Unnecessary Operation Prevention Method of Islanding Detection in Photovoltaic Power Generation

Background

When distribution lines are disconnected from the utility system due to distribution line failure or maintenance, dangerous islanding phenomena of distributed power generation sources (DG) are prevented by detecting voltage change or frequency change including sudden voltage phase change under such disconnection of distribution lines. On the other hand, sudden voltage phase change occurs in normal conditions during route changes of distribution lines and so on. As a result, DG power sources may stop their operations simultaneously due to mistaken islanding detection. Simultaneous stoppage of operations may cause either abnormal drop of the distribution line voltage or instability of the whole system.

CRIEPI is developing a technique for coping with both prevention of the unnecessary detection in normal operation and rapid *1 reliable detection of islanding, based on past research and development concerning the islanding detection method. For establishment of the method, it is necessary to clarify improved methods by testing and evaluating the unnecessary detection characteristics of the current islanding detection function.

Objectives

The purpose of this study is to test and evaluate unnecessary detection characteristics regarding sudden voltage phase changes in the power conditioning subsystem (PCS) for residential photovoltaic (PV) power generation currently being disseminated. Also, an improved method for balancing prevention of the unnecessary detection and speeding up necesary detection of islanding is clarified through developing a simulation model for analyzing transient characteristics of the PCS.

Principal Results

1. Characteristics of unnecessary detection to sudden phase change and proposal of improved method

A demonstration test of sudden phase change for 10 Japanese representative types of PCSs is carried out. As the result, it is clear that 70% of the PCSs tend to stop the operation by the unnecessary detection of islanding detective function in the event of phase sudden change less than actual 10 degrees. On the other hand, it is also clear that establishment of a detection time counter is useful for preventing the unnecessary detection because PCS considered the continuance time of the deviation from threshold level does not reach the unnecessary detection. From the result, an improved method based on the current method of detecting the frequency change rate is proposed. In this method, frequency change rate is calculated by moving average of 2 cycles and islanding is detected when the frequency change rate exceeds threshold level continuously more than twice as much as the moving average cycles.

2. Development of simulation model for transient analysis and evaluation of developed method

Based on both the result of past investigation including demonstration test and above experimental result of PCS, a generalized model of PCS control and main circuits is developed for the transient analysis less than 5 seconds (Fig.1). From the results of EMTP simulation using the developed model comparing with the conventional passive islanding detection method, it is confirmed that both prevention of the unnecessary detection in normal operation and rapid reliable detection of islanding are best satisfied by the proposed method shown in Table 1. Besides, proper operation of the proposed method according to design is also confirmed by a demonstration test. From above, the validity of the proposed method is verified.

Future Developments

We will establish stable operation technique for PV through investigating prevention of unnecessary detection in the event of voltage sag in addition to the sudden voltage phase change.

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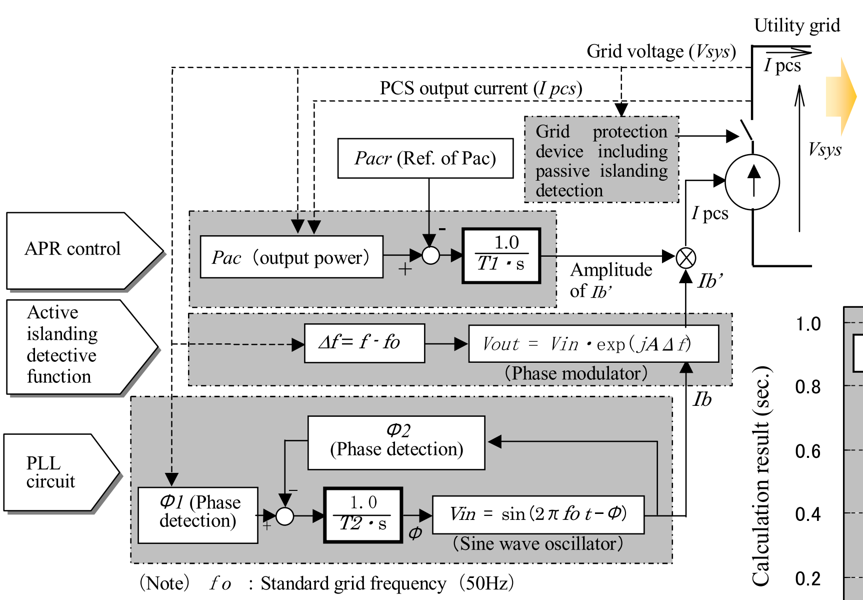
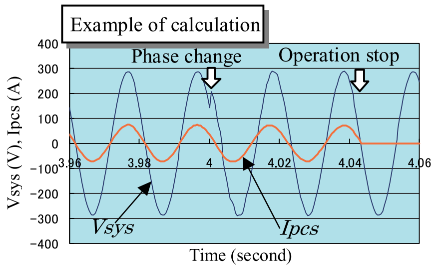
Reference

H. Kobayashi, et.al., 2008, "Development of Transient Analysis Model of Grid Interconnected PCS for Photovoltaic Power Generation", CRIEPI Report R07027 (in Japanese)

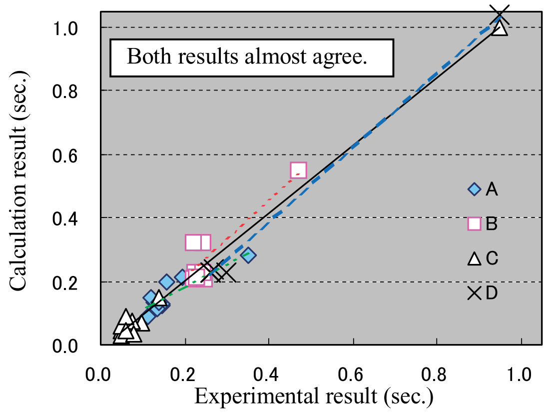
H. Kobayashi, et.al., 2008, "Development of Islanding Detection Measure for PV Power Generation to Achieve Stable Operation in Sudden Phase Change of the Grid Voltage", CRIEPI Report R07029 (in Japanese)

*1 : 0.1 second is targeted taking account of required system shut down time in the event of ground fault of 6.6kV high voltage distribution line due to failure of pole mounted transformer supplying low voltage customers.





a) Simulation model of PCS for PV power generation



b) Comparison between experimental result and calculation result of islanding time of each PCS.

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Fig.1 Developed transient analysis model of PCS for PV and result of validity conformation

Table 1 Simulation results of passive islanding detection methods

Type of islanding detection	Detection method	Response to sudden phase change (0 to 90 deg.)	Frequency of over 0.1 sec. detection of islanding 〈Note)	Ranking
<Conventional> Sudden voltage phase change detection I	・Monitoring phase change ・Detection time counter ：N.A.	Detection over 6 deg. (×)	Small	3
<Conventional> Sudden voltage phase change detection II	・Monitoring phase change ・Detection time counter ：More than 4 cycles deviation from threshold level.	No detection (○)	Midle	2
<Proposed> Improved frequency change rate detection	・Monitoring frequency change rate ・Detection time counter ：More than 4 cycles deviation from threshold level.	No detection (○)	Small	1

(Note) Characteristic when frequency shift method is combined.