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Conventional and modified MPPT techniques with direct control and dual scaled adaptive step-size

Aamir Amir[a], Asim Amir[a], Jeyraj Selvaraj[a], Nasrudin A. Rahim[a,b,*], Abdullah M. Abusorrah[b]

[a] UM Power Energy Dedicated Advanced Centre (UMPEDAC), Level 4, Wisma R & D, University of Malaya, Jalan Pantai Baharu, 59990 Kuala Lumpur, Malaysia
[b] Renewable Energy Research Group, King Abdulaziz University, Jeddah 21589, Saudi Arabia

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ABSTRACT

Conventionally, for adaptive MPPT change in power over change of voltage (dP_{PV}/dV_{PV}), change in power over change of current (dP_{PV}/dI_{PV}) or change in power over change of duty (dP_{PV}/dD) had been utilized for variable stepping. However, this paper presents dual scaled adaptive step sizing, depending on change of power (dP_{PV}). This technique reduces complexity, improves transient and dynamic response to sudden irradiance changes. As, PV characteristic curve has two different slopes, one at the left and the other at the right of MPP. Nevertheless, a constant fine-tuned scaling factor for operation at left of MPP may cause overshoot or undershoot at right side of MPP. Similarly, constant scaling factor offering good performance at right slope of the MPP may give slow voltage response when the system operates at left of MPP. Therefore, dual scale adaptive technique dependent on change of power (dP_{PV}) has been proposed to attain credible performance at both sides of the slope. This technique has been employed on conventional and modified MPPT schemes with direct control, explicitly on modified Incremental Conductance (IncCond) method. Further, the aim is to establish the fact that even with direct implementation, IncCond remains a specific implementation of P & O, by comparatively analyzing the performance of each method. Simulation and experimental results authenticate the validity of the proposed scheme.

1. Introduction

Amongst the many available renewable energy sources, solar energy remains the most promising choice because it is abundant, clean, reliable, emission free, and does not require rotating parts which make its installation easy in remote areas (Ascione, 2017; Kuhn, 2017; Huld, 2017; Michael and Selvarasan, 2017; Ando et al., 2017). However, solar energy generated from PV arrays confronts issues of weather dependency, low efficiency, a very high initial cost and the well-known nonlinear I–V characteristics (Hirata and Aihara, 2017; Xu et al., 2017; Al-Obaidi et al., 2017; Nofuentes et al., 2017; Alik and Jusoh, 2017; Hosseinnezhad et al., 2017). To address these shortcomings, most of the research on PV system has been on harnessing maximum output from the PV arrays. In addition, the point on the PV curve where output power is optimum is the known as the MPP. It exists at the knee of PV curve. Many MPPT techniques have been employed by researchers, a wide range of MPPT techniques with digital and analog classification has been presented in Amir et al. (2016). Although many MPPT techniques have been proposed, the conventional MPPT techniques such as hill climbing (Tan et al., 2015; Xiao et al., 2016), perturb and observe (P & O) Alik and Jusoh, 2017 and incremental conductance (IncCond) Tey and Mekhilef, 2014 methods offer the simplest implementation and are widely employed. Previously, IncCond method was considered to have better performance than the P & O method, in terms of reduced steady-state oscillations and correct response under sudden irradiance changes (Hussein et al., 1995). Nevertheless, (Sera et al., 2013) has demonstrated that these conventional techniques are actually almost similar, mathematically equivalent and offer identical efficiencies under both static and dynamic conditions. However, conventional techniques with direct control method (Safari and Mekhilef, 2011; Ahmed and Shoyama, 2010) have not been compared. Hence, in this paper an attempt has been made to discuss the working principle of the various conventional MPPT schemes with direct implementation and to compare their performances in terms of tracking speed, exact MPP tracking ability, implementation complexity, cost, efficiency and stability of the system. The primary issue of all the conventional MPPT methods is the choice of the duty cycle step-size, which appears as a trade-off between the magnitude of the steady-state oscillation and the

* Corresponding author at: UM Power Energy Dedicated Advanced Centre (UMPEDAC), Level 4, Wisma R & D, University of Malaya, Jalan Pantai Baharu, 59990 Kuala Lumpur, Malaysia.
E-mail addresses: aamir.a@siswa.um.edu.my (A. Amir), asim20588@gmail.com (A. Amir), jeyraj@um.edu.my (J. Selvaraj), nasrudin@um.edu.my (N.A. Rahim), aabusorrah@kau.edu.sa (A.M. Abusorrah).

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