STUDY OF ISLANDING TEST METHOD USING MULTIPLE INTERCONNECTED PHOTOVOLTAIC INVERTERS
- EXAMINATION BY DIFFERENCE IN MOTOR LOAD INSTALLATION CONDITIONS -

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ABSTRACT: There are high expectations for photovoltaic (PV) power generation systems as a means of curbing the carbon dioxide (CO_2) emissions that cause global warming. Recently there has been rapid growth in the use of PV power generation systems installed locally (i.e. concentrated interconnection) to a specific power distribution system, and therefore there are issues regarding the safety of such systems and the quality of the electric power generated, such as rises in system voltage, increases in higher harmonics, and the emergence of the phenomenon of islanding operation.

This may be attributed to the launch by the New Energy and Industrial Technology Development Organization (NEDO) of verification research for concentrated interconnection PV power generation systems as a five-year program beginning in fiscal 2002 to aid the smooth and reliable growth of residential PV power generation systems in concentrated interconnection. The research and development concerned has included engineering development to meet the technical requirements for performing concentrated interconnection, such as the construction of systems allowing the effective utilization electric power generated by PV power generation systems. However, since no method of evaluating devices for detecting islanding operation during concentrated interconnection of PV power generation systems exists, there is an urgent need to establish a method of testing multiple interconnected photovoltaic inverters, and this has resulted in the launch of a two-year program of basic experiments and study of test methods beginning in fiscal 2006.

In this report, we identify issues that need to be resolved when developing the testing method, and perform studies under different motor load installation conditions, one of the issues to be examined.

Keywords: Photovoltaic, Interconnected, Interconnected photovoltaic inverters, Islanding, Motor Load, Resonance circuit,

1 INTRODUCTION

Recently there has been rapid growth in the use of PV power generation systems installed locally (i.e. concentrated interconnection) to a specific power distribution system, and therefore there are issues regarding the safety of such systems and the quality of the electric power generated, such as rises in system voltage, increases in higher harmonics, and the emergence of the phenomenon of islanding operation.

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2 OUTLINE OF RESEACH

2.1 Development of method of testing multiple interconnected photovoltaic inverters

No clear method of testing and evaluating multiple interconnected photovoltaic inverters has been offered to date, because the rapid spread of PV power generation systems was not taken into account in devising the JET test [(3)] setting method “Guidelines for technical requirements for interconnected electric power systems” [(2)] which has as its main purpose the evaluation of performance in islanding operation. However, due to a recent increase in the installation of multiple interconnected photovoltaic inverters in the same distribution line, the Japan Electrical Manufacturers' Association (JEMA) has determined the testing and operation methods required for multiple interconnected photovoltaic inverters, and begun to release the results of tests [(4)] for use in the installation of inverters.

Issues concerning methods for testing multiple interconnected photovoltaic inverters to be examined are identified on the basis of the JEMA testing methods.

2.2 Issues for study concerning testing methods for multiple interconnected photovoltaic inverters

The test results published by JEMA are the results of tests conducted by PCS manufacturers on their own

premises, not of tests conducted under identical conditions, due to differences in equipment and the like, however do reveal that evaluation is performed using motor load under the load conditions. In addition, the conditions of distribution lines and suchlike are not clarified, because the test is performed for the purpose of confirming mutual stopping of the PCSs. In terms of the conditions of the distribution line, there is a difference in the size of the PV power generation system in which a grid will be cut off, depending on the grid severance point of the distribution line. For instance, there may be a ten-fold or more difference between the amount of PV power generation on the secondary side of the cylindrical transformer and the PV power generation separated by the section switch as shown in Figure 1 "Outline of grid cut-off".

