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WAVELET PACKET TRANSFORM BASED FAULT LOCALIZATION IN A MICROGRID

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Abstract: In this work an approach is taken to locate and detect the fault. The developed simulation in MATLAB environment is used to generate some of the fundamental component of transient parameters such as current and voltage both in frequency domain and time domain. As the utility companies for more revenue try to make the supply uninterrupted, so they need to act instantly in case of detection of fault. In hybrid system due to different auxiliaries the fault detection is bit difficult. For the detection of fault and to know its location wavelet transform is used in hybrid system. The waveform containing pre fault and post fault is taken for analysis. We have used discrete wavelet packet transform for processing these collected data. The wavelet packet transform method has the ability to determine information concurrently in time as well as frequency domain from the transient data for which it is used in disintegration of transients. Here for simulation of the different types of symmetric as well as asymmetric faults and dissimilar operating conditions MATLAB is used. The power system network is the collective combination of different components and sources that may be nonconventional or conventional which has the different degree of contribution towards the network. At the point of common coupling (PCC) the voltage reading is extracted and this data is processed through wavelet packet transform tool to figure out the irregularities. For the reliable fault analysis, the pinpoint location of fault distance and type to be found out.

Keywords: Fault detection, Distributed generation, Fault location, Wavelet transform packet (WPT).

1. INTRODUCTION

To restore the power as quickly as possible in the network quick detection of fault is utmost important so that the interruption in the power network will be minimum, so that reliability of the network can be improved. There are various techniques that include impedance based numerical method, Fourier analysis method, and traveling wave methods for quick detection of fault. Traditional methods now days are getting obsolete due to the introduction of high frequency components. It is seen that Fourier transform method have a non-acceptable error for time localization of time varying signals but earlier it is used to calculate fundamental frequency component. It is utmost important for the wavelet transform to scrutinize the waveform patens on a time scale as compared to frequency domain, which shows its importance in fault location calculation. Here wavelet transform packet is used in the paper because of its effectiveness of analyzing the fault as time varies. When the loads are nearer to the generating unites the losses that occur in transmission and distribution is minimized. Injecting the power of DG to the grid improves the dependability of the power system. Global toxic gas injection to the environment compiled the engineers to introduce the micro grid concept, so that the emission of and CO like gasses will be controlled. In this concept all the DGs are individually connected to form a micro grid. This voltage level is typically 400V or less so that it can be put in the distribution side to countering load demand. When mismatch between demand and supply occurs then the DGs are comes

into picture and supply according to their capacity. These micro grids are connected to the main grid at a point which is called point of common coupling. There are some protection circuits for the micro grid that is combination of relay and circuit barkers which protects the micro grid in case of fault. In addition to normal faults some specific care should be taken for large scale installation. Main protection challenge arises after connecting the micro grid with the power system. Abnormality in the voltage and current profile can be defined as fault. Some of the sensitive equipments will fail to operate in liner region if voltage and current level deviates from the pre-specified values. The fault location calculation becomes must if the line is long and running across inaccessible areas where patrolling can't be done easily and bad weather is also a cause of calculation of the fault point. The traditional process of fault detection is also time consuming and sometimes becomes impossible.

As locating a fault is of prior importance for a grid so for locating a fault a number of technologies have been followed. In literature [1] a real time approach was proposed based on the concept of fuzzy logic and wavelet theory. There are some difficulties in normal voltage and current measurement and that can be solved by wavelet analysis. Chunju et. al., [2] have proposed a method for identification of faulted phase based on neural network and fuzzy logic. Idea of extending the fault approach using neural network from single circuit double circuit line is discussed in reference [3].

Definitely if the location of the fault can be determined automatically reliability will improve. For the proper detection of these abnormal conditions voltage or current change and deviation in frequency are measured[4]. For fault study along FFT and FT now a day's emphasis is given on method like Welch algorithm and z transform for monitoring of electrical parameters [5]-[7]. In these procedures there is no time information only frequency information available; which creates problem for non-stationary signals. To avoid above mentioned problems s-transform, short-time-Fourier Transform (STWF), wavelet transform (WT) were reviewed and applied to fault analysis. But various traditional methods are used for fault analysis mainly traveling wave and impedance method[8].The paper is structured in the following way. Section II introduces the modeling of micro grid. Section III presents the Wavelet packet Transform techniques for detection of fault and in Section IV simulation and result analysis have done. Finally the conclusions drawn from the study is briefed in Section V.

