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A New Method of Power Quality Detection on Limited Capacity System

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Abstract. For the operating characteristics of limited capacity micro-grid, power quality disturbance impacting on the micro-grid is to be significantly larger than the civilian power grid, especially the transient power quality disturbances can not be ignored. By combining the advantage of wavelet transform and FFT (Fast Fourier Transform) respectively in the steady-state and transient power quality detection, a new method of power quality detection on limited capacity micro-grid is proposed. Firstly, limited capacity micro-grid model is established by MATLAB, then, the common micro-power system disturbance models are generated, finally, wavelet transform and FFT are combined to complete the detection and analysis of harmonic, and the detection and location of transient power quality disturbances. The simulation results show the effectiveness of the method which provides a new research idea for detection and location of power quality in limited capacity micro-grid.

Introduction

With the rapid development of new energy technology, more and more lack of energy areas such as mountains and islands have set up corresponding new energy power generation system. But the power system capacity is limited, the transient power quality disturbance is bound to impact on power system caused great and even can make power system collapse when sudden access some impact, or pulse load. In addition, the power supply quality will also have a great influence because of the harmonic ,therefore it is crucial to detection the power quality disturbance signal[1-3].

The essence of the signal detection of power quality disturbance is the point of the disturbance signal mutation detection.The method for the detection of harmonic detection method based on power definition of the instantaneous reactive power detection algorithm and FFT detection method based on frequency domain . it is widely used in the harmonic detection and analysis because of the algorithm is simple, easy to implement,and its good real-time performance. The main method of transient power quality detection such as short time Fourier transform, wavelet transform , HHT (Hilbert huang transform),and artificial intelligence algorithm. Short-time Fourier transform using a fixed window function, , the resolution is determined and can't change its shape once window function established. Short time Fourier transform is used to analysis stationary signal and the effect is well,it can be used for steady-state harmonic analysis and testing,but for transient power quality disturbances such as non-stationary signal analysis has certain weaknesses; Hilbert huang transform the complex signal is decomposed into a set of intrinsic mode function of single component signal—empirical mode decomposition, HHT can deal with the nonlinear and non-stationary signal effectively, get signal time, frequency and energy characteristics, but the HHT produces modal aliasing in the process of signal decomposition , and bring certain difficulty on signal analysis; Artificial intelligence algorithm convergence speed is too slow, it need a lot of training samples, the real-time performance is poorer and can mot quickly solve the problem of power quality detection; Wavelet transform is a kind of time and frequency domain analysis method which fixed window size and changed shape , it is well real-time performance and can effectively detect the mutation of non-stationary signal[4-6].

This paper get the model of the limited capacity system, at first use fast Fourier transform for power system harmonic detection and analysis, Then use the wavelet transform to perform the

transient power quality disturbance signal detection,due to the layer number of wavelet and decomposition of detecting precision is crucial, this paper filter precision higher layer number of wavelet basis function and decomposition through a lot of experimental simulation, completed the limited capacity system of power quality detection accurately.

Fast Fourier transform

FFT is a fast algorithm of DFT(Design for Testability) and it can effectively solve the large amount of calculation and poor real-time performance problem in the DFT, the algorithm is simple and easy to implement, the computation of small advantages for steady-state harmonic analysis is obviously[7]. Depending on the decomposition and the selection method for sequence produced a variety of FFT algorithm, the basic algorithm for dit and 2 dif.Define the type of DFT as follows:

$$X(k)=\sum_{n=0}^{N-1}x(n)W_N^{kn}R_N(k) \qquad (1)$$

Usually in all complex W_N^{kn} calculation good cases indexd, calculating $X(k)$ a need N complex multiplication and $N-1$ plural addition, then calculate the N time $X(k)$ a total of all N^2 complex multiplication and $N(N-1)$ plural addition, and the amount of calculation is proportional to N^2.

The basic idea of FFT is put the big points DFT decomposed into several small points combination, and reduce the amount of calculation based on W_N the two basic characteristics.

Periodic: $W_N^{(k+N)n}=W_N^{kn}=W_N^{(N+k)k}$ (2)

Symmetry: $W_N^{(k+N/2)}=-W_N^k$ (3)

The basic theory of Wavelet Transform

Wavelet transform is a method of time - frequency analysis has the ability of denoting local signal characteristics in both time and frequency domain, and has lower time resolution in low frequency part and high frequency resolution, and in the high frequency part with high temporal resolution and low frequency resolution,it is pretty suitable for detecting signals in the midst of transient abnormal phenomenon and ingredients, so wavelet transform is also said to "mathematical microscope".

