WAVELET TRANSFORM BASED FAULT DETECTION AND CLASSIFICATION IN TRANSMISSION LINE

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ABSTRACT

This paper presents a Wavelet Transform based approach to detect and classify different shunt faults that may occur in transmission lines. The algorithm is based mainly on calculating the RMS values of the wavelet coefficients of current signals at both the ends of the transmission line over a moving window length of half cycle.The current signals are analyzed with 'db4' wavelet to obtain detail coefficients and compared with threshold values to detect and classify the faults. To illustrate effectiveness of proposed technique extensive simulation studies using PSCAD/EMTDC and MATLAB have been carried out for different types of faults considering wide variations in fault resistances, inception angle and loading levels. Fault data generated by PSCAD/EMTDC have been used for fault detection and classification by a MATLAB program. Thus, the proposed technique is well suited for implementation in digital distance protection schemes.

Keywords: *Wavelet transforms, Transmission Line Protection, Threshold value, PSCAD/EMTDC.*

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I. INTRODUCTION

Electromagnetic transients in power systems result from a variety of disturbances on transmission lines, such as faults, are extremely important**.** It is very important to detect and classify faults for efficient and reliable operation. There are various techniques for fault classification. Some of the techniques are: (i) Fuzzy logic-based [1-3] (ii) Artificial Neural Network based [4] and (iii) Wavelet Transforms based [5-8]. Although, the Fuzzy and neural-network-based approaches have been quite successful in determining the correct fault type, the main disadvantages of Fuzzy and ANN are; requires a considerable amount of training effort for good performance. The wavelet transform based approaches have been quite successful in fault detection and classification due to its ability to express faulted signal both in frequency and time domain.

Chul-Hwan Kim, Hyun kim, et al in [5] proposed a method to detect high impedance arcing faults in high voltage transmission lines using wavelet transforms. Joe-Air Jiang, et al [6] have used Haar Wavelet for fault detection and faulted phase selection in transmission lines.

Shaikh Abdul Gafoor and Ramana Rao [7] used WT multi resolution approach for detection, classification and localization of faults in the transmission line was accomplished within a half a cycle using detail coefficients of currents at both the ends.

In this paper, Wavelet Transforms based Fault detection and classification technique has been proposed. This method identifies all ten types of faults (e.g., a-g, b-g, c-g, a-b, b-c, c-a, a-b-g, b-c-g, c-a-g, a-b-c/a-b-c-g) on the transmission line. Fault data is generated using EMTDC/PSCAD [9] software. Fault data generated by EMTDC have been used for fault classification by a MATLAB [10] programme.

II. WAVELET TRANSFORM

The wavelet transform (WT) is the versatile tool with very rich mathematical content and great potential for applications. The wavelet transform decomposes transients into a series of wavelet components i.e. approximation and detail components. The resulting decomposed signals can then be analyzed in both time and frequency domains. Hence, the wavelet transform is feasible and practical for analyzing power system transients.

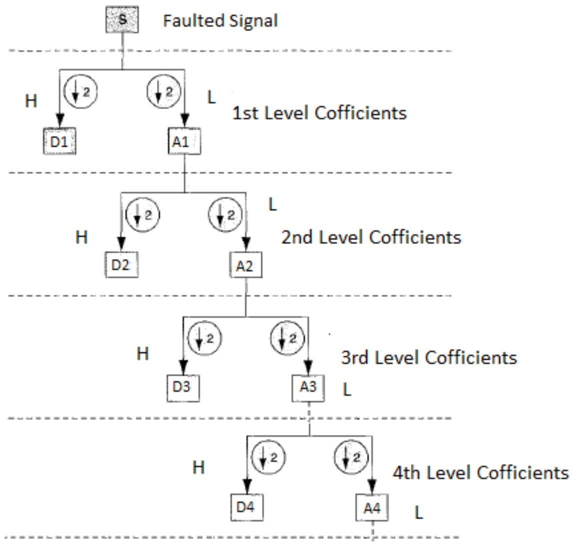

Fig. 1. Wavelet Decomposition method

An approximation contains the general trend of the original signal while a detail embodies the high frequency contents of the original signal. Approximation and details are obtained through a succession of convolution processes. The details and approximations of the original signal are obtained by passing it through low-pass filters which remove high frequency components and high-pass filters which pick out high frequency components in the signal being analyzed as shown in the Fig. 1.

III. FAULT DETECTION AND CLASSIFICATION STRATEGY

A. PSCAD Simulation Model

The technique has been developed on the basis of simulation studies carried out on the transmission line model shown in Fig. 2 Using PSCAD/EMTDC software. The parameters of the test model are given in Appendix [11].

