Advanced Science and Technology Letters
Vol.111 (NGCIT 2015), pp.60-64
http://dx.doi.org/10.14257/astl.2015.111.12

A novel active current disturbance method

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Abstract. Islands simulation test is conducted in the case of the inverter output power and load input power to match, the test results show that this method can quickly detect islanding, and effectively prevent pseudo-island phenomenon of false positives. Selecting an effective wavelet domain values as the voltage harmonic detection amount islanding detection.

Keywords: Active current disturbances; Three-phase photovoltaic-to-grid system

1 Introduction

Three-phase grid inverter with the distributed generation system of island detection technology is becoming a hot research topic[1], in which P-U, Q-f power island detection method of a given curve has small detection blind-area, but its application object needed contains power control links, and detection time by power outside ring of effects; adapted phase offset method can detect fast without blind area, and has small normal grid frequency, yet based on the adaptive three-phase island phase shift need to be researched indeed; Sandia frequency deviation method[2] applied to three-phase constant power system detection performance attenuation occurs; Pertur-bation constant active current law does not give an analysis for the case of load mismatch, and continuous injection of active disturbance current makes the inverter has been in over-load or under-load run, which affects the life or efficiency of the inverter. Current periodic perturbation method [3] is often used to eliminate blind spots islanding detection; disturbance size and period features are on the grid voltage total harmonic distortion (THD) have an impact.

2 Active current disturbance methods

In the active current disturbance islanding detection method, the current disturbance does not cause breaker tripping problem in the normal grid when the system injecting appropriate current disturbances, but in the island, the current disturbance will cause the amplitude of the PCC's voltage significant changes, to determine the occurrence of island by OVP / UVP judgment. Distributed power grid islanding detection system is shown in Fig.1.The amplitude of PCC's voltage is U_{gm} for grid-connected inverters

ISSN: 2287-1233 ASTL

operation, while the switch S_1, S_2 is closed. When the switch S_2 is open, means the island occurring, inverter output current and *RLC* load determine the *PCC*'s voltage together, then the amplitude is shown *U*am=*Ri*d, i_d is a three-phase output current of the direct-axis component , and is the active current.

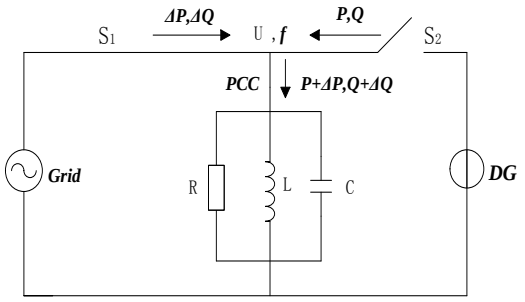

Fig.1. Distributed power to grid system

Fig.2 shows the three-phase active current disturbance detection principle: the inverter output current terminal sampling phase current ia, ib, ic and three-phase voltage ua, ub, uc, and the sampling phase current is supplied to the fundamental wave extractor to extract the corresponding control fundamental component, which is injected into a given current idref and iqref as the amount of interference given by the sampled current and voltage control, the output control signal is applied to PWM inverter control.

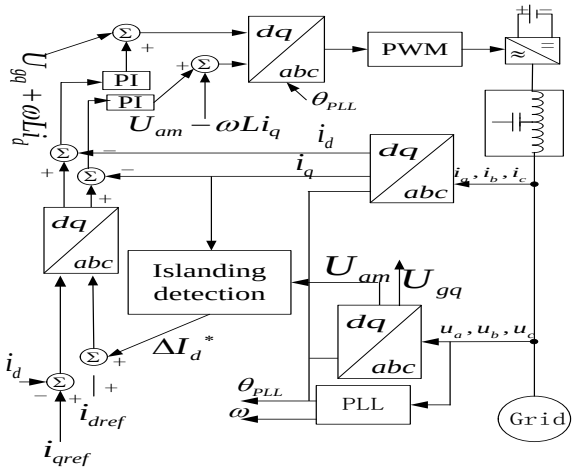

Fig.2. Main circuit for islanding detection

3 Wavelet Transform and Wavelet Basis Selection

Wavelet multi-scale decomposition analysis can decompose harmonic current signal into different frequency signals and hold real-time tracking of harmonic changes, of which are all high frequency harmonics, low frequency of the fundamental. Reading the voltage and frequency signal from the distributed generation system, amplifying frequency signal for the sake of the less instantaneous content, and identifying the voltage and frequency high-frequency component using Daubechies wavelet transform is abnormal or not. PCC voltage and frequency of the signal through the discrete wavelet transform of the sampling circuit was subjected to quantitative analysis, artificial high-frequency harmonics filtering process introduced, it will improve the low and high frequency characteristics of the signal as an active fundamental extractor enter the amount, according to the voltage and frequency of the test results to help identify and detect network system operation and protection of islands determine accuracy.

