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A Hybrid Islanding Detection Technique Using DC Link Voltage Control of Inverter Based DG


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ABSTRACT:

Distributed generation (DG) has been widely used in the power industry due to market deregulation and environmental concerns. Islanding protection is one of the most important issues to address in DG applications. the islanding is defined as a condition in which a portion of an electric power system is solely energized and separated from the rest of the electric power system. The DG unit should detect the islanding and disconnect the islanded system in a timely manner to avoid damages. This paper presents a new method for islanding detection of inverter-based distributed generation (DG). The main idea of this paper is to change the dc-link voltage considering the PCC voltage changes during islanding condition.

A simple islanding detection scheme has been designed based on this idea. The proposed method has been studied under multiple-DG operation modes and the UL 1741 islanding tests. The simulations results, carried out by MATLAB/Simulink, show that the proposed method has a small non-detection zone. Also, this method is capable of detecting islanding accurately within the minimum standard time.

I. INTRODUCTION:

Distributed generation (DG) has been widely used in the power industry due to market deregulation and environmental concerns. Islanding protection is one of the most important issues to address in DG applications. The islanding is defined as a condition in which a portion of an electric power system is solely energized and separated from the rest of the electric power system.

The DG unit should detect the islanding and disconnect the islanded system in a timely manner to avoid damages. Unintentional islanding of DG may result in power-quality (PQ) issues, interference with protection devices, and reliability reduction for customers.

There are three main methods of islanding detection: 1) passive, 2) active, and3) communication-based methods. This paper presents a new islanding detection method, which has the advantages of active and passive islanding methods, small NDZ, and good accuracy.

The control strategy of the voltage-source inverter has been designed to operate at unity power factor. Also, the dc side has been modeled by a controllable dc voltage source. The main idea of this paper is to change the dc-link voltage considering the PCC voltage changes during the islanding condition.

A simple and easy-to-implement method, such as the over/under voltage protection (OVP/UVP), can be used to detect an islanding condition. Once the magnitude of voltage exceeds a determined threshold value, an islanding condition is detected and DG is disconnected.

II. SYSTEM UNDER STUDY:

The system, which has been studied in this paper, is shown in Fig. 1. This system consists of a distribution network modeled by a three-phase voltage source behind impedance, a load modeled by a three-phase constant impedance, and a DG system. The DG is modeled by a controllable dc voltage source behind a three-phase inverter. The rating of this inverter is 100 kW.

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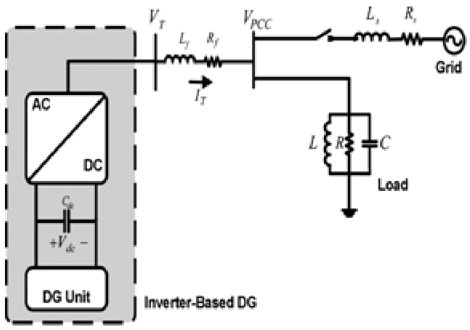

Fig. 1. Modeled system.

Fig. 2 shows the control scheme based on synchronous reference frame. In this system, the dc-link voltage controller and reactive-power controller determine and components, respectively. The input power extracted from the DG unit is fed into the dc link. Therefore, the voltage controller counteracts the voltage variation by specifying an adequate value of the axis inverter current to balance the power flow of the dc link.

The reactive power controller, shown in Fig. 2, specifies the reference value for the component of the converter current. The reactive power reference value is set to zero in order to model a unity power factor DG operation. Also, Fig. 2 shows two proportional-integral (PI) controllers for the d- and q–axis current controls.

The outputs of these controllers obtain the reference voltages for the PWM signal generator. The main features of the current control strategy are the limitation of the converter output current during a fault condition, providing over current protection, and reducing the fault current contribution of the unit.

III. PROPOSED ISLANDING DETECTION METHOD:

The acceptable voltage deviation is in the range of 88% to 110% of the nominal voltage. Any voltage deviation in this range should not be detected and the corresponding load condition would be considered within the NDZ. It is assumed that DG has been designed to operate at a constant dc voltage of 900 V. In this section, a new analytical formulation is derived by the linearization of system state equations. Then, a new characteristic of DG will be explained, and the performance of this method will be evaluated.

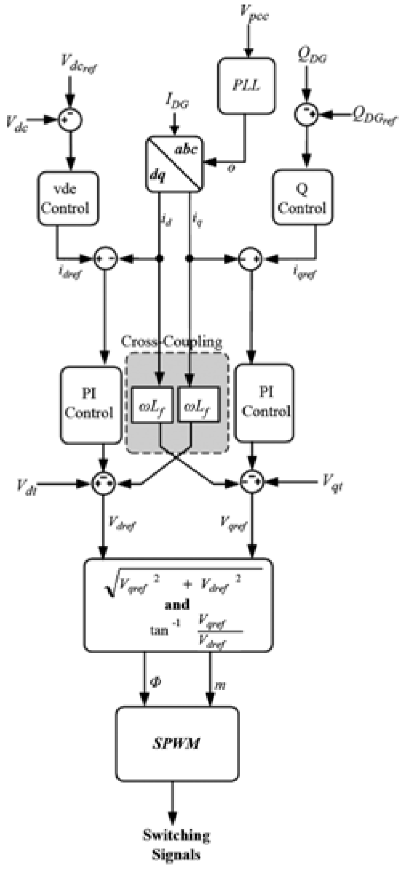

Fig. 2. Block diagram of the DG inverter controller.

