A NOVEL APPROACH FOR FAULT LOCATION IN TRANSMISSION LINES USING MODERN WAVELET TRANSFORMS

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ABSTRACT

Protection of transmission lines which are being exposed to atmospheric conditions and faults is necessary for the effective operation of the transmission system. A new approach has been proposed to find fault location which is suitable for mutually coupled tower geometries as well as series capacitor compensated lines.The proposed methodology developed is based on the traveling waves of transmission lines. The results obtained confirm that the global performance of the fault location algorithm proposed is highly satisfactory with regard to accuracy and speed of response for all the tests considered.

***Keywords**: transmissionlines, wavelets, wavelet transform, fault*

INTRODUCTION

Until recently, many power companies have made very little investment in overhead fault location equipment [1], assuming that most of the faults are transient [2] and there is no need to find fault location. Furthermore, it has been assumed that the accuracy of the results provided by *reactance* [3] based methods of fault location were not reliable [4] enough to justify sending staff to confirm the locations [5] of transient faults. Consequently, fault location activities were initiated only when a fault was permanent [6] and action was unavoidable. With the privatization and regulation [7] of electricity supply companies throughout the world [8], efforts are being made to achieve the higher plant utilization factors [9], and better standards of quality of supply that a competitive market demands. Power companies are now adopting a ‗pro-active' approach to many of their activities with more emphasis on using wavelet technology [10] to find overhead line faultlocations.‗

INTRODUCTION TO WAVELETS

Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. It is a linear transformation much like the Fourier transforms. Table 1 gives the Functioning and disadvantages of Fouriertechniques.

Table.1 Functioning & disadvantages of Fourier techniques

Technique	Functioning	Disadvantage
Fourier Series	It is the representation of a signal in frequency domain and that signal must be a periodic signal.	Not applicable for non-periodic signals.
Fourier Transform	Representation of an arbitrary or non periodic signal over the entire interval.	Time information of signal is loosed.
Short Time Fourier Transform	A window technique is used and a two dimensional information of a signal is available.	Window is not adjustable.
Wavelet Transform	All the necessary information of signal is available	Window is also adjustable

They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. 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 earth quake prediction.

WAVELET TRANSFORM

Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information. Fig.1illustrates wavelet transform of a signal

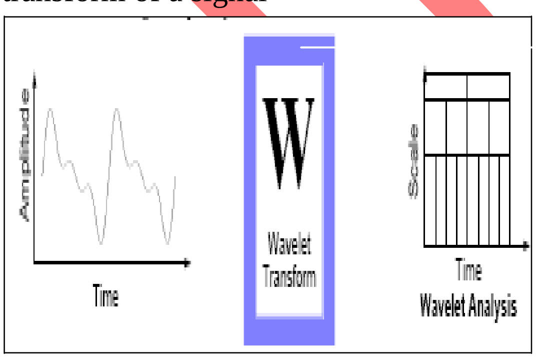

Fig.1 Wavelet Transform of a signal

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TIME AND FREQUENCY RESOLUTIONS

In this section resolution properties of the wavelet transform are discussed. The resolution problem is the main reason for switching from Short Time Fourier Transform to Wavelet Transform.

Fig.2 illustrates how time and frequency resolutions are interpreted. Every box in Fig.2 corresponds to a value of the wavelet transform in the time-frequency plane. Note that the boxes have a certain non-zero area, which implies that the value of a particular point in the time-frequency plane cannot be known. All the points in the time-frequency plane that falls into a box are represented by one value of the Wavelet Transform(WT).

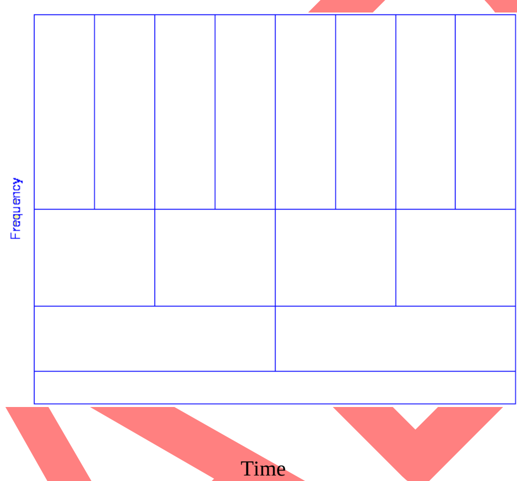

Fig.2 time and frequency resolutions interpretation

In Fig.2 although the widths and heights of the boxes change, the area is constant, which means that each box represents an equal portion of the time-frequency plane, with different proportions of time and frequency. At low frequencies, the height of the boxes are shorter (which corresponds to better frequency resolutions, since there is less ambiguity regarding the value of the exact frequency), but their widths are longer (which correspond to poor time resolution, since there is more ambiguity regarding the value of the exact time). At higher frequencies the width of the boxes decrease, i.e., the time resolution gets better, and the heights of the boxes increase, i.e., the frequency resolution gets poorer.