2. PROPOSED MODEL

For carrying out the research on the operation and behavior of the different cases during power system operation in presence of Distributed generation, a simulation design has been carried out. It is very important that the proposed simulated system display an authentic system in all vital components. Here two distributed generators are connected to the existing grid. Both the DFIG wind turbine and micro turbine are connected in the distribution side. The voltage signals are extracted from the point of common coupling. Point of common coupling is at distribution side. The proposed model single line diagram is shown in the Figure 1.

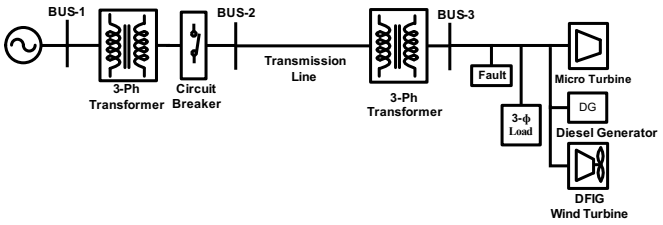

Figure 1: Single line diagram of micro grid

A three phase source is connected to the 3 phase transformer in the proposed model. The first transformer step-up the voltage to reduce the transmission losses. Another step down transformer is connected to reduce the voltage in the distribution side. The circuit breaker used in the network is at normally closed condition. It is attached to a 60 km long pi-section transmission line and in parallel to a three phase load. Fault block is connected near the PCC from where the voltage signals are extracted. The wind turbine and micro turbine are connected in the distribution side. Wind turbine is connected along

with a doubly fed induction generator in the region of point of common coupling.

3. WAVELET PACKET TRANSFORM

Analysis of wavelet packet transform is actually an extension of wavelet transform [9]-[12]. Both wavelet transform and wavelet packet transform are localized in time, but for representing a signal wavelet packet transform offers more flexibility than wavelet transform. Scaled and translated wavelet packet functions determines about wavelet packet approximations. This below wavelet packet functions are generated from the base function [13] as:

$$W_{jbk}(t) = 2^{j/2} W_b(2^{-j}(t - k)) \quad (1)$$

Here j, b, and k are the resolution level, number of oscillations and translation shift respectively. Signal $f(t)$ can be represented as orthogonal summation of base wavelet functions at different oscillations, scales and locations in case of wavelet packet analysis:

$$f(t) \approx \sum_j \sum_b \sum_k w_{j,b,k} W_{j,b,k(t)} \quad (2)$$

To satisfy orthogonality property the value of the summation for j, b and k the oscillations summation is chosen accordingly. An advanced algorithm called splitting algorithm [14] which is inspired by the pyramid algorithm [15] for discrete wavelet transform is utilized for the tabulation of the wavelet packet table. Algorithms are different for both cases. Here low pass and high pass filters are used for the decomposition of wavelet packet transform. All the coefficients like detailed and approximate are retained, including the coefficients used in the further decomposed stages. Best basis algorithm [9] is used for selecting optimal bases (transforms) from wavelet packet tables. Wavelet packet transform algorithm automatically adapts the transform to best match the characteristics of the signal. The best basis algorithm finds the wavelet packet transform "W' that minimizes the additive cost function,

$$E(W) = \sum_{j,b} E(w_{j,b}) \quad (3)$$

where, E is the set of index pairs of the components in the transform? Finding the entropy function minimum value is like finding the minimum value of default cost function. Feature extraction is done by selecting the suitable fault or islanding signals from the point of common coupling. Multi resolution of that signal is done for detection of the disturbances by using wavelet packet transform. Wavelet packet transforms multi resolution analysis techniques is discussed by many researchers in literatures [16], [17], [18]. Image coding based on energy sorted wavelet packets is discussed by Kong [19]. For the case of wavelet packet decomposition all the approximate signals are sorted according to their calculated energies. From the selected all signals the most important signals are analyzed and stored for detection of disturbances.

4. SIMULATION RESULTS

In this paper detection and location of fault was performed on the proposed model which is 20km long, 120kv long, 50Hz over head transmission line. Using MATLAB SIMULINK simulation was performed. This section presents the simulation and analysis of the system and techniques for fault disturbance detection in power system using wavelet packet transform under different operating conditions. The study is being implemented with Distributed generators like wind and micro turbine are connected. The disturbance detection study using wavelet packet transform is presented hybrid power system under different operating conditions. The voltage signal is captured from the point of common coupling. The voltage signal is then being processed by wavelet packet transform to detect the disturbance and the simulated results of the coefficients by using db5 wavelet packet transform is shown in Figure 2-8. This signal is collected in two different conditions. In the first case islanding occur in presence of the distributed generator resource and in second case line to line fault is taken into consideration. The results of all the coefficients are shown in Table 1 and 2. For detecting the disturbances the signals received from the point of common coupling are imported to the wavelet packet tool box. The fault is created after 20km distance, with a simulation time of 0.5 sec. Figure 2 and 3 shows the detection of disturbances.

