Wavelet approach for the transient current based three terminal transmission system protection scheme

M. Vaidehi

Asst. Prof
Mudundi.vaidehi@gmail.com

Abstract-This thesis introduces a wavelet based analysis for a three terminal transmission network. Increment in the power transfer ability and the effective usage of accessible transmission lines, enhancing power framework dependability and controllability have gained ground and made flexible AC Transmission (FACTS). This work presents a productive strategy dependent on wavelet analysis. A wavelet based multi resolution analysis is utilized to determine the point by point coefficients which are used to compute fault index. The detection and classification of the transient current is done by comparing the threshold value with the fault index. This proposed scheme can be proved in detecting the fault on transmission line irrespective of the line impedance, line inception angle, and the distance of the transmission line at which fault is occurred.

Keywords: Wavelet analysis, detailed co-efficient, fault index, multi resolution analysis

1. INTRODUCTION

Traditional electro-mechanical distance relays can be considered the first in a series of attempts to realize the aim of fault distance location. However, the conventional methods provide rapid and reliable indication of the normal faulted area rather than furnish fault distance estimates with pin-point accuracy.

Distance relay based protection provides economic advantages when installed on high-voltage power transmission lines. Unlike over-current relays, the fault convergence of distance relays is independent of source impedance variations [1]. The basic principle that all distance relays work on is the linear relationship between transmission line impedance and its length [2].

The performance of the power system is affected by faults on the transmission lines, which result in the interruption of power flow. From the transient phenomena, fault on transmission lines need to be detected, classified, locate accurately, and should be cleared as fast as possible. In transmission line protection and fault phase identification of fault are the two most important items which need to be addressed in a reliable and accurate manner. Identification and classification of faults on transmission line are essential for relaying decision and auto-reclosing requirements.

This thesis presents a Wavelet approach for three terminal transmission system protection schemes. Wavelet transform analyzes transient voltage and current signals associated with faults both in frequency and time domain.

The Global Position System (GPS) based algorithms with better performance and accuracy have been proposed. In this paper, Wavelet Multi Resolution Analysis is used for detection and classification of faults on transmission lines [5]. Detail D1 coefficients of current signals using Bior1.5 wavelets are used to detect and classify fault. This paper presents an efficient method based on wavelet transforms both fault detection which is almost independent of fault impedance, fault location and fault inception angle of three terminal transmission line fault currents.

2. WAVELET ANALYSIS

Wavelet Transform is a linear transformation much like the Fourier transform, however with one important difference: it allows time localization of different frequency components of a given signal. So, in signal analysis we use mathematical technique Wavelet analysis is particularly efficient where the signal being analyzed has transients or discontinuities, e.g., the post fault voltage/current waveform [7].

In wavelet transform, the analyzing functions, which are called Wavelets, will adjust their time width to their frequency in such a way that, higher frequency wavelets will be very narrow and lower frequency ones will be boarder. To study the each component with a resolution matched to its scale, Wavelet transform is used which is a tool that cuts up data or functions or operators into different frequency components. The high frequency components and low frequency components are detected accurately by adjusting the band analysis is the main advantage of this transformation technique.. Results from the wavelet transform are shown on both the time domain and the frequency domain [8].

The wavelet transform can expand signals in term of using shift in time as well as compression in time or dilation of a fixed wavelet function named as the mother wavelet. For the power system utilities, Power transmission line protection is one of the most important concerns. Wavelets are the set of basic functions; by dilation and translation of mother wavelet we decompose the signal in various frequency bands. Hence the incidence and amplitude of each frequency can be found accurately. Given, a function f(t), its continuous wavelet transform(WT) be calculated as follows

$$WT(a,b) = \frac{1}{\sqrt{a}} \int x(t) g\left(\frac{t-b}{a}\right) dt$$

Where a and b are the scaling (dilation) and translation (time shift) constants respectively, and Ψ is the wavelet function which may not be real as assumed in the above equation for simplicity.
Based on type of application mother wavelet is selected. In the following section a fictious method of detection and classification of faults using Multi Resolution Analysis of the transient currents associated with the fault is discussed [6].

