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A new wavelet based fault detection, classification and location in transmission lines

Abdul Gafoor Shaik [a,*], Ramana Rao V. Pulipaka [b]

[a] *Centre for Information and Communication Technology, Indian Institute of Technology, Jodhpur, India*
[b] *Department of Electrical and Electronics Engineering, ANU College of Engineering and Technology, Guntur, India*

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ABSTRACT

This paper deals with the application of wavelet transforms for the detection, classification and location of faults on transmission lines. A Global Positioning System clock is used to synchronize sampling of voltage and current signals at both the ends of the transmission line. The detail coefficients of current signals of both the ends are utilized to calculate fault indices. These fault indices are compared with threshold values to detect and classify the faults. Artificial Neural Networks are employed to locate the fault, which make use of approximate decompositions of the voltages and currents of local end. The proposed algorithm is tested successfully for different locations and types of faults.

Introduction

The performance of a power system is affected by faults on transmission lines, which results in interruption of power flow. Quick detection of faults and accurate estimation of fault location, help in faster maintenance and restoration of supply resulting in improved economy and reliability of power supply. Wavelet Transform (WT) is an effective tool in analyzing transient voltage and current signals associated with faults both in frequency and time domain.

Kim, et al. [1] have used Wavelet Transforms to detect the high impedance arcing faults. Jiang, et al. [2] have used Haar Wavelet to detect dc component for identifying the faulty phases. Distance protection schemes using WT based phasor estimation are reported in [3,4]. Wavelet multi resolution analysis for location of faults on transmission lines is reported in [5]. A powerful high speed traveling wave-based protection technique using wavelet/PCA analysis is proposed in [6]. Artificial Neural Networks (ANN) with their excellent pattern recognition capabilities, are used to estimate the fault location [7,8]. Silva et al. [9] have Wavelet Transform and ANN for detection and classification of faults in power transmission lines. Computer based relaying system for power system has been reported in [10]. Roy et al. [11] presented software reliability allocation of digital relay for transmission line protection using a combined system hierarchy and fault tree approach. Due to fast developing communication techniques, it is possible to develop communication-aided high-speed digital protection scheme, which suits the EHV transmission. Better performance can be achieved using two terminal synchronized sampling of signals. Global Position System (GPS) based algorithms with better performance and accuracy have been proposed in [12,13].

Wavelet analysis

Wavelet Transform (WT) is an efficient means of analyzing transient currents and voltages. Unlike DFT, WT not only analyzes the signal in frequency bands but also provides non-uniform division of frequency domain, i.e. WT uses short window at high frequencies and long window at low frequencies. This helps to analyze the signal in both frequency and time domains effectively. A set of basis functions called Wavelets, are used to decompose the signal in various frequency bands, which are obtained from a mother wavelet by dilation and translation. Hence the amplitude and incidence of each frequency can be found precisely.

Wavelet Transform is defined as a sequence of a function $\{h(n)\}$(low pass filter) and $\{g(n)\}$(high pass filter). The scaling function $\varphi(t)$ and wavelet $\psi(t)$ are defined by the following equations

$$\varphi(t) = \sqrt{2}\sum h(n)\varphi(2t-n)$$

$$\psi(t) = \sqrt{2}\sum g(n)\varphi(2t-n)$$

Where $g(n) = (-1)^n h(1-n)$

* Corresponding author. Tel.: +91 291 244 9039; mobile: +91 7742725795.
E-mail address: saadgafoor@iitj.ac.in (A.G. Shaik).

