A NEW METHOD TO IMPROVE MICRO-GRID ISLANDING OPERATION

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Abstract— *In the recent developed world we have to use electricity in an efficient way so we have to use micro-grids which is a grid system we have another operation that is Islanding mode but its detection is a great challenge in connecting distributed generation (DG) in electrical power systems. These detection methods are of two groups, one is communication based methods, active, and passive methods. Communication based methods are established based on communication between utilities and DGs which maintenance and operation is expensive to use. Active methods perturb are used where the disturbance is detected and analyzed. This detection circuit model of the micro-grid islanding is simulated by the software of MATLAB/Simulink, and the simulation results show that the islanding detection method gave better results and find the micro-grid islanding detection easily*

Keywords— Islanding Detection; Distributed Networks; Hybrid Islanding Detection Methods

1. INTRODUCTION

As the global energy crisis deepened, the promotion of renewable energy and the development of green power has become a hot topic in the field of electrical [1-3]. With the increasing penetration of renewable energy and the application of large area, the concentration of power production in the form of more decentralized development. Therefore, the micro network as a part of the main network provides a lot of auxiliary services to network. It is a difficult task to guarantee the stability and reliability of micro grid, especially in the isolated island mode [4].

The micro-grid is aimed to provide electricity for small communities (buildings, schools, industry), which is a small scale grid. The fossil fuels (diesel, gas turbine) and renewable energy (photovoltaic, wind turbine) is its main source of electricity. The micro grid architecture is shown in Fig.1.The power is supplied by DG. Distributed storage systems store energy when they produce more than they consume, and provide energy when consumption is greater than production. In the micro-grid, the consumer of power is the load [4-6].Electrical connection between the micro grid and the main power grid through the point of common coupling (PCC).

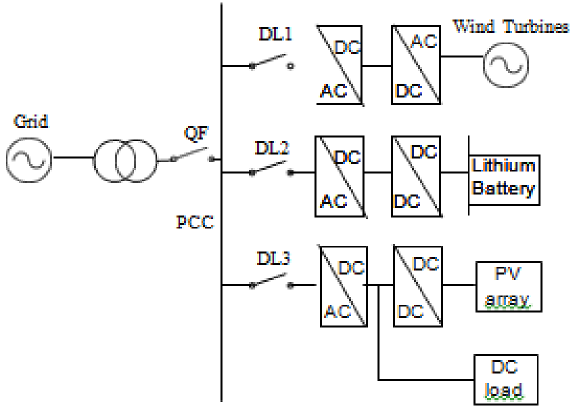

Fig. 1 Architecture of a micro-grid

Islanding is a major issue in penetration of DGs in the power system . Equivalent islands Circuit is shown in Fig.
2. As stated in [7] the islanding condition happens when "a portion of the utility system that contains both load and distributed resources remains energized while it is isolated from the remainder of the utility system".

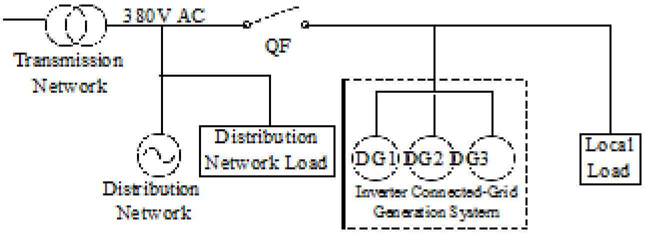

Fig. 2 Equivalent Islands Circuit

Unintentional islanding may lead to adverse consequences such as uncoordinated protection, inadequate grounding, and safety aspects. Current standards such as IEEE 929-1988 and IEEE 1547-2003[8] requires the disconnection of the DG immediately and with delay of 2 seconds, respectively. If the DG is allowed to work autonomously [9], fast islanding detection is required to make appropriate decisions to control the DG in the autonomous mode. Hence, detecting islanding correctly and as fast as possible is essential in connecting DGs to the utility system.

2. ISLANDING DETECTION METHODS

Islanding detection methods can be divided into two main groups. DG resident techniques, Communication based techniques. Communication based methods [10]: These methods are based on communication between the DG and the utilities. These methods have a zero Non Detection Zone (NDZ) but due to their high costs are rarely used [11]. Islands Circuit is shown in Fig. 3.

