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Detection, classification, and location of faults in power transmission lines

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ABSTRACT

This paper presents a pattern recognition approach for current differential relaying of power transmission lines. The current differential method uses spectral energy information provided through a new Fast Discrete S-Transform (FDST). Unlike the conventional S-Transform (ST) technique the new one uses different types of frequency scaling, band pass filtering, and interpolation techniques to reduce the computational cost and remove redundant information. Further due to its low computational complexity, the new algorithm is suitable for real-time implementation. The proposed scheme is evaluated for current differential protection of a transmission line fed from both ends for a variety of faults, fault resistance, inception angles, and significant noise in the signal using computer simulation studies. Also the fundamental amplitude and phase angle of the two end currents and one end voltage are computed with the help of the new formulation to provide fault location with significant accuracy. The results obtained from the exhaustive computation show the feasibility of the new approach.

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Introduction

Differential relaying has been already applied for a wide variety of protective systems for the generators, transformers, bus bars, transmission lines and provides high speed fault clearance [1–3]. For transmission lines both the current and power differential protection schemes [4–6] have been used for the detection and classification of faults in the protected zone. Further the implementation of Global Positioning System (GPS) based synchrophasors makes differential protection of transmission lines a practical idea [7,8], even for very long transmission lines [9] in a smart grid environment. A SONET architecture [8] that follows a redundant and reliable asymmetric communication scheme results in the end-to-end time delay of a few milliseconds. The speed of response of the differential scheme is hardly influenced by this communication delay. The concept of using synchrophasors for digital protection has already been attempted [10]. The use of phasor measurement units (PMU) have been suggested [11] for measuring current at the two ends of a transmission line and use these values for determining the restraining and operating quantities for differential protection. However, these schemes suffer from line charging current and CT saturation and thus time-frequency methods have been suggested for differential protection of transmission lines. Amongst the various time-frequency techniques, the discrete wavelet transform (DWT) has been introduced [12,13] for a variety of protection of power system elements including the differential energy based approach for differential protection of transmission lines.

Although the wavelet transform provides a variable window for low- and high-frequency components in the voltage and current waveforms during faults, special threshold techniques are needed under noisy conditions [14]. Also the wavelet transform uses high pass and low pass filters to splint the power signal into a detail and an approximation repeatedly until a required level of decomposition is achieved. As it only decomposes the signal approximations, it may fail in cases where certain informations belong to the high frequency regions. Thus for more accuracies wavelet packet transform is used for protection purposes [15]. Additionally, the detailed amplitude, instantaneous phase or frequency of the fundamental components, necessary for protection purpose cannot be obtained easily without a complex set of calculations [16]. In recent years S-Transform (ST) has been used for the protection of transmission lines [14] and power signal disturbance detection due to its superior properties of localizing the time-frequency components. However, unlike the DFT, the ST can vary the amount of time and frequency over which measurements are averaged, depending on the frequency under consideration. This is an important property that differentiates wavelets and the ST from the DFT. A further

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