

# Optimal Location of Series-Shunt Facts Devices in Transmission Line and Impact of SSSC Compensated on Performance of Distance Relay

Vinod Kumar Shivran, Sanjay Jeenjawadia, Saumya Singh, Deeksha Mittal

**Abstract**— The research works says that the impacts of facts devices changes with the change of their location on transmission line. Basically in power system we have two types of compensation devices. First is series facts devices, second is shunt facts devices by using these devices controlling of transmission line voltage and power flow is possible. Facts devices are also very useful to control the reactance power of transmission line and damping of power system oscillation for high power is possible. Series facts devices are connected in series of transmission line and works as a controllable voltage source. Shunt facts devices are connected in shunt with power system line. it works as a controllable current source.

During the SLG fault, shunt capacitance of SSSC-compensated line affects the performance of distance relay. Research also shows the impact of ignoring the shunt capacitance of the line on the distance relay over and under reach conditions. By using MATLAB we can study the effects of series and shunt compensation according to the variation of location of these in transmission line. We can find the most suitable and optimal location of series, shunt or the combination of both compensation.

**Index Terms**—SLG, SSSC, Relay, Distance relay

## I. INTRODUCTION

It is known that the facts devices can rise the quality of power system operation in both normal situation and during outage situation with high level of controllability. But the use of facts devices the distance relay is adversely influence. This paper includes the effect of variable impedance and variable voltage source converters, on the distance relay during phase to ground fault. An equivalent model is prepared to analyze the capacitance of shunt compensator during SLG fault.

The power demand of world is increasing and the growth in demand is unequal in world and the power station is located away from the load for this we need transmission line to provide inter connection between load and generation but we know that the power required is change with time with load change the consequences that voltage collapse will be there for the solution the reactive power compensators are used to increase the ac transmittable power. It increases the efficiency of line, control the real and reactive power, improve system stability of system, reduce the cost and environmental impact. Finding the value of facts device is not easy the value of impedance of capacitor and inductor, and finding the location of facts is another problem. This exercise is carried out using MATLAB package with a view to identify the best possible response.

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## CONCEPT AND TECHNOLOGY OF FACTS

Due to the stress the transmission line may get closer to steady and thermal limit.

Facts devices are high speed electronic devices, which reduce the congestion and more fully utilize the existing transmission system without compromising the reliability and security of system.

### THERE ARE THREE TYPES OF COMPENSATOR

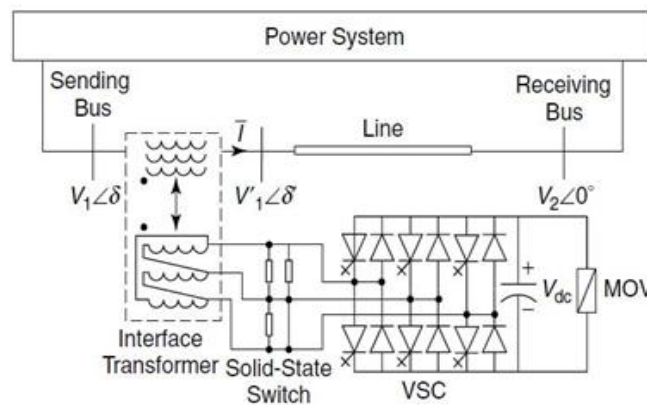
Series controller:-

This has variable impedance like capacitor and reactor. It has power electronic based variable source. This only absorbs or delivers the reactive power as the system required (SSSC), (TCSC) (It inject voltage)

Types of series controller :-

Static synchronous series compensator:-

Static series compensation is a type of series controller. In this we use GTO based VSI that provide compensating voltage to us. This voltage is controllable. It inject voltage in series and able to give bidirectional compensation.



Thyristor controlled series compensation:-

Thyristor controlled series reactor is a parallel combination of a capacitor bank and inductive reactor. This inductive reactor is controlled by thyristor. The range of firing angle of the thyristor is between  $90^\circ$  and  $180^\circ$ . TCSC operate in three different mode

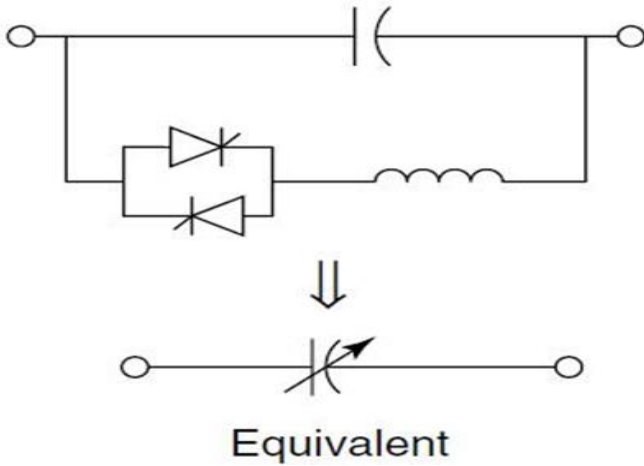
1. Bypass thyristor mode
2. Blocked thyristor mode
3. Vernier mode

In bypass thyristor mode it works as a parallel combination of capacitor and inductor.