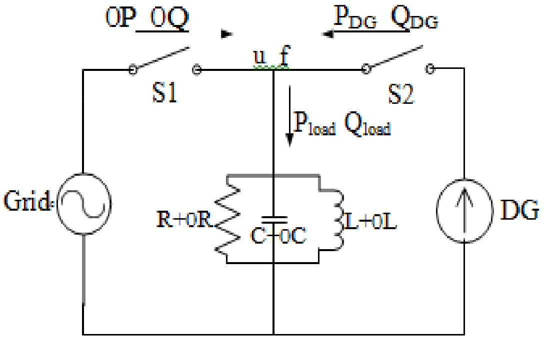

Fig. 3 Islands Circuit

DG resident methods: resident methods are divided into, active, passive, and hybrid methods [12].

A. *Passive methods*

In passive methods certain system parameters such as frequency, voltage, phase angle, and total harmonic distortion are monitored continuously and islanding detection is performed from the variation of these parameters (over/ under voltage or frequency, rate of change of voltage and frequency, fast changes in the voltage phase, voltage harmonic, etc.).An appropriate threshold for these parameters should be set to detect islanding situation.

The main drawback of these techniques is their large NDZ. Particularly, when the power which the DG generates is equal to the power absorbed by the loads, no power is exchanged between the grid and the DG. The grid parameter changes are negligible and may not be detected by the islanding detection technique.

B. *Active methods*

Active techniques reduce the NDZ of passive methods [13-15]. These techniques perturb the system with a periodic or transient disturbance and estimate the systems response to detect islanding. In one way, active methods could be classified in two subgroups.

Impedance measurement or detection [16], slip-mode frequency shifting (SMS) [17], and active frequency drift [18] are a number of active techniques introduced in the literature. One setback of these methods is that they enter a disturbance to the grid and may degrade the power quality of the system. Furthermore, in micro grids which have large number of DGs, interference between DGs can occur.

C. *Hybrid methods*

Hybrid islanding detection techniques combine the principles of active and passive techniques. By merging active and passive techniques the shortcoming of both of them can be prevailed. This islanding detection technique is effectual even when there is a close mismatch between the DG power generation and the power absorbed by the load. In hybrid methods the active islanding detection method only injects disturbances to the system when the islanding is suspected by the passive method.

In [19] a hybrid islanding detection method which uses total harmonic distortion and continuous feedback and selection is presented. In [20-23] a covariance index is used as the passive method, to activate adaptive reactive power shift action.

In this paper a hybrid islanding detection method which is on the principles of VU and HF impedance is presented. The imbalance of PCC voltage is measured, if it is above the selected threshold, a HF voltage is injected to the system and the impedance of the DG is estimated at the injected frequency. The propose method can detect islanding in 32(ms) and discriminate islanding from other system disturbances.

In this paper, the micro-grid islanding detection methods are discussed. Masses of islanding detection algorithms have been developed in the past few years, corresponding to the islanding test circuit of standard UL1471-2001 as shown in Fig.4.

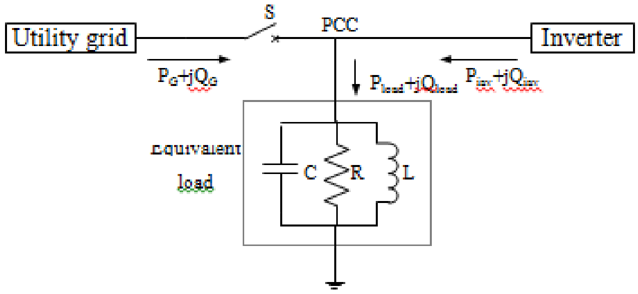

Fig.4 Islanding test circuit

3. INVERTER MODELING

Inverters are the main interference sources of the micro-grid. In this paper, two control strategies are used to control the inverters installed in the micro-grid.

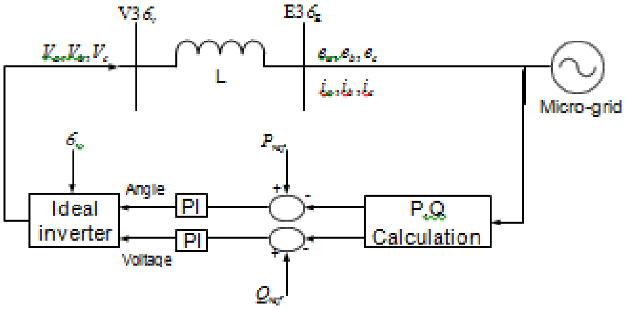

Fig .5 Basic structure of the PQ inverter control scheme

(1) PQ inverter control. This kind of inverter is controlled to inject certain values of active and reactive power into the Micro-grid. The PQ inverter control strategy is used to interface SSMT, SOFC and the two photovoltaic panels. The basic structure of the inverter's PQ controller is shown in Figure 5. P ref in Figure 2 represents the active power which is produced by the micro-source, which is connected to the Micro-grid by that inverter. Q ref represents the amount of reactive power injected into or absorbed from the Micro-grid at the inverter's bus. In this model, all PQ inverters operate at unity power factor ,which means there is no reactive power conversion between the PQ inverter and the Micro-grid system. In nature, PQ inverters were worked at unity power factor to reduce the ratings of those inverters and the cost.

