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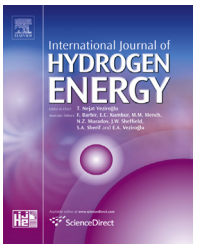

Fuzzy-PSO controller design for maximum power point tracking in photovoltaic system

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ABSTRACT

Photovoltaic power generation system becomes increasingly important, highly attractive as a clean and renewable energy sources, widely used today in many applications. Recently, researchers have strongly promoted the use of solar energy as a viable source of energy due to its advantages and which it can be integrated into local and regional power supplies. The P–V curve of photovoltaic system exhibits multiple peaks under various conditions of functioning and changes in meteorological conditions which reduces the effectiveness of conventional maximum power point tracking (MPPT) methods and the Particle swarm optimization (PSO) algorithm is considered to be highly efficient for the solution of complicated problems.

In this paper, the application of this approach based MPPT algorithm for Photovoltaic power generation system operating under variable conditions is proposed to optimize and to design an intelligent controller comparing to conventional one. PSO Approaches is considered to select and generate an optimal duty cycle which varies with photovoltaic parameters in order to extract the maximum Power. Simulation results show that the proposed approach can track the maximum power point faster and can improve the performance of the system compared to the conventional method.

Introduction

Nowadays, the research and the development of new energy sources such as wind, water, geothermal and solar energy around the world is continuously enhanced and it has become an increasingly important topic with the problem of energy crisis and the development of society. The renewable energy sources have become a more important contributor to the total energy consumed in the world. Among all the renewable and sustainable energy sources, solar energy provides the opportunity to generate various power scales without emitting any greenhouse gas [1]. It is envisaged to be a popular source of renewable energy due to several advantages, notably low operational cost, almost maintenance free and environmentally friendly. Despite the high cost of solar modules, PV power generation systems, in particular the grid-connected type, have been commercialized in many countries because of its potential long-term benefits [2]. Photovoltaic solar energy is a clean, renewable, green energy with a long service life and high reliability, which is inexhaustible and environment friendly. Photovoltaic source are widely used today in many applications such as: battery charging, water heating system, satellite power system, and others, it becomes one of the most

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promising alternatives for conventional energy sources and the most important renewable and sustainable energy system [3].

Recently, one of the major challenges for the researchers is to achieve power from clean and green energies. They have strongly promoted the use of solar energy as a viable source of energy which it possesses characteristics that make it highly attractive as a primary energy source that can be integrated into local and regional power supplies since it represents a sustainable environmentally friendly source of energy [4]. The research activities in the application of PV systems are being conducted in an attempt to gain further improvement in their cost, efficiency, reliability and to get benefit from their application. But, conversion efficiency of photovoltaic cells is low and the output of photovoltaic array is quite dependent to the environmental and operational conditions. Among all the factors affecting the output power of a PV array, ambient temperature, insulation, dirt, shading and sunlight characteristics can be counted as more important ones. Decreasing the solar irradiation due to cloudy weather and ambient temperature increment are the common factors which decrease the output power of a PV panel. Maximum power point tracking (MPPT) is the newest concept which helps to extract the maximum possible power from a PV array [5]. Due to the obvious non linear, the maximum power tracking (MPPT) circuit was connected between the photovoltaic devices and for the effectiveness of photovoltaic cells and typical diagram of such connection system is shown in Fig. 1. The maximum power point tracker (MPPT) is normally employed in conjunction with the power converter (*Dc–Dc* converter and/or inverter) to optimize the utilization of large arrays of PV in order to ensure that the system can always harvest the maximum power generated by the PV arrays. Conventional maximum power point tracking (MPPT) controllers are widely used due to simple implementation and show a good performance in tracking Maximum Power Point (MPP) when solar irradiance is uniform. However, considering their difficulty in tracking under variable conditions, tracking to MPP becomes complicated as multiple peaks exist on the Power–Voltage (P–V) characteristic curve. The P–V characteristic curve exhibits a maximum power point (MPP) that varies nonlinearly with these conditions, thus posing a challenge for the tracking algorithm where these techniques vary in complexity, accuracy and speed. Each method can be categorized based on the type of the control variable it uses: voltage, current or duty cycle [6].

Fuzzy logic has been considered as an efficient and effective tool in managing uncertainties and nonlinearities of systems. A fuzzy logic controller is generally designed in the light of experience and expert knowledge [7–9]. The use of the fuzzy logic controller in photovoltaic systems has been considered by several researcher [10–12] and [13] which it depends on expertise and that whatever the results.

Soft computing based algorithms were recently developed to obtain the global optimal solution under varying environmental conditions. The PSO is a swarm intelligence-based algorithm used to find the global optimal solutions. The reasons why PSO has gained the popularity is because it has only a very few parameters that need to be adjusted [14–16].

This paper focuses on the performance of maximum power point tracking controller to extract maximum power from PV system under variable conditions using an intelligent approach. The selected MPPT algorithms that have been proposed include Fuzzy Logic Controller and Particle swarm optimization. We propose a hybrid PSO algorithm capable of choosing an optimized fuzzy controller of Mamdani zero-order depending on the system performance, where the controller inputs and the output are respectively: the error, derivative of error, the power and the duty cycle. The algorithm automatically adjusts the triangular membership functions of the inputs and output. Results show that the simulated MPPT controller is capable of tracking the maximum power and performance of the proposed technique have been modeled and analyzed under Matlab/Simulink.

Photovoltaic equivalent circuit model

PV cells are basic units in the structure of a PV module. Based on the photoelectric phenomenon, they can transfer the energy of sunlight photons to the electrical energy. The model of solar cell can be categorized as p–n semiconductor junction; when exposed to light, the DC current is generated. The nonlinear and exponential relation between current and voltage of a PV module is extensively described by many researchers; the generated current depends on solar irradiance, temperature, and load current [17]. The typical equivalent circuit of PV cell is shown in Fig. 2. Among various modeling

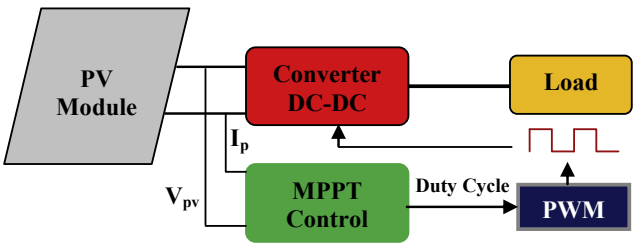

Fig. 1 – Diagram of MPPT in PV system.

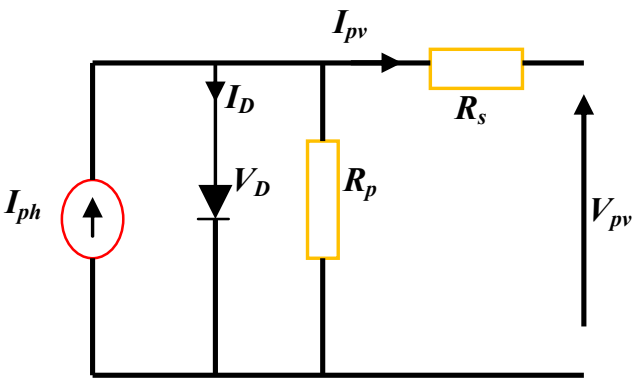

Fig. 2 – Electrical circuit scheme of solar cell.

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