LOCALIZED AREA ANALYSIS CAPABILITY OF A WAVELET TRANSFORM

One major advantage afforded by wavelets is the ability to perform local analysis, that is, to analyze a localized area of a larger signal. Consider a sinusoidal signal with a small discontinuity which is so tiny and barely visible as illustrated in fig.3

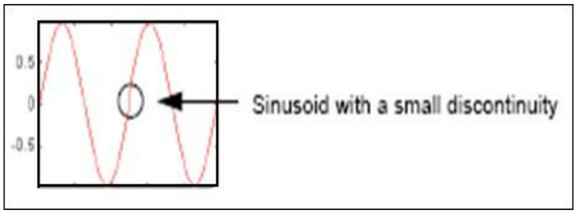

Fig.3 Sinusoidal signal with a tiny discontinuity.

From fig.4, a plot of the Fourier coefficients (as provided by the Fast Fourier Transform (FFT) command) of this signal shows only a flat spectrum with two peaks representing a single frequency.

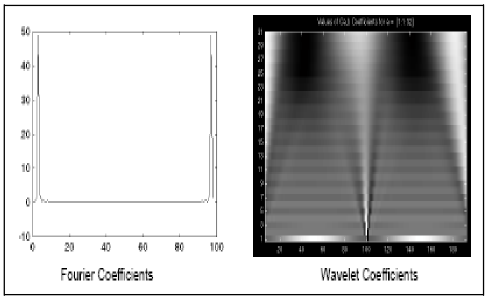

Fig.4 Fourier coefficients and Wavelet coefficients of the Sinusoidal signal

However, a plot of wavelet coefficients clearly shows the exact location in time of the discontinuity.When wavelets are compared 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. By looking at pictures of wavelets and sine waves, it can be seen intuitively that signals with sharp changes might be better analyzed with an irregular wavelet than with a smooth sinusoid, just like some foods can be better handled with a fork compared to a spoon. Local features can be described better with wavelets as illustrated in fig.5

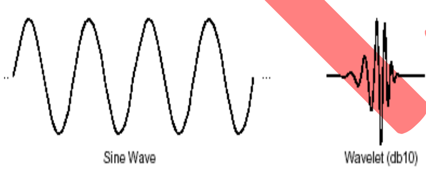

Fig.5 wavelet of sine wave

The most popular wavelet transform applications in power systems are the following:

- » Power systemprotection
- » Powerquality
- » Power systemtransients
- » Partialdischarges

» Loadforecasting
» Power systemmeasurement

Fig.6 illustrates % of wavelet publications in different power system areas.

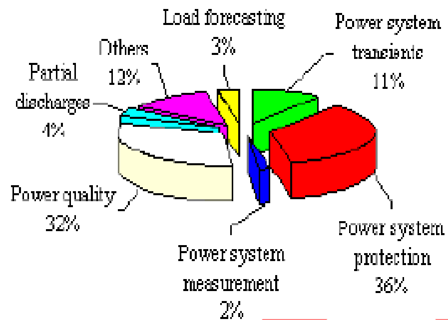

Fig.6 % of wavelet publications in different power system areas.

FORMULATION OF THE PROBLEM

Consider a system consisting of two Generators and a parallel & a single line transmission system as illustrated in fig.7

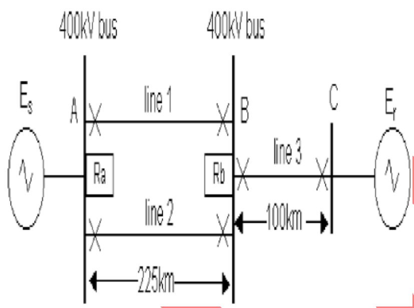

Fig.7 sample power system

A single line to ground fault occurs on a transmission line at a distance ***d*** from bus A; this will appear as an abrupt injection at the fault point. This injection will travel like a surge along the line in both directions and will continue to bounce back and forth between the fault point and the two terminal buses until the post fault steady state is reached. Hence, the appeared fault transients at the terminals of the line will contain abrupt changes at intervals commensurate with the travel times of signals between the faults to the terminals.

