Optimized MPPT Control for a Photovoltaic Pumping System

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ABSTRACT

This work presents a new control strategy for maximum power point tracking (MPPT) of a photovoltaic pumping system (PVPS). This system consists of a photovoltaic generator (PVG) connected to a direct current (DC) motor coupled to a centrifugal pump via a DC-DC boost converter. The duty of the boost converter is regulated by using a non-singular fast terminal sliding mode control (NFTSMC) technique. The Particle Swarm Optimization algorithm (PSO) is exploited to optimize the gains of the developed controller. To show the efficiency of the designed controller, a comparative simulation in the Matlab/Simulink platform with Perturb and Observe (P&O) and finite time sliding mode control (FTSMC) is realized. The simulated results demonstrate the best tracking performance and fast-tracking response convergence in the finite time of the proposed controller.

Keywords: NFTSMC, PSO, PVPS.

1 Introduction

Photovoltaic pumping system presents one of the principal solar photovoltaic applications, particularly in isolated areas where electric power is not available. To maximize the performance of PVPS, a controller MPPT is employed to track the maximum power point (MPP) of PVG. In literature, many works are proposed for PVPS based on DC motors in order to extract maximum power from PV panels: (P&O) method [1], intelligent control [2], [3], and sliding mode control approaches [4]– [6]. In this work, a fast optimal MPPT controller for a photovoltaic pumping system using a DC Motor is proposed.

2 Methodology

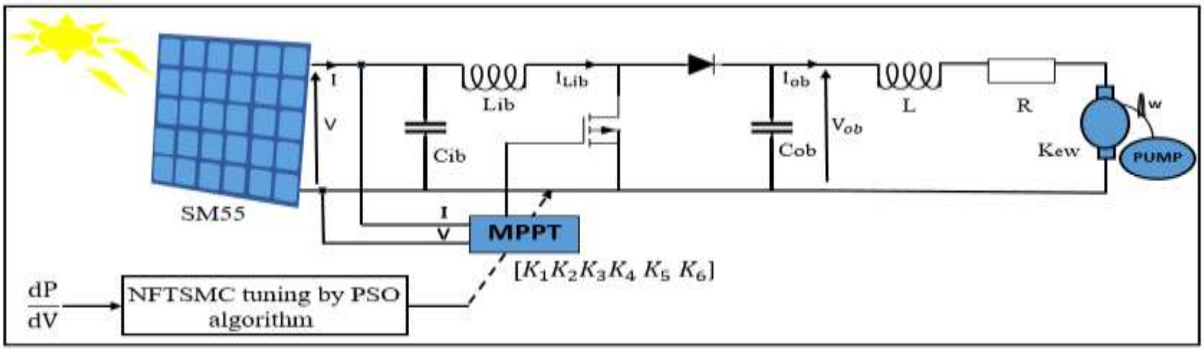

Figure 1: *PV pumping system*

The Fig.1 demonstrates the configuration of the proposed PV pumping system. It's composed of PV array followed by a boost converter coupled to the unit DC motor- centrifugal pump. The objective of our controller is to force the PV panel to operate at its MPP in a fast time response.

To achieve this objective, let's consider the following dynamic [5]:

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = f(x,t) + g(x,t)u + \varepsilon(x,t) \end{cases} \tag{1}$$

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where $x_1 = \frac{dP}{dV}$, $u = 1 - \alpha$, and ε represents an unknown bounded function such as: $|\varepsilon| \le \bar{\varepsilon}$.

The NFTSMC controller is constructed as follows [7]:

$$u = \frac{1}{g}\left[-f - \frac{|x_2|^{2-K_4}}{K_3K_4}(1 + K_1K_2|x_1|^{K_2-1})sign(x_2) - K_5 sign(S) + K_6 S\right] \quad (2)$$

$$S(x,t) = x_1 + K_1|x_1|^{\frac{q_1}{p1}} sign(x_1) + K_3|x_2|^{\frac{d_1}{b1}} sign(x_2) \quad (3)$$

Where S is the sliding surface, $1 < K_2 = \frac{q_1}{p1} < 2$, $K_4 = \frac{d_1}{b1}$ and $K_2 > K_4$, $K_5 = \bar{\varepsilon} + \eta$, with η is a small positive constant. The positive gains constants K_1, K_2, K_3, K_4, K_5, and K_6 are determined by using the PSO algorithm [8].

3 Results and Discussion

The efficiency of the proposed controller (NFTSMC-PSO) is tested through comparison with the P&O algorithm and FTSMC presented in [1], [6]. The simulation results, obtained in a Matlab/Simulink environment, for different levels of irradiation and temperature, are shown in Tables (1, and 2).

Table 1: *Response time comparison*

G (W/m²)	**T (°C)**	**Response time (s)**		
		NFTSMC-PSO	FTSMC	P&O
1000	45	0.22	0.8	1.675
1000	25	0.04	0.25	0.45
600	25	0.025	0.1665	0.8

Table 2: *Control performance comparisons.*

	NFTSMC-PSO	FTSMC	P&O
ISE	$4.6706e^{7}$	$6.3632e^{7}$	-
P(w)	$1.7743e^{14}$	$1.771e^{14}$	$1.668e^{14}$

It can be observed that the response time for different climatic conditions is smaller with NFTSMC than with FTSMC and P&O results. Otherwise, ISE (Integral Square Error) is minimal with our proposed controller than other approaches. In addition, the panel produces more power in the NFTSMC method.

4 Conclusion

In this paper, we applied MPPT based on the NFTSMC technique and PSO algorithm to PVPS. NFTSMC approach is introduced to ensure fast convergence of PV power to its maximum. The PSO algorithm is used to optimize the proposed control parameters. The simulation results and comparison with P&O and

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FTSMC show the remarkable superiority of the proposed controller in terms of fast convergence of PV power to its desired, robustness and generation of max of power.

How to Cite

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