (MPPT), Photovoltaic (PV), Perturb and Observe(P&O)

Introduction

Photovoltaic systems use cells to convert solar radiation into electricity. When light incident on the photovoltaic cell it generates an electric field across the layers, causing electricity to flow. The greater the intensity of the light, the greater the flow of electricity is However, the power generated by PV systems is an irregular energy source presenting two major problems: (a) low efficiency, and (b) the nonlinear output characteristic that varies with the atmospheric conditions such as temperature and irradiance. Therefore, to improve the output power of the PV system, maximum power point tracking (MPPT) controller is applied to adapt constantly the operating point of PV generator to maximize the power transferred to the load.

Literature review

In this paper, a SOFT-MPPT algorithm has been proposed which, in a simple way, aims to improve both the steady state as well as the tracking performance of both P&O and InC algorithms. An adaptive step size is used to track the MPP, which provides a faster tracking performance. The proposed algorithm identifies the attainment of the steady state and then stops the artificial perturbations.[1]

In this paper, a variable perturbation size adaptive perturb and observe (P&O) maximum power point tracking (MPPT) algorithm is proposed to track the maximum power under sudden changes in irradiance. The proposed method consists of three algorithms, namely current perturbation algorithm (CPA), adaptive control algorithm (ACA), and variable perturbation algorithm (VPA). CPA always tries to operate the photovoltaic (PV) panel at maximum power point (MPP).[2]

In this paper, the concept of power tracking for PV systems is highlighted and an overview on 40 old and recent Maximum Power Point Tracking (MPPT) methods, available in the literature, is presented and classified. These methods are mathematically modeled and presented in such a way the reader can select the most appropriate method for his own application. A comparative table is presented at the end of the paper to simplify the classification of the different methods.[3]

This paper presents evaluations among the most usual maximum power point tracking (MPPT) techniques, doing meaningful comparisons with respect to the amount of energy extracted from the photovoltaic (PV) panel [tracking factor (TF)] in relation to the available power, PV voltage ripple, dynamic response, and use of sensors.[4]

This paper proposes a deterministic particle swarm optimization to improve the maximum power point tracking (MPPT) capability for photovoltaic system under partial shading condition.[5]

This paper proposes a novel Overall Distribution (OD) MPPT algorithm to rapidly search the area near the global maximum power points, which is further integrated with the Particle Swarm Optimization (PSO) MPPT algorithm to improve the accuracy of MPPT. [6]

In this respect, a novel framework is developed in this paper for the MPPT algorithm based on a sliding mode controller (SMC) applicable to PV panels with partial shading conditions (PSC) and uniform conditions. This model employs the modified shuffled frog leaping algorithm (MSFLA) to derive the desired values of the parameters of the controller that utilizes the variable step-size perturb and observe (P&O).[7]

This paper proposes two new Maximum Power Point Tracking (MPPT) methods which improve the conventional Fractional Open Circuit Voltage (FOCV) method. The main novelty is a switched semi-pilot cell that is used for measuring the open-circuit voltage.[8]

This paper discusses an improved constant voltage based maximum power point tracking method for extracting maximum power from photovoltaic (PV) system. The improved method has better performance than the conventional fractional open circuit voltage (FOCV) method.[9]

The paper deals with the basic concepts, mathematics, and design aspects of variable structure systems as well as sliding modes as a principle operation mode The control algorithms and data processing used in variable structure systems are analyzed. The potential of sliding mode control methodology is demonstrated for versatility of electric drives and functional goals of control.[10]

3. Methodology

P&O MPPT:

P&O MPPT (Perturb and Observe Maximum Power Point Tracking) is a type of MPPT algorithm used in photovoltaic systems to track and maintain the maximum power point of a solar panel. It is one of the most commonly used MPPT algorithms due to its simplicity and ease of implementation. The P&O MPPT algorithm operates by perturbing (i.e., slightly changing) the operating voltage or current of the solar panel and observing the corresponding change in the power output. The algorithm then determines the direction of the change that results in an increase in power output and continues to perturb the voltage or current in that direction until it reaches the maximum power point. When the maximum power point is reached, the P&O algorithm switches to a smaller perturbation size to ensure that the operating point stays close to the maximum power point. If the operating conditions change, such as due to cloud cover or shading, the algorithm starts again from the open-circuit voltage to find the new maximum power point.