(2) Voltage source inverter (VSI) control. This kind of inverter is used to feed the Micro-grid with predefined values of voltage and frequency subsequent to islanding occurrence. VSI in this paper is used to interface the storage device (flywheel) to the Micro-grid and represents the reference bus (slack bus) for each Micro-grid during islanding mode. The VSI emulates the behavior of a synchronous machine in conventional power systems. As a voltage source, The VSI is controlled through droops with the magnitude and frequency of the output voltage, as described by the following functional relation:

$$f = f_0 - k_p \times p \qquad V = V_0 - k_Q \times Q \qquad \text{C13}$$

Where P and Q are the inverter active and reactive output powers, Kp and KQ are the frequency and voltage droop slopes (positive quantities), respectively. f0 and V0 are the idle values of the frequency and voltages. A three-phase model of a VSI implementing the droop concepts described by Equation (1) was developed and is shown in Figure 6.

In this model, the amount of active and reactive powers injected into or absorbed from the Micro-grid will control the voltage and frequency of the Micro-grid.

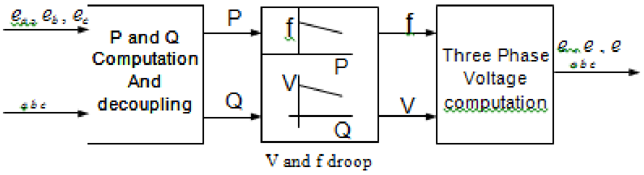

Fig. 6 Voltage source inverter control model.

4. RELATIONSHIP OF FREQUENCY WITH ISLANDING OPERATION

Fig.4 shows the power flow chart of inverter ,which is based on DG (IBDG) and connected load in the presence of the utility. At the instant when the utility is disconnected, the active and reactive power will imbalance. Under the islanding operation, the power flow can be described as

$$P_{\text{inv}} + jQ_{\text{inv}} = P_{\text{Load}} + jQ_{\text{Load}} \qquad \text{C23}$$

Where

$P_{\text{inv}} + jQ_{\text{inv}}$ is the active and reactive power supplied by IBDG, and $P_{\text{Load}} + jQ_{\text{Load}}$ is the active and reactive power of the load.

Because the load is replaced by equivalent RLC elements and is connected in parallel, PCC voltage across R and parallel LC are the same. The load power can be calculated as

$$P_{\text{Load}} = V_{\text{PCC}}^2 / R \qquad \text{C33}$$

$$Q_{\text{Load}} = V_{\text{PCC}}^2 \left(\frac{1}{\xi L} - \xi C\right) \qquad \text{C43}$$

Where ξ is the islanding angular frequency and can be expressed as $\xi = 2\pi f$ f is the islanding frequency.

$$\xi^2 + \frac{Q_{\text{Load}}}{P_{\text{Load}} RC}\xi - \frac{1}{LC} = 0 \qquad \text{C53}$$

The islanding angular frequency ξ can be calculated as

$$\xi = \frac{1}{2}\left(\sqrt{Z^2 + \frac{4}{LC}} - Z\right) \qquad \text{C63}$$

where the parameter Z is formed as

$$Z = \frac{Q_{\text{Load}}}{P_{\text{Load}} RC} \qquad \text{C73}$$

According to the above analysis, the following conclusions can be get:

The PCC voltage V_{PCC} is the function of the output active power of the inverter as shown in Eq.(2).

(1) The islanding angular frequency ξ is the function of the parameter Z and the load parameters RLC as shown in Eq.(5). The angular frequency ξ increases when Z decreases and vice versa. So from Eq.(6), it can be concluded that ξ will increase when Q $_{\text{Load}}$ decreases or P $_{\text{Load}}$ increases, and vice versa.

