A Novel Approach to Detect Symmetrical Faults Occurring During Power Swings by Using Frequency Components of Instantaneous Three-Phase Active Power

Behnam Mahamedi and Jian Guo Zhu, *Senior Member, IEEE*

***Abstract*—Since distance relays are prone to interpret a power swing as a three-phase fault, they should be blocked during the power swing to prevent undesired trips. On the other hand, if any fault occurs during a power swing, they should be fast and reliably unblocked. Although unblocking the relay is straightforward in the case of asymmetrical faults by using the zero-sequence and/or negative-sequence component of current, detecting symmetrical faults during a power swing is still a challenge. This paper presents a novel method for detecting symmetrical faults occurring during a power swing. Based on the damping frequency component of 50 (or 60) Hz created on instantaneous three-phase active power profile after inception of a symmetrical fault, the proposed method will be able to detect the fault in less than one power cycle. This detection method can be readily implemented, and is immune to the power swing slip frequency, fault inception time, and fault location. To test the proposed method, several power swings and faults are numerically simulated in MATLAB/SIMULNK, and the simulation results show that the proposed method is sensitive as well as reliable.**

***Index Terms*—Distance relay, instantaneous three-phase active power, power swings, symmetrical faults.**

I. Introduction

DISTANCE relays operate on the basis of impedance they measure. Once a fault occurs, the impedance will enter into the relay protective zones and consequently the relay will trip after a predefined time delay. On the other hand, during power swings, the impedance trajectory can also enter into the protective zones and eventually cause relay to issue an undesired trip [1]. Power systems may experience a power swing when they are recovered from a disturbance like a fault and/or heavy load rejection. To be precise, when the frequency of a generator (or a group of generators) deviates from the nominal power system frequency (50 or 60 Hz), a power swing will occur. Since there is no unbalance during a power swing, this phenomenon appears like a three-phase fault. It is crucial then for distance relays to distinguish a power swing from a three-phase fault. To overcome the adverse effect of power swings, several power swing detection methods that block the protective zones during power swings have been proposed. However, if an asymmetrical or a symmetrical fault occurs during a power swing, the protective zones should be released and allowed to trip in a proper manner.

The most popular method for detecting a power swing is to measure the rate of change of impedance as it travels into the protective zones of the relay [2]. Once a distance relay is blocked by using this method, zero-sequence and/or negative-sequence components of current are used to unblock the relay when a fault occurs as it is the most common fault detection method in numerical distance relays [3], [4]. It is clearly known that this fault detection method fails to unblock a distance relay when a symmetrical fault occurs since there is neither a zero-sequence nor negative-sequence component. This is the main disadvantage of this fault detection method.

Su *et al.* [5] utilized the features of swing center voltage (SCV) to detect symmetrical faults occurring during power swings. This method is based on the SCV profile during a power swing and after the fault inception. Li *et al.* [6] presented a method based on the measured three-phase active and reactive powers for detecting symmetrical faults. Mechraoui and Thomas [7], [8] introduced a method by monitoring the voltage phase angle at the relay location to discriminate faults from power swings. Only single-phase faults have been simulated, and the method has not been applied to symmetrical faults. Lotfifard *et al.* [9] presented a method using the dc component of three-phase currents, extracted by the Prony method.

Wavelet-based signal-processing techniques are effective tools for power system transient analysis and feature extraction [10]–[12]. Several fault detection methods based on the wavelet transform (WT) are proposed [13], [14]. Brahma [15] utilized the WT for detecting faults during power swings, taking advantage of the presence of high-frequency components created on the voltage at inception of fault. Pang and Kezunovic [16] presented another wavelet-based symmetrical fault detection method which needs the modal transform in addition to WT.

This paper presents a fast symmetrical fault detector for distance relays, based on the detection of frequency components of an instantaneous three-phase active power profile. It will be demonstrated that during a power swing, the instantaneous

Manuscript received June 27, 2011; revised April 07, 2012; accepted May 12, 2012. Date of publication June 12, 2012; date of current version June 20, 2012. Paper no. TPWRD-00552-2011.

B. Mahamedi is with the School of Electrical, Mechanical and Mechatronic Systems, University of Technology Sydney, Ultimo, NSW 2007, Australia, and also with the Iran Grid Management Company, Tehran IR-15175–648, Iran (e-mail: behnam.mahamedi@student.uts.edu.au).

J. G. Zhu is with the School of Electrical, Mechanical and Mechatronic Systems, University of Technology Sydney, Ultimo NSW 2007, Australia (e-mail: jianguo.zhu@uts.edu.au).

Digital Object Identifier 10.1109/TPWRD.2012.2200265