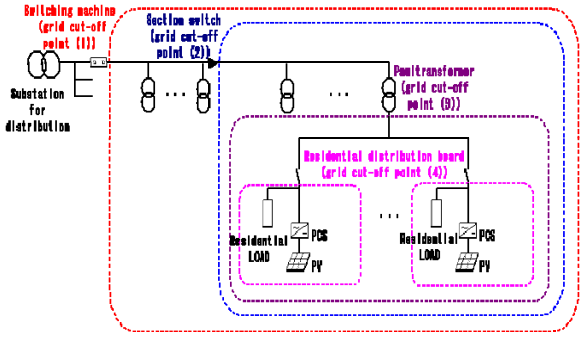

Figure 1: Outline of grid cut-off

3 EXAMINATION Of EXPERIMENTAL CONDITIOS

3.1 Experiment examining method of motor load installation.

The motor load is a load that makes inspection of islanding operation difficult when the power supply is cut off in the system [5]. Therefore, when examining the testing method, the number of loaded motors and the conditions of motor load installation and the like become critical issues.

In this study, islanding operation time is measured with regard to the effect of motor load on each PCS in the following cases: (Case 1) The proportion of PCSs for the number of the loaded motors is made equivalent (i.e. 1:1) and the motor load is dispersed for installation as shown in Figure 2, and (Case 2) The motor load is concentrated on one point and installed as shown in Figure 3. In addition, the types of PCS are defined as four and the number of PCSs increased in the order of 1, 2, 4, 6 and 8 to perform verification.

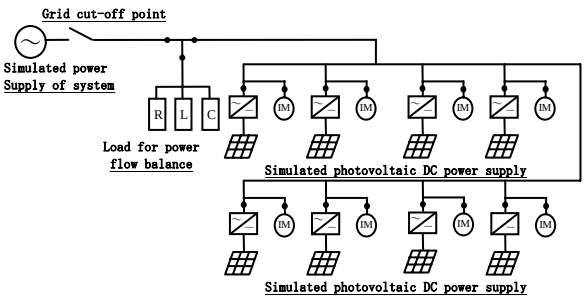

Figure 2: Setting up motor load-dispersion

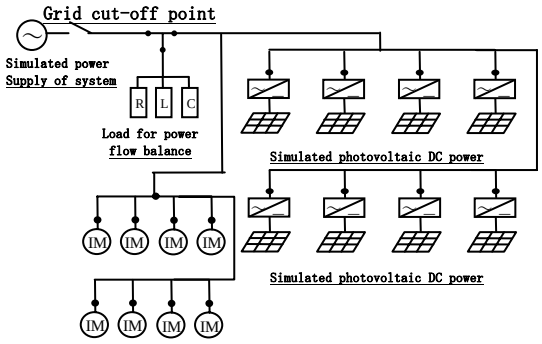

Figure 3: Setting up motor load-concentration

3.2 Result of experiment on method of motor load installation

The result of the experiment on islanding operation shows a similar tendency under load condition (Q=0) except when reactive power is in equilibrium, even when the motor load is dispersed or concentrated and installed and the number of interconnected PCS is changed. In addition, in the case of reactive power in a state close to equilibrium (Q=0), a tendency to extended islanding operation is confirmed.

In terms of the minimum duration of islanding operation, it can be confirmed that no notable difference exists even when the motor load is dispersed or is concentrated and installed and the kinds of PCS or the number of interconnected photovoltaic inverters for the PCS is changed. However, in terms of the maximum duration of islanding operation as shown in Figure 4 (for motor load-dispersion installation) and Figure 9 (for motor load-concentration installation), it can be confirmed that a difference in the duration of islanding operation exists, due to a difference in the number of two kinds of interconnected photovoltaic inverters respectively for Company B and Company D.

