DISTANCE PROTECTION CHALLENGES ASSESSMENT IN HIGH VOLTAGE SERIES COMPENSATED TRANSMISSION LINES

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Abstract – In order to increase power transfer capability, improve dynamic and voltage stabilities, reduce transmission losses, and enhance voltage control; series capacitor compensation is used. However the great advantages obtained by using series capacitor compensation, there are some operational challenges associated with this type of compensation. Distance protection of series compensated lines is one of these complex issues that arise and need special techniques to be properly implemented. In this paper, Thyristor-Controlled Series Compensation (TCSC) system is modeled, then distance protection of TCSC based transmission line is illustrated and the associated protection challenges such as overreaching of distance protection are explained in details. After that, a proper solution for this problem is proposed and implemented in order to overcome this challenge associated to distance protection of such compensated systems. Finally, a case study of a series compensated transmission project in Kingdom of Saudi Arabia is presented and the associated distance protection challenges are illustrated. Accordingly, proposed solutions for these challenges are presented.

Index Terms – Flexible Alternating Current Transmission System (FACTS), Thyristor-Controlled Series Compensation (TCSC), Adaptive Protection, Overreaching, and Degree of series Compensation (K_{se})

I. NOMENCLATURE

K_{se} :	Degree of Series Compensation.
α :	Thyristor Firing Angle.
Z_0 :	Surge (Characteristic) Impedance.
P_0 :	Surge Impedance Loading (SIL).
21 :	Distance Relay.
:	Relay Characteristic Angle (RCA).
:	Line Angle.

II. INTRODUCTION

Flexible Alternating Current Transmission Systems (FACTS), according to IEEE definition, are "Alternating current transmission systems incorporating power electronic-based and other static controllers to enhance controllability and increase power transfer capability" [1]. These FACTS are used to improve a power system performance by modifying the transmission line parameters.

One of FACTS techniques that are used nowadays extensively for long high-voltage transmission lines is Series Compensation (SC). In series compensation, FACTS devices are connected in series with the transmission line in order to compensate a part of the line inherent inductive reactance hence; the long transmission line will be operated as a short line.

Series compensation is classified into Fixed-Series Compensation (FSC) and controlled series compensation. In fixed series compensation, the value of the compensation inserted is constant all the time. However, in controlled series compensation, the compensation is controlled to match the variable requirements of the line loading. This control of the compensation can be either manual or automatic and for automatic controlled compensation, the control can be continuous (i.e. regulatory) or in steps.

One important application of FACTS in series compensation of long transmission lines is the Thyristor- Controlled Series Compensation (TCSC). This compensation technique is based on continuous regulating of the amount of compensation reactive power according to the power system requirements. This technique has great merits over the fixed and stepped compensation such as [2]:

- Increasing of the Power-Transfer Capability (PTC).
- Improvement of the power system stability.
- Damping of Power oscillations.
- Mitigating of Sub-synchronous resonance.
- Improvement of the power quality.

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