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Improve the energy efficiency of PV systems by installing a soft switching boost converter with MPPT control

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ABSTRACT

To improve the energy consumption rate of solar cells and reduce switching loss, a maximum power point tracking (MPPT) control approach is presented to manage the boost converter and achieve soft switching. A method for determining the optimal values of the soft switching boost converter design parameters has been proposed, by determining the ideal values for the inductor, capacitor, and duty cycle of the boost converter with soft switching, this method enables the key matching of the PV system with the DC/DC converter configuration. In addition to presenting an analysis of several MPPT methodologies, the entire design of the PV converter system is also included. This study compares the perturb-and-observe (P&O) method and the incremental conductance (IC) method for maximum power point tracking (MPPT) in the MATLAB/Simulink application. The PV systems with both MPPT algorithms have been simulated beginning with an implemented model of the photovoltaic (PV) array together with the soft switching boost converter and its MPPT control. The simulation results based on irradiance and temperature are then shown. In the end, soft-switching is more efficient than hard-switching, especially when operating at full load.

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1. INTRODUCTION

Research and development of alternative energy sources that are cleaner, renewable, and have less impact on the environment have been sparked by the rising demand for energy and the potential for limited availability of conventional fuels [1]. Due to the ongoing price decline of PV modules and the rise in solar PV cell efficiency, solar photovoltaic (PV) power systems have become the most extensively used electricity sources worldwide [2]. Photovoltaic (PV) technology, which has grown in popularity, has been adopted by many industrial purposes, from small battery chargers to massive power plants supplying electricity for the electric power grid. A viable alternative for feeding future smart grids and smart cities is PV applications, which are regarded as a sustainable energy source [3]–[6]. Making PV systems competitive with traditional power sources that produce electricity using fossil fuels has become a recent problem [7]–[9]. This objective could be accomplished by lowering the cost of the PV system's components (PV modules and soft switching boost converters) as well as increasing conversion efficiency. Because it is the most significant component affecting the total efficiency of PV systems, the soft switching DC-DC boost converter efficiency has caught the attention of researchers and engineers [10]–[13]. The negative impacts associated with the second disadvantage may be significantly reduced if the magnitude of the duty-cycle perturbations are matched to the