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A review of Power excellence optimization using a novel feedback controller of a three-phase grid-connected photovoltaic system

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ABSTRACT

In three-phase grid-connected solar photovoltaic (PV) systems, a novel nonlinear feedback controller based on direct current (DC) voltage control is proposed to control the flow of active and reactive power between the PV system and the grid with improved power quality v considering pure sinusoidal current injection with lower total harmonic distortion (THD), as well as to ensure unity power factor or to compensate for the reactive power required by the load, i.e. the electrical network. The output power of the PV array is fed to the grid via a maximum power point tracking (MPPT) boost converter and an inverter. The simulation results of the proposed controller show good robustness under rated conditions, parameter variations and load disturbance, which is the main advantage of this controller compared to the existing controller. The performance of this work was evaluated using the MATLAB/Simulink environment.

INTRODUCTION

Currently, a trend of rapid growth in energy needs is observed in the world. As a result, most countries use renewable energy sources (RES) to generate electricity. What is new is the integration of RES, such as wind and solar energy, into the energy grid at the distribution level [1]. These distributed energy sources inject electrical energy directly through a solar or wind system based on power electronic converters [2], [3]. Photovoltaic (PV) system topology is divided into two categories: The first type is a single-stage PV system [4]–[6] in which the grid is connected directly to the PV sources via DC/AC. current (DC/AC) inverter to achieve maximum power point tracking and unity power factor (UPF). The second type is a two-stage PV system [7]–[9] in which PV panels are connected to the grid via a DC/DC boost power converter that operates with maximum power point tracking (MPPT) and a DC/AC converter to achieve UPF.

In this work, two-stage power conversion in the distribution network was used. Therefore, photovoltaic solar systems consist of an array of solar modules, a DC-DC power converter and a DC-AC converter as the final interface [10], [11].

The goal of the main control of grid-connected photovoltaic systems is to extract the maximum power from the PV and inject active and reactive power into the grid within the maximum available power, while improving the quality of the delivered power [12]. Traditional linear controllers [13]–[15] are often used for their simplicity of construction and versatility in solving various practical control problems. However, due to the nonlinearities of grid-connected PV systems in the presence of parametric uncertainties. Several studies have been conducted in the literature review on grid-connected photovoltaic systems. Lalili et al. [18] propose a feedback linearization (FBL) technique to eliminate inherent nonlinear effects in a photovoltaic system by converting the system to partially or fully linearized. However, these feedback linearization controllers are extremely sensitive to parameter changes. In [19], [20], the authors propose a sliding mode controller that guarantees the fulfillment of control objectives even in the case of nonlinearities, fluctuations of model parameters and external disturbances. However, the oscillations are caused by high-frequency switching and can reduce the output power due to jitter [21].

The feedback controller based on the Lyapunov function overcomes some of the disadvantages of the feedback linearization controller by taking into account the full nonlinearities of the system. In [22], [23], the authors propose a design of a feedback controller for the non-linear behavior of the switching current on the inverter side to control only active power while ensuring unity power factor (UPF) with assumed reactive power. be zero. However, this control method was not able to achieve the objectives with good performance under PV system constraints (climate changes, parametric uncertainties and load change). In addition, the reactive power required by the load must be provided by the power grid or external compensation devices, which is extremely expensive.

OBJECTIVE OF THEWORK

the aim of this study is to develop a new feedback controller based on DC link voltage control as in [24] to meet the control objectives of ensuring maximum power consumption and controlling the flow of active and reactive power between the PV system and the grid. , as well as improving power quality by injecting sinusoidal current with low harmonic distortion, even in the presence of parameter changes and external disturbances. This method can eliminate the limitations of existing controllers by optimizing the dynamic responses of the PV system, controller robustness and performance stability. The rest of the paper is structured as follows: first, the system description and dynamic model are presented in Section 2. In section 3, there is a design of the controller strategy of the boost converter and the three-phase AC converter. Section 4 is devoted to simulation results with different analyses. Finally, a conclusion is formulated.

Conclusion

In this paper, a novel feedback controller based on DC link voltage control using a power balance method is proposed to control the flow of active and reactive power in a grid-connected solar PV system. The performance of the implemented controller is evaluated using numerical simulations in the MATLAB/Simulink environment. The system continues to meet the overall objectives under the various operating conditions for which it was developed, such as i) tracking the maximum power point, ii) controlling the DC link voltage at a given reference value, and iii) injecting active and reactive power into the grid with lower harmonics.

As shown by the simulation results, the proposed feedback controller performs satisfactorily in terms of improving the power quality by reducing the THD of the current injected into the grid. This controller is also found to be globally stable under changing atmospheric conditions compared to the existing controller. The proposed controller can also ensure the maximum energy input to the grid under different operating conditions by maintaining the energy balance inside the grid-connected PV system.

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