(2) On the basis of the Chinese Standard GB/T15945-1995 as Ref, the normal operation frequency should be limited within the range of 49.5 Hz to 50.5 Hz in the utility system with small capacity. If IBDG output power $P_{\text{inv}} + jQ_{\text{inv}}$ is equal or approximate to the rated load power $P_{\text{Load}} + jQ_{\text{Load}}$, the PCC voltage frequency will under the threshold at the moment, at the instant the utility is disconnected, the islanding detection fails.

5. SIMULATION

In this part, simulation results are shown to verify the effectiveness of the proposed islanding detection algorithm. The difference between inverter output capacity and rated load capacity is described as

$$OP = P_{\text{inv}} - P_{\text{Load0}} \quad \text{And} \quad OQ = Q_{\text{inv}} - Q_{\text{Load0}} \qquad \text{C83}$$

If the OP or OQ is large, the angular frequency will shift quickly because of Eqs. (5) and (6).

In this case, the islanding frequency will go beyond the allowable range (49.5 Hz—50.5 Hz) immediately, and the islanding can be confirmed. A lot of simulations have proved that the proposed algorithm has the same validity as the other islanding detection algorithm for this case Three extreme but possible islanding cases can be used, in which many other algorithms may not success to detect the islanding. In this part, these cases are simulated to prove the validity of the proposed algorithm.

The simulation parameters of the system are shown in Table 1

TAB.1 SIMULATION PARAMETERS

Parameters	Value
Voltage	220V
Frequency	50HZ
P_{Load0}	5KW, 9.68fi
Q_I	10KVar, 15.4mH
Q_C	5KVar, 328.8μH
$f_{\max} = \xi_{\max} / 2\nu$	50.3HZ
$f_{\min} = \xi_{\min} / 2\nu$	49.7HZ

In this case, we assume that the capacity of IBDG approximates to the local load, and OP is not large but OQ=0. If OP < 0 and the proposed algorithm is not applied, the PCC voltage frequency may be within the allowable operating range.

For example, we set $OP = -1\% P_{\text{Load0}}$ and the utility is disconnected at t=0.1s , accordingly the PCC voltage frequency change a little, and still within the allowable range as shown in Fig.7, so the islanding detection fails.

Fig.7 Simulation results

If OP > 0, for example $OP = 1\% P_{\text{Load0}}$, the islanding frequency should also shift continuously when the proposed algorithm is applied. As shown in Fig.9, the islanding is confirmed because the islanding frequency has exceeded the higher limit for 3 times within 0.1 s. Simulation results show the effectiveness of the proposed algorithm.

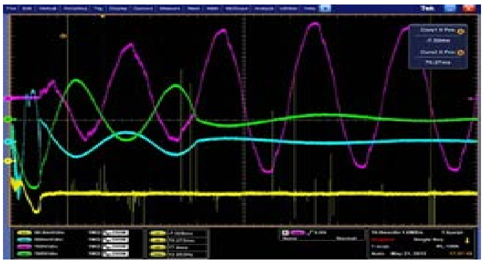

Fig.9 Simulation results

6. CONCLUSION

In this paper a hybrid islanding detection method using VU and HF impedance is presented. The voltage unbalance is measured at PCC and if it overreaches the threshold settings, the situation is suspicious of islanding. Therefore, a HF voltage is injected in the DG control loop and the PCC voltages and current are measured to estimate impedance at the injected frequency.

This hybrid method merges the advantages of active and passive methods. Furthermore, the method does not lead to system instability since the active method does not change any parameters of the system. The Ul1741 test system is simulated in PSCAD/EMTDC to investigate the credibility of the method. The detection method can detect islanding in 32ms (3 cycles) which is supported by UL1741 standard.

In conclusion, compared to other existing algorithms, the non-detection region of this algorithm is very smalloAt the same time, it also provides an excellent detection speed of the island. The effectiveness of the algorithm is proved by the simulation results.

However, this islanding frequency should shift continuously if the proposed algorithm is applied. Fig.8 shows that the islanding frequency exceeds the lower frequency limit for 3 times within 0.1 s.

So the islanding is detected though the frequency shift is very small at the beginning of the islanding.

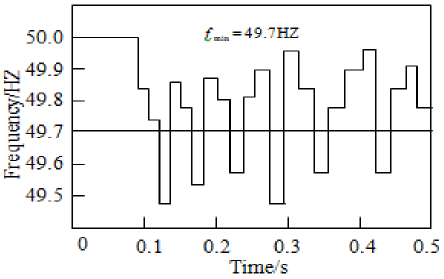

Fig.8 Simulation result of Case

7. ACKNOWLEDGEMENTS

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