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ScienceDirect

Energy Procedia 117 (2017) 699–707

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Power Engineering, Computing and CONtrol, PECCON-2017, 2-4 March 2017, VIT University, Chennai Campus

Analysis of Effectiveness of SSSC in Transmission Network using PI Controlled Technique

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Abstract

Today's scenario of power industry is increasing in power demand and limiting in transmission infrastructure. The huge amount of power is transmitted every day over the transmission network. The extension in transmission line facilities may be restricted up to a certain instant due to various reasons like environmental issues, use of land etc. Regulatory pressures also play an important role in the extension of the transmission line and high initial cost can't be avoided. Hence, there are huge restrictions in the path of extension of the transmission line. Earlier due to unavailability of high speed switching semiconductor devices, the dynamic changes in the lines such as voltage suppression, apparent power flow control cannot be compensated immediately. So, in order to meet these issues, FACTS devices have been introduced. The most important member of this family is Static Synchronous Series Compensator (SSSC), which controls the voltage profile and apparent power flow in the line. In this paper, two machine model system with SSSC have been considered which is simulated in MATLAB/SIMULINK. Also, an improved PI (Proportional & Integral) controlled technique utilizing SSSC model has been introduced to improve the parameters such as voltage and apparent power flow in the line. A comparison of these parameters between a compensated and uncompensated line have been carried out and the results show that the distortion level is also at the satisfactory levels.

Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.

Keywords- FACTS, PI controller, SSSC, Voltage Source Converter (VSC).

I. INTRODUCTION

Modern interconnected power system is highly complex in nature. Reliability and security are the two basic requirements of any system. So these qualities of any power system cannot be avoided. To make any complex power system stable is still a challenge to researchers and engineers. As a counter measure against above problems, the FACTS devices can be effectively deployed. FACTS devices may be utilised in many areas of power system such as congestion management, line tripping and stability.

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1876-6102
Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.
10.1016/j.egypro.2017.05.184

SSSC is one of such FACTS device which can control line impedance and voltage phasor simultaneously. SSSC is also called Voltage Source Inverter (VSI), when SSSC, capacitor and a series transformer are connected to the power transmission line in series configuration and this enables the control of apparent power and voltage phasor of the transmission line. Therefore, when SSSC is connected in series with the power system network, it helps in apparent power compensation along with phase shifting responsibly. In addition to this, SSSC has an important secondary function of damping the power system oscillations which may improve the transient stability of the power system.

In this paper, the two machine power system model with SSSC based on damping controllers have been discussed and also, two faults conditions i.e. two-phase ground fault and single phase fault have been considered. The output of the suggested controller is tested for various disturbances and parameter variations. Due to the use of SSSC, the enhanced dynamic response and faster time response of the system over conventional controller can be verified from the results. As, this approach is very easy and simple so, it can be realized in power system networks. Also, the effectiveness of SSSC based PI controller technique has been applied to the power transmission network. The primary objective of the paper is to compare various parameters between compensated and uncompensated line for the same transition time (i.e. 0.2 sec. to 0.3 sec.).

A static synchronous series compensator have been proposed in [1] i.e. based on a multi-bridge inverter. It consists of six H-bridge modules per phase and is capable of generating 13 pulses for each half cycle. A SSSC model along with multi-control technique for load flow analysis have been introduced in [2], which can be utilized for steady state power flow control. The SSSC model along with a fixed capacitor has been presented in [3] i.e. used to avoid the instability of the system. The research has been reported in [4] to provide VSC-HVDC with synchronizing and damping power to reach steady-state in minimum time after a transient. The control schemes for both SSSC and STATCOM based on the principle of VSC have been proposed [5]. It has been realised for voltage stabilization and reactive power compensation of the electrical grid system. The addition of dielectric capacitors to lower the cost of series compensation by SSSC have been reported [6]. Voltage stability analysis with appropriate representations of STATCOM and SSSC have been considered [7]. The dynamic performance of STATCOM and SSSC by theoretical and exact digital simulation techniques have been reported [8]. The investigation based on the effect of two modes of operation on the transient stability limit, synchronizing power and damping power of radial power system have been shown [9]. The analysis and simulation of SSSC for Sub-Synchronous Resonance (SSR) mitigation have been introduced [10-12]. A control strategy for SSSC for SSR mitigation have been derived and analyzed. A damping control algorithm for STATCOM in case of a series compensated Wind Park to mitigate SSR and reducing various power system oscillations have been considered [13]. A comparison of various FACTS controllers for voltage stability analysis has been investigated [14]. The hybrid series compensated power system network with SSR characteristics have been investigated in [15] where, a method for removal of sub-synchronous components of line current utilizing filter have been proposed. The enhancement of low voltage phenomenon using new series grid interface topologies through capability curves of self-excited induction generator based wind turbines have been analyzed [16].

II. ROLE OF SSSC IN POWER SYSTEM

FACTS controllers may broadly be classified on basis of their connection to the system as shunt controller, series controller, phase angle compensating devices and a combination of the above three types. The SSSC is more frequently used to provide series compensation in power transmission lines. SSSC is a power electronic-based VSC that injects a sinusoidal voltage. The phase angle difference between voltage and line current is 90^0. By a series coupling transformer, the power transmission line is connected in series with the SSSC converter block. Unlike other series compensators, the SSSC is capable of providing inductive or capacitive series compensation which may be independent of line current.

A. Principle operation of SSSC:-