When a fault occurs on transmission line it causes: voltage instability, insulation failure, damage to the equipment, interruption of power to consumers and so on. Hence, the location of faults is necessary to maintain system voltage, voltage stability, to prevent fire hazards, in order to clear faults quickly and restore power supply to consumers and is essential for power companies to speed the restoration of service and to pinpoint the trouble areas. Wavelet Transform is the best suited method to determine the fault locationquickly.

A. *Steps for the fault location &isolation of the fault system*

The steps involved in the proposed Wavelet Transform method are as follows:

Creating an SLG fault on phase –a on transmission line -1

- Recording of faultsignals.
- Analyzing these signals using WaveletTransform.

B .*Wavelet transform analysis*

The signals that are obtained after transformation are transformed from the time domain into the time-frequency domain by applying the Wavelet transform (WT).

The WT is well suited to wideband signals that are non periodic and may contain both sinusoidal and impulse transients as it is typical in power system transients. Wavelets are useful for transient analysis. Much of power system analysis is steady analysis. However, in the area of electric power quality analysis, transients play an important role.

In the case of the wavelet transform, the analyzing functions, which are called wavelets, will adjust their time-widths to their frequency in such a way that, higher frequency wavelets will be very narrow and lower frequency ones will be broader. This property of multi resolution is particularly useful for analyzing fault transients which contain localized high frequency components superposed on power frequency signals. Thus, wavelet transform is better suited for analysis of signals containing short lived high frequency disturbances superposed on lower frequency continuous waveforms by virtue of this zoom-in capability.

C.Distance measurement

By measuring the time delay between the two consecutive peaks in the wavelet transform coefficients of the recorded fault signal at scale 1, with db4 as mother wavelet and taking the product of the wave velocity and half of this time delay, the distance to the fault can easily be calculated for different kinds of faults. The fault distance is given by theequation:

$d = (v*t_d)/2.$

Where,

d is the distance to the fault.

v is the wave velocity.

$t_d$isthetimedifferencebetweentwoconsecutivepeaksofthewavelet transform coefficients. The difference of the current magnitudes at buses A and B is given by $I = I_a\text{-}I_b$

The implementation of the fault location method using Wavelet Transform is done using MATLAB simulink tool.

D.*Implementation steps*

Step-I: Simulate the system using simulink and record the waveform.

Step-II: The obtained waveform is loaded into Mat labworkspace.

Step-III: The loaded signal is decomposed using discrete wavelet transform using code.

Step-IV: The approximation and detail coefficients are extracted from the signal and are plotted.

Step-V: The arrival time of the transient signal is determined by analyzing the detail coefficients.

Step-VI: Knowing the time and traveling wave velocity, the distance of fault location is determined.

MATLAB SIMULATION

A simulation model is developed for the system in fig.7 using simulink.

A. Simulation model without fault:

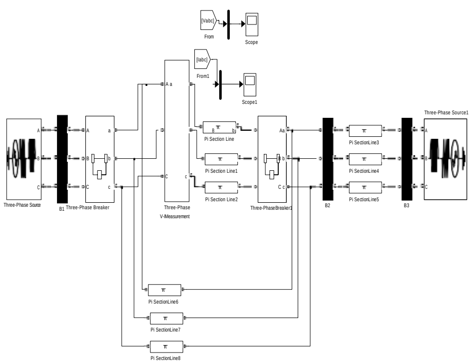

Fig.8 Simulation model without fault.

The healthy phase currents of the simulation model given in fig.8 (i.e. without fault) are illustrated in fig.9