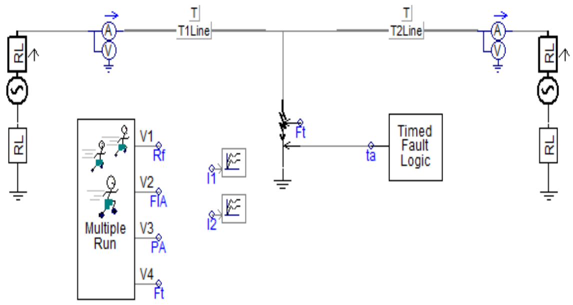

Fig. 2. Transmission line model in PSCAD

B. Fault involving ground

The RMS values of sum of absolute value of reconstructed detail coefficients of both receiving and sending end currents of each phase is calculated.

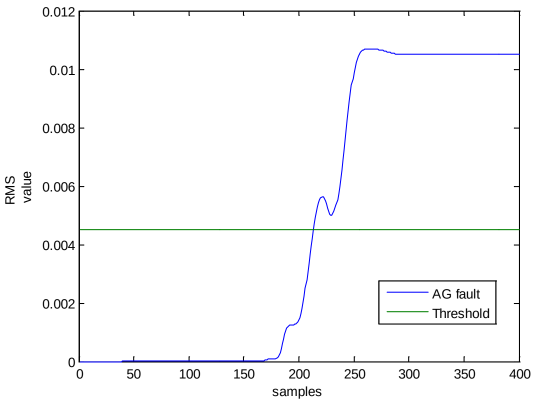

Fig. 3. Variation of RMS value of D in phase-*a*

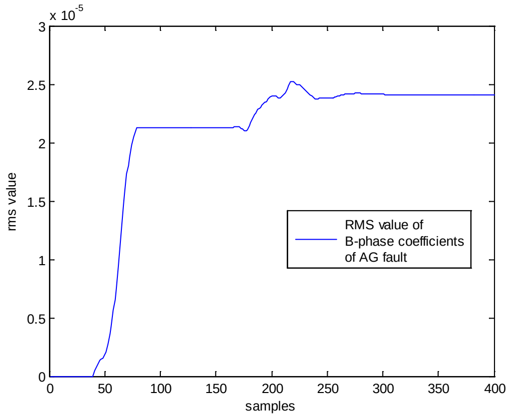

Fig. 4. Variation of RMS value of D in phase-*b*

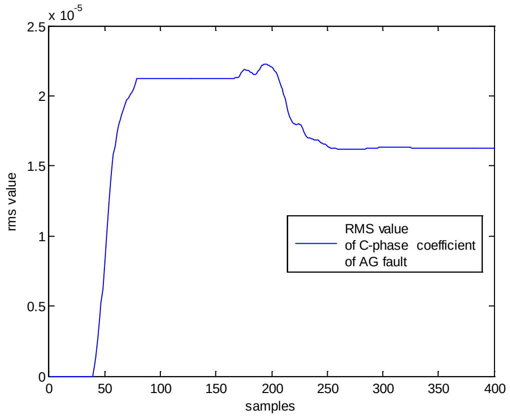

Fig. 5. Variation of RMS value of D in phase- *c*

Fig.3, 4 and 5 shows the variation of RMS value of reconstructed detail coefficients (D) of *a*, *b* and *c* phases for *a-g* fault. It is observed that the RMS value of faulty phase is large as compared to those of healthy phases. Fig. 6 shows RMS value variation in phases *a & b* for *ab-g* fault.

