A NEW ACTIVE ISLANDING DETECTION METHOD OF DG

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ABSTRACT

Islanding detection of DG is one of the most important aspects when interconnecting DGs to distribution systems. Recently various methods are presented but this paper proposes a method that it can detect islanding in worst conditions loading according to IEEE1547 or UL1741 standards and various study cases. The proposed method is high speed and can be used in both anti islanding detection protection and micro grid applications. To confirm the method is simulated by PSCAD/EMTDC environment and results confirm performance integrity the proposed method.

INTRODUCTION

A Distributed Generation (DG) is islanded when it supplies power to some loads while the main utility source is disconnected [3]-[6]. From the perspective of the electric utility, the concerns with the islanded network are [1],[2]:

- Reconnection non synchronous two systems by action of re-closer
- Safety issues for utility personnel
- In-adequate grounding

Therefore, DG should be off after occurrence of islanding which that could begin as a result of (i) pre-planned switching events, (ii) electrical faults and their subsequent switching incidents or (iii) equipment failure [1].

Typically Islanding Detection (ID) techniques be divided into passive and active strategies. Passive methods monitor selected variables and then compare those with threshold limits. Although the methods are economically attractive due to their simplicity, the existence of large non detection zone (NDZ) is a major drawback. Active methods introduce a deliberated disturbance into the system, and monitor the disturbance effect for detection. These methods reduce the existence of NDZ, but singly do not have appropriate reliability and that appropriates to use along a backup method in which hybrid technique [3].

This paper proposes the method that can detect islanding in worst conditions loading according to IEEE1547 or UL1741 standards and various study cases. The proposed method has high reliability and is high speed and can be used for micro grid applications.

TEST SYSTEM FOR ID

Any ID method must be tested under UL1741 or IEEE1547 standards anti-islanding test to be certified. Fig.1 shows the test system, where it is assumed that the DG is interfaced with a current controlled VSC converter. The UL.std requires that for load of Quality Factor $QF \le 1.8$, the DG stops delivering power 2sec after the 3-pole breaker is opened [8].

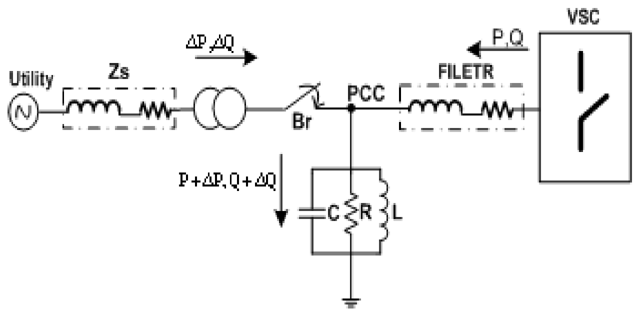

Fig.1 Single line diagram of the test system

Passive method used

Voltage and frequency relays used in PCC point are simple and usual methods for ID [3].

Under of Fig.1, the utility delivers powers ΔP & ΔQ to system. Prior to islanding the load power equals to $P_{Load} = P_{utility} + P_{DG}$. Post islanding, there is no power delivering in utility thus the load faces shortage of power. Equation (1) shows active and reactive power of the RLC load:

$$P_L = \frac{3V_{PCC}^2}{R} \tag{1}$$

$$Q_L = 3V_{PCC}^2\left(\frac{1}{\omega L} - \omega C\right) \tag{2}$$

In (1), it can be observed that the value of the load active power is dependent on the PCC voltage and load reactive power dependent on the PCC voltage and frequency. If the amount of power mismatch (ΔP & ΔQ) is large enough, the deviation in PCC voltage and frequency will be sufficient to trigger the voltage and frequency relays. Otherwise (or no exchange power in utility), the method cannot detect The conditions are worst case. If we draw relay operation regions in P-Q space to provide the NDZ region of the method (Fig.2) [6],[10].

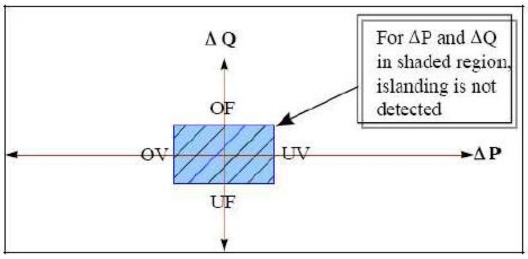

Fig.2 NDZ of voltage and frequency relays

Active method used

In worst conditions loading, passive methods can not detect, consequently we use injection of current disturbance signal as an active method is mentioned in [4]. Disturbance signal $i_{\mathrm{dis}} = I_{\mathrm{d}} \cos(2\pi f_{\mathrm{d}} t)$ with amplitude I_{d} and frequency f_{d} is injected to the system.