Discrete wavelet transform

Usually the signal acquisition is discrete form in the actual, so through the discrete continuous wavelet transform in the scaling factor α and translational factor β, discrete wavelet transform and reduce the amount of calculation.The discrete wavelet transform is:

$$(Wf)(a,b)=\left\langle f,\psi_{a,b}\right\rangle=\left|a_0\right|^{-m/2}\int_{-\infty}^{+\infty}f(t)\overline{\psi\left(a_0^{-m}t-nb_0\right)}dt \qquad (4)$$

Among them： $a=a_0^m, b=nb_0a_0^m, m,n\in Z$.

Multi-resolution analysis

The essence of the multi-resolution analysis is put signal respectively after high and low pass filter to get the signal of high and low frequency approximation classification,then put the low frequency approximation component decomposed time further to classification high and low frequency, and so on, the resulting signals under different scales of decomposition coefficient of the high frequency component and low frequency component. In the case of three layers of decomposition, the decomposition process is shown in figure 1 in which A for low frequency component and D for high frequency component.

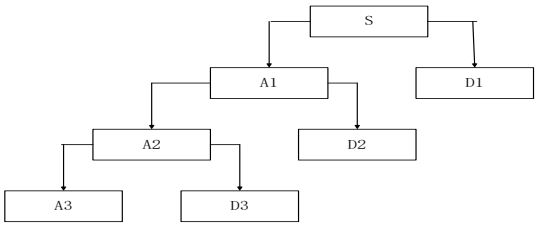


Figure .1 three layers of wavelet decomposition structure

Simulation Analysis

The limited capacity of the system modeling

The limited capacity system compared to the civil power grid system, the power quality disturbance caused the impact more obvious by impact and pulse load heavy use , on the other hand, with the diversification of load type and precision level of ascension,the requirements for power quality and power supply quality is becoming more and more high. By MATLAB simulation software to build the limited capacity system model, the diesel generator as a power generation unit, Join conventional resistance load, including controlled rectifier power electronic load, pulse load and asynchronous motor as impact load , the simulation model is shown in figure 2:

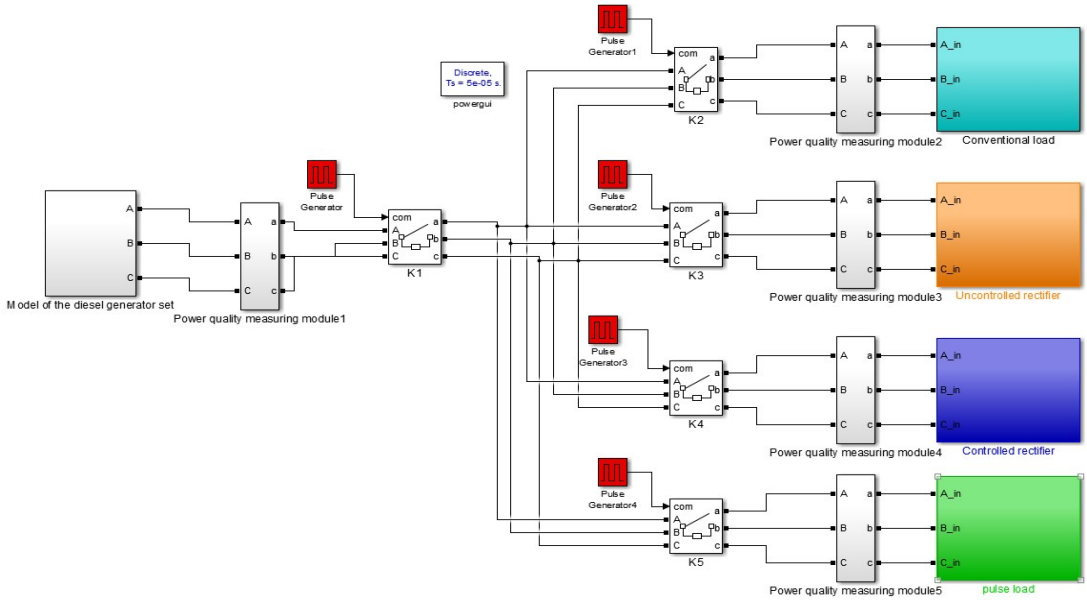


Figure. 2 the limited capacity system simulation model

Harmonic detection and analysis

Harmonic generated by the limited capacity system model, the sampling frequency is 20000 hz, the sampling point number is 4000, the simulation time for ten period t = 0.2 s, power frequency harmonic simulation waveform is shown in figure 3:

