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Adaptive design of distance relay for series compensated transmission line

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Abstract

The objective of this paper is to evaluate the impact on the operation of conventional three-stepped distance relaying schemes for protecting the series compensation transmission line and to analysis the effects series compensation on different carrier aided transfer trip scheme under different fault condition. The presence of series compensation in transmission creates over-reaching issues in distance relay due to the net fault impedance of transmission line reduce. Analytical studies of such situation are simulated by using PSCAD and analyzed various responses of distance relays for different fault and system conditions. An enhanced distance protection scheme is implemented to eliminates issues on distance relay for series compensated line. It is also simulated the auto-recloser schemes to discriminating between the temporary and permanent fault.

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Keywords: FACTs devices; Quadirlateral relay; Carrier-aided schemes; Series Compensation; Auto-Recloser; PSCAD.

1. Introduction

Now a day, demand of electrical power is continuously rising at a very high rate due to rapid development of industries and population. With the lack of new generation and transmission facilities and over misuse of the existing facilities lead to the imbalance between the power generation and power demand, that leads to issues on the power system instabilities, load encroachment and power quality etc. To meet this demand, it is essential to raise the transmitted power along with the existing transmission facilities with maintaining stability and reliability of the system within the acceptable limit.

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To utilize the existing transmission capacity optimally to address the issue mentioned already, there are various researches going on. One of the solution can be Flexible Alternating Current Transmission (FACT) devices. That improves the voltage stability, increases the power transfer capability. On the other-hand, implementation of FACT devices in existing power system produce dynamic changes due to FACTS devices severely affect the setting of the existing protection scheme of the transmission line.

One of the commonly used FACTS devices is series compensator. Series Compensated (SC) in transmission line introduces several problems like voltage and current inversion, sub-synchronous resonance (with mechanical system), ferro-resonance (with line inductance) and reaching problems (distance measurements). SC badly affects accuracy, selectivity and reliability of distance relay which leads to an unsecure power system. It is responsible for mal-operation of distance relays, particularly the reaching characteristic of the relay. In this paper made an attempt to find the solution to address the effects of the change in apparent impedance seen by distance relay after inclusion the series compensator.

Literatures have been explained about protection to a FACT device installed in transmission line [1]–[7]. In [1] Sidhu analyses the impact of the TCSC on the performance of conventional communication transfer trip schemes and proposes modified schemes for mitigating the effects of TCSC on the performance of distance relays. In [2] proposed a new approach for the protection of TCSC line using a support vector machine (SVM), in this method post fault current samples are used for half cycle from the inception of the fault and firing angle as inputs to the SVM. Then, SVMs are trained with polynomial kernel and Gaussian kernel with different parameter values to get the most optimized solution. M.K. Zadeh [3] analyzed the different factors and conditions which can affect Transient Recovery Voltage (TRV) in the series compensated transmission line, by estimating the TRV amplitude and RRRV variations are used to evaluate the capability of circuit breaker and to decide appropriate breaker device for a specific transmission system. In [4] propose current differential protection of transmission lines by transforming the instantaneous line current(s) by using a moving window averaging technique. During fault the transformed current is deviate from the nominal zero value which leads to development of a sensitive, secure and fast current differential protection scheme. In [5] have discussed about the development of a new protection method for series-compensated double-circuit transmission lines using current transients, by comparing the polarities of wavelet coefficients of the branch currents to identified the faulted circuit of double-circuit transmission lines, and compared the proposed scheme with the conventional distance and phase comparison protection schemes. In [6] proposes a fault direction estimation technique for a line with series compensation. To estimate the direction of fault for voltage and current inversion, variation in source capacity, fault resistance, balanced/unbalanced fault, and close-in fault, an integrated approach is implemented by using three positive-sequence-based classifiers are combined with the voting method.

The objective of this paper is to analyze the impact of series compensation on the distance protection relays under normal operation and fault conditions at different locations. The paper is organized as follows; Section II gives a description of the series compensation and test system. Section III gives simulation study of the system model. Sections IV is discuss the performance of distance relay with carrier aided distance scheme. Finally, the inferences of this study are presented in section V.

2. System Model

The effect of the Series Compensation on the performance of distance relays are studied using the PSCAD software. The system modelling and impact of series capacitor on distance relay are described in the section.

2.1. Series Compensator (SC)

The reduction of the series inductive reactance of the transmission line by the addition of the series capacitor provides for increased line loading levels as well as it leads to the over-reach issue on distance relay of protective line. Due to over-reach problem on distance relay leads to the misidentification of zones of operation of protective and back-up line.