3. PROPOSED SYSTEM

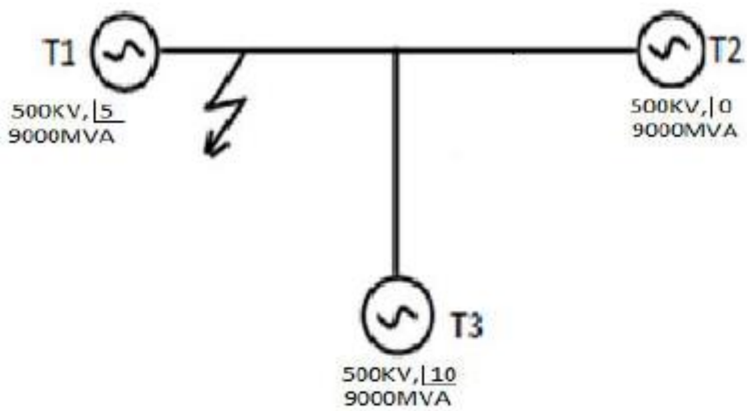

Figure 1. The Proposed System model

The test system is simulated Using the power system block set (PSB) and the SIMULINK software. The test system is shown in Figure.1 Three 110km length transmission line from each terminal to centre point of three terminal transmission system, 9000MVA short circuit levels (SCLs) sources and the angle difference 20°. The parameters such as positive sequence parameters, negative sequence parameters and zero sequence parameters of transmission line and positive sequence impedance, negative sequence impedance and zero sequence impedance are assumed here. The threshold value for fault index considered to be 1600.

4. DETECTION AND CLASSIFICATION OF FAULTS

The three phase currents of the local terminal are analyzed with Bior.1.5 mother wavelet to obtain the detail coefficients ($D1_L$) over a moving window of half cycle length. These $D1_L$ coefficients are then transmitted to the remote end. The detail coefficients received from the remote bus (D1R) are subtracted to the local detail coefficients ($D1_L$) to obtain effective D1 coefficients ($D1_E$). The Fault Index (If_1) of each phase is then calculated.