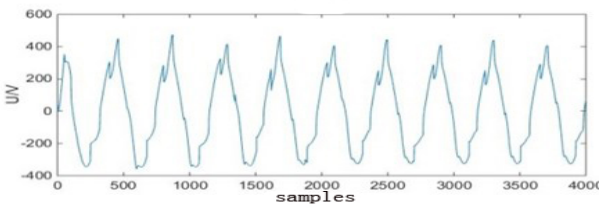
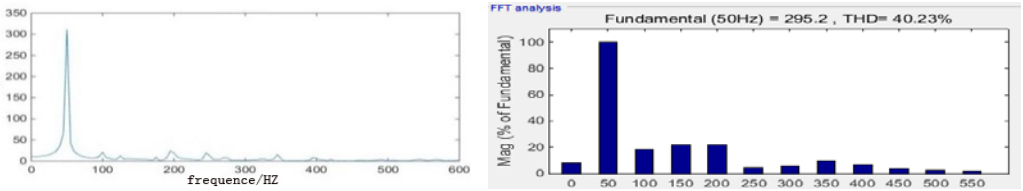


Figure. 3 harmonic wave

Detect the harmonic content of voltage waveform by FFT, diagram of the signal amplitude and frequency harmonic component analysis results respectively as shown in figure 4 (a), (b) :



(a) (b)

figure .4 Harmonic analysis diagram

First by MATLAB programming of the system to produce the harmonic signal amplitude frequency detection, and the harmonic wave type and amplitude can be seen from the amplitude-frequency diagrams system, then using the FFT analysis of the harmonic signal detection in the SIMULINK, the voltage signal and harmonic components contained in content can be accurately detected by FFT .

The transient power quality disturbance detection

This paper through into different kinds of load to simulate the disturbance types of the limited capacity system: common voltage interruption, voltage rise and voltage pulse three kinds of signal. As the signal of power quality disturbance detection using wavelet transform, the wavelet base selection and the determination of decomposition layers on the accuracy of the disturbance signal detection is crucial, through a large number of tests, the final choice "db3 “wavelet decomposition, the disturbance signal do three layer voltage interruption, voltage rise, and voltage pulse signal wavelet decomposition map were shown in figure 5-7:

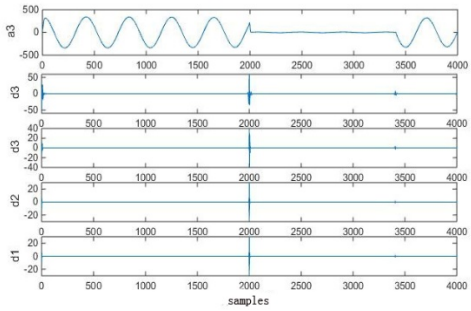


Figure. 5 voltage sag diagram

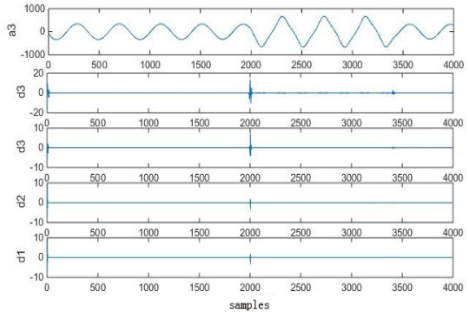


Figure. 6 voltage rise diagram

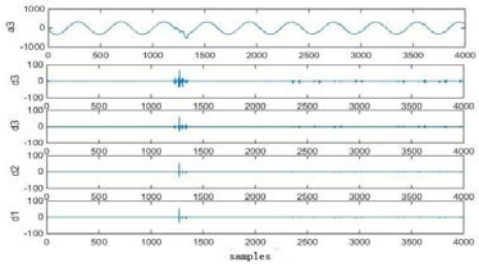


Figure .7 voltage pulse diagram

After wavelet decomposition in 3 layers of three kinds of power quality disturbance signals, a3 for low frequency approximation coefficients, contains the fundamental frequency signal information, reflect the general characteristics of base band signal and the general picture, d1— d3 for high frequency detail coefficient, reflect the discrete wavelet transform to the scale of detail information, the disturbance signal can be seen from the d3 layer at the end and the happening ,the d3 layer can accurately reflect the signal mutation moment, thus the disturbance duration is calculated.The onset detection of power quality disturbance signal cross-references are shown in table 1:

Table 1 test results table

disturbance signal types	disturbance start time /ms			disturbance over time /ms		
	actual value	readings	relative error	actual value	readings	relative error
Voltage interruption	100	99.1	0.9%	170	169.5	0.29%
voltage rise	100	99.15	0.85%	170	170.75	0.44%
voltage pulse	60	60.3	0.5%	67.5	68.3	1.19%

Conclusion

It is critical for power quality to the safe operation of power equipment, it is a decisive role to how to quickly accurate detection the power quality disturbance signals to the next step to take the necessary protective measures . This paper through to model the limited capacity system and select effectively to the layer number of wavelet basis and decomposition ,and proposed based on fast Fourier transform and wavelet transform with the combination of comprehensive power quality detection method, through the simulation validation that the method can be accurately and effectively to detect harmonic components and content and can accurately detect and position the transient power quality disturbance signal.This method also has the advantage that real-time performance and high precision.

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