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Active islanding detection method for the grid-connected photovoltaic generation system

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ABSTRACT

This paper proposes an active islanding detection method incorporated into the control of the grid-connected inverter to protect the photovoltaic generation system from the islanding operation. The proposed active islanding detection method performs the grid-connected inverter as a virtual resistor with the operation frequency slightly higher or lower than the fundamental frequency of the utility voltage. The function of virtual resistor will not be actuated when the utility is nominal, and the grid-connected inverter can convert the DC power from the solar array to an AC power. When the strong utility is lost, the grid-connected inverter acts as a virtual resistor with the operation frequency slightly higher or lower than the fundamental frequency of the utility voltage. Thus, the frequency and the amplitude of the local load voltage will be away from their normal values under the islanding operation. Hence, the proposed active islanding detection method can immediately detect the islanding operation. A prototype is developed and tested to demonstrate the performance of the proposed active detection method. Both computer simulation and experimental results verify that the performance of the proposed active islanding detection method is expected.

1. Introduction

The interest in renewable energy has been increased due to Kyoto agreement on the global reduction of greenhouse emissions. Small-capacity distributed power generation systems, including solar power, wind power, are directly incorporated into the utility for supplying electric power to local load or injecting into the utility [1,2]. The photovoltaic generation system is an important small-capacity distributed power generation system. Fig. 1 shows the system configuration of a grid-connected photovoltaic generation system. The utility is adapted to supply AC power with an almost fixed frequency. The grid-connected photovoltaic generation system includes a solar cell array, a DC/DC converter and a DC/AC inverter. The DC/DC converter is used to trace the maximum power point of the solar cell array and regulate the voltage generated by the solar cell array to match the required DC voltage of the DC/AC inverter. The DC/AC inverter is adapted to convert a DC power into an AC power for supplying to the local load or injecting into the utility. The utility and the grid-connected photovoltaic generation system are connected in parallel via circuit breakers. The circuit breaker CB1 is for connecting or disconnecting the local load to the utility, while the circuit breaker CB2 is for connecting or disconnecting the grid-connected inverter to the local load.

When the utility power interruption occurs, the grid-connected photovoltaic generation system still supplies power to the local load. This phenomenon is known as the "islanding operation" [3–5]. There are many reasons for being the islanding operation undesirable.

First, it creates a safety hazard to maintenance workers. Second, islanding operation may cause unregulated voltage and frequency of the electric power, which may damage the electrical equipment. Third, the standard protection relays installed at the grid-connected point may function incorrectly. Finally, once the utility is recovered, islanding operation may cause asynchronous problem between the grid-connected photovoltaic generation system and the utility. Hence, many islanding control standards, such as UL 1741 [6], IEEE Std. 1547.1-2005 [7], IEEE Std. 929-2000 [8] and VDE 0126-1-1 [9], have been established for the grid-connected system. IEEE Std. 929-2000 and UL 1741-2000 address the issue of islanding operation and suggest a procedure for testing and qualifying the distributed power generation system. The IEEE 1547.1-2005 has been developed to address the interconnection issues for all types of the distributed power generation systems.

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