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Two effective methods for impedance estimation in distance relays based on the DC offset removal

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ABSTRACT

This paper introduces the eigensystem realization (ER)-based identification algorithm and the Z-domain method (ZDM) to improve the impedance estimation of transmission lines under fault conditions, which is achieved by removing the exponential decaying DC offset from current signals in distance relays. Both methods effectively work employing a one-cycle rectangular window; specifically, the Z-domain method works in less than a fifth of one-cycle window, ensuring timely, accurate, and prompt estimates. To confirm the effectiveness and performance of the proposed algorithms, they are evaluated under steady-state and dynamic conditions by using time-domain simulations performed in PSCAD©and DIgSILENT©PowerFactory. They also are compared with the well-known discrete Fourier transform (DFT). The attained results indicate that both the ER-based and Z-domain methods can become a powerful tool to reduce the adverse influence of exponentially decaying DC offsets in distance relays.

1. Introduction

Accurate voltage and current phasors are frequently used to furnish protection functions in digital relays. Becoming their accuracy and time-response the main characteristics to assess any algorithm for impedance estimation in digital distance relays. In this context, many digital algorithms have been proposed in the last two decades [1–11], being the discrete Fourier transform (DFT)-based algorithms the most employed to estimate such phasors [12]. One of their advantage is its straightforward implementation and low computational complexity. Nevertheless, when exponential decaying DC offsets are present in current channels under fault conditions, the DFT exhibits an error yielding a tendency of over-reach or underreach phenomena in distance relays [13,14]. This fact represents a challenging problem that must be taken into consideration to estimate phasors at the fundamental frequency.

To tackle the phasor estimation problem derived from the presence of exponential decaying DC components, different methods have been introduced to accomplish the phasor estimation by mitigating the exponential decaying DC effects. This is achieved by post-processing the data or extending the analysis data window [13,15]. However, the accuracy of these methods does not only depend on the correct estimation at the fundamental frequency, but it also relies on the suppression of other frequency components; meanwhile the time-response is highly depending on the length of the analysis window [16].

Conventionally, methods such as the mimic circuit are employed to mitigate the DC component effect [13,17]. The mimic filter may completely remove the decaying DC offset only when exist a match between the actual and presumed time constants of the DC offset [13]. It uses the X/R ratio of a burden circuit which should be equal to the X/R system ratio. However, the X/R ratio varies with the network switching

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