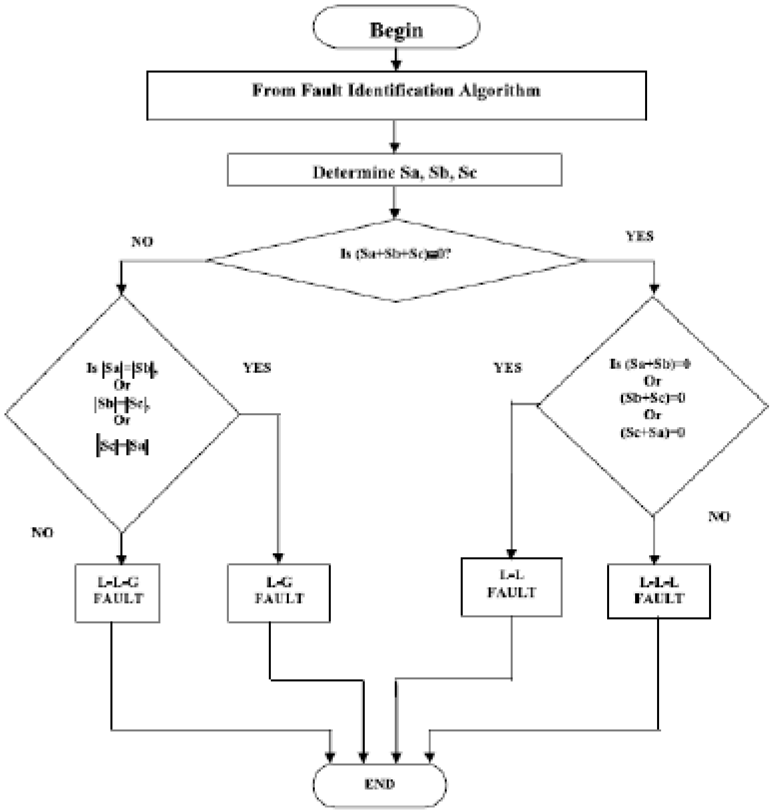

Figure 2. Flow chart for the detection of the fault

The complete flow chart for fault classification is as shown in Figure 2. When the algebraic sum of S_a, S_b and S_c is zero, then the fault can either L-L-L or L-L fault. The discrimination between these two types of faults is based on the fact that the magnitudes of S_a, S_b and S_c are comparable to each other in case of L-L-L fault. But in the case of L-L fault, the addition of coefficients of any two faulty phases tends to nearly equal to zero. The remaining healthy phase coefficient is very small and almost negligible compared to coefficients of other two faulty phases having equal values with opposite signs. When the summations of S_a, S_b and S_c is not equal to zero, then it can be either L-G or L-L-L-G fault.

If the absolute values of any two coefficients are equal and always much smaller than the absolute value of the remaining coefficients, then it is an L-G fault. If the calculated value of any two coefficients is and is always much higher and not equal to zero, then it is an L-L-G fault.

5. RESULT ANALYSIS

The results are by using the algorithm for different faults are given below. Figures 7-10 illustrates the Variation of fault index for transmission system with and without SVC at fault inception angle 800 with LG, LL, LLG and LLLG Faults on Phase ABCG on terminal1, terminal2 and terminal3

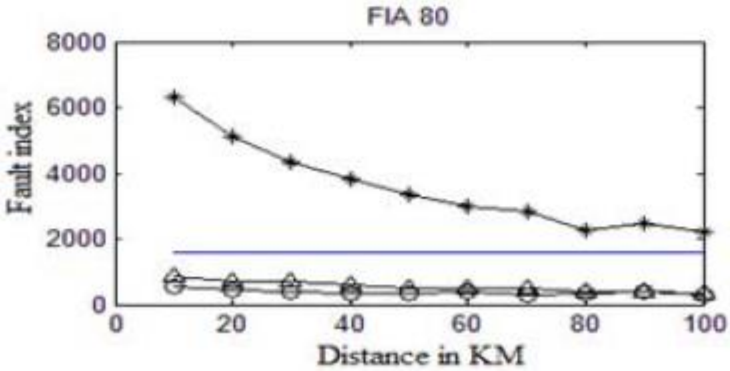

Figure 3(a)

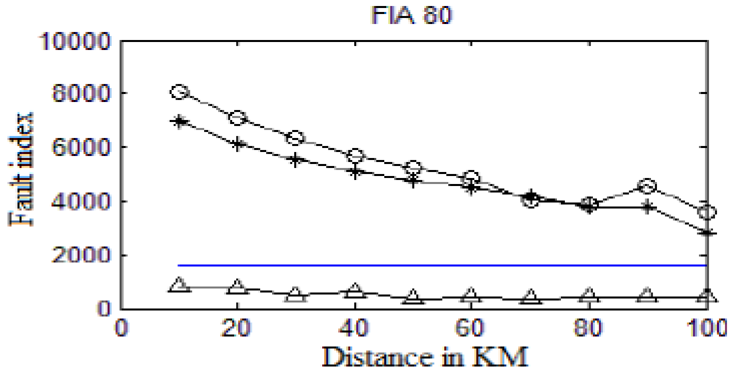

Figure 3(b)

Figure 3. Variation of fault index for transmission line at 80^0 from terminal 2 (a) LG fault on phase A (b) LLG fault on phase ABG

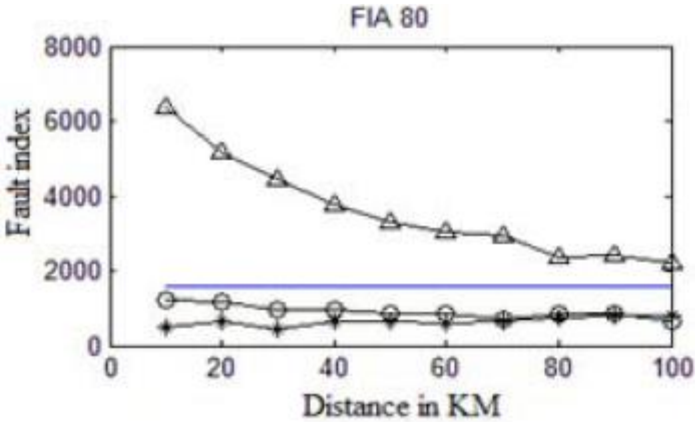

Figure 4(a)