According to Figs.3,4, prior to islanding for the reason of low impedance of utility than the load, disturbance is entered to utility but post islanding disturbance is entered to load necessarily. Therefore, by changing the disturbance track in prior and post islanding, changes will occur in PCC frequency voltage [4],[7],[9].

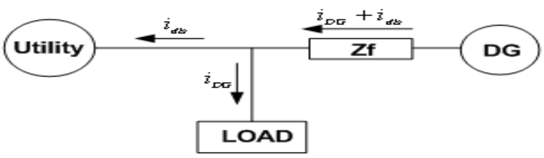

Fig.3 tracking of disturbance current in prior islanding

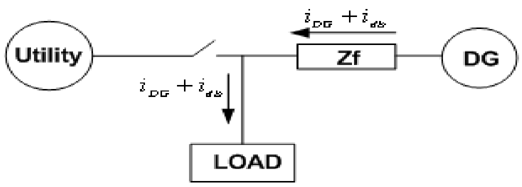

Fig.4 tracking of disturbance current in post islanding

Frequency deviation detector

For frequency deviation detection the digital circuit is used in Fig.5. In Fig.5, PCC voltage is entered zero-crossing detector. Then its output is compared to zero to eliminate negative signals. Output of the comparator is reference signal. Mono stables T1,T2 are used for consideration of nominal and desired frequency band of UL.std (59.9-60.1 Hz). Finally control and reference signals are compared through logic circuit then to activate the counter and consequently the islanding indicator [4]. The method has problems such as that mistakes (specially in zero-crossing block) in transient states of system (e.g. import and export of loads suddenly), or a imposed disturbance through system upon voltage waveform. Therefore this method is proper only in primary detection and that does not have enough reliability in transient states.

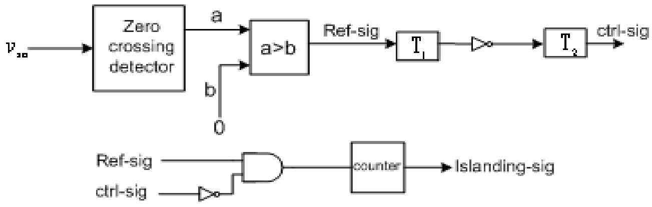

Fig.5 frequency deviation detector

PROPOSED ALGORITHM FOR ID

Utilization of the counter for ID is not reliable and would be sensitive to nuisance of system. For presentation of operation infirmity of the counter in special case studies, the circuit of Fig.1 is simulated by PSCAD/EMTDC software with parameters is mentioned in appendix and in various scenarios when those have mentioned in follow.

Survey of the active methodes which are used

First we survey the active method of ID presented in paper. According Fig.6 with occurrence of islanding at t=1sec and transit of disturbance signal from the load, frequency of PCC beginning to deviation from its nominal value and because this deviations are in level of activation the counter, to activate it and detect islanding in 50 ms.

Abrupt import of load

To demonstrate infirmity of counter for ID in transient states, to assume in Fig.1 the load is imported at t=1s suddenly. With import a RLC tank to system, transient state occurs which then activates the counter while the islanding state has not occurred. Considering Fig.7, by occurrence of islanding, the counter is activated falsely. The transient states may occur in power systems very much. Thus n algorithm must be applied to condone this transient states and to not assign it under the topic of islanding phenomena. The proposed algorithm has this capability.

Imbalance conditions

The objective of this scenario to study cases that only one or two of the three breakers be opened. It can be seen in Fig.8 that because to exist another track for disturbance to utility in post islanding, to not change frequency of PCC and to not activate the counter and it do not detect islanding. In follow the paper presents the proposed method and its good capability in various scenarios. The results of simulations are brought in I-III tables.

Proposed method

In this method, we utilize the counter block as the primary detection. Another indicator in islanding is frequency waveform because to be assured in to activating the counter and to no disorder in counter circuit and or nuisance operation. According to previous subsection, in imbalanced cases do not change frequency of PCC. For solving the problem, the algorithm proposes to select the RMS of zero sequence voltage of PCC as another indicator of islanding. In Fig.9 the effect of imbalance upon zero sequence voltage is considered. Hence in such statuses this indicator will be useful.