In blocked thyristor mode it works as a capacitive reactance.

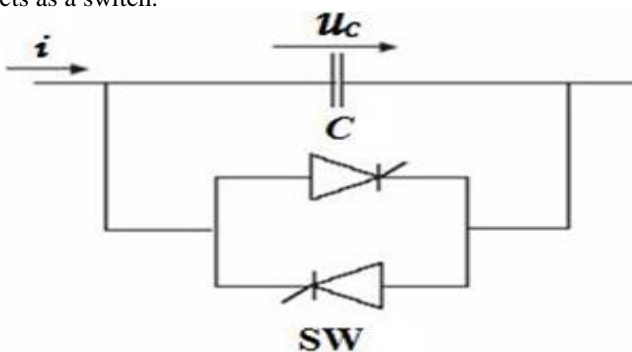
In vernier mode it works as either continuously capacitive reactance or inductive reactance that is controllable.

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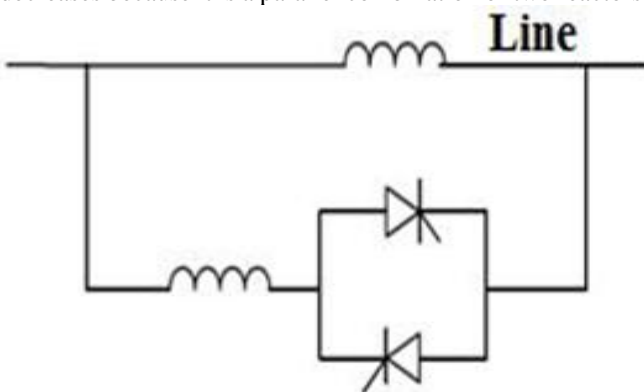
**Thyristor switched series capacitor (TSSC):-**

In thyristor switched series capacitor the capacitor bank is connected in parallel with a pair of thyristor. When any one of thyristor is triggered the capacitor start compensation, so it acts as a switch.



**Thyristor controlled series reactor (TCSR):-**

TCSR consist a parallel combination of two inductive reactance in which one inductive reactance is controlled by the thyristor so also called thyristor controlled reactance. It provide series inductive reactance when the firing angle is  $180^\circ$ . In this condition there is no controlled action. When the firing angle decreases from  $180^\circ$  the total inductance value decreases because it is a parallel combination of two reactors.



**Shunt controller:-**

Shunt controller have variable impedance or variable source or it may be the combination of both. It absorbs or delivers the reactive power, it injected current when require quadrature with voltage ex: (STATCOM, SVC).

**Combined shunt series controller:-**

In this both are combines and they controlled in coordinated manner. The current injected by shunt part and voltage will injected by series part ex: (UPFC)

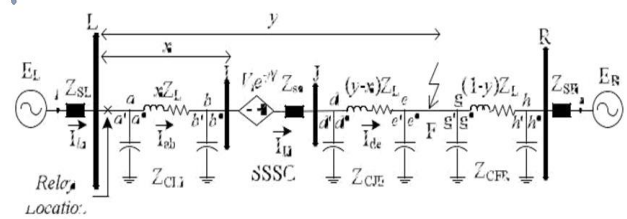
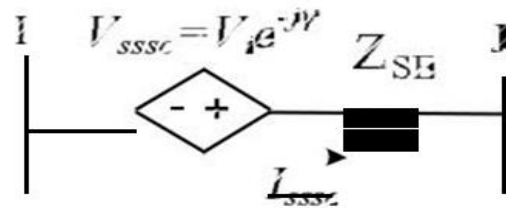
**Performance analysis of compensated transmission line:-**

Transmission line has three main values inductance, capacitance and resistance. The value of power transmitted is highly dependent of inductive reactance, we use parallel line to improve the inductive reactance of line, but it is costly. Facts give new control.

**Impact of shunt capacitance on performance of distance relay:-**

If we take shunt capacitance of transmission line compensated by a static series synchronous compensators other factor those are affecting the line. In this paper we find the precise value of apparent impedance seen by the ground element of the distance relay. We also discuss the effects of ignoring the shunt capacitance of transmission line on relay under reach or over reach.

**Apparent impedance calculation :-**



Here we have a single circuit transmission with end voltage of  $E_L$  and  $E_R$  whose relative magnitude and phase angle are represented by  $h$  and  $\delta$ , respectively i.e.  $E$

$$E_R = h e^{j\delta} E_L$$

Here we have compensators between two buses bus I and bus j, from the bus I the distance is "x". In this system we have single line to ground faults.

After zero sequence compensation the apparent impedance seen by the ground elements of any phase.

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