A study of parameter estimation method for PV panel from weather information

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In recent years, the trend toward lower carbon of energy demand in the world is accelerating, so the introduction of photovoltaic (PV) power generation system is rapidly growing. However, it is conceivable that the cost required for maintenance of the entire systems will increase with the rapid progress in diffusion of PV power generation systems in the future. Therefore, for the purpose of suppressing the maintenance cost, the method for remotely identifying the state of the PV power generation system will be needed. In this study, we propose the estimation method for the equivalent circuit parameters of the PV panel using weather information, and we verify the proposed method by the numerical simulation.

Firstly, we describe the mathematical model of the PV power generation system. The PV power generation system is composed of the PV panel and the power conversion system, and the PV panel is expressed as the equivalent circuit consisting of the diode, the series resistance and the parallel resistance. The exponential function is contained in the Shockley diode equation; the current-voltage relation of the equivalent circuit model of the PV panel can be described by using Lambert W function. In the next place, we consider the system which charges the battery with the boosting chopper circuit connected to the PV panel as the power conversion system, and we express the dynamics of the power conversion system as the local time-averaged state space model. The PV panel cannot be treated like the ideal current source, and the current output of the PV panel is determined by the current-voltage characteristic dependent on the parameters of the equivalent circuit and the weather conditions. So, the power conversion system controls the duty ratio of the switching devise in the boosting chopper circuit for extracting power from the PV panel efficiently. The optimum operating point of the power conversion system is called the maximum power point; and the power conversion system can extract maximum power from the PV panel at the maximum power point. The control method tracking the optimum operating point by referring to the change in power with respect to voltage is called the maximum power point tracking (MPPT) control, which is the algorithm adopted to many converters. We consider the system operated by MPPT control as the model of the power conversion system.

Secondly, we describe the estimation of the parameters of the PV panel. The power-voltage characteristic of the PV panel gives the extremum at the maximum power point. Therefore, constraint equation is given under the condition that the power conversion system operates at the maximum power point from the analysis of the current-voltage relation including the Lambert W function. To this constraint equation, we assign the measured current, voltage and weather conditions; we can estimate the unknown parameters of PV panel.

Finally, we confirm the validity of our proposed method by the numerical simulation.

Keywords: Solar cell, Remote sensing, Maximum power point control