While P&O MPPT is a simple and effective algorithm, it can suffer from some drawbacks, such as oscillations around the maximum power point, slow tracking of rapid changes in irradiance, and reduced efficiency under partial shading conditions. However, these issues can be addressed by incorporating additional features and techniques into the algorithm, such as adaptive perturbation size, fuzzy logic control, and multi-level MPPT.

P&O MPPT Matlab code

```
function D  = PandO(V, I,deltaD)
Dinit = 0.42;  %Initial value for D output
Dmax = 0.8;   %Maximum value for D
Dmin = 0.08;   %Minimum value for D
deltaD = abs(deltaD)*1e-2; %Increment value used to increase/decrease the duty cycle D
 persistent Vold Pold Dold;
 dataType = 'double';
 if isempty(Vold)
 Vold=0;
 Pold=0;
 Dold=Dinit;
end
P= V*I;
dV= V - Vold;
dP= P - Pold;
if dP < 0
if dV < 0
D = Dold - deltaD;
else
```

```
D = Dold + deltaD;
end
else
 if dV < 0
 D = Dold + deltaD;
 else
 D = Dold - deltaD;
 end
 end
 if D >= Dmax | D<= Dmin
D=Dold;
End
 Dold=D;
Vold=V;
 A Pold=P;
```

SLIDING MODE CONTROLLER

Sliding mode controller is a type of control strategy used in control systems to regulate a system's output to follow a desired reference signal, despite disturbances or uncertainties. The sliding mode control technique involves creating a sliding surface, which is a function of the system's state variables, that defines a boundary between desired and undesired system behaviour.

The basic idea behind sliding mode control is to design a control law that drives the system's state trajectory to slide along the sliding surface, ensuring that the system tracks the desired reference signal. This is achieved by creating a control law that generates a discontinuous control signal that drives the system's state towards the sliding surface and then along it, effectively "sliding" the system's state trajectory to the desired reference signal.

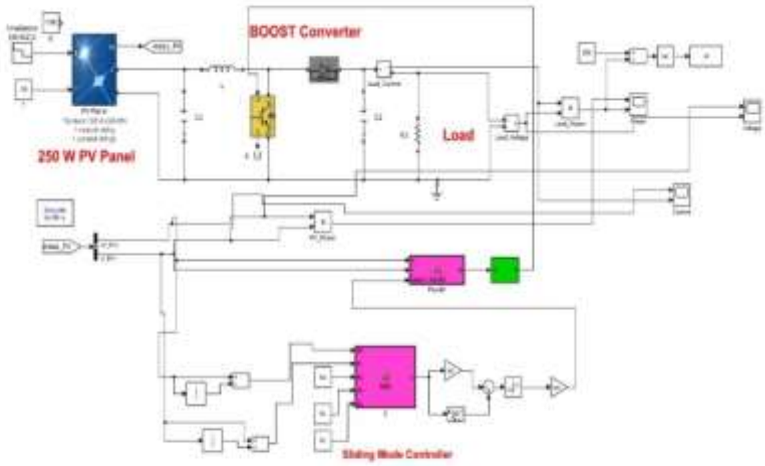
Sliding mode control is particularly useful for controlling systems that are subject to disturbances or uncertainties, such as those found in aerospace, robotics, and automotive systems. It is a robust control technique that is able to tolerate a wide range of uncertainties, making it an attractive option for controlling complex and nonlinear systems.

However, sliding mode control also has some drawbacks, such as chattering, which is an undesirable high-frequency oscillation that can occur near the sliding surface. To address this issue, researchers have developed various modifications and extensions of the basic sliding mode control technique, such as higher-order sliding mode control, adaptive sliding mode control, and variable structure control, among others.

