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Transmission lines distance protection using artificial neural networks

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ABSTRACT

This work presents the development and implementation of an artificial neural network based algorithm for transmission lines distance protection. This algorithm was developed to be used in any transmission line regardless of its configuration or voltage level. The described ANN-based algorithm does not need any topology adaptation or ANN parameters adjustment when applied to different electrical systems. This feature makes this solution unique since all ANN-based solutions presented until now were developed for particular transmission lines, which means that those solutions cannot be implemented in commercial relays.

1. Introduction

Transmission lines are one of the most important power system components, responsible for delivering energy from generating plants to consumers. Those lines may present a high failure rate since, in most cases, they cover large distances and are exposed to different climate conditions.

The distance protection method is one of the most used techniques for preventing damages that can be inflicted to transmission lines. The conventional distance protection is based on impedance measurement elements that estimate the line impedance from the relay to the fault point using voltage and current phasor quantities. The ANN-based algorithms have been developed as an alternative to conventional methods, since they present very promising results with regard to precision and operating time.

Refs. [1–7] present ANN-based algorithms that act as classifiers, indicating whether the fault is located inside or outside the protection zones. Refs. [8–10] present ANN-based algorithms that act as function approximators which point out, directly or not, the fault distance.

The algorithms presented in [4,6,10] are based on the phasor quantities of voltage and current fundamental components, obtained via DFT. Those components are used as inputs for their ANN. The other algorithms but [9] are based on voltage and/or current samples. Those samples are used as inputs for their ANN.

The ANN-based transmission line protection methods described in [1–10,16] surely present limitations once they are trained to correctly respond only to a particular transmission line. Therefore, considering such methods, it shall be necessary to re-create a new simulation environment set containing hundreds or thousands of fault cases for each change made at the transmission line characteristics. Besides that, it shall be also demanded to repeat the whole ANN training process, resuming the major drawback presented by those algorithms.

It is proposed then the development and implementation of a new ANN-based algorithm, suitable for protecting any transmission line, regardless of its characteristics (such as tower geometry, type of conductors, length and voltage level). This new ANN-based algorithm does not need any topology adaptation or ANN parameters adjustment when applied to different transmission lines [17–19]. It was developed to exceed the existing limitations of previously developed ANN-based algorithms, allowing it to be implemented in commercial relays.

This ANN-based algorithm operates as a function approximator, estimating the line impedance from the relay to the fault point. Similarly to conventional distance protection relays, this algorithm is also based on six impedance measurement elements, which estimate the line impedance, based on current and voltage samples provided by CTs and VTs, respectively.

2. Impedance measurement elements

The conventional distance relays have six impedance measurement elements. Three of them (phase elements AB, BC and CA) are responsible for detecting faults that involve more than one phase. The remaining elements (three ground elements AN, BN and CN) are responsible for detecting phase-to-ground faults.

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