Wavelet multi-scale decomposition for the given original signal to de-noise, filter and reconstruct to obtain the reconstructed signal, and to select the appropriate wavelet function basis for the degree of similarity of the reconstructed signal with the original signal. In this paper, S_1 is the square wave test signal, S_2 is the reconstructed signal after wavelet multi-scale decomposition process, taking into account the overall S_1 and S_2 and the local bias may exist to formula (1) as the error calculation method, assuming λ1 overall bias factor, (1-λ1)extreme deviation factor, and λ1⩾0..

$$e = \frac{\lambda_1 \sqrt{\rho(S1,S2)^2 / N} + (1-\lambda_1)\left(\max\left(|S1-S2|\right)\right)}{\sqrt{\sqrt{\rho(S1,S2)^2 / N}}} \tag{1}$$

And, $\rho(S1,S2) = \sqrt{\sum_{i=1}^{N}\left(S_{1i} - S_{2i}\right)^2}$,N is for Signal length.

Build wavelet domain value test circuit model in Matlab/Simulink environment, including photovoltaic inverter unit input DC voltage of 600V, the output power of 50kw, and network interface filter inductance L = 0.5mH, C = 3.174μF, other test circuit parameters is seen in Table 1.

Table1. Wavelet threshold test parameter

RLC load				grid		
R (Ω)	*L* (*m*H)	*C* (*m*F)	*Q*	U_m (V)	*i* (A)	*f* (Hz)
2	3.24	3.174	1.8	380	20	50

4 Three-phase single-islanding detection test

Considering IEEE.std.1547 provisions worst case that the grid system output power and load power matching, RLC parallel load parameters: R = 2.95Ω, L = 3.750mH, C = 2740.2μF, quality factor Q_f = 2.5, resonance frequency f_r = 50Hz. The simulation time is set to 1.5s, using ode23tb simulation solver for solving the three-phase circuit breaker switch off analog islands in the 0.6s at the occurrence of active current improved its Matlab/Simulink environment disturbance islanding detection method PCC frequency waveform in the simulation results shown in Fig.3 and Fig.4.

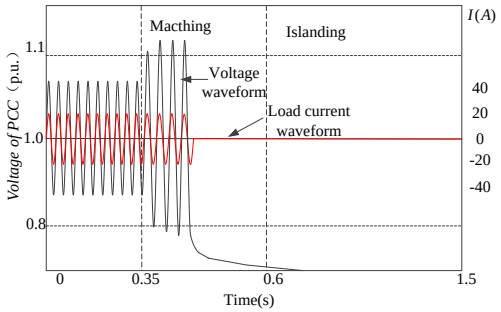

Fig.3: Waveform of active current disturbance

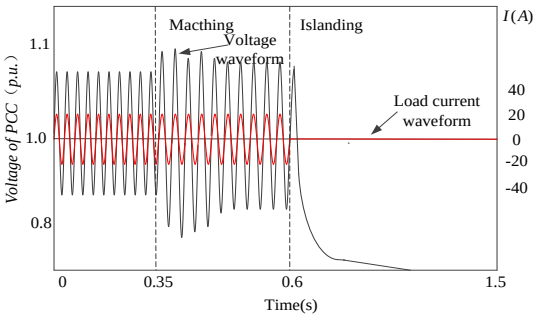

Fig.4. Waveform of active current disturbance based on wavelet analysis

The active current disturbances islanding detection shown in Fig.8, when the load power matches with inverter output power, PCC voltage amplitude fluctuation is small and within the allowable voltage range, voltage period after 0.35s second voltage fluctuation becomes large, the load current value 0.45s is zero, the voltage has a sharp decline, the active current islanding detection device operates, but this time not yet out of the grid plan, indicating that the active current islanding detection misuse.

In Fig.4, the wavelet analysis to improve the active current disturbances based islanding detection; PCC voltage amplitude despite continued volatility in a relatively

short period of time beyond the voltage range, the load current waveform has been stable. After the power off, can rapidly detect the islanding signals and respond within IEEE.std.1547 detection time. Fluctuations in the amount of harmonic detection based on wavelet transform method reaches a given threshold islanding detection, accurate feature quantity extracted to an island, to avoid affecting the local load and harmonic fluctuations may be caused, at the same time effectively identify pseudo-island phenomenon.

5 Conclusion

In this paper, to extract the PCC voltage harmonic components by the discrete wavelet transform, and to value effective Layer 7 high-frequency signal domain as current perturbation detect characteristic amount for islanding detection judgment. Compared with pure active current perturbation method, this method can reduce the disturbance of current injection frequency, and narrow islands judgment cycle appropriately. In case of power matching to analysis voltage waveform, we can reduce the chance of false positives islands, and have no significant effect the power quality.

Acknowledgments. This work was supported by The Education Department of Hubei Province (Research on islanding detection of positive feedback voltage variable coefficient NO. D20121403) and Science and Technology Department of Hubei Province (Research on SOC estimation algorithm and equalizing charge of HEV lithium ion battery NO. 2010CDB05802).

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