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A Renewable Energy Source Approach for Identification and Classification of Transmission Line

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Abstract: ***The purpose of the analysis is usually a guide to the selection of a particular representation. For a particular geophysical application one has to determine whether wavelet representation is needed in the first place and then to select the best wavelet representation for the problem at hand. This requires a good understanding of the properties of wavelets and how each property could be used for extracting certain information from a process. For remedy of the faulted zone a precise study of the waveforms of voltage and current during the fault incidence is required. A new technique is proposed for identification and classification of different type of fault on a transmission line using discrete wavelet analysis.***

Keywords: wavelets, Multi Resolution Analysis, Fourier

1. Introduction

Wavelet analysis is becoming a common tool for analyzing localized variations of power within a time series. Wavelet transforms are relatively recent developments that have fascinated the scientific, engineering, and mathematics community with their versatile applicability.

Wavelet transform has provided not only a wealth of new mathematical results, but also a common language and rallying call for researchers in a remarkably wide variety of fields: mathematicians working in harmonic analysis because of the special properties of wavelet bases; mathematical physicists because of the implications for time-frequency or phase-space analysis and relationships to concepts of renormalization; digital signal processors because of connections with multi rate filtering, quadrature mirror filters, and sub band coding; image processors because of applications in pyramidal image representation and compression; researchers in computer vision who have used "scale-space" for some time; researchers in stochastic processes interested in self-similar processes, 1/f noise, and fractals; speech processors interested in efficient representation, event extraction and mimicking the human auditory system.

The identification and classification of the fault is an important aspect of transmission line protection. In future the dependence on renewable sources such as sun, wind, biomass etc. will increase as the non-renewable energy resources are depleting day after day. The discrete wavelet analysis has been used for fault analysis of transmission lines in power system which consist of two power sources connected through a transmission line. In the proposed work, power system will consist of one power source S and one renewable energy source (sun, wind, and biomass) connected through the single circuit power line. The technique used here is wavelet analysis which is used for fault analysis. This is a new form of signal analysis which is far more efficient than Fourier analysis whenever a signal is dominated by transient behavior or discontinuities.

2. Wavelet Transforms

A wavelet is a waveform of effectively limited duration that has an average value of zero. Compare wavelets with sine waves, which are the basis of Fourier analysis. Sinusoids do not have limited duration they extend from minus to plus infinity, and where sinusoids are smooth and predictable, wavelets tend to be irregular and asymmetric. Fourier analysis consists of breaking up a signal into sine waves of various frequencies. Similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet. It also makes sense that local features can be described better with wavelets that have local extent [5]. The wavelet transform allows resolving the resolution problem encountered in STFT. The basic functions allow to trade off the time and frequency resolution in different ways. If a large region of low frequency signal is to be analysed, a wide basis function will be used. Similarly, if a small region of high frequency signal is to be analysed, a small basis function will be used. The basic functions of the wavelet transform are known as wavelets. There are a variety of different wavelet functions to suit the needs of different applications.

Unlike Fourier, this relies on a single basis function. This is a new form of signal analysis is far more efficient than Fourier analysis whenever a signal is dominated by transient behaviour or discontinuities. In wavelet analysis we often speak about approximations and details. The approximations are high scale, low frequency components of the signal. The details are the low scale, high frequency components. The filtering process at its most basic level, like: the original signal decomposes through two complementary filters and emerges as two signals. This decomposition process can be iterated, with successive approximations being decomposed in turn, so that one signal is broken down into many lower resolution components. This decomposition process called as Multi Resolution Analysis (MRA).

The Wavelet Transform provides a time-frequency representation of the signal and uses multi-resolution technique by which different frequencies are analysed with different resolutions. The wavelet analysis described is known as the continuous wavelet transform or CWT. More formally it is written as:

$$y(s,T)=\int f(t)\psi^{*}s,T(t).dt \qquad (1)$$

Where * denotes complex conjugation. This equation 1 shows how a function f(t) is decomposed into a set of basic functions called the wavelets. The variables s and t are scale and translation parameters respectively are the new dimensions after the wavelet transform. The Wavelet Series is just a sampled version of CWT and its computation may consume significant amount of time and resources, depending on the resolution required. The Discrete Wavelet Transform (DWT), which is based on sub-band coding, is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required.

$$\psi\, j.k(t)=\frac{1}{\sqrt{soj}}\psi(tktosoj)/soj \qquad (2)$$

In equation (2) j and k are integers and s0 > 1 is a fixed dilation step. The translation factor o depends on the dilation step. In the case of DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. The signal to be analyzed is passed through filters with different cut off frequencies at different scales. The DWT is computed by successive low pass and high pass filtering of the discrete time-domain signal.