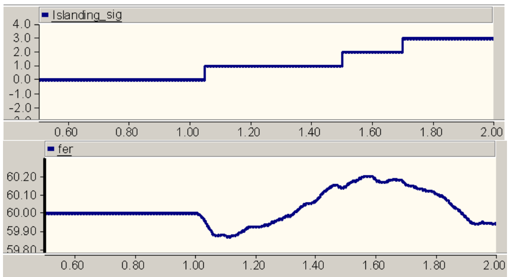

Fig.6 a-counter-sig b-frequency, occurrence of islanding at t=1s

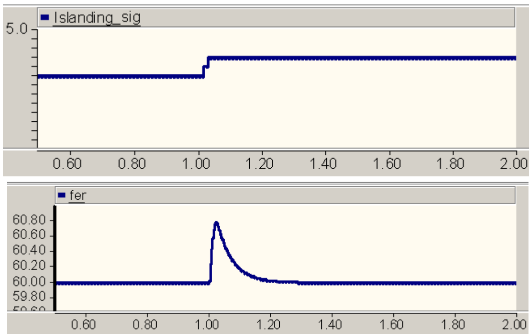

Fig.7 a-counter-sig b-frequency in abrupt import of load

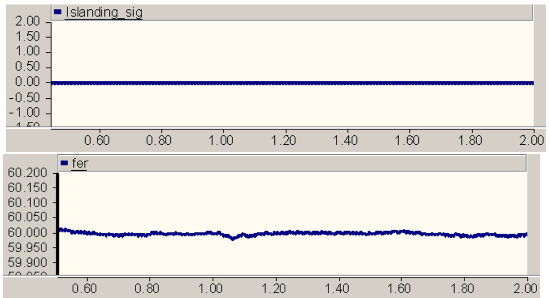

Fig.8 a-counter-sig b-frequency in incorrect operation of breaker

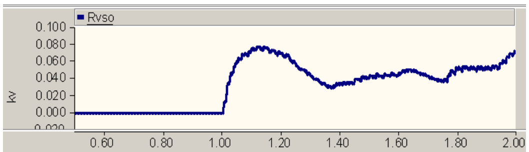

Fig.9 RMS of zero sequence voltage of PCC

For increasing the detection speed and reliability, frequency waveform is filtered by transfer function (3) and filtered signal will be another indicator for detection.

$$\mathrm{F}(s) = G\frac{\frac{s^2}{\omega_C^2}}{1+2\xi\frac{s}{\omega_C}+\frac{s^2}{\omega_C^2}} \tag{3}$$

Parameters of the filter (3) are in appendix. Dc gain of the filter is zero and in transient states and high frequency have high gain. This property of (3) can be caused that the transients are detected immediately and either reliable of transient occurrence. To simulation by conditions of B, the output of filter will be Fig.10. Occurrence of transient state at t=1s has traced upon output of F(s) (Fig.10).

To apply the indicators to be mentioned in previous sections and to analysis data mining of various disturbances in I-III tables, the algorithm of Fig.11 is proposed for reliable ID. As shown in Fig.11, $|V_{SO}|$ is RMS of zero sequence voltage of PCC, $|FRF|$ is absolute value the output of F(s), f is frequency of PCC. The parameters of a, b, w, C1, C2 are threshold values that those are extracted by various simulations and to be brought in appendix.

As shown in table.I, both methods detect islanding correctly even if the utility not be stiffness. In table.II obviously the transient states, result of load importing are more sever than exporting. Thus the counter method mistakes but proposed method operates correctly in various impedances of utility. Almost the results of table.II are correct for motor loads. In table.III be seen for imbalanced conditions, the counter method does not detect islanding but proposed method is capable. The scenarios to be considered in tables, were only for to present of this subject that some of conditions in the result of existence transient states or another disturbances, the ID method may mistake or non detect. Thus must apply method that it is able to detect islanding phenomena in several conditions of power system. The method considering of data mining approach, must be able to distinguish islanding phenomena from another incidents and to detect islanding according to standard requirements.

The proposed algorithm in this paper be able to distinguish islanding from another incidents and to detect it according to UL.std requirements as topics both anti ID protection and micro grid applications.

