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Performance enhancement of solar photovoltaic system using novel Maximum Power Point Tracking

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ABSTRACT

The electrical power supplied by the photovoltaic (PV) array depends on insolation, temperature and load. On the other hand, the actual power produced by the PV array is not fully transferred to the load. Therefore, it is necessary to extract maximum power from PV array. Maximum Power Point Tracking (MPPT) is a power electronic system that extracts maximum power from PV system. MPPT varies the electrical operating point of the PV modules and enables them to deliver maximum available power. In this work, a new MPPT algorithm is designed that uses open circuit voltage and short circuit current, sampled from a reference PV Panel. Using these measurements the maximum power is been tracked from main panel without breaking the power transferred to load. A buck boost converter was used to match impedance between source and load to facilitate maximum power transfer. The proposed algorithm was checked for its performance in local environmental condition.

1. Introduction

Out of different technologies available for harnessing the solar energy, photovoltaic (PV) is the simple and reliable technology which directly convert solar energy into electricity which is the most convenient form of energy for utilization. The output power from the PV system depends on PV cell efficiency, irradiation, cell temperature and load impedance. For given PV cell, extracting maximum power for given atmospheric condition, depends on the capability of the system operating close to maximum power point. The Maximum Power Point Tracking (MPPT) involves the adjustment of output voltage and/or current of the PV system for given load, irradiation and cell temperature. Tracking maximum power not only increases the power output, but also increases the life of the system [1].

So far, different types of MPPT methods have been developed and employed [2–9]. These methods can be differentiated depends on the sensors used, convergence speed, cost, range of effectiveness, implementation hardware requirements and popularity [3]. Based on the approach used for generation of the control signal, these methods are categorized as online method, offline method and hybrid method.

Offline method is very simple [10–12] and further classified into open circuit voltage (OCV) method and short circuit current (SCC) method. Open circuit voltage (V_{oc}) method uses approximate linear relation between OCV and maximum power point voltage (V_{mpp}) at different environment conditions (Eq. (1)). Short circuit current (I_{sc}) method also uses approximate linear relation between SCC and maximum power point current (I_{mpp}) at different environment conditions (Eq. (2)).

$$V_{mpp} \approx k_1 V_{oc} \tag{1}$$

and

$$I_{mpp} \approx k_2 I_{sc} \tag{2}$$

where k_1 and k_2 are constants depend on the solar cell characteristics. Due to practical problems related measurement, the SCC method is more accurate and efficient than the OCV method [12]. The main drawback of the offline method is load interruption occurring during measurement of I_{sc} or V_{oc}. Also, this method fails to predict the exact maximum power point using either the Eq. (1) or Eq. (2) [4].

In online methods, the instantaneous values of the PV output voltage or current are used to generate the control signals. This includes perturbation and observation method (P&O), extremum seeking control method (ESC) and incremental conductance method (IncCond). In perturbation and observation method, PV system voltage or current is changed by applying a series of small and constant perturbations on a step-by-step basis until the power delivered is maximum [8,13,14]. The problems associated with this method are amplitude of perturbation and rate of convergence. Extremum seeking control method (ESC) is a real-time