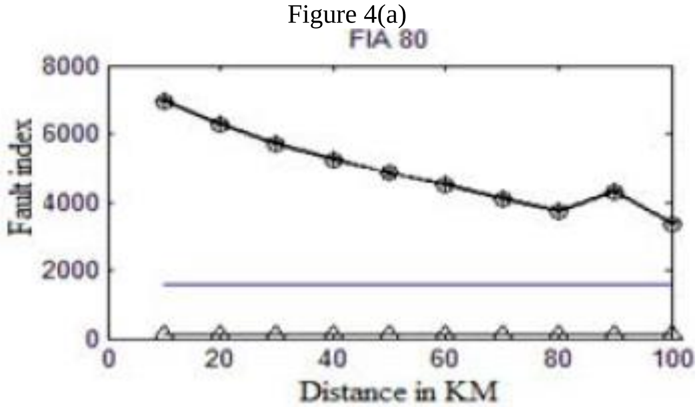

Figure 4(b)

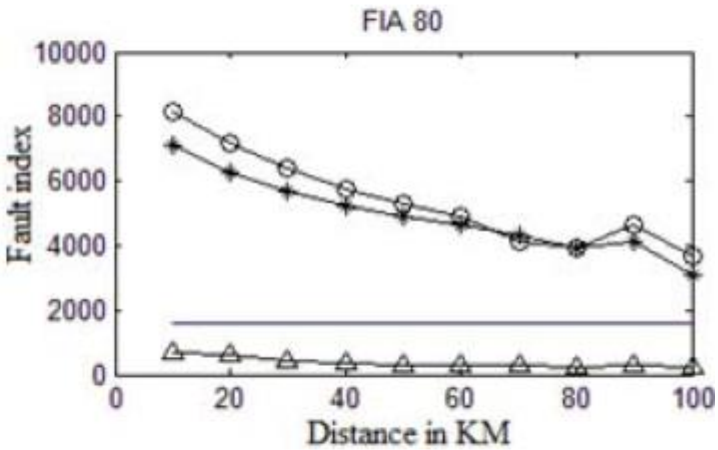

Figure 4(c)

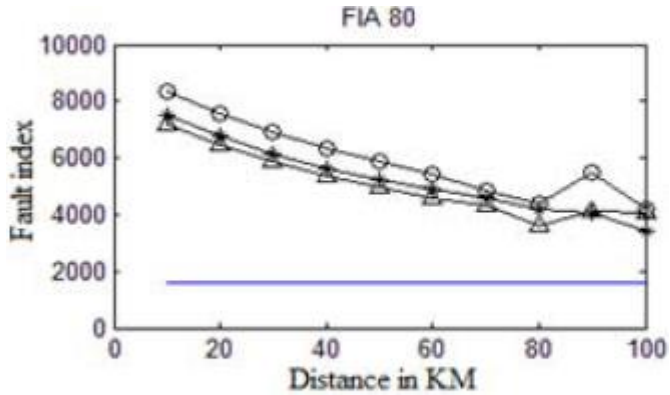

Figure 4(d)

Figure 4. Variation of fault index for transmission line at 80^0 from terminal 1 (a) LG fault on phase A (b) LL fault on phase AB (c) LLG fault on phase ABG (d) LLLG fault on phase ABCG

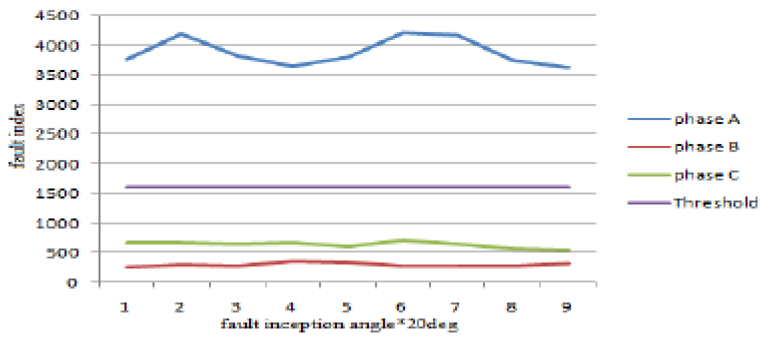

Figure 5(a)

