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Optimal Design OF MPPT Controllers for Grid Connected Photovoltaic Array System

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Abstract

Integrating photovoltaic (PV) plants into electric power system exhibits challenges to power system dynamic performance. These challenges stem primarily from the natural characteristics of PV plants, which differ in some respects from the conventional plants. The most important challenge is how to extract and regulate the maximum power from sun. This paper presents optimal design for the most commonly used Maximum Power Point Tracking (MPPT) techniques based on Proportional Integral tuned by Particle Swarm Optimization (PI-PSO). These suggested techniques are, (1) the incremental conductance, (2) perturb and observe, (3) fractional short circuit current and (4) fractional open circuit voltage techniques. A comprehensive comparative study with respect to the energy availability ratio from photovoltaic panels was performed. The simulation results have proved that the proposed controllers have an impressive tracking response. The system dynamic performance improved greatly using the proposed controllers.

Keywords

Photovoltaic; maximum power point tracking techniques; PI controller; particle swarm optimization (PSO); energy availability ratio.

1. Introduction

Over the past two decades, interest in the use of environmentally friendly renewable energy resources has intensified. Of various alternative energy sources, solar energy is one of the most prominent sources of electrical energy in years to come. The increasing concerns to environmental issues demand the search for more sustainable electrical sources. Solar energy along with wind turbine and fuel cells are possible solutions for environmental energy production [1].

The photovoltaic (PV) generation is one of the most useful applications of renewable energy sources. PV sources are used today in many applications such as battery charging, water pumping, home power supply, swimming pool heating system, satellite power systems etc. they have many advantages like pollution free, silent and electricity is directly fed into distribution networks.

Despite all the advantages presented by the PV energy generation, the maximum power extracted is currently low, and the initial cost for its implementation is still considered high. Thus, it becomes necessary to use technologies to extract the maximum power from these panels to meet maximum operation efficiency.

This paper is presented as follows; section 1: is the introduction, section 2: presents a comprehensive description for the system under study, and some ideas about system modeling point of view as it relates to equivalent circuit analysis. Then, Section 3: describes generally what MPPT entails. Next, the concepts of the most commonly used MPPT techniques were introduced in section 4. These concepts were followed by discussion of an ideal basic PI controller and the need for optimal parameters tuning. Section 5: concludes the simulation results by discussing how solar irradiance, temperature, current and voltage relate to maximum power and energy. The main conclusion is presented in section 6.

2. System Configuration and Modeling

In this section the proposed system comprises of 100kW PV array, dc-dc boost converter, dc-ac converter (inverter) and distribution grid [2-3]. The block diagram of the developed system is shown in fig.1.The general mathematical model for the solar cell has been studied over the past three decades [4].The equivalent circuit of the solar cell model consists of photo current diode, parallel resistor (leakage current) and series resistor as shown in Fig.2.The mathematical model of solar cell can be written as follows [5-6]:

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