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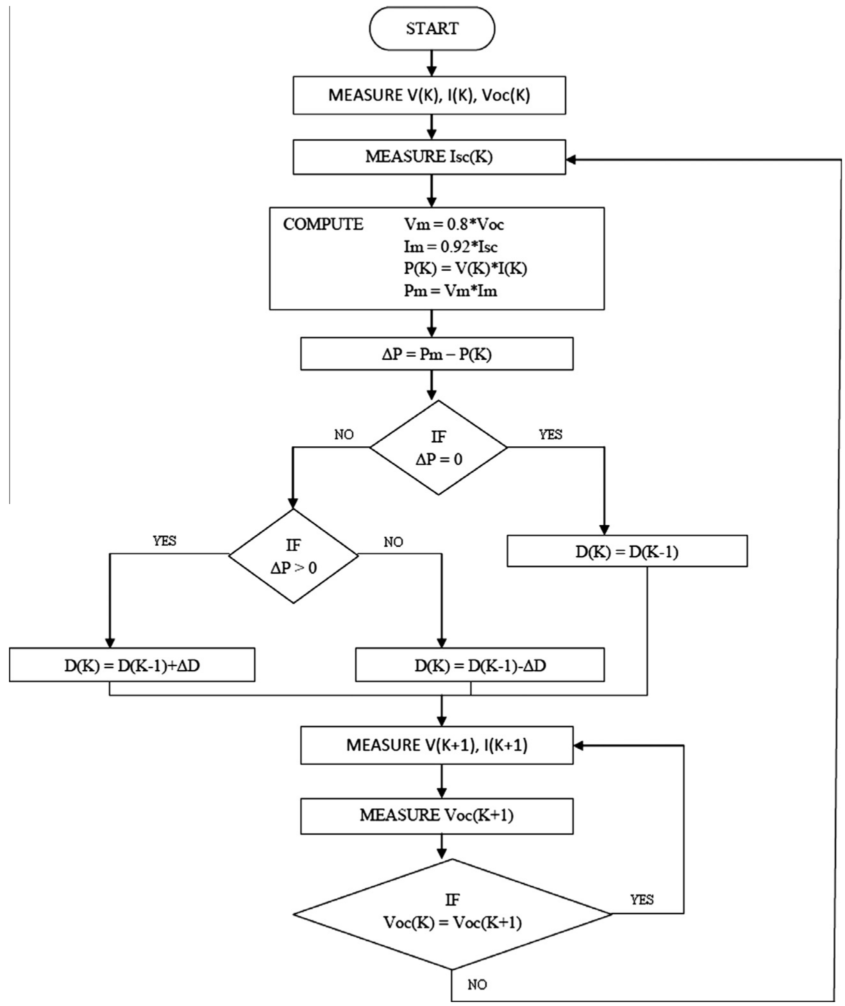

Fig. 1. Flow chart of proposed MPPT algorithm.

Table 1
Details of the PV panel used.

Solar panel model	USL 12 (Udhaya photovoltics)
Panel power	12 Wp
Maximum voltage	17.1 V
Maximum current	0.70 A
Open circuit voltage	21.5 V
Short circuit current	0.79 A

optimization methodology for a nonlinear dynamic system with adaptive feedback, employed to track MPPT [15–17]. The disadvantages of the ESC method are its complexity in implementation and the evaluation of relatively low amplitude signals. The incremental conductance (IncCond) method is based on the fact that the slope of the PV array power curve is zero at the MPP [18–20]. The main drawback of this method is that it requires complex control circuitry. In hybrid method [21], both offline and online methods are used in sequence to locate the MPPT accurately to optimize the complexity. Offline method is used to locate the MPP approximately first, then online method is used to locate the point accurately.

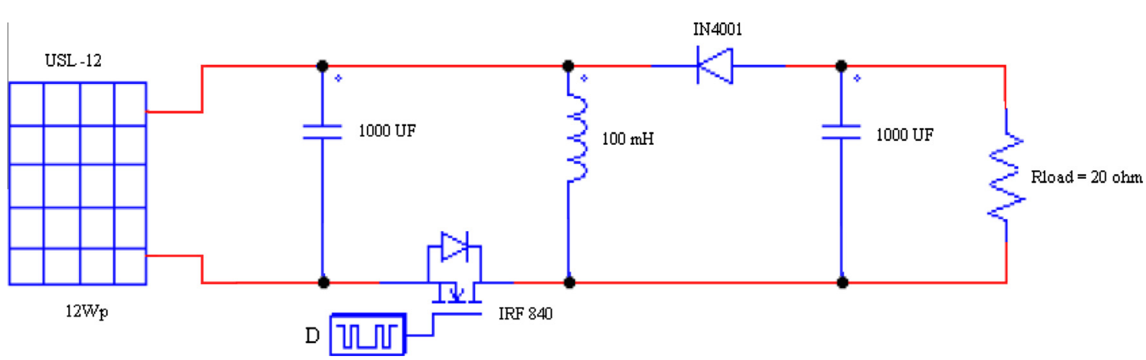

Fig. 2. Schematic of Buck–Boost Converter.