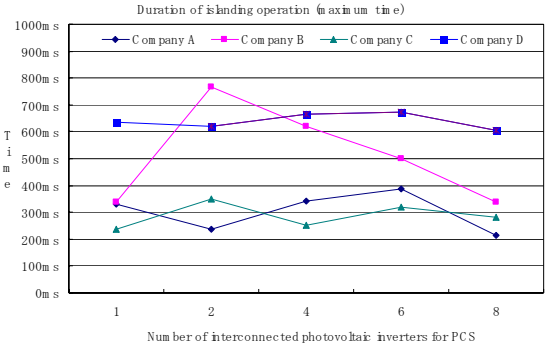

Figure 4: Result of setting up motor load-dispersion (maximum time)

Figure 5: Result of setting up motor load-dispersion (minimum time)

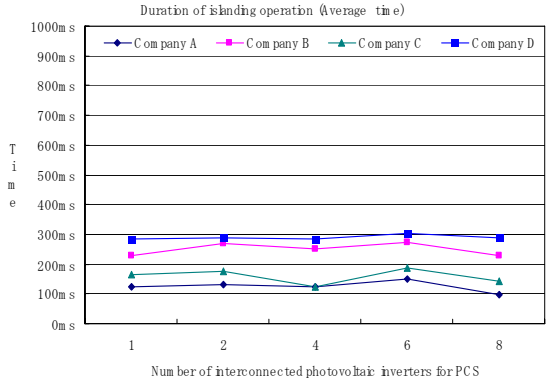

Figure 6: Result of setting up motor load-dispersion (average time)

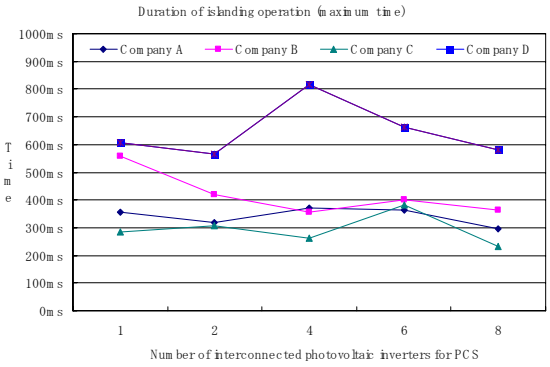

Figure 7: Result of setting up motor load- concentration (maximum time)

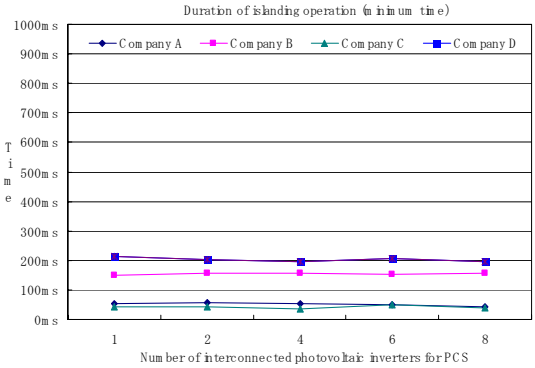

Figure 8: Result of setting up motor load- concentration (minimum time)

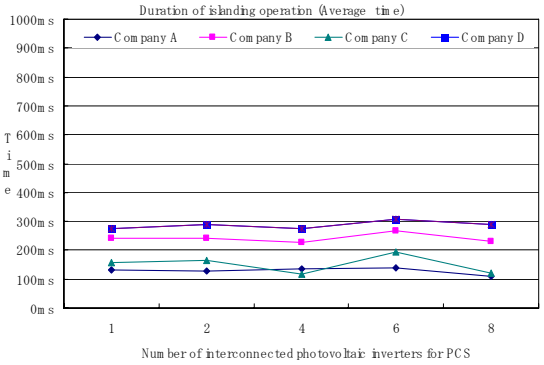

Figure 9: Result of setting up motor load-concentration (average time)

4 Conclusion

The above results show that whether the motor load is dispersed or is concentrated and installed has no effect on the duration of islanding operation; however a difference in duration of islanding operation can be confirmed when the number of interconnected photovoltaic inverters for PCS is changed. Our next step will be to study conditions such as impedance between PV power generation systems, and also to identify the duration of islanding operation depending on differences in the number of interconnected photovoltaic inverters for PCS.

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