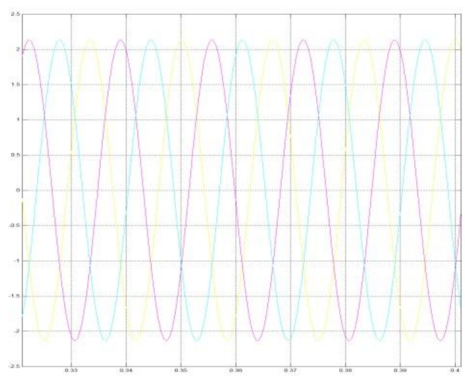

Fig.9 Healthy phase currents

B. Simulation model withfault

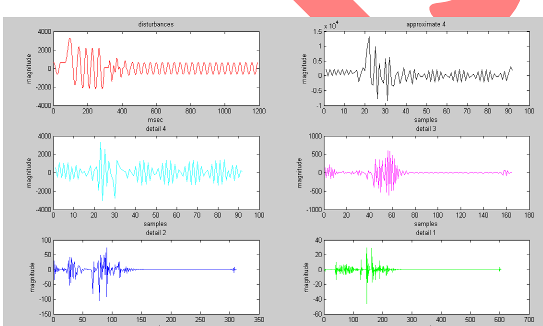

Fig.11 phase currents with fault

C. Results of waveletanalysis

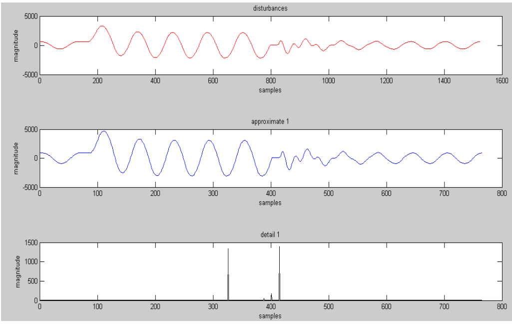

Fig.12 Results of wavelet analysis.

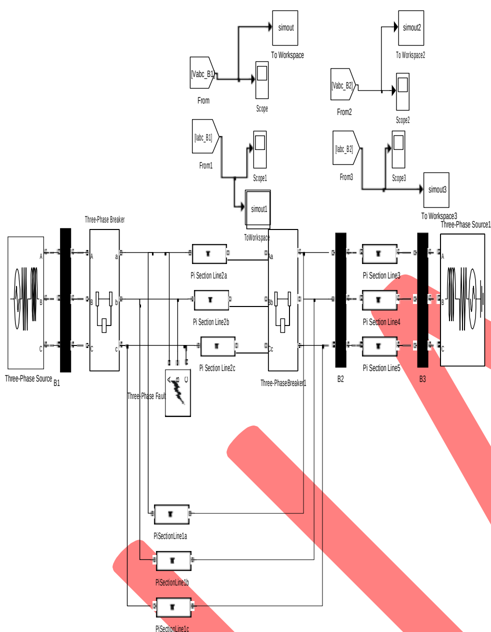

Fig.10 Simulation model with fault fig.11illustrates phase currents with fault.

Fig.12 illustrates the results obtained with wavelet analysis for one level decomposition with quick identification of fault location in the transmission line for single line to ground fault

CONCLUSION

This paper presents a new wavelet transform application to analyze the high frequency transients in a transmission system generated by a fault, with the purpose of determining its accurate location. The proposed fault location method is suitable for mutually coupled tower geometries as well as series capacitor compensated lines and is independent of Fault impedance, Fault type, and position&Fault inception angle

REFERENCES

1. Robi Polikar-–Wavelet tutorial introduction‖,www.users.rowan.edu/polikar/WAVELETS/WTpreface.html
2. JaidevaC.Goswami, AndrewK.Chan-–Fundamentals of wavelets‖.
3. G. Kaiser,–A Friendly guide to wavelets‖,Birkhauser,Boston, 1994.
4. www.amara.com/current/wavelet.html ―An Introduction toWavelets‖.
5. Badri Ram, D.N.Vishwakarma-–Power System Protection and Switchgear‖, Tata McGraw-Hill Publications, 1995.
6. D.C.Robertson,0.I.Camps,J.S.Mayer,andW.B.Gish,–WaveletsandElectromagneticPower System Transients‖, *IEEE Transactions on Power Delivery*, Vol.11, No.2, pp. 1050-1058, April 1996.
7. S. Santoso,E. Powers,W. Grady, and P.Hoffmann, –PowerQuality Assessment via Wavelet Transform Analysis‖, *IEEE Transactions on Power Delivery*,Vol.11.
8. I. Daubechies, *Ten Lectures on Wavelets,* SIAM, Philadelphia, Pennsylvania,1992.
9. C.KimandR.Aggarwal,–WavelettransforminPowerSystems,‖Inst,Elect.Eng.PowerEng.J., Vol.15, no.4 pp.193-202,Aug.2001.
10. Abur.A.:Ozgun,O.:Magnago,F.H.–AccurateModelingandSimulationofTransmissionline Transients using frequency dependent modal transformations‖, IEEE power Engineering society Winter Meeting,2001.

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