Published in IET Renewable Power Generation
Received on 6th December 2012
Revised on 7th May 2013
Accepted on 17th May 2013
doi: 10.1049/iet-rpg.2012.0362

ISSN 1752-1416

Development of adaptive perturb and observe-fuzzy control maximum power point tracking for photovoltaic boost dc–dc converter

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Abstract: This study presents an adaptive perturb and observe (P&O)-fuzzy control maximum power point tracking (MPPT) for photovoltaic (PV) boost dc–dc converter. P&O is known as a very simple MPPT algorithm and used widely. Fuzzy logic is also simple to be developed and provides fast response. The proposed technique combines both of their advantages. It should improve MPPT performance especially with existing of noise. For evaluation and comparison analysis, conventional P&O and fuzzy logic control algorithms have been developed too. All the algorithms were simulated in MATLAB-Simulink, respectively, together with PV module of Kyocera KD210GH-2PU connected to PV boost dc–dc converter. For hardware implementation, the proposed adaptive P&O-fuzzy control MPPT was programmed in TMS320F28335 digital signal processing board. The other two conventional MPPT methods were also programmed for comparison purpose. Performance assessment covers overshoot, time response, maximum power ratio, oscillation and stability as described further in this study. From the results and analysis, the adaptive P&O-fuzzy control MPPT shows the best performance with fast time response, less overshoot and more stable operation. It has high maximum power ratio as compared to the other two conventional MPPT algorithms especially with existing of noise in the system at low irradiance.

1 Introduction

In recent years, various research works have been done on the use of photovoltaic (PV) energy as alternative resource. PV energy is one of the most promising renewable energy resources and it is much clean, inexhaustible and free to harvest [1]. Several applications employing this technology have been developed such as satellite power systems, solar power generations, solar battery charging stations and solar vehicles [2–5]. The main disadvantage of PV is the low efficiency of energy conversion as compared with other alternative resources. PV is a non-linear source that depends on irradiation and temperature in its operation. Maximum power point tracking (MPPT) is introduced to extract the maximum power from the PV array.

Currently, perturb and observe (P&O) algorithm is the most popular and used widely since it is the simplest algorithm and easy to be implemented as compared with other methods [6–9]. However, it still has common drawbacks as follows:

- Poor tracking, not intelligent enough and less efficient during rapid change of the irradiance because it moves away from the real maximum power point (MPP) [10, 11].
- Inability to verify whether the higher new output power value is because of the new irradiation amount or the new duty cycle value [10].
- Continuous oscillations around the optimal operating point make the average power level is deviated from the MPP especially at low irradiance [12, 13].
- It goes back and forth around the MPP and unable to stick exactly [14].
- Slow time response [15].

Another possible significant drawback of this algorithm is its inability to perform well with existing of noise. In such PV system, noise factor exists and must seriously be considered not only because of non-linearity of PV source, but may come from the embedded controller, voltage and current measurements [16]. The noises from both measurements have significant effect on the decisions made by the MPPT algorithm [16–18]. In specific case, for example, at the MPP, the algorithm is expected to make an equal number of decisions for incrementing and decrementing the reference, leaving the operating point constant on average [16]. With noisy voltage and current measurements, some of the decisions made by the algorithm become incorrect. The noise from voltage measurement will affect the right hand side of the PV