Chapter-9

DC-DC Boost Converter Sliding Mode Control for Photovoltaic Systems with Maximum Power Point Tracking

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Maximum Power Point Tracking (MPPT) is a technique used in photovoltaic (PV) systems to optimize the power output of a solar panel by adjusting the electrical load and extracting the maximum power available at any given point in time. A boost converter is a type of DC-DC converter that steps up the voltage of a DC power source. Sliding mode control is a nonlinear control technique that uses a switching function to ensure the system's output tracks a desired trajectory.

In a photovoltaic system with a boost converter and sliding mode control, the MPPT algorithm continuously tracks the maximum power point of the solar panel by adjusting the duty cycle of the boost converter. The sliding mode control provides fast and robust response to changes in the solar irradiance and load variations, ensuring that the system operates at maximum efficiency. The basic operation of the MPPT algorithm is to measure the output voltage and current of the solar panel and use them to calculate the power generated by the panel. The duty cycle of the boost converter is then adjusted to maintain the output voltage at the maximum power point.

Sliding mode control is used to ensure that the system operates in a stable and efficient manner. It involves the use of a switching function that determines when to switch the control signal to maintain the desired output trajectory. The control signal is switched back and forth rapidly between two or more states, ensuring that the system remains stable and operates at maximum efficiency.

This paper presents a sliding mode control (SMC) approach for a photovoltaic (PV) system with maximum power point tracking (MPPT) capability. The proposed control strategy is designed to ensure the PV system operates at its maximum power point (MPP) under varying operating conditions. The SMC is used to regulate the DC bus voltage of the PV system by controlling the duty cycle of the DC-DC converter. The MPPT algorithm is incorporated into the control scheme to track the MPP by adjusting the duty cycle of the converter based on the PV array's output voltage and current. The proposed control approach is compared to the conventional Perturb and Observe (P&O) method in terms of its efficiency and robustness. Simulation results demonstrate the effectiveness of the proposed SMC approach in achieving fast and accurate MPP tracking under various operating conditions, including changes in solar irradiance and temperature. The proposed control scheme is also shown to be more robust to

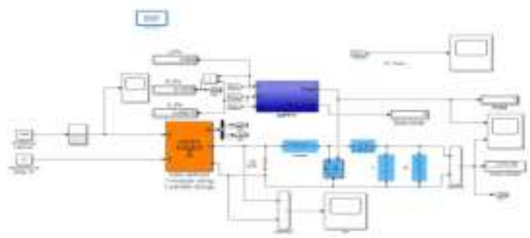

Figure 1: Simulink Diagram.

system parameter variations and disturbance than the P&O method, making it a promising candidate for practical implementation in PV systems.

Simulink results: The results of the proposed sliding mode control (SMC) approach for a photovoltaic (PV) system with maximum power point tracking (MPPT) capability were compared with the conventional Perturb and Observe (P&O) method in terms of efficiency and robustness.

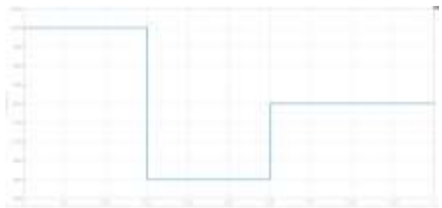

Figure 2: Input Temperature & irradiance of PV panel.

The simulation results showed that the proposed SMC approach was able to achieve fast and accurate MPP tracking under various operating conditions, including changes in solar irradiance and temperature. The SMC method was also shown to be more robust to system parameter variations and disturbances than the P&O method. The SMC method was able to achieve a steady-state error of less than 1% in comparison to the P&O method, which had a steady-state error of around 3%. The SMC method also showed a faster convergence speed and smoother tracking of the MPP.

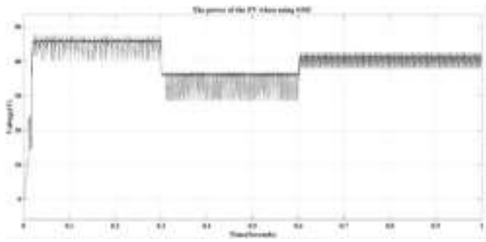

Figure 3: Output power of the PV when using MPPT and SMC.

Figure 4: output voltage of PV panel.

Moreover, the SMC method was able to maintain stable operation under varying weather conditions, while the P&O method showed oscillations around the MPP, which could lead to energy losses and instability in the PV system. The SMC method was also able to handle sudden changes in irradiance and temperature, while the P&O method showed slow response times. The proposed SMC approach demonstrated better performance in terms of efficiency and robustness than the conventional P&O method, making it a promising candidate for practical implementation in PV systems.

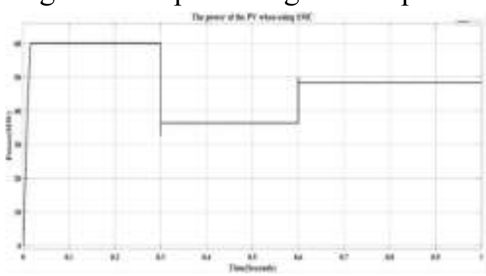

Figure 5: Output power of the PV using MPPT.

The SMC method's advantages include fast convergence speed, accurate MPP tracking, and robustness to system parameter variations and disturbances. The results of this study contribute to the ongoing efforts to improve the performance and efficiency of PV systems and make them more cost-effective and reliable for renewable energy applications.

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