Fault Location on Double-Circuit Series-Compensated Lines Using Two-End Unsynchronized Measurements

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***Abstract*—This paper presents an accurate fault-location algorithm for double-circuit series-compensated lines. Use of two-end current and voltage signals is taken into account and a more general case of unsynchronized measurements is studied. Different options for analytical synchronization of the measurements are considered. The algorithm applies two subroutines, designated for locating faults on particular line sections, and in addition, the procedure for selecting the valid subroutine. The subroutines are formulated with the use of the generalized fault-loop model, leading to compact formulas. Consideration of the distributed parameter line model ensures high accuracy of the fault location. The proposed selection procedure allows for reliable selection of the valid subroutine. The developed fault-location algorithm has been thoroughly tested using signals taken from Alternate Transients Program–Electromagnetic Transients Program versatile simulations of faults on a double-circuit series-compensated transmission line. The presented fault-location evaluation shows the validity of the derived fault-location algorithm and its high accuracy.**

***Index Terms*—Alternate Transients Program–Electromagnetic Transients Program (ATP–EMTP), double-circuit line, fault location, series capacitor compensation, simulation, two-end unsynchronized measurements.**

I. Introduction

Accurate location of faults on overhead power lines for inspection-repair purposes [1]–[2] is of vital importance for expediting service restoration and, thus, for reducing outage time, operating costs, and customer complains. Assuring high accuracy of the fault location on series-compensated lines [3]–[11] is especially important since these lines are usually spreading over a few hundreds of kilometers and are vital links between the energy production and consumption centers.

Different fault-location algorithms for series-compensated lines have been developed so far. They apply one-end [3]–[8] and two-end measurements [9]–[10] for two-terminal lines, or three-end measurements [11] for teed lines. In particular, the impedance-based approach [3]–[10] is the mostly utilized one. In [6], the application of artificial neural networks (ANNs), combined with the impedance-based approach to fault location, has been presented. Use of artificial neural networks, combined with the discrete wavelet transform for fault location on thyristor-controlled series-compensated lines has been considered in [7]. In turn, in [11], different options for traveling-wave methods have been considered for locating faults on teed circuits with mutually coupled lines and series capacitors.

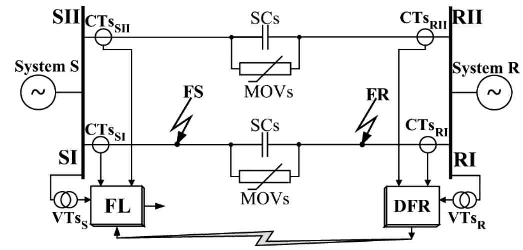

Fig. 1. Schematic diagram of a two-end location of faults on a double-circuit series-compensated line.

This paper presents a new fault-location algorithm for double-circuit series-compensated lines, with the use of two-end unsynchronized measurements. Fault-location techniques dealing with series compensation and coupled line sections have been considered for example in [8] and [11]. In particular, in [8], the one-end impedance-based approach, while in [11] the traveling-waves method, have been introduced. Use of two-end measurements is assumed in this paper, with the aim of improving fault-location accuracy, in comparison to the case of utilizing only one-end measurements [8]. Digital measurements can be acquired at two line ends synchronously—with the use of the global positioning system (GPS) [10], [12], or asynchronously [9], [13], [14]. The more general case of asynchronous two-end measurements has been taken into consideration in this paper.

The presented fault-location algorithm is designated for application to a line compensated with one three-phase compensating bank of fixed series capacitors (Fig. 1). The algorithm is also suitable for thyristor-controlled series-compensated lines, under the condition that only one bank is applied.

For the compensating banks in both parallel lines (Fig. 1), only SCs and their MOVs (applied for overvoltage protection) are shown, without the other details as, for example, the thermal

Manuscript received January 08, 2008; revised July 23, 2009; accepted May 29, 2011. Date of publication July 19, 2011; date of current version October 07, 2011. Paper no. TPWRD-00022-2008.

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Digital Object Identifier 10.1109/TPWRD.2011.2158670