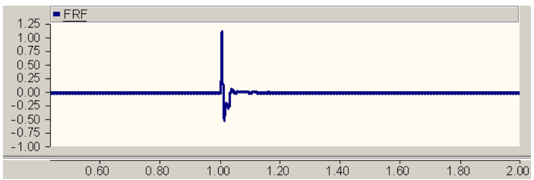

Fig.10 output of F(s)

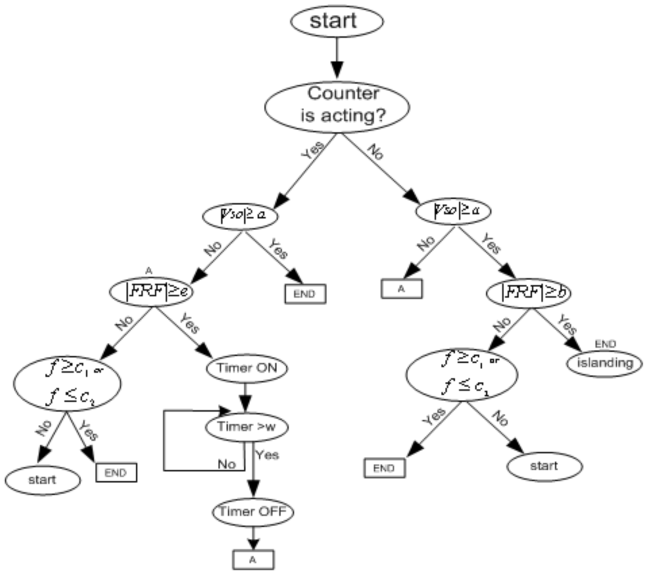

Fig.11 proposed algorithm for ID

TABLE I ID for RLC load

Utility impedance	A	B
$Z_S = 0$	✓	✓
$Z_S = 0 + j0.144$	✓	✓
$Z_S = 1 + j0.144$	✓	✓
$Z_S = 0.1 + j2.22$	✓	✓
$Z_S = 0.01 + j0.222$	✓	✓

TABLE.II abrupt import & export of RLC load

Utility impedance	A		B
$Z_S = 0$	import	×	✓
	export	✓	✓
$Z_S = 0 + j0.144$	import	×	✓
	export	✓	✓
$Z_S = 1 + j0.144$	import	✓	✓
	export	✓	✓
$Z_S = 0.1 + j2.22$	mport	×	✓
	export	✓	✓
$Z_S = 0.01 + j0.222$	impor	×	✓
	export	✓	✓

TABLE.III imbalance conditions (incorrect operation of breaker)

Utility impedance	A	B
$Z_S = 0$	×	✓
$Z_S = 0 + j0.144$	×	✓
$Z_S = 1 + j0.144$	×	✓
$Z_S = 0.1 + j2.22$	×	✓
$Z_S = 0.01 + j0.222$	×	✓

A= counter method B= proposed method

✓ correct detection
× incorrect detection

CONCLUSION

In this paper, an active islanding detection method was introduced and evaluated. The method has some problems loading conditions such as the lack of timely diagnosis, misdiagnosis and poor reliability. To solve these problems, an algorithm was developed for the active method. The proposed algorithm could detect islanding in various conditions of system.

Appendix

Parameters transfer function F(s):
$\xi = 0.5$, $G = 10$, $\omega_C = 60$

Threshold values of indicators of the algorithm:
a=0.06 b=0.006 C1=60.1
C2=59.9 w=25 ms

Parameters of power system in Fig.1

$v_{sLL}\ (kV)$	0.6
$V_{dc}\ (kV)$	1.2
$P_{VSC}\ (MW)$	0.5
$L_f\ (mH)$	1.15
$R_f\ (\Omega)$	0.029
Q_f	1.8
$R\ (\Omega)$	0.72
$L\ (mH)$	1.061
$C\ (\mu F)$	6631.5
Transformer	0.6/13.8

REFERENCES

[1] Standard for Interconnecting Distributed Resources With Electric Power Systems, IEEE Std. 1547, 2003.
[2] Ph.Barker, 2002 "Over voltage considerations in applying distributed resources on power systems," *Proc. Int. Conf. on Power System*.
[3] M.Ropp, 2002 "Evaluation of islanding detection methods for photovoltaic utility interactive power systems" *Sandia National Laboratories*.
[4] G.González, 2006 "Current Injection for Active Islanding Detection of Electronically-Interfaced Distributed Resources", IEEE.TRANS, VOL. 21.
[5] F.Katiraei, 2005 "Micro-Grid Autonomous Operation During and Subsequent to Islanding Process "IEEE. TRANS , VOL.20.
[6] Ye.Kolwalkar, 2004 "Evaluation of anti islanding schemes based on non detection zone concept", IEEE. TRANS, Vol. 19, No. 5
[7] C.Schauder, 1993 "Vector analysis and control of advanced Static VAR compensators", *Proc. Inst. Elect. Eng.*, vol. 140, pp. 299–306.

[8] Inverter, converters and controllers for use in Independent power systems, UL Std. 1741, 2002
[9] H.Zeineldin, 2006 "Impact of DG Interface Control on Islanding Detection and Non detection Zones", IEEE. TRANS, VOL. 21, NO. 3,