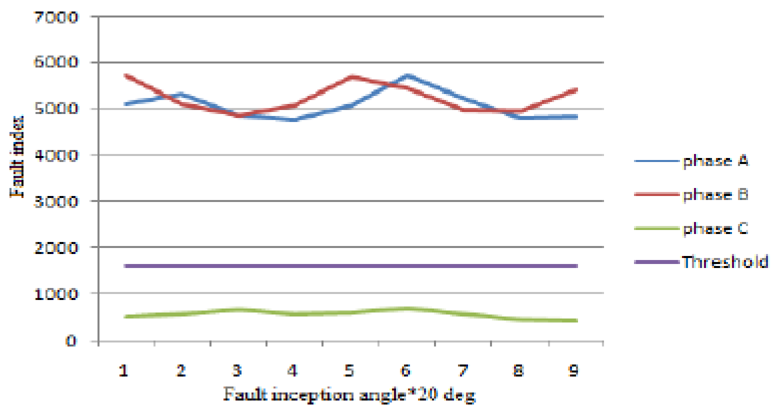

Figure 5(b)

Figure 5. Variation of fault index at 50km from terminal 2 (a) LG fault on phase AG (b) LLG fault on phase ABG

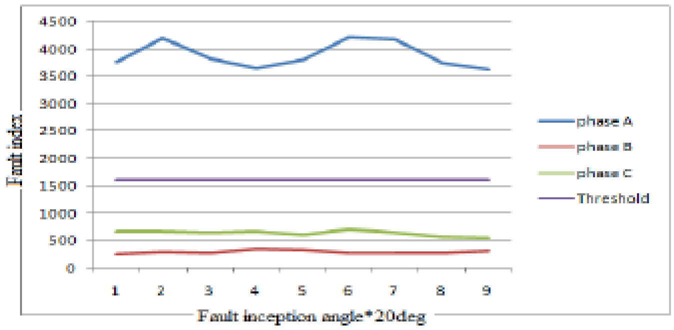

Figure 6(a)

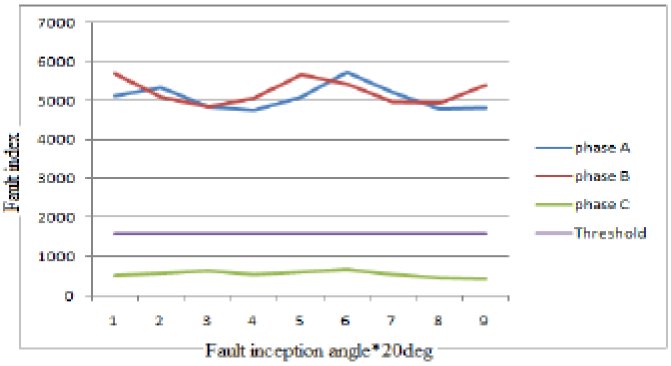

Figure 6(b)

Figure 6. Variation of fault index at 50km from terminal 1 (a) LG fault on phase AG (b) LLG fault on phase ABG

From the above results it is clearly observed that the faulty index of the healthy phase is lesser than the faulty phase. Thus the number of faulty phases is determined by comparing the Fault Index (If_1) with a Fault Threshold (I_{th}).The proposed algorithm has been tested for all types of faults, considering variations in fault locations and fault incidence angles (θ) in the range 0-180^0.

6. CONCLUSION

The conventional distance relay is likely to over reach or under reach depending upon the mode, type of FACTS devices incorporate in the transmission system can be rectified by wavelet based multi-resolution analysis approach that is applied for effective detection and classification. This scheme is proved to be unaffected by the presence of SVC by testing the protection scheme on same transmission system without SVC. By using this method i.e., by using the detailed coefficients of currents at all the ends we can detect and classify the fault within the half cycle. The proposed protection scheme is found to be fast, reliable and accurate for various types of faults on transmission lines with and without SVC, at different locations and with variations in incidence angles.

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