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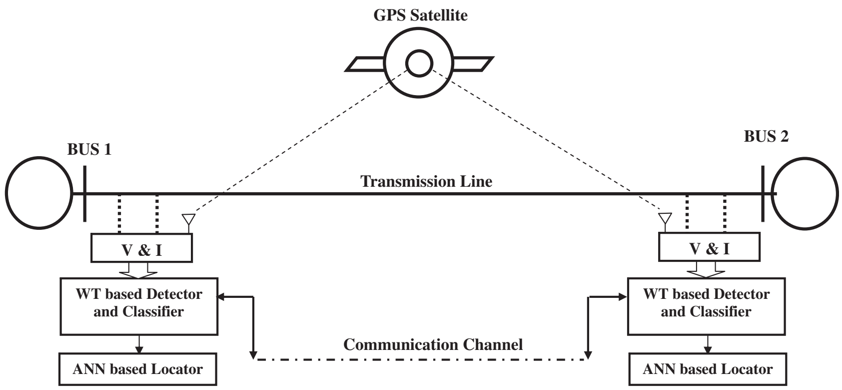
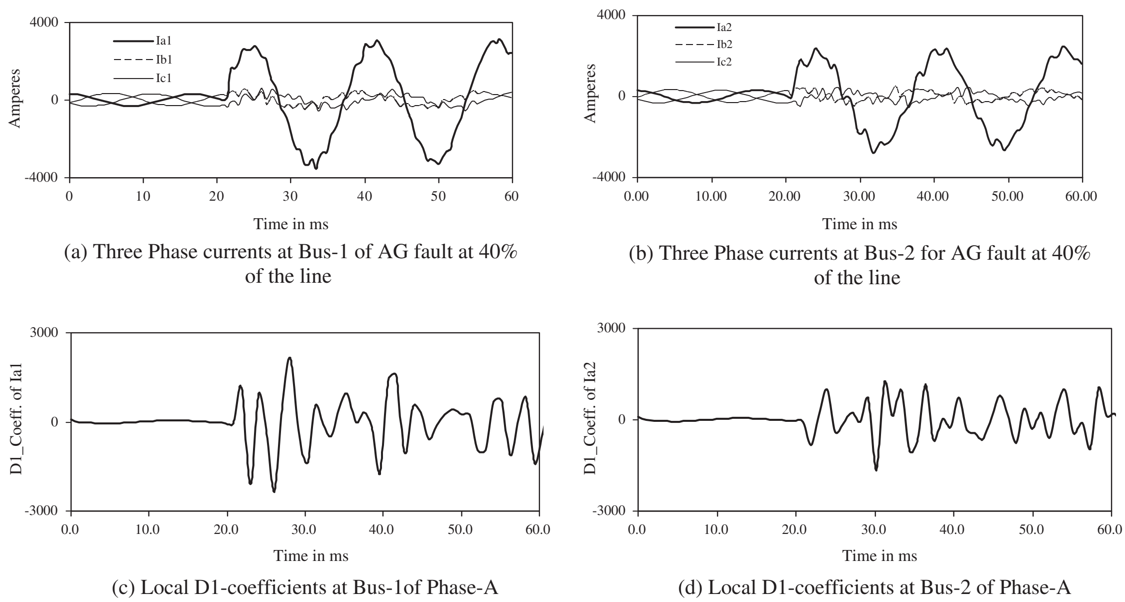


Fig. 1. System considered along with the proposed scheme.



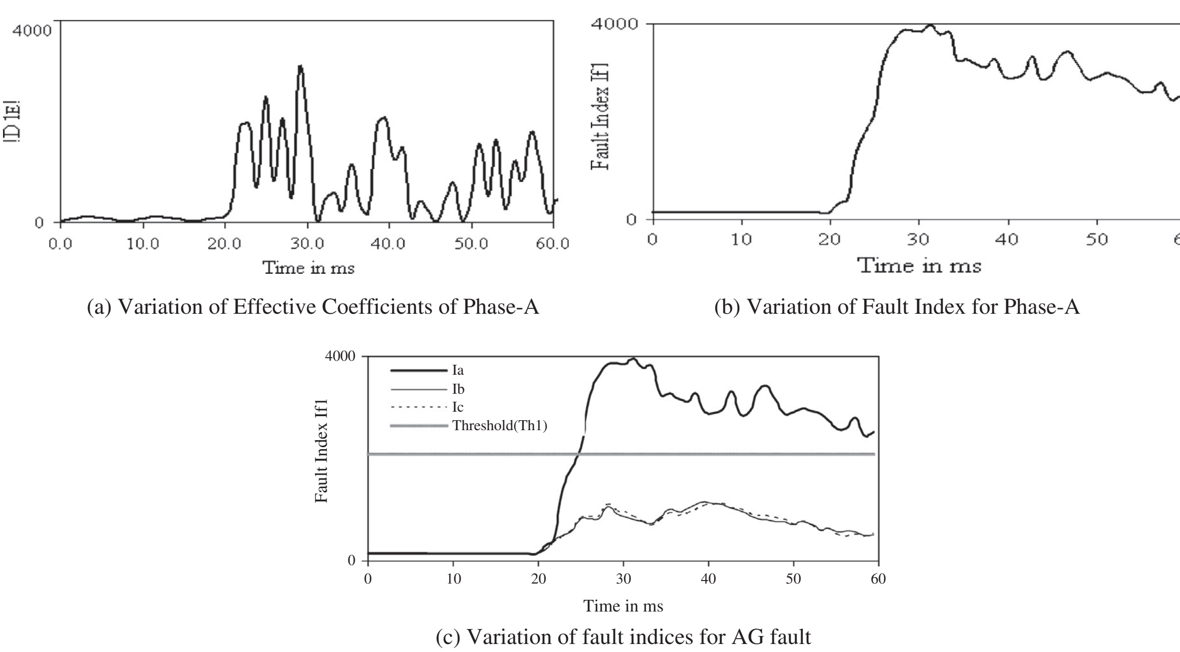
(a) Three Phase currents at Bus-1 of AG fault at 40% of the line

(b) Three Phase currents at Bus-2 for AG fault at 40% of the line

(c) Local D1-coefficients at Bus-1of Phase-A

(d) Local D1-coefficients at Bus-2 of Phase-A

Fig. 2. Fault current transient and their detail coefficients.



(a) Variation of Effective Coefficients of Phase-A

(b) Variation of Fault Index for Phase-A

(c) Variation of fault indices for AG fault

Fig. 3. Computation of Fault Index and detection of fault phases.