Wavelet transform are classified into discrete wavelet transforms (DWTs) and continuous wavelet transforms (CWTs). Note that both DWT and CWT are continuous-time transforms. They can be used to represent continuous-time signals. CWTs operate over every possible scale and translation whereas DWTs use a specific subset of scale and translation values or representation grid. The wavelet Transform of a continuous signal x (t) is defined as:

$$WT(a,b)=\tfrac{1}{\sqrt{a}}\times\int_{-\infty}^{\infty}\times(t)*g\left(t-\frac{a}{b}\right).dt \qquad (3)$$

Where a and b are the scaling and translation parameters respectively and g is the mother wavelet function.

3. Motivation

The increasing complexity of the power systems, concomitant with a demand to drive the network harder without compromising on the quality of power supply, has meant that power engineers it continuously strive for a improved alternative methods of transient analysis, for the purposes of designing new equipment to efficiently and expeditiously deal with abnormal transient phenomena. In this respect, the present methods of transients analysis have limitations. For instance, a Fourier series requires periodicity of all the time functions involved, this effectively means that the basic functions (i.e. sine and cosine waves) used in Fourier analysis. Traditional Fourier analysis does not consider frequencies that evolve with time, i.e. non-stationary signal. Finally, certain adverse effect such as the Gibbs phenomenon and aliasing associated with the discrete FT (DFT) exists when analyzing certain waveforms. However, the drawback is the windowed FT (Also known as the short-time FT or STFT) has the limitations of the fixed window width which needs to be fixed a prior, this effectively means that it does not provide the requisite good resolution in both time and frequency, which is an important character for analyzing transient signals comprising both high and low-frequency components [5]. Wavelet analysis overcomes the limitations of the Fourier methods by employing analysis functions that are local both in time and frequency. The WT is well suited to wideband signals that are not periodic and may contain both sinusoidal and impulse components as is typical of fast power system transients. In particular, the ability of wavelets to focus on short-time intervals for high frequency components improves the analysis of signals with localized impulses and oscillation, practically in the presence of fundamental and low-order harmonics. In a sense, wavelets have a window that automatically adapts to give the appropriate resolution.

4. Objectives

Keeping in view the study of the existing research, the present paper has been undertaken with the following objectives:

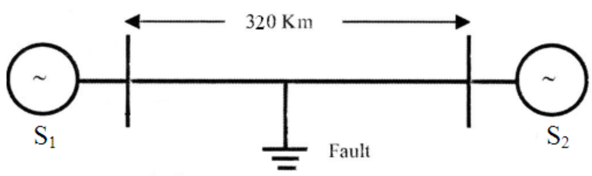
- To study the wavelet techniques for power system fault analysis.
- To identify the different type of faults on the system.
- To make a model for a power system having renewable energy resource as a source of energy of a power station MATLAB simulator.
- To analyse the system transmission faults using DWT.
- To identify and classify various types of faults.
- Comparison is to be done with the reference system.

5. Proposed Scheme

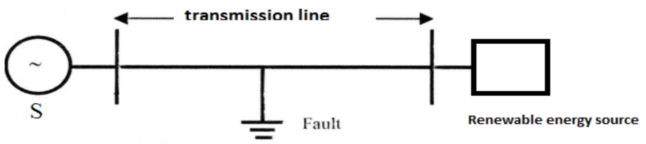
The identification and the classification of the faulty phase/phases is an important aspect of transmission line protection. Discrete wavelet analysis has been used to analyse the faulty signal. At the incident of fault, variation of both voltage and current at the location of protective relay is expected. Severity of the distortion from normal waveform depends mainly on the type of fault. The normal operation of system has taken as reference for our analysis. Wavelet decomposition of the normal state will gives information about occurrence of fault. Faults are simulated for the power system including with ground faults and without ground faults. This can be identified by zero sequence component of the system. Taking the maximum value of the percentage of energy spectrum of signal as the base value of each decomposed waveform and comparing it with the three phase currents during the fault and it is possible to differentiate between similar types of faults. The faulty signal also analyzed with respective approximation and detailed coefficients.

