A Study of a Two Stage Maximum Power Point Tracking Control of a Photovoltaic System under Partially Shaded Insolation Conditions

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Recently, the photovoltaic (PV) system attracts a great deal of attention with the trend of electric power deregulation and environmental preservation. However, the output density of the PV is low and the output of the PV depends highly on an insolation condition and a surface temperature of the PV array. Moreover, there are several local maximum power points in the Current—Power (*I—P*) characteristic under non-uniform insolation conditions, whereas only one maximum power point in the *I—P* characteristic of the PV under uniform insolation condition. Therefore, the Maximum Power Point Tracking (MPPT) control is performed to maximize the efficiency of the PV system. Many papers have been reported in relation to the MPPT control technique under the partially shaded insolation distribution. Those papers are based on, for example, fuzzy theory, genetic algorithm and so forth. However, most of those control processes are rather complicated, and sometimes the operating point is likely to converge on a local maximum power point which is not the true peak power point on the *I—V* curve of the PV array.

Considering the above-mentioned situation, this paper describes a two stage MPPT control method which enables to track the real maximum power point on the *I—V* curve swiftly with relatively simple control process even under non-uniform insolation conditions. Fig.1 shows the movement of the operating points during the process of the proposed MPPT method. The two Stage MPPT control consists of the first step control and the second step control. The first step of the control process is to move the operating point to the vicinity of the real peak power point to avoid to converge to the local maximal power point. The second step control, the dV/dI control algorithm is used. Since the derivative of the output power *P* in terms of current *I* is equal to zero at the maximal point, equation (1) can be obtained.

$$\frac{V}{I} = -\frac{dV}{dI} \quad \cdots\cdots\cdots\cdots \quad (1)$$

In order to switch from the first step to the second step, the concept of an equivalent resistance R_{pm}, proportional to the ratio of the open circuit voltage V_{oc} to the short circuit current I_{sc}, is introduced into this control process, where both V_{oc} and I_{sc} are monitored by online measurement. R_{pm} is given by equation (2).

$$R_{pm} = \frac{V_{pm}}{I_{pm}} \quad \cdots\cdots\cdots\cdots \quad (2)$$

It is reported that V_{pm} and I_{pm} are approximately equal to 80% of V_{oc} and 90% of I_{sc} respectively. Then, if V_{oc} and I_{sc} are monitored by online measurement, the approximate value of R_{pm} can be obtained.

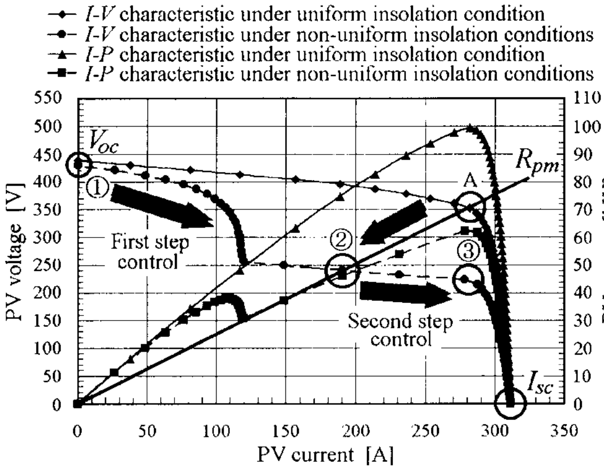

Fig.1. Characteristics of the PV array under uniform insolation condition and non-uniform insolation conditions, and the two stage MPPT control.

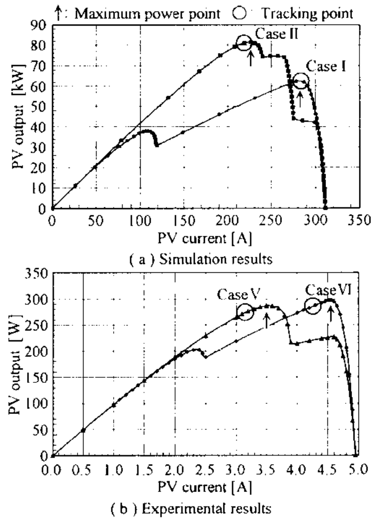

Fig.2. Tracking point of each case and the maximum power point.

It is confirmed by simulation study that this MPPT control system can track the real peak power point under non-uniform insolation conditions even when the insolation conditions dramatically changes. In addition, small-scale experiment confirms fundamental operation of the two stage MPPT control. Fig.2 shows the results of simulation and small-scale experiment. As mentioned above, the two stage MPPT control can track the maximum power point in each case.

The two stage MPPT control method combined with the instant online measurement of V_{oc} and I_{sc} was proposed in this paper. The feasibility of this control method was confirmed by the simulation and experimental study for various patterns of non-uniform insolation conditions.