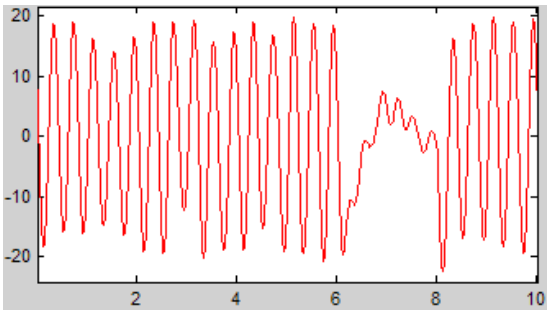

Figure 2: Original signal of Islanding

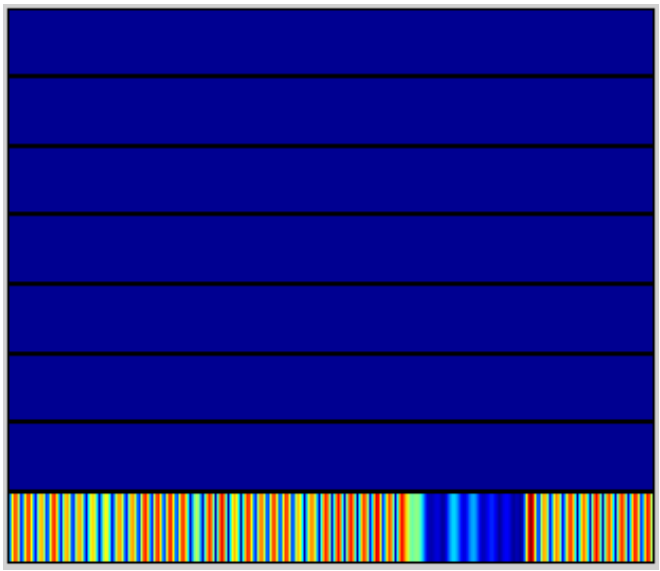

Figure 3: Detection of Islanding using db5 wavelet packet

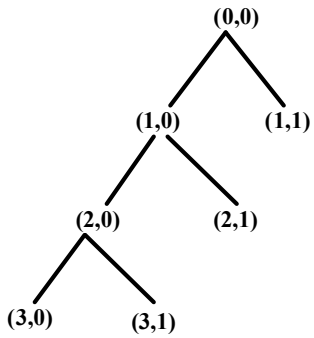

Figure 4: Wavelet Tree of the signal

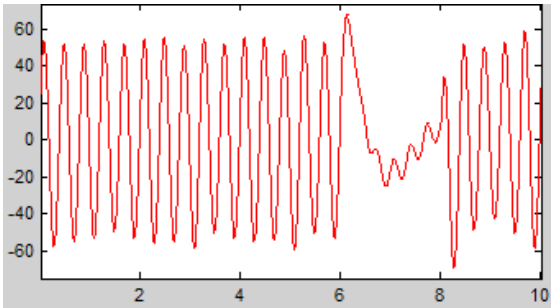

Figure 5: Original signal of Line to Line fault

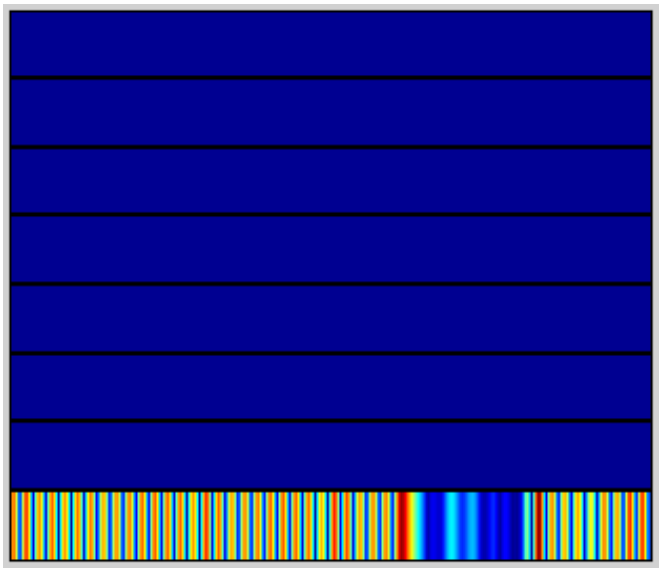

Figure 6: Detection of fault using wavelet packet

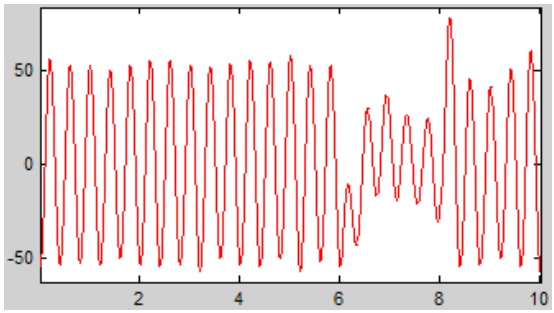

Figure 7: Original signal of Line to ground fault

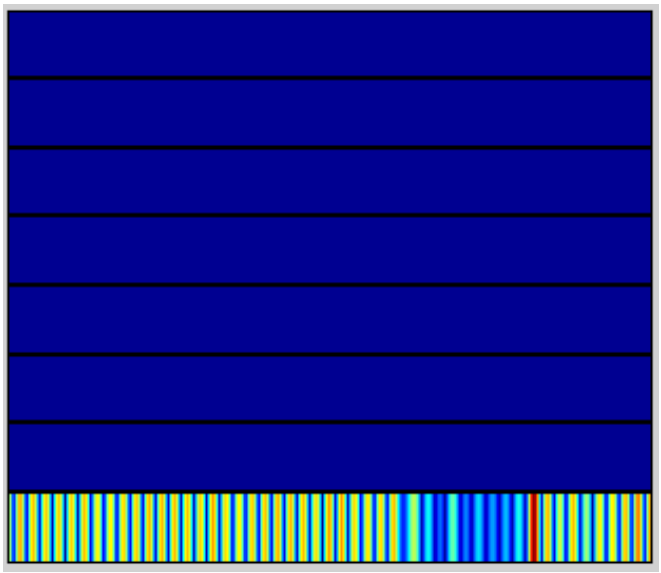

Figure 8: Detection of fault using wavelet packet

Estimate distance (km) of fault location = 17.1 + 2.5 = 19.6. The proposed method is able to locate the fault with a error of 2%. Table 1 and 2 shows the

Table 1
Differences between maximum scale db5

Coefficients	*db5 (max)*			
	A1	*H1*	*V1*	*D1*
Coefficients (Post Fault)	694.3	344	383.6	292.4
Coefficients (Pre Fault)	696.8	313.3	346.3	236.6
Differences	–2.5	30.7	37.3	55.8

Table 2
Differences between minimum scale db5

Coefficients	*db5 (min)*			
	A1	*H1*	*V1*	*D1*
Coefficients (Post Fault)	97.7	279.3	340.9	265.3
Coefficients (Pre Fault)	114.8	261.9	322.9	215.9
Differences	–17.1	17.4	18	49.4

pre fault and post fault wavelet packet coefficients (Diagonal details, horizontal details, approximate details and vertical details) at 20 km using the db5 wavelet packet. Coefficient scales are depending upon the minimum and maximum scale. Fault location of the proposed model was predicted after adding the non negative values of the scales after deducting the pre fault coefficients from post fault coefficients. The voltage signal with its detection results by detail and approximate coefficient of db5 wavelet packet is presented in Table 1 and 2. The voltage signal represents the variation which is also being detected by the wavelet packet coefficients. In the signal and the corresponding detection in the detail and approximate coefficients of db5 wavelet packet are reflected in figure. It is observed from the detail coefficient that the instant fault occurrence is clearly detected with a sudden variation magnitude and when the fault is cleared, the voltage and its coefficients become normal.

5. CONCLUSION

In this paper wavelet packet-transform is used for the location of fault and disturbance detection in a grid connected hybrid system. The reason of using wavelet packet-transform is because it is sensitive to the sudden change of signal. When there is a fault or disturbances occurs the energy extracted by using wavelet packet transform at the point of common coupling shows drastic change. Performance was measured by taking different types of fault such as islanding and line to line fault conditions. Finally it was shown here that the proposed method able to detect and locate the fault in a power system network in presence of distributed generators. Detection of disturbances is detected using db5 wavelet packet transform along its wavelet tree diagram.

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