One Terminal Digital Algorithm for Adaptive Single Pole Auto-Reclosing Based on Zero Sequence Voltage

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Abstract: This paper presents an algorithm for adaptive determination of the dead time during transient arcing faults and blocking automatic reclosing during permanent faults on overhead transmission lines. The discrimination between transient and permanent faults is made by the zero sequence voltage measured at the relay point. If the fault is recognised as an arcing one, then the third harmonic of the zero sequence voltage is used to evaluate the extinction time of the secondary arc and to initiate reclosing signal. The significant advantage of this algorithm is that it uses an adaptive threshold level and therefore its performance is independent of fault location, line parameters and the system operating conditions. The proposed algorithm has been successfully tested under a variety of fault locations and load angles on a 400KV overhead line using Electro-Magnetic Transient Program (EMTP). The test results validate the algorithm ability in determining the secondary arc extinction time during transient faults as well as blocking unsuccessful automatic reclosing during permanent faults.

Keywords: Adaptive Auto-reclosing, Secondary Arc, Transmission Line Protection, Zero Sequence Voltage.

1 Introduction
Statistics show that above 80% of faults on overhead lines are transient, with more than 90% of these are single phase to earth faults. The most common causes of transient faults are over voltages induced by lightning, which result in flashover of insulator. Other possible causes are swinging wires and temporary contact with foreign objects. For such faults, single pole auto-reclosing (SPAR) provides a means of improving transient stability and reliability. Furthermore, as in SPAR only the faulted phase is tripped, 58% of transmission capacity is still retained via the two healthy phases [1].

Conventional single pole and three pole auto-reclosing techniques applied to extra high voltage (EHV) transmission lines adopt fixed time interval reclosing techniques [1]. However employing a fixed prescribed dead time can pose problems. In the case of an arcing fault, for example, a fault restrike due to insufficient time for the fault path to fully de-ionise can threaten system stability and reliability. On the other hand, unsuccessful reclosing during a permanent fault may aggravate the potential damage to the system and equipment [2]. For some EHV lines, especially near generating plants, the classical automatic reclosing of breakers cannot be used and therefore adaptive reclosing schemes have been introduced over the past decades [3]. Such schemes prevent unsuccessful reclosing on permanent faults, and during arcing faults reclosing is done only after full extinction of the secondary arc and complete deionisation of the arc path. Many approaches have been proposed for adaptive reclosing. In [1] the root mean square (RMS) value of faulted phase is calculated over a period and when the difference between present RMS and the previous one at each time step attains a value above a certain threshold level, a reclosing command signal is generated. The authors of [1] have stated that the threshold value is dependent on the application environment. Ref. [2] uses the current of one of the two healthy phases and compares its power of high frequency components with a threshold level. The disadvantage of this approach is the dependency of the threshold value to fault conditions and system parameters. In [4] the value of voltage induced from healthy phases to the faulted one is used. Results from this approach also vary under different load conditions and fault locations. To overcome this problem the authors of [5] proposed a discriminator based on fuzzy logic, which its shortcomings are complication of developing fuzzy rules. Since the voltage waveform of the faulted phase

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