6. Methodology

The discrete wavelet analysis has been used for fault analysis of transmission lines in power system which consist of two power sources connected through a transmission line.



In the proposed work, power system will consist of one power source S and one renewable energy source (sun, wind, and biomass) connected through the single circuit power line. The technique used here is wavelet analysis which is used for fault analysis. This is a new form of signal analysis which is far more efficient than Fourier analysis whenever a signal is dominated by transient behaviour or discontinuities.



The simulation model of system will be developed by Matlab/ Simulink Software.

7. Simulation Results

In this section, the proposed method has been simulated and the simulation results are presented. The simulink modal implemented for three phase power grid connected wind power source with common transmission lines is as:

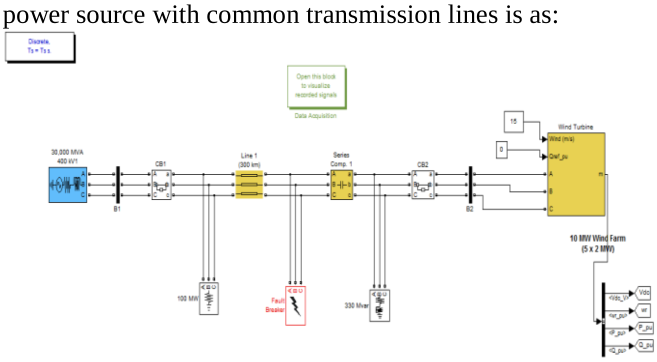


Figure 1: Wind turbine connected grid simulink model

Here the wind farm is represented by a block which includes turbine and drive train, inverter, DC-DC boost converter, generator unit and control unit.

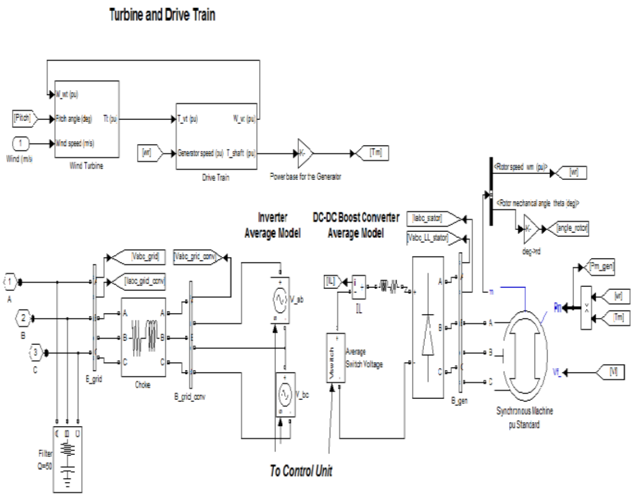


Figure 2: Wind Turbine Unit

This is the most important unit of the system under consideration. This can be broken down into different units. This unit is responsible for providing the input from the wind farm. This block is simulated using the Simulink blocks available in the MATLAB.

Post fault samples of three phase current, and voltages have been collected from the circuit breaker of the bus bar 1 and 2. By using the fault signal data wavelet decomposition bas been performed. The sampling interval is 1ms and the circuit breaker transition time is set to 0.04. The transition time of the fault breaker is set to 0.1 to create (apply) fault in the transmission line network. Applying different type of faults and taking part of the waveform from the circuit breaker, before and after the fault incident is analyzed by discrete wavelet analysis. To determine the involvement of ground in fault, presence of zero sequence components have been considered simulation can be done by taking the faulty waves from circuit breaker either one end or two ends of the transmission line. Effectiveness of the proposed methodology has been evaluated by conducting different trials.

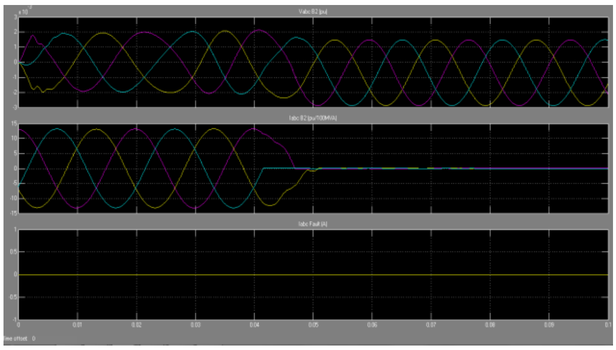


Figure 6.1 : No Fault condition

6.1 Phase To Phase Fault

lt is between line A and line B can be identified from the waveform recognition.