VDC-VPCC CHARACTERISTICS:

The characteristic of DG and dc reference voltage have been shown in Fig. 3. In this figure, there are 2 lines which presenting the lower and upper dc voltage limits. Assuming VL-Lo equal to 1 p.u, the slope of these lines can be determined for Vrmdc 900 V and the dc voltage limits. The intersect point of DG and dc-link reference voltage curves is called the islanding operating point.

In this figure, points " A" and "B " represent the operating point of the lower and upper dc-link voltage limits, respectively. Each operating point between these two lines is in the NDZ. In addition, in any kind of loading condition, the dc-link voltage would be placed within or without these boundaries. If is accommodated within these limits, the voltage deviation will be in the allowable values, and the islanding can occur and will not be detected (NDZ).

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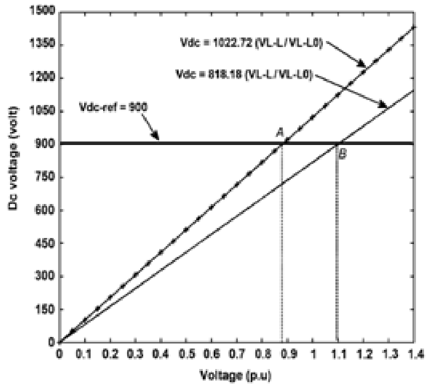

Fig.3. DC voltage versus PCC voltage characteristic

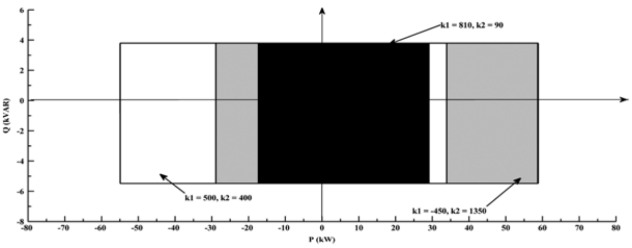

Fig. 4. NDZ of the VDC-VPCC characteristic for a different amount of k1and k2.

The performance of the proposed islanding detection method as well as its NDZ depends on the DG characteristics. This paper examines the NDZ of an OVP/UVP and OFP/UVP islanding scheme in case of using the implemented VDC-VPCC characteristic for different amounts of k1and k2. The results have been plotted in Fig. 4.

IV. SIMULATION RESULTS:

In this section, the test system shown in Fig.1 has been simulated by MATLAB/Simulink . The system, DG. The parameter has been set to 0 MVAr. The Islanding detection method has been tested for load with a quality factor of 1.77. The proposed islanding detection method has been also tested for various loading conditions specified in the UL 1741 Standard.

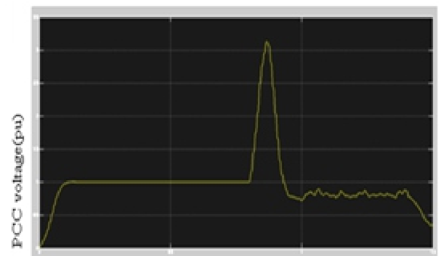

Fig.5 PCC voltage using the proposed Vdc-Vpcc characteristics for 50kw

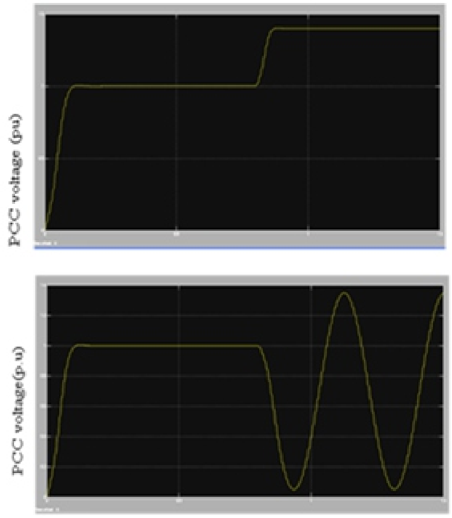

Fig.6 PCC Voltage with proposed Vdc-Vpcc characteristics for three cases.

Fig.7 System response during load switching-inverter active & reactive power (load 1).

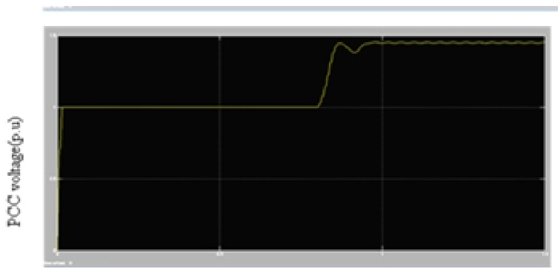

Fig.8. PCC voltage for different values of Qf

CONCLUSION:

This paper proposes a new method for islanding detection of an inverter-based DG unit by using the Vdc-Vpcc characteristic. The Vdc-Vpcc characteristic has been chosen so that the DG maintains its stable operation in grid-connected and islanding condition modes. Applying the proposed Vdc-Vpcc characteristic to the DG results in a simple islanding detection method, this can be similar to OVP/UVP protections.

The suggested method has been studied for the inverter-based DG unit under the multiple-DG operation mode and the UL 1741 test conditions. The simulation results show the effectiveness of the new islanding detection method for different operating conditions. In addition, it has been shown that this method does not distort any voltage or current waveforms by injecting perturbations and, thus, it has high performance from a PQ point of view. This method is also capable of detecting islanding conditions accurately within the minimum standard time.

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