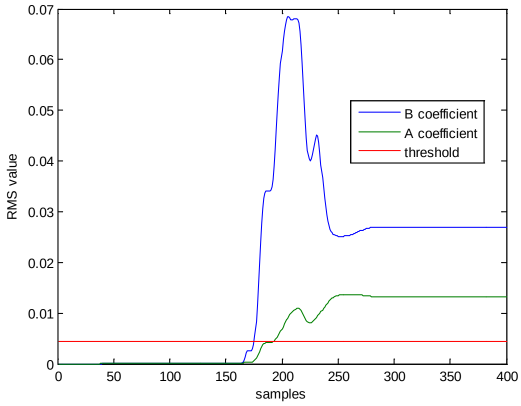

Fig. 6. Variation of RMS value of D in phases- *a & b*

C. Algorithm for Detection and Classification

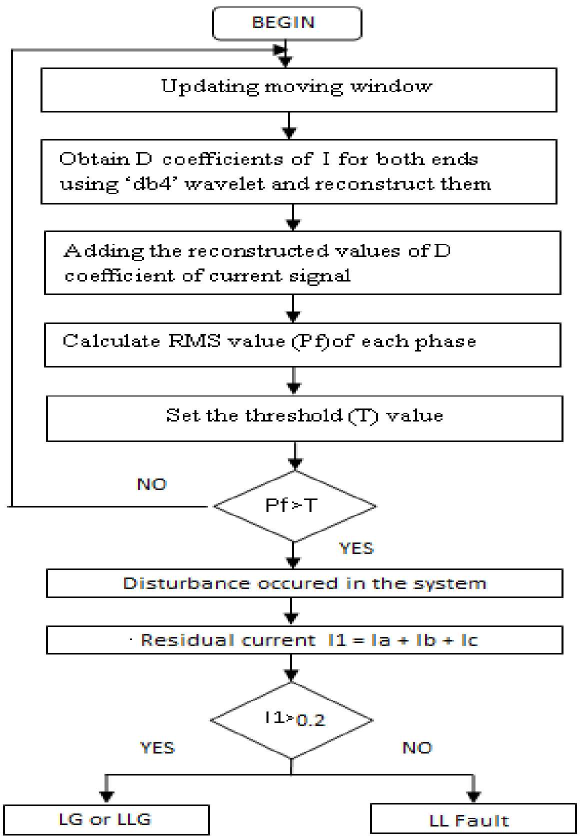

Fig. 7. Fault Detection and Classification Algorithm

D. Fault not involving ground

To achieve discrimination between the faults *l-l* and *ll-g*, $I_1 = (I_a + I_b + I_c)$ is calculated.

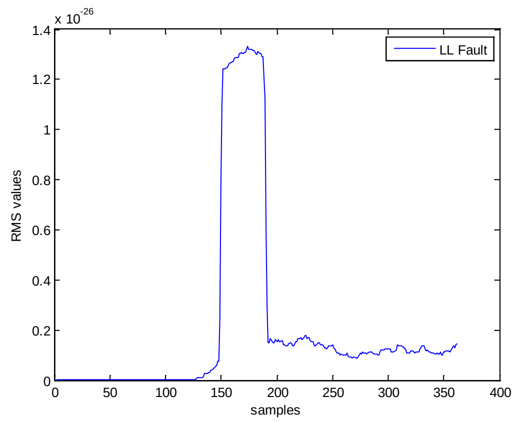

Fig. 8. Variation of RMS value of I_1 for *ll* Fault

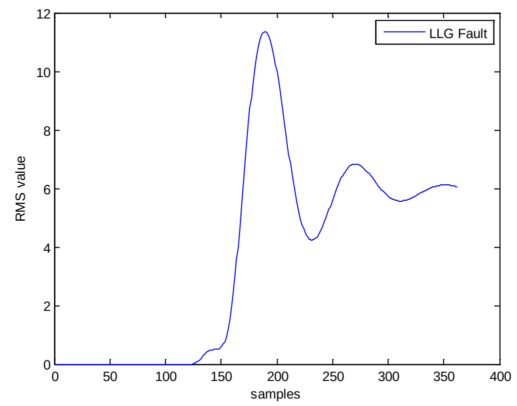

Fig . 9. Variation of RMS value of I_1 for *ll-g* Fault

Fig. 8 and 9 shows variation of RMS value of I_1 for *l-l* and *ll-g* fault. It has been observed that RMS value of current I_1 for *ll-g* fault is greater than *l-l* fault.

IV. CONCLUSION

To test the effectiveness of the proposed fault detection and classification scheme, a large number of fault simulation studies have been carried in test system shown in Fig. 2 using the PSCAD/EMTDC software. The Bergeron line model based transmission line has been represented in PSCAD/EMTDC. Wide variations in fault resistance, power angle and fault inception angle which have been chosen for this study are as follows: R_f: 0 Ω, 5 Ω, 25 Ω, 50 Ω ; δ: 10^0,20^0,30^o; FIA: 10^0, 30^0, 60^0, 90^0, 190^0. For each of these combinations, all ten types of short-circuit faults are applied. The proposed method is tested at distances 0.2L, 0.4L, 0.6L and 0.8L, where L is the length of the line. All these locations have proved the accuracy of the proposed technique.

V. APPENDIX

Source Data at both Sending and Receiving Ends:

Positive-sequence impedance = 1.31+ j15.0 Ω;

Zero-sequence impedance = 2.33 + j26.6 Ω;

Frequency = 50 Hz;

Transmission Line Data:

Length = 300 km;

Voltage = 400kV;

Positive-sequence impedance = 8.25 + j94.5 Ω;

Zero-sequence impedance = 82.5 + j308 Ω;

Positive-sequence capacitance = 13nF/km;

Zero-sequence capacitance = 8.5 nF/km;

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