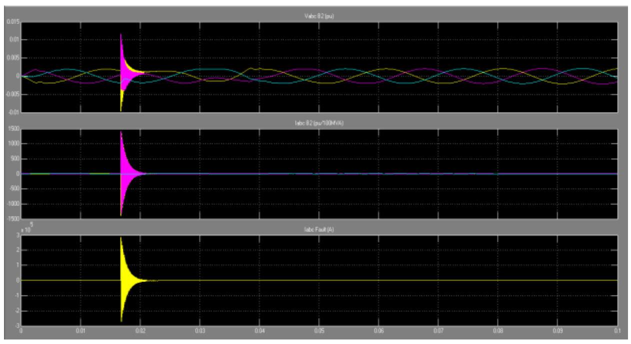


Figure 6.2: Phase A to Phase B fault

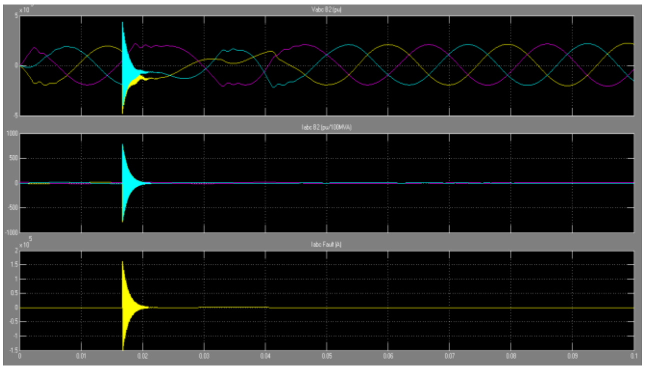


Figure 6.3: Phase A to Phase C fault

6.2 phase to Ground Faults

When faults occur between any phase/ line and ground, it can be identified from the given waveforms. Figure 5.4 illustrates the fault on transmission line between phase A and ground, figure 5.5 illustrates the fault on transmission line between phase B and ground, figure 5.6 shows the fault on transmission line between phase C and ground.

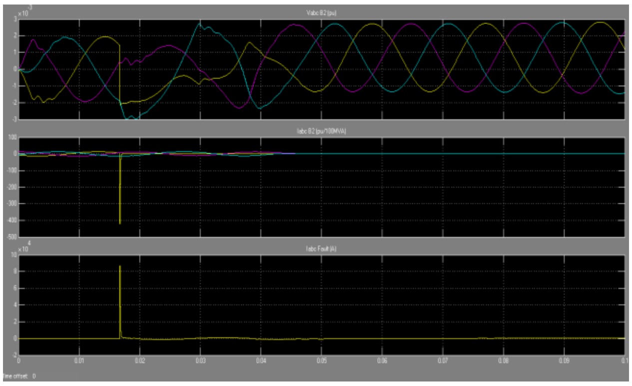


Figure 6.4 : Phase A to ground fault

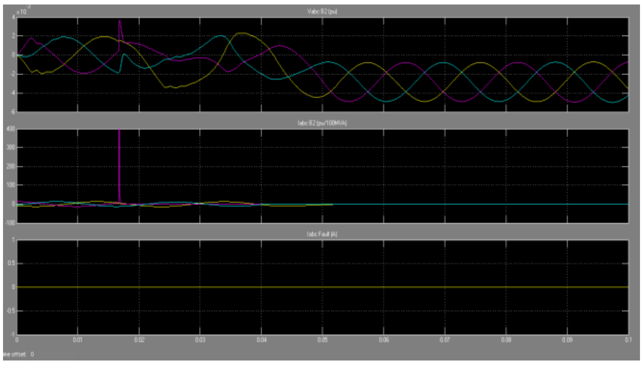


Figure 6.5: Phase B to ground fault

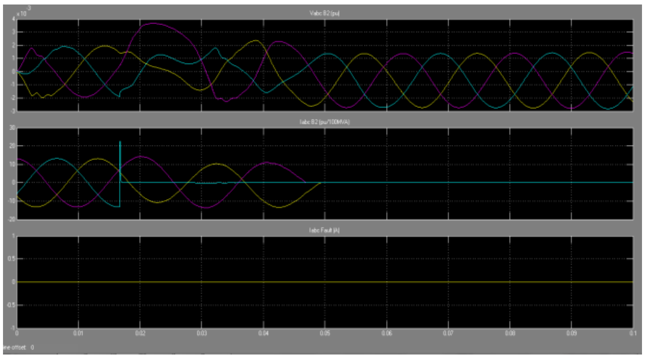


Figure 6.6: Phase C to ground fault

6.3 Double Line to Ground Faults

In few cases, line to line fault is further connected to earth which can be treated as double line to ground fault. The se faults can be identified and classified from the below mentioned waveforms.

