



Improvement of DEA performance against harmonic distortion

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ABSTRACT

This paper presents a filtering application to improve the behavior of the Differential Equation Algorithm (DEA) against harmonic distortion in transmission and distribution power systems. The proposed filter is based on Fast Fourier Transform (FFT) techniques during steady-state conditions. The voltage and current continuous-time equations are also considered, in fault conditions, to estimate the fundamental component waveforms of voltage and current. Simulations results show the singularities problems of DEA algorithm against harmonic distortion and the accurate operation achieved within 0.32 cycles using this filtering application.

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1. Introduction

The basic requirement of a distance protection algorithm is the capability of high speed and selective isolation of faulted sections in the power system. Fourier analysis techniques are the most widely used tools in signal processing for distance relaying [1]. However, the time these methods need for operation is in the range of at least one and a half cycles. Protection algorithms based on traveling waves principle [2–4] offer the fastest operation time after fault inception, but put too high demands on current and voltage sampling time for accurate operation [4,5]. Unlike these algorithms, the Differential Equation Algorithm (DEA) [5–9] has an operating time below 0.32 cycles with less sample time requirements than traveling wave techniques. Thus, a relay based on the DEA is suitable since high speed operation is achieved including fault detection, estimation of fault location, fault classification and tripping decision within the operation time.

In [9] the behavior of the DEA algorithm is analyzed under different situations in a power distribution system without considering harmonic distortion and fault resistance, resulting in an efficient algorithm for fault detection and location.

However, the increasing application of electronic power facilities in the industrial environment bears to a significant harmonic distortion in the waveforms of voltages and currents [10]. This harmonic distortion in conjunction with the fault resistance and the transient components contained in the waveforms of voltages and

currents during the fault period, introduces important measuring errors in the DEA algorithm [8]. These uncertainties implicit in the measured data must be removed to avoid misoperations and power disruption. This emphasizes the need to analyze the behavior of DEA in a power system with harmonic distortion aiming to develop suitable filtering methods to enhance the accuracy of the algorithm.

Some authors have proposed different filtering applications for harmonic waveforms. In [1] a mimic phasor estimator is proposed by using discrete Fourier Transform, where the filtered waveform is established in at least 0.5 cycles, but it is based on an iterative adaptive scheme for voltage and current phasors where convergence depends on variation of fault parameters. Otherwise, [8] proposes a medium post-filtering for DEA algorithm that rejects singularities problems due to harmonic distortion; however it demands an additional time in this stage before an accurate convergence to the fault distance. In [11] a recursive algorithm based on minimization of the absolute error in the waveform estimation is presented, where convergence time is in the range of 2.5 cycles and it is applied to study symmetrical components in unbalanced power systems. Unlike digital filters, several active filters have been proposed [12–15] to mitigate harmonic current effect over the power quality of the power system. These active filters offer a selective elimination of harmonic components, however under fault conditions, the accuracy of harmonic elimination is reduced and the filtered fundamental waveform may be misleading for DEA algorithm.

The method introduced in this paper takes the presumption that the peak value relation between the fundamental frequency component and the harmonic components remains similar in both prefault and fault state. Under this scope, a straightforward filter-

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