4. Working and operation

The simulink model Different illuminations and temperature values are given to the 1Soltech 1STH-250-WH solar panel. Output of the PV panel is given to the sliding mode controller and optimal gain values are given to SMC and it generates duty cycle that is given to the pulse modulation generator. Output of the PWM generator pulses given to the boost converter. The main part of the simulation it uses the P&0 algorithm. The algorithm is based on the disturbance of the output voltage V(k) of the PV panel and the corresponding output power P(k), which is compared with the previous perturbing cycle P(k-1).

SIMULATION DIAGRAM:



Simulation of P&O MPPT by sliding mode control

OUTPUT WAVEFROMS:

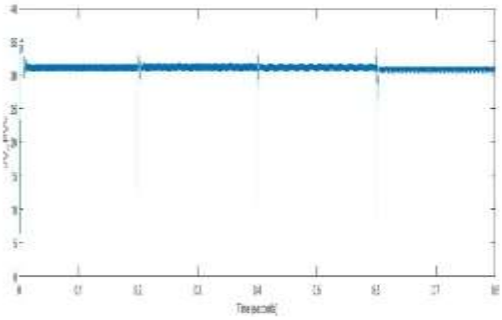


Fig PV panel output voltage

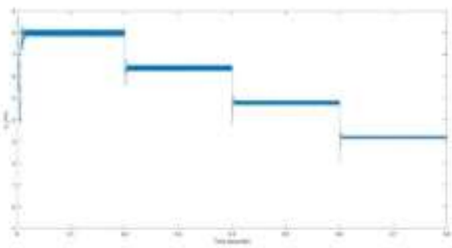


Fig PV current

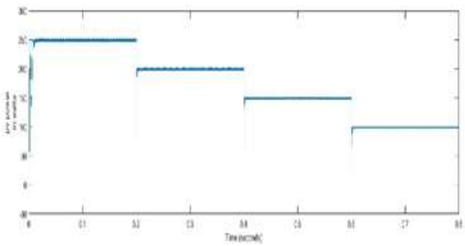


Fig PV panel power

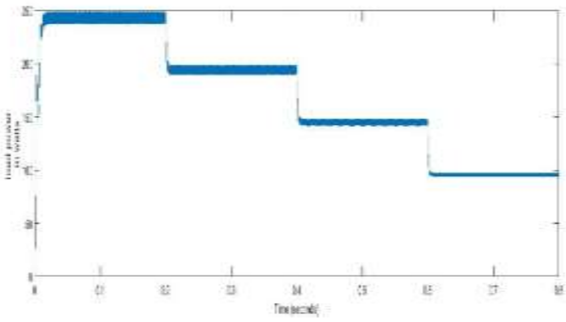


Fig Load Power

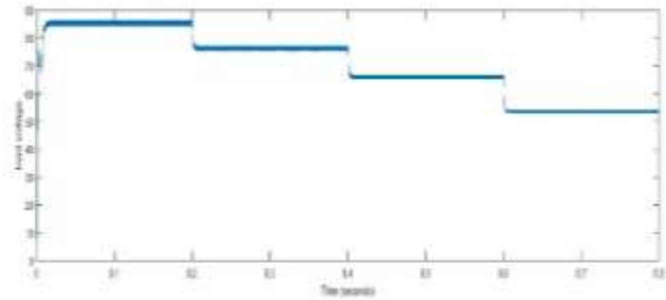


Fig Load Voltage

5. Conclusion

This gives information about the maximum power point tracking and what is the use of MPPT in a solar PV power generation system and its advantages and disadvantages. MPPT controller is necessary in the PV power generation system for extracting the maximum power from the PV panel. This report also consists of different MPPT techniques and brief survey on individual MPPT techniques and their algorithms. Perturb and observe algorithm is one of the popular and effective algorithms it continuously measures the power and voltage and its algorithm helps to extract the maximum power. Furthermore In this report we presented a simulation of P&O MPPT using sliding mode controller. The outputs of the load power are also observed. We developed a hardware model on energy management, in this the based on the PV output voltage the loads will work. If the PV generated output is more, then all the loads will get supply if it is low then some of the loads will be turned off.

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