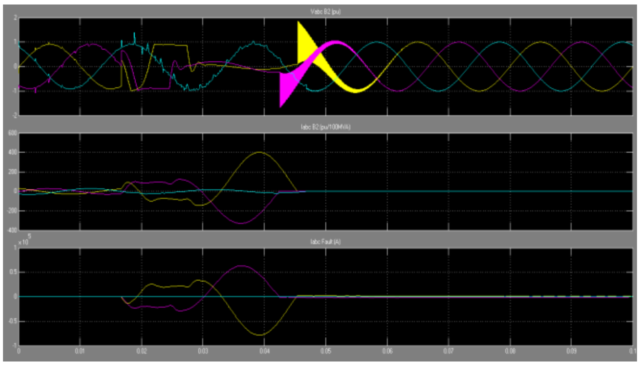


Figure 6.7: fault on Phase A- Phase B to ground

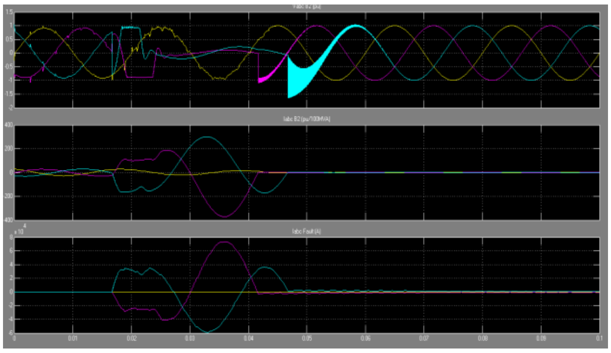


Figure 6.8: fault on phase B – phase C to ground

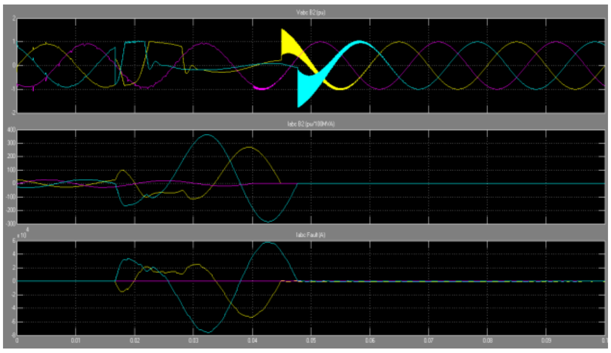


Figure 6.9: fault on phase A – phase C to ground

7.4 Triple line to ground fault (LLL-G)

Triple line to ground fault on transmission line can be identified from the below mention:

Waveforms in figure 10, all the faults occurred on the transmission line can be identified and classified by waveform recognition**.**

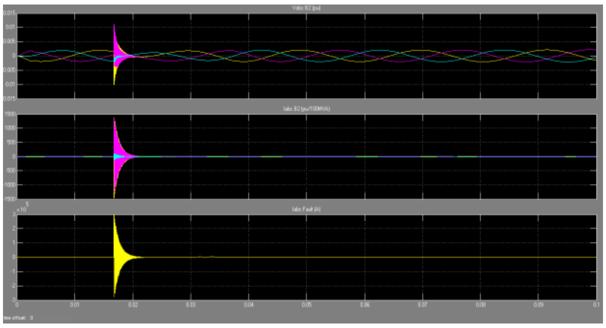


Figure 6.10: LLL to ground fault

8. Conclusions

The paper highlights that wavelets are mathematical functions and studies each component with a resolution matched to its scale. Wavelets were developed independently in the fields of mathematics, quantum physics, electrical engineering, and seismic geology. Interchanges between these fields during the last ten years have led to many new wavelet applications such as image compression, turbulence, human vision, radar, and earthq0uake prediction. The paper aims at detecting and classifying the power system transmission line faults and presents